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# 8 LOS ALAMOS NATIONAL LABORATORY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at LANL. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including LANL) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to LANL are discussed in Chapter 13 of this EIS. This chapter also includes tribal narrative text that reflects the views and perspectives of the Nambe Pueblo, Santa Clara Pueblo, Pueblo de San Ildefonso, and the Cochiti Pueblo.

The tribal text is included in text boxes in Section 8.1. Full narrative texts provided are in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes unless otherwise noted. DOE recognizes that American Indians have concerns about protecting traditions and spiritual integrity of the land in the LANL region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

## 8.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various resource areas evaluated for the GTCC reference location at LANL. In order to have enough acreage to evaluate for Alternatives 3 to 5, the GTCC reference location at LANL is composed of three undeveloped and relatively undisturbed areas within Technical Area 54 (TA-54) and TA-51, on Mesita del Buey: Zone 6, North Site, and North Site expanded (Figure 8.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at LANL.

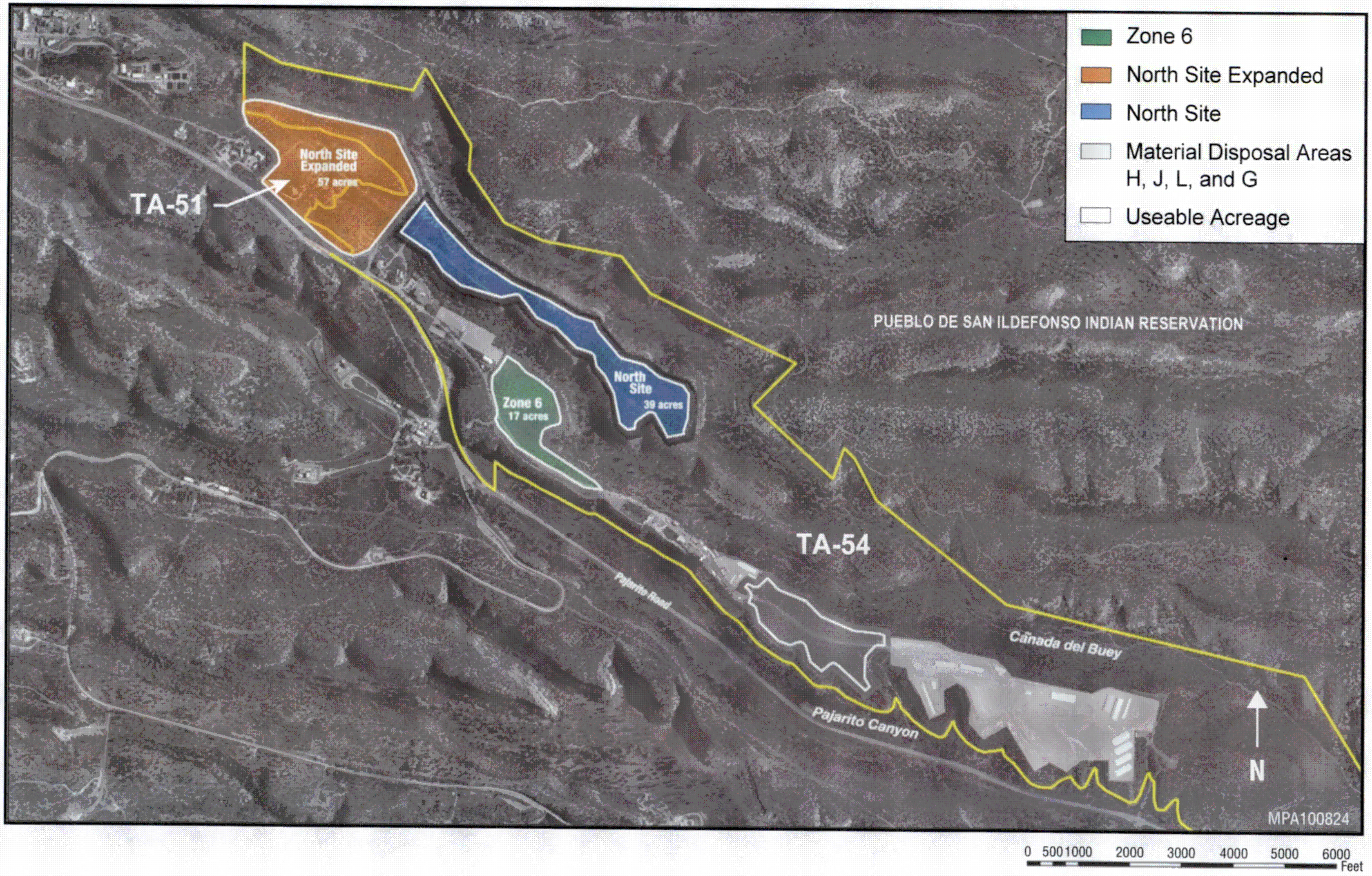



**FIGURE 8.1-1 GTCC Reference Locations at LANL: North Site, North Site Expanded, and Zone 6**

### 8.1.1 Climate, Air Quality, and Noise

#### 8.1.1.1 Climate

The LANL site has a temperate, semiarid mountain climate with four distinct seasons (Bowen 1992). Winters are generally mild, with occasional winter storms. Spring tends to be windy and dry, and summer begins with warm, often dry, conditions, followed by a two-month rainy season. Fall has typically drier, cooler, and calmer weather. Because of the complex topography around the site (e.g., 300-m [1,000-ft] elevation changes), there are large differences in locally observed temperature and precipitation.

The complex topography of the LANL site influences local wind patterns, notably in the absence of large-scale disturbances. Surface winds often vary dramatically with time of day, location, and elevation (Bowen 1992). Daytime winds at the four Pajarito Plateau meteorological towers are predominantly from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande Valley, as shown in the wind roses in Figure 8.1.1-1 (LANL 2007). On the other hand, nighttime winds are lighter and more variable than daytime winds from the west. This condition results from a combination of the prevailing westerly winds and the downslope flow of cooled mountain air. Winds atop Pajarito Mountain, which are much faster than those over the Pajarito Plateau, are more representative of upper-level flows, reflecting the prevailing westerly winds in the area. In general, winds at LANL are light, averaging about 2.8 m/s (6.3 mph) in a year, and prevailing directions are from the south during the day and west-northwest at night (Bowen 1992). Wind speeds are the fastest in spring, slower in summer and fall, and the slowest in winter.

For the 1910–2010 period, the annual average temperature at the LANL site was 8.9°C (48.0°F) (WRCC 2010). January is the coldest month, averaging –1.8°C (28.7°F) and ranging from –7.7 to 4.1°C (18.1 to 39.3°F), and July is the warmest month, averaging 20.0°C (68.0°F) and ranging from 12.8 to 27.1°C (55.1 to 80.8°F). During the years 1910–2010, the highest temperatures reached 35.0°C (95°F), and the lowest reached –27.8°C (–18°F). Daily temperature ranges are large (as high as 14°C [57°F]) at Los Alamos, because of the thin, dry air and frequent clear skies (about three-quarters of the time), which allow strong solar heating during the day and rapid radiative cooling at night (Bowen 1992). Unlike other DOE facilities, LANL is located on high ground: 2,250 m (7,380 ft) above sea level. Atmospheric pressure averages 776 mbar (22.9 in. of Hg), which is about 76% of standard sea-level pressure.

For the 1910–2010 period, annual precipitation at the LANL site averages about 47 cm (18 in.) (WRCC 2010). Winter is the driest season and summer is the wettest; about 36% of the annual precipitation falls from convective storms during July and August (Bowen 1992). Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. For example, in a year, White Rock often receives 13 cm (5 in.) less precipitation, and the eastern flanks of the Jemez Mountains often receive 13 cm (5 in.) more. Snow typically occurs from September through May, peaking in December through March. The annual average snowfall in the area is about 134 cm (53 in.) but is quite variable from year to year (WRCC 2010). The highest recorded snowfall for one season was 389 cm (153 in.), and the

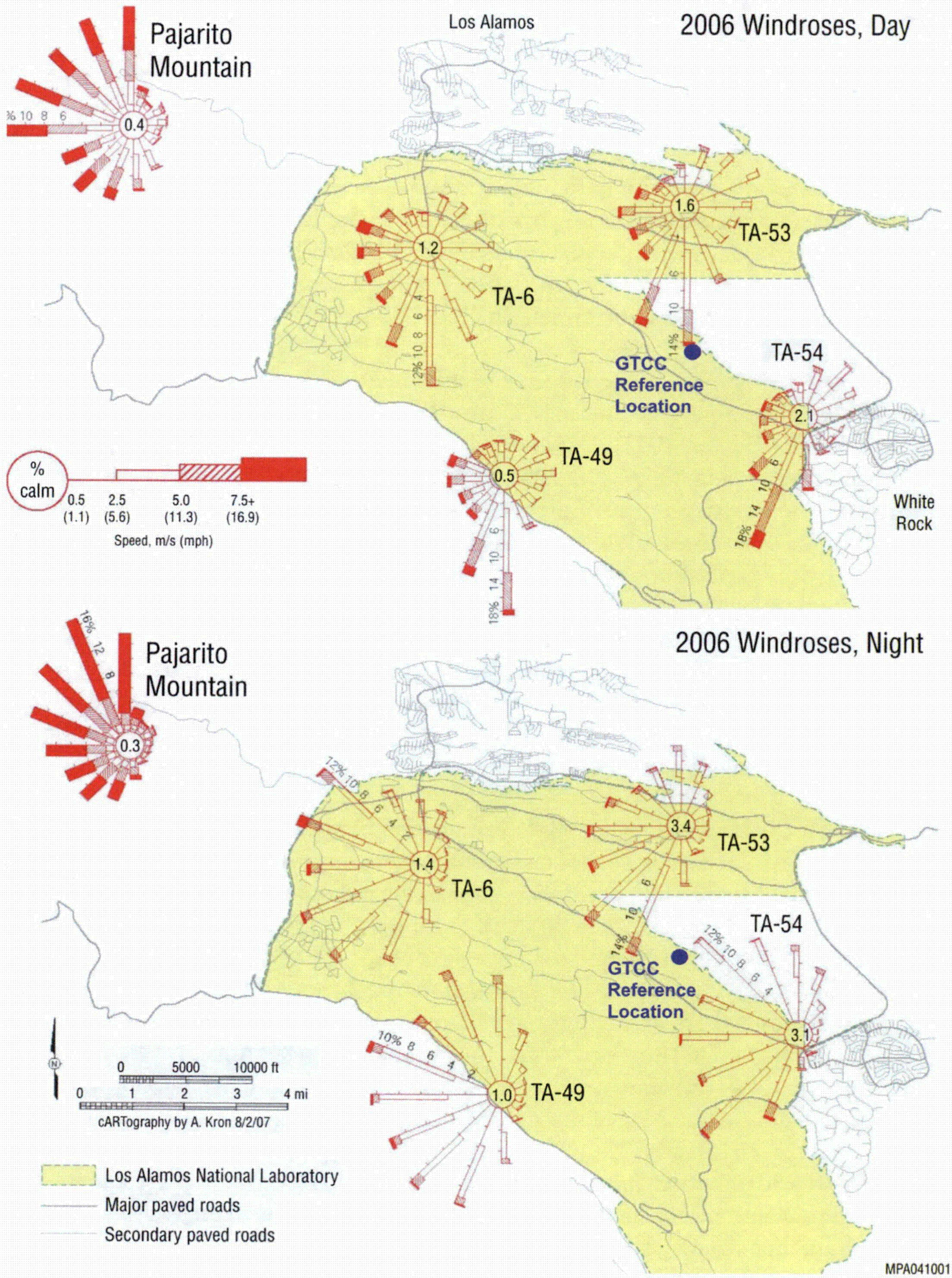



**FIGURE 8.1.1-1 Daytime and Nighttime Wind Roses at and around the LANL Site in 2006 (Source: LANL 2007)**

maximum daily snowfall was 56 cm (22 in.). Large snowfalls may occur locally as a result of orographic lifting of the storms by the high terrain.

Thunderstorms are common at the LANL site, with 61 occurring in an average year (Bowen 1992). Most thunderstorms occur during July and August. The combination of moist air from the Gulf of Mexico and the Pacific Ocean, strong sunshine, and warm surface temperatures promote the formation of afternoon and evening thunderstorms, especially over the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

Tornadoes in the area surrounding the LANL site are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 512 tornadoes were reported in New Mexico, with an average of 8.8 tornadoes per year. Most tornadoes occurred at lower elevations in eastern New Mexico next to Texas (NCDC 2008). Historically, no tornadoes have ever been reported in Los Alamos County. For the period 1950–2008, a total of 18 tornadoes with an average of 0.3 tornado per year were reported in Santa Fe County, which includes a portion of the LANL site. However, most tornadoes occurring in Santa Fe County were relatively weak (i.e., there were fourteen F0 and four F1 tornadoes on the Fujita scale). No deaths and no substantial property damage (in excess of $250,000) were associated with any of these tornadoes.

American Indian Text

The Pueblo people, having lived since the beginning of time in the region of the proposed GTCC waste disposal site, are concerned about meteorological climate shifts occurring over hundreds of years and longer term climate changes occurring over thousands of years. Such shifts impact vegetation. During dryer periods vegetation burns increase and post-burn erosion is accelerated. The Cerro Grande fire increased post-fire storms' runoff flows in some drainages more than 1,000 times the pre-fire levels. These higher runoff flows increased erosion and moved radioactive and hazardous materials downstream towards the Pueblo people.

During warmer periods, more intense rainfall episodes occur and less snow falls in winter, thus increasing erosion. Tree ring data document shifts in annual rainfall between 1523 and today, with a rainfall high in 1597 of 40 inches to a low in 1685 of 2.4 inches.

During the Holocene, major shifts occurred in this region, and the GTCC disposal is to be evaluated for a duration of 10,000 years. These climate shifts are both culturally important to the Pueblo people who conduct ceremonies to balance climate and pertinent to the consideration of GTCC proposal.

#### 8.1.1.2 Existing Air Emissions

Pursuant to the federal CAAA and Title 20, Chapter 2, Part 70, "Operating Permits," of the *New Mexico Administrative Code* (20.2.70 NMAC), Los Alamos National Security LLC is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100–M1 (LANL 2007). Emission sources specified in the permit include multiple boilers, two steam plants, a data disintegrator, carpenter shops, three degreasers, and asphalt production. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities. In 2006, LANL demonstrated full compliance with all other permit applicable terms and conditions and met all reporting requirement deadlines, except for an excess emission at the Asphalt Plant, which slightly exceeded the smoke opacity limit.

Annual emissions for major facility sources and total point and area sources for year 2002 for criteria pollutants and VOCs in Los Alamos and Santa Fe Counties, New Mexico, which encompass the LANL site, are presented in Table 8.1.1-1 (EPA 2009). Area sources consist of nonpoint and mobile sources. Data for 2002 are the most recent data available on the EPA website. There are few major point sources in the area; LANL is one of the major sources in Los Alamos County. Area sources account for most of the emissions of criteria pollutants and VOCs.

**TABLE 8.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Los Alamos and Santa Fe Counties Encompassing the LANL Site[a]**

| | Emission Rate (tons/yr) | | | | | |
|---|---|---|---|---|---|---|
| Emission Category | $SO_2$ | $NO_x$ | CO | VOCs | $PM_{10}$ | $PM_{2.5}$ |
| Los Alamos County | | | | | | |
| *Los Alamos National Laboratory*[b] | *1.3* | *65* | *28* | *40* | *10* | *9.6* |
| | *2.2%*[c] | *12%* | *0.82%* | *8.0%* | *0.47%* | *3.4%* |
| | *0.31%* | *0.90%* | *0.04%* | *0.47%* | *0.02%* | *0.15%* |
| Point sources | 1.3 | 65 | 28 | 40 | 10 | 9.6 |
| Area sources | 60 | 480 | 3,400 | 460 | 2,200 | 280 |
| Total | 61 | 540 | 3,400 | 500 | 2,200 | 290 |
| Santa Fe County | | | | | | |
| Point sources | 0.0 | 54 | 72 | 33 | 40 | 27 |
| Area sources | 370 | 6,600 | 62,000 | 7,900 | 53,000 | 6,000 |
| Total | 370 | 6,700 | 62,000 | 7,900 | 53,000 | 6,000 |
| Two-county total | 430 | 7,200 | 65,000 | 8,400 | 55,000 | 6,300 |

a Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, $NO_x$ = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 μm, $PM_{10}$ = particulate matter ≤ 10 μm, $SO_2$ = sulfur dioxide, VOCs = volatile organic compounds. Values have been rounded to two significant figures. Totals may not add up because of the independent rounding of values within the table. Traffic at LANL is the primary contributor to air quality impacts at the site.

b Data in italics are not added to yield total.

c The top row and bottom row with % signs show emissions as percentages of Los Alamos County and two-county total emissions, respectively.

Source: EPA (2009)

On-road sources are major contributors to the total emissions of $SO_2$, $NO_x$, CO, and VOCs; miscellaneous sources are major contributors to emissions of $PM_{10}$ and $PM_{2.5}$. Nonradiological emissions associated with activities at the LANL site are 12% or less of those in Los Alamos County and 1% or less of those in the two counties combined, as shown in the table.

Under the Title V Operating Permit program, LANL is classified as a major source on the basis of its potential to emit $NO_x$, CO, and VOCs (LANL 2007). In 2006, the TA-3 steam plant and boilers located across the LANL site were the major contributors of $NO_x$, CO, and PM. R&D activities were responsible for most of the VOCs and hazardous air pollutant emissions. Stationary standby generators are major contributors to sulfur oxides ($SO_x$) emissions. Table 8.1.1-2 presents a five-year (2002–2006) history of criteria pollutant and VOC emissions for emissions inventory reporting to the NMED. Emissions for 2005 and 2006 were very similar and remained relatively constant following the sharp decline in 2004 emissions from the higher emissions in 2002 and 2003. The sharp decline in 2004 may have resulted from air curtain destructors being taken out of service in October of 2003.

American Indian Text

Contaminated air emissions either from fugitive dust, violent storms, dust devils, emission stacks, bomb testing, burn pits, or from the Cerro Grande fire have spread to surrounding Pueblo lands and communities. A Santa Clara Pueblo wind monitor meteorological station recorded a wind of 70 miles per hour. Dust devils have been recorded by LANL at 73 miles per hour. Santa Clara, Pueblo de San Ildefonso, Pueblo de Cochiti, and Jemez perceive that they have received contaminated ash and air from the Cerro Grande fire, from more than 110 historic and active LANL emission stacks, and bomb testing detonations. Nambe, Pojoaque, and the surrounding Pueblos perceive that they too received contaminated ash from the Cerro Grande fire. The contaminations from these events exposed natural resource users ranging from hunters of animals to gatherers of clay for pots. Even normal Pueblo residents were exposed in many ways from farming to outdoor activities to everyday life.

The Pueblo de Cochiti is situated within Sandoval County, and emissions rates here were not compared in the GTCC to emission rates of LANL. The Pueblo de Cochiti is located south of LANL and adjacent to the PSD [Prevention of Significant Deterioration] Class I Bandelier National Monument. The Pueblo de Cochiti could thus be considered a PSD Class I area as well and all emissions pose a threat to this classification.

All the Accord Pueblos (Pueblo de San Ildefonso, Pueblo de Cochiti, Santa Clara, and Jemez Pueblo) are currently conducting independent studies of air emissions from LANL. These studies have been ongoing for about ten years. Some Pueblos have their findings evaluated by independent laboratories. These studies are monitoring tritium, plutonium, uranium, americium, and other radionuclides and metals. Some of the studies have documented contaminated air emissions on Pueblo lands.

**TABLE 8.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds at LANL during 2002–2006 for Emissions Inventory Reporting to the New Mexico Environment Department[a]**

| | Emission Rate (tons/yr) | | | | |
|---|---|---|---|---|---|
| Year | $SO_2$ | $NO_x$ | CO | VOCs | PM |
| 2002 | 1 | 65 | 28 | 40 | 15 |
| 2003 | 2 | 50 | 32 | 50 | 22 |
| 2004 | 0.3 | 25 | 17 | 10 | 3 |
| 2005 | 0.2 | 24.5 | 18 | 13 | 3.3 |
| 2006 | 0.4 | 24.5 | 18 | 14 | 4.4 |

[a] CO = carbon monoxide, $NO_x$ = nitrogen oxides, PM = particulate matter, $SO_2$ = sulfur dioxide, VOCs = volatile organic compounds.

Source: LANL (2007)

#### 8.1.1.3 Air Quality

Among criteria pollutants ($SO_2$, $NO_2$, CO, $O_3$, $PM_{10}$ and $PM_{2.5}$, and lead), the New Mexico SAAQS are identical to the NAAQS for $NO_2$ (EPA 2008a; 20.2.3 NMAC), as shown in Table 8.1.1-3. The State of New Mexico has established more stringent standards for $SO_2$ and CO, but there are no standards for $O_3$, PM, and lead. In addition, the State has adopted standards for hydrogen sulfide ($H_2S$) and total reduced sulfur and has retained the standard for total suspended particulates (TSP), which used to be one of criteria pollutants but was replaced by $PM_{10}$ in 1987.

The GTCC reference location within LANL is situated mostly in Los Alamos County, with a small section (northeast) being in Santa Fe County. These two counties that encompass LANL are designated as being in attainment for all criteria pollutants (40 CFR 81.332).

Currently, the Nonradiological Air Sampling Network (NonRadNet), which was implemented in 2001, conducts monitoring to (1) develop a database of typical background levels for selected nonradiological species in the communities nearest LANL and (2) measure LANL's potential contribution to nonradiological air pollution in the surrounding communities (LANL 2007). The program consists of six ambient PM ($PM_{10}$ and $PM_{2.5}$) monitoring units at three locations, plus selected Ambient Air Monitoring Network (AIRNET) samples, which are analyzed for three nonradiological constituents: aluminum, calcium, and beryllium.

The highest concentration levels of all criteria pollutants except for $O_3$ and $PM_{2.5}$ around LANL are less than or equal to 60% of their respective standards in Table 8.1.1-3 (EPA 2009; LANL 2004–2006, 2007). The highest $O_3$ and $PM_{2.5}$ concentrations are 84% and 80% of their

**TABLE 8.1.1-3 National Ambient Air Quality Standards (NAAQS) or New Mexico State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at LANL, 2003–2007**

| | | | Highest Background Level | |
|---|---|---|---|---|
| Pollutant[a] | Averaging Time | NAAQS/ SAAQS[b] | Concentration[c,d] | Location (Year) |
| $SO_2$ | 1-hour | 75 ppb | –[e] | – |
| | 3-hour | 0.5 ppm[d] | 0.079 ppm (16%) | San Juan Co. (2003)[f] |
| | 24-hour | 0.10 ppm | 0.013 ppm (13%) | San Juan Co. (2005)[f] |
| | Annual | 0.02 ppm | 0.003 ppm (15%) | San Juan Co. (2004)[f] |
| $NO_2$ | 1-hour | 0.100 ppm | – | – |
| | 24-hour | 0.10 ppm | – | – |
| | Annual | 0.053 ppm | 0.019 ppm (38%) | Albuquerque, Bernalillo Co. (2004)[f] |
| CO | 1-hour | 13.1 ppm | 3.0 ppm (23%) | Santa Fe, Santa Fe. Co. (2005) |
| | 8-hour | 8.7 ppm | 1.9 ppm (22%) | Santa Fe, Santa Fe. Co. (2003) |
| $O_3$ | 1-hour | 0.12 ppm[g] | 0.070 ppm (58%) | Santa Fe, Santa Fe. Co. (2007) |
| | 8-hour | 0.075 ppm | 0.063 ppm (84%) | Santa Fe, Santa Fe. Co. (2007) |
| TSP | 24 hours | 150 $\mu g/m^3$ | – | – |
| | 7 days | 110 $\mu g/m^3$ | – | – |
| | 30 days | 90 $\mu g/m^3$ | – | – |
| | Annual geometric mean | 60 $\mu g/m^3$ | – | – |
| $PM_{10}$ | 24-hour | 150 $\mu g/m^3$ | 90 $\mu g/m^3$ (60%) | White Rock, Los Alamos Co. (2003) |
| $PM_{2.5}$ | 24-hour | 35 $\mu g/m^3$ | 28 $\mu g/m^3$ (80%) | Los Alamos, Los Alamos Co. (2003) |
| | Annual | 15 $\mu g/m^3$ | 8.0 $\mu g/m^3$ (53%) | Los Alamos, Los Alamos Co. (2005) |
| Lead | Calendar quarter | 1.5 $\mu g/m^3$ [h] | 0.03 $\mu g/m^3$ (2.0%) | Albuquerque, Bernalillo Co. (2004)[f] |
| | Rolling 3-month | 0.15 $\mu g/m^3$ | – | – |
| $H_2S$ | 1 hour | 0.010 ppm | – | – |
| Total reduced sulfur | 1/2 hour | 0.003 ppm | – | – |

a CO = carbon monoxide, $H_2S$ = hydrogen sulfide, $NO_2$ = nitrogen dioxide, $O_3$ = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, $PM_{10}$ = particulate matter ≤10 μm, $SO_2$ = sulfur dioxide, TSP = total suspended particulates.

b The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

c Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; the highest for 24-hour $PM_{10}$ and $PM_{2.5}$; second-highest for 3-hour and 24-hour $SO_2$, 1-hour and 8-hour CO, and 1-hour $O_3$; 4th-highest for 8-hour $O_3$; arithmetic mean for annual $SO_2$, $NO_2$, and $PM_{2.5}$.

d Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

e A dash indicates that no measurement is available.

f These locations with the highest observed concentrations in the state of New Mexico are not representative of the LANL site but are presented to show that these pollutants are not a concern over the state of New Mexico.

g On June 15, 2005, the EPA revoked the 1-hour $O_3$ standard for all areas except the 8-hour $O_3$ nonattainment EAC areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour $O_3$ standard.

**Footnotes continue on next page.**

**TABLE 8.1.1-3 (Cont.)**

[h] Used old standard because no data in the new standard format are available.

Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, $NO_x$ = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 µm, $PM_{10}$ = particulate matter ≤ 10 µm, $SO_2$ = sulfur dioxide, VOCs = volatile organic compounds. Values have been rounded to two significant figures. Totals may not add up because of the independent rounding of values within the table. Traffic at LANL is the primary contributor to air quality impacts at the site.

Sources: EPA (2008a, 2009); LANL (2004–2006, 2007); 20.2.3 NMAC (refer to http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.pdf)

standards, respectively. Overall, background concentration levels around the LANL site are below the standards for all criteria pollutants. Nearby urban or suburban measurements are typically used as being representative of background concentrations for LANL. Criteria pollutants are primarily the result of vehicular traffic of employees as part of the normal commuting to, from, and within the LANL site.

LANL and its vicinity are classified as PSD Class II areas. The nearest Class I area is Bandelier National Monument, about 5 km (3 mi) southwest of the GTCC reference location (40 CFR 81.421). Three more Class I areas are within 100 km (62 mi) of the GTCC reference location, including (in order of distance) the Pecos, San Pedro Parks, and Wheeler Peak Wilderness Areas. Currently, there are no facilities operating at LANL that are subject to PSD regulations.

#### 8.1.1.4 Existing Noise Environment

Noise, air blasts (also known as air pressure waves or over pressures), and ground vibrations are intermittent aspects of the LANL site environment (DOE 1999a).

Although the State of New Mexico has established no quantitative noise-level regulations, Los Alamos County has promulgated a local noise ordinance that establishes noise level limits for residential land uses. Noise levels that affect residential receptors are limited to a maximum of 65 dBA during daytime hours and 53 dBA during nighttime hours (i.e., 9 p.m. to 7 a.m.). Between 7 a.m. and 9 p.m., the permissible noise level can be increased to 75 dBA in residential areas, provided that the noise is limited to 10 minutes in any one hour. Activities that do not meet the noise ordinance limits require a permit (DOE 1999a).

Noise levels around the LANL site are combined effects from LANL-related activities and activities unrelated to LANL. LANL-related noise sources include the movement of vehicles to and from LANL, activities at technical areas, aboveground testing of high explosives, and security guards' firearms practice sessions (DOE 1999a). Noise sources within Los Alamos County unrelated to LANL include predominantly traffic movements and, to a much lesser degree, other residential-, commercial-, and industrial-related activities within Los Alamos and White Rock communities. Detailed noise and vibration sources at LANL and noise measurements are presented in the 1999 LANL SWEIS (DOE 1999a). The 2008 SWEIS (DOE 2008c) also refers to the data in the 1999 SWEIS.

Currently, data on the levels of routine background noise, air blasts, and ground vibrations generated by LANL operations (including explosives detonations) are limited (DOE 1999a). Measurements of nonspecific background ambient noise in the LANL area have been taken at a couple of locations near LANL boundaries next to public roadways. Background noise levels ranged from 31 to 35 dBA at the vicinity of the entrance to Bandelier National Monument and New Mexico State Road (SR) 4. At White Rock, background noise levels ranged from 38 to 51 dBA; this is slightly higher than the level found near Bandelier National Monument, probably because of the higher levels of traffic and the presence of a residential neighborhood as well as the different physical setting. These noise levels are typical of rural or quiet suburban residential areas (Eldred 1982).

For the general area surrounding the LANL site, the countywide $L_{dn}$ (based on population density) is estimated to be 40 dBA for Santa Fe County and 44 dBA for Los Alamos County — typical of rural areas (Miller 2002; Eldred 1982).

American Indian Text

The Sacred Area is currently monitored for noise by Pueblo de San Ildefonso. Noise, which from a Pueblo perspective is an unnatural sound, does disturb ceremony and the place itself. Currently non-Indian voices, machinery, and processing equipment have been recorded by Pueblo de San Ildefonso monitors as coming from Area G to the Sacred Area.

### 8.1.2 Geology and Soils

#### 8.1.2.1 Geology

**8.1.2.1.1 Physiography.** LANL is located on the Pajarito Plateau, within the Rio Grande rift zone, in the Southern Rocky Mountain physiographic province (and immediately adjacent to the eastern edge of the Colorado Plateau), in north-central New Mexico. The east-sloping Pajarito Plateau is composed predominantly of volcanic material (tuffs) and covers an area of about 620 km$^2$ (240 mi$^2$). LANL is situated on about 93 km$^2$ (36 mi$^2$ or 23,040 ac) in its central part. The plateau overlies the western portion of the Española Basin, extending to the southeast from the Sierra de los Valles on the eastern rim of the Jemez Mountains to White Rock Canyon and the Española Valley (Figure 8.1.2-1). The plateau was formed by the deposition of volcanic ash from calderas in the central part of the Jemez Mountains. Surface water flow across the Pajarito Plateau has created a mesa and canyon landscape. Its surface is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. The canyon bottoms are covered with a thin layer of alluvium; mesa tops show little soil formation. Drainage is by ephemeral and intermittent streams that discharge to the Rio Grande, which lies just to the east of the plateau (Purtymun 1995; Broxton and Vaniman 2005; DOE 2008c).

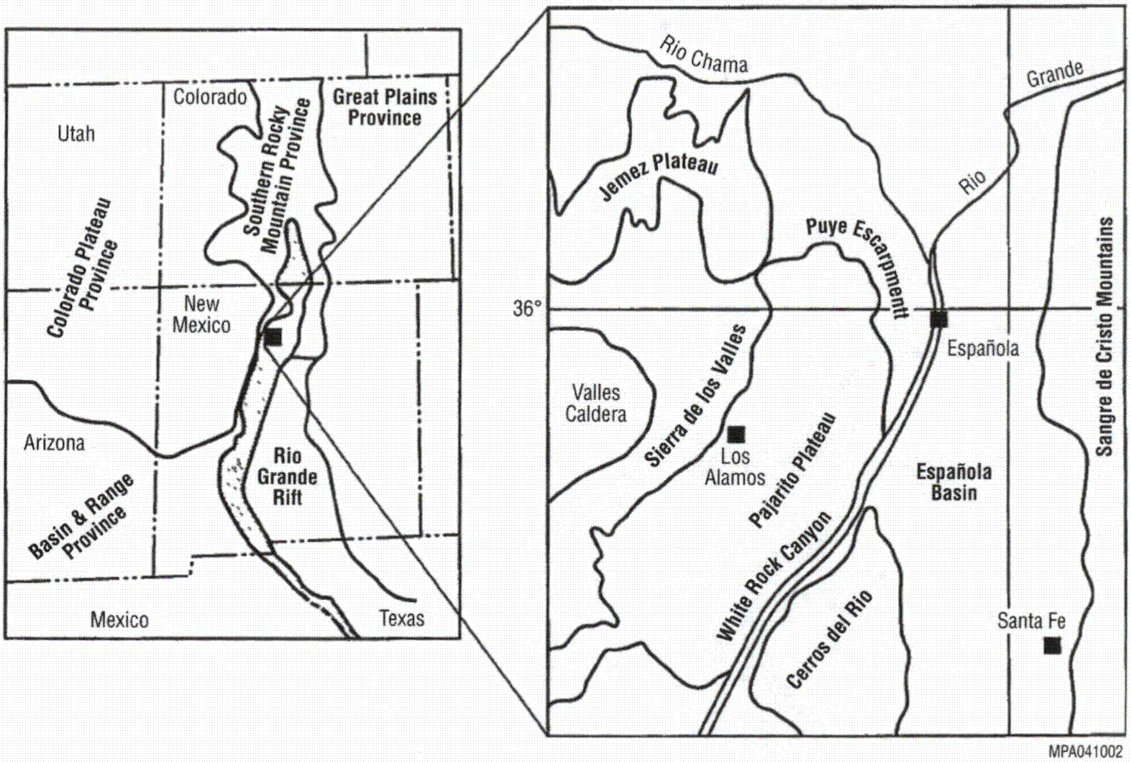
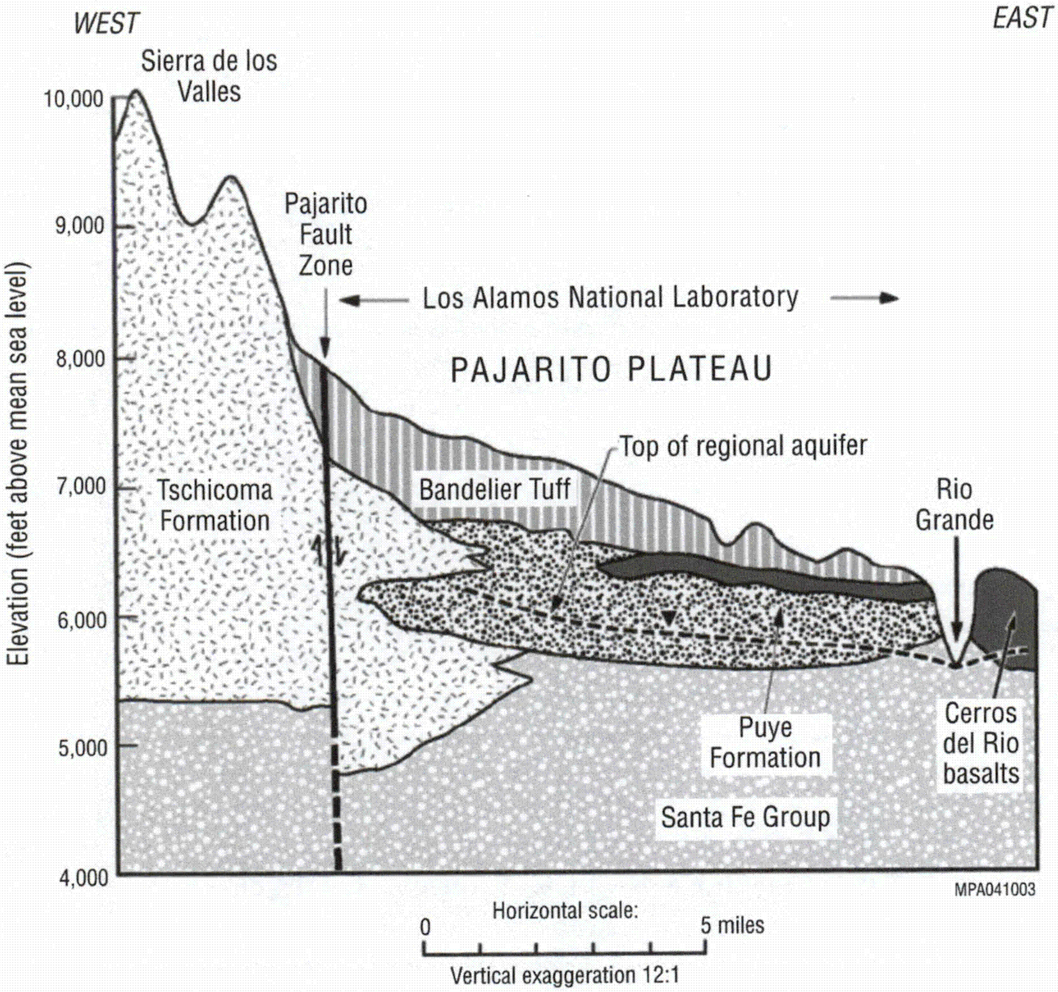



**FIGURE 8.1.2-1 Location of LANL in the Southern Rocky Mountain Physiographic Province (Source: Purtymun 1995)**

**8.1.2.1.2 Topography.** The maximum elevation in the Sierra de los Valles is 3,505 m (11,500 ft) MSL. The Pajarito Plateau forms an apron 13- to 26-km (8- to 16-mi) wide and 48- to 64-km (30- to 40-mi) long around the eastern flanks of the Sierra de los Valles (Purtymun 1995). Elevations on the plateau range from 2,377 m (7,800 ft) MSL on the slopes of the Sierra de los Valles to 1,900 m (6,200 ft) MSL along the eastern edge, where it terminates at the Puye Escarpment and White Rock Canyon (Figure 8.1.2-1). The mesa top elevation at TA-54 is about 1,768 m (5,800 ft) MSL.

Running along the east side of the plateau, the Rio Grande drops from an elevation of about 1,676 m (5,500 ft) MSL to about 1,634 m (5,360 ft) MSL as it flows from Los Alamos Canyon to Frijoles Canyon (Purtymun 1995; DOE 2008c).

**8.1.2.1.3 Site Geology and Stratigraphy.** The Pajarito Plateau consists of a complex sequence of rocks of volcanic and fluvial origins that together form a vertical intergradation of wedge-shaped strata (Figure 8.1.2-2). Volcanic units consist of volcaniclastics and volcaniclastic-derived sediments from the Jemez Mountain volcanic field to the west. Fluvial deposits are associated with alluvial fan development from Precambrian basement rock in the highlands to the north and east of the site (DOE 2008c).




Notes:
1. The thickness of geologic units has been exaggerated on this figure to illustrate unit relationships and topography.
2. Offset of the Tschicoma formation on the Pajarito Fault zone is schematic due to the variation along the trace of the fault.
3. To convert feet to meters, multiply by 0.3048.

Source: LANL 2005j.

**FIGURE 8.1.2-2 Generalized Cross Section of Pajarito Plateau (Source: DOE 2008c)**

The GTCC reference locations are situated on the northwest end of TA-54. TA-54 is an elongated area with a northwest-southeast trend that sits on the narrow part of Mesita del Buey (Figure 8.1-1). It is bounded to the south by Pajarito Canyon and to the north by Cañada del Buey. The boundary between LANL and the Pueblo de San Ildefonso is on the far side of Cañada del Buey. The Bandelier Tuff makes up the majority of surface exposures and near surface rocks; it is composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs deposited during eruptions of the Valles caldera, about 18 km (11 mi) west of TA-54 (Krier et al. 1997).

The following summary of stratigraphy for Mesita del Buey is based on the work of Purtymun (1995), Krier et al. (1997), Reneau et al. (1998), Gardner et al. (1999), and Broxton and Vaniman (2005) and on material presented in the latest SWEIS (DOE 2008c). A generalized cross section of the plateau is shown in Figure 8.1.2-2. Figure 8.1.2-3 presents a stratigraphic column of the Pajarito Plateau.

**Middle to Upper Tertiary (Oligocene to Miocene) Rocks.**

***Santa Fe Group.*** The Santa Fe Group encompasses the sediments of the Española Basin. It is subdivided into several formations (from oldest to youngest): the Tesuque Formation, the older fanglomerate deposits of the Jemez Mountain volcanic field, the Totavi Lentil, and the Puye Formation.

The Miocene Tesuque Formation is composed of fluvial deposits derived from Precambrian granite, pegmatite, sedimentary rocks from the Sangre de Cristo Range, and Tertiary volcanic rocks from northern New Mexico. Beds are typically greater than 3-m (10-ft) thick, massive to planar- and cross-bedded, light pink to buff siltstone and sandstone, with minor lenses of pebbly conglomerate. There are no exposures of this formation within LANL site boundaries; however, exposures may be found on the eastern margins of the Pajarito Plateau and along the canyon walls to the north (e.g., Los Alamos Canyon).

Older fanglomerate deposits are widespread on the Pajarito Plateau. Deposits are composed of volcanic detritus and dark lithic sandstone with gravel and cobbles. The unit is up to 500-m (1,650-ft) thick and interfingers with the Tschicoma Formation.

The Totavi Lentil consists of poorly consolidated and well rounded sands, gravels, and cobbles deposited by the ancestral Rio Grande. The unit is highly variable in thickness (from 10 to 30 m [30 to 100 ft]) and rests conformably on top of the older fanglomerate deposits.

The Puye Formation is composed of large alluvial fans made up of volcanic material and alluvium; its source rocks are the domes and flows in the Sierra de los Valles. The formation has two facies: fanglomerate and lacustrine. The fanglomerate is an intertonguing mixture of stream flow, sheet flow, debris flow, block and ash fall, pumice fall, and ignimbrite deposits, up to 330-m (1,100-ft) thick. The lacustrine facies may be up to 9-m (30-ft) thick and include lake and river deposits in the upper part of the section, consisting of fine sand, silt, and clay. The Puye Formation is well exposed on the Pajarito Plateau and unconformably overlies the Santa Fe Group.

The total thickness of the Santa Fe Group is as much as 1,460 m (4,800 ft) in the eastern and northern part of the basin. Prebasin strata are exposed along the basin margins; they include Upper Paleozoic (Mississippian to Permian), Mesozoic marine, terrestrial sedimentary rocks, and Upper Tertiary Laramide synorogenic deposits.

***Cerros del Rio Basalts.*** The thick, dense-fractured mafic lava flows and rubbly flow breccias of the Cerros del Rio Basalts underlie and interfinger with the sedimentary

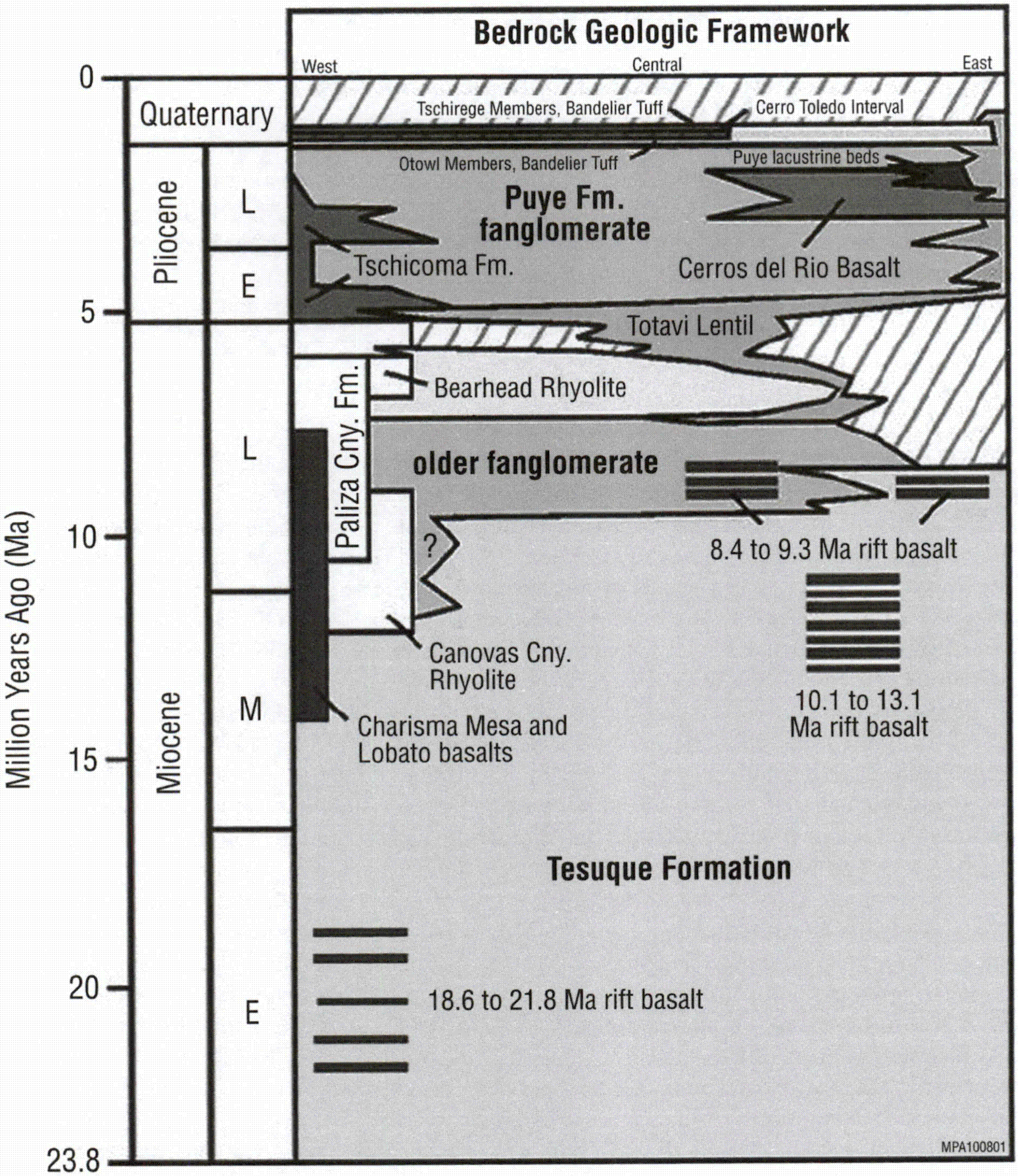



**FIGURE 8.1.2-3 Stratigraphic Column for the Pajarito Plateau at LANL (Source: Modified from DOE 2008c)**

conglomerates and fanglomerates of the Puye Formation (Figures 8.1.2-2 and 8.1.2-3). Their thicknesses beneath T-54 are unknown but are at least 82 m (269 ft) in places.

***Tschicoma Formation.*** The Tschicoma Formation interfingers with the deposits of the Puye Formation. It consists of thick dacite and low-silica rhyolite lava flows erupted from the Sierra del los Valles. The unit has a thickness of up to 762 m (2,500 ft) in the Sierra del los Valles (Figure 8.1.2-1). Beneath the Pajarito Plateau surface, the formation is lenticular. It extends broadly across the plateau, thinning eastward.

**Quaternary Deposits.**

***Bandelier Tuff.*** The Bandelier Tuff forms the upper surface of the Pajarito Plateau, lapping up onto the Tschicoma Formation along its western edge (Figure 8.1.2-2). The tuff is thickest to the west of LANL (near its source) and gets thinner as it goes eastward across the plateau. The upper two members of the Bandelier Tuff, the Tshirege Member (upper) and the Otowi Member (lower), are separated by an ash-fall/fluviatile sedimentary interval (referred to as the Cerro Toledo interval) (Figure 8.1.2-4). The lowest member, the Guaje Member, underlies the Cerro Toledo interval and rests conformably on rocks of the Puye Formation. All three members are present on Mesita del Buey.

The following discussion uses the nomenclature originally adopted by Baltz et al. (1963) to describe the stratigraphic units of the Bandelier Tuff (e.g., Units 1a, 1b, 2a, 2b, and 3) because investigators such as Krier et al. (1997) have used it, both for simplicity and to maintain continuity with previous investigations related to waste disposal and hydrologic issues in TA-54.

The Tshirege Member at Mesita del Buey consists of (from youngest to oldest) Units 2b, 2a, 1b, and 1a and the basal Tsankawi pumice bed. According to Krier et al. (1997), Units 2b through 1b crop out on the tops and sides of Mesita del Buey; units older than 1b have only been observed in borehole samples deeper than the base of the mesa. Unit 2b is the brittle and resistant caprock that forms the tops of mesas, including Mesita del Buey. It is about 12-m (40-ft) thick in the southeastern portion of TA-54 and is composed of crystal-rich devitrified pumice fragments in a matrix of ash, shards, and abundant phenocrysts. It is extensively fractured as a result of contraction due to cooling after deposition. Fractures are typically filled with smectite clays to a depth of about 3 to 4 m (10 to 13 ft), with opal and calcite below this depth. Opal and calcite deposition is associated with the presence of tree root molds; live tree roots have been observed at depths of up to 20 m (66 ft). The base of this unit is commonly marked by a thin interval (less than 10 cm or 4 in.) of crystal-rich material that is the size of fine-grained sand (called surge beds) that represents deposition from the basal surge associated with violent eruptions. The surge beds on Mesita del Buey have been displaced by small faults.

Unit 2a underlies Unit 2b; it consists of devitrified ash-fall and ash-flow tuff. The unit is about 14-m (46-ft) thick in the southeastern portion of TA-54 and is slightly welded at its base, becoming moderately welded further up the section. Some of the more prominent cooling

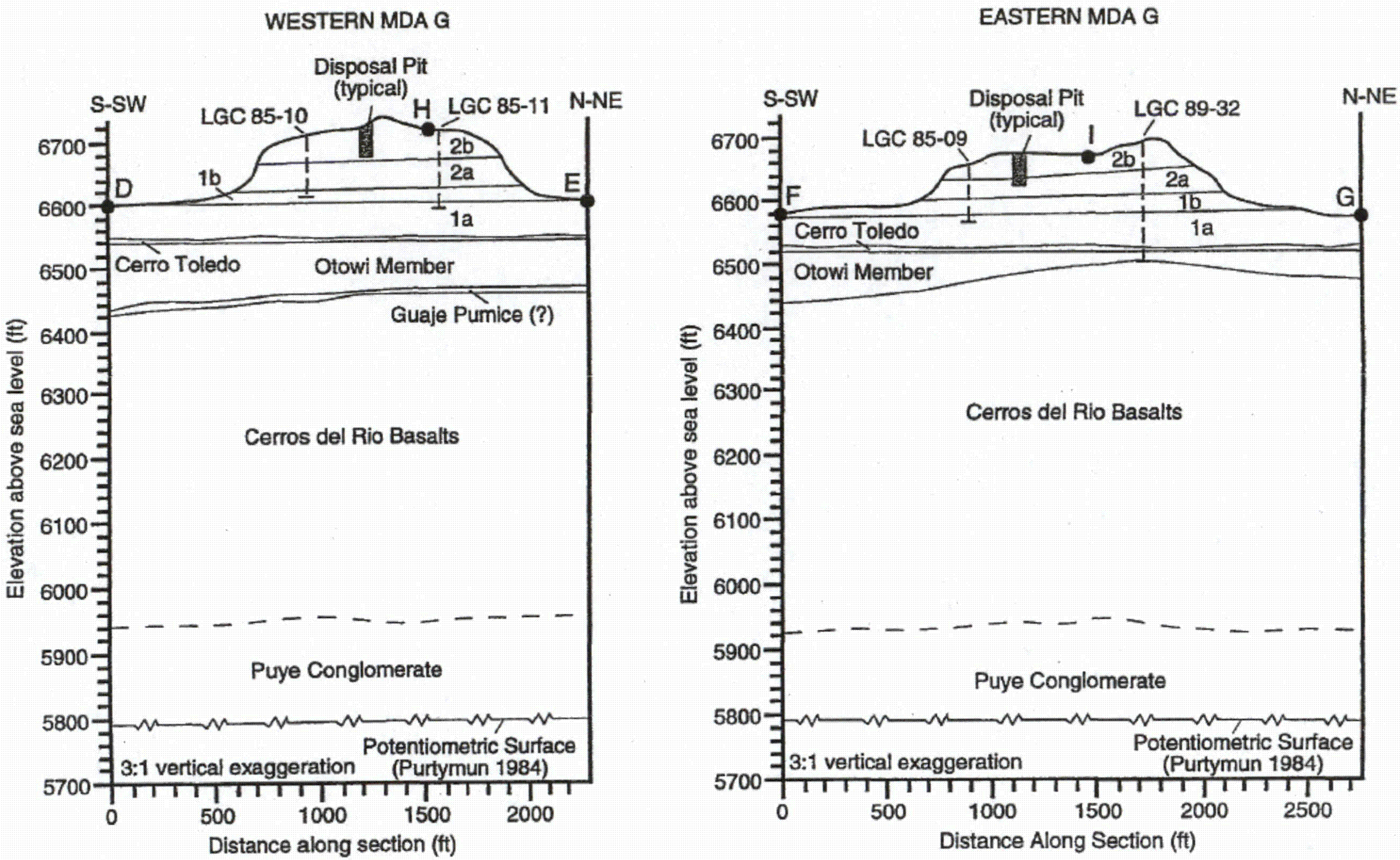



**FIGURE 8.1.2-4 Stratigraphy of the Bandelier Tuff at Material Disposal Area G, to the Southeast of the GTCC Reference Location (Source: Krier et al. 1997)**

fractures originating in Unit 2b extend down into Unit 2a. Attempts to retrieve core samples from this unit invariably result in unconsolidated material.

Unit 1b underlies Unit 2a; it is a slightly welded to welded, devitrified ash-flow tuff that becomes increasingly welded toward its center. It has a greater content of unwelded pumice lapilli than the overlying Unit 2b, and it exhibits little of its fracturing characteristics. Unit 1b ranges from 7- to 15-m (23- to 49-ft) thick in the southeastern portion of TA-54.

Unit 1a is the oldest unit of the Tshirege Member. It is a vitric, pumiceous, nonwelded ash-flow tuff with a thickness of up to 15 m (50 ft) in the southeastern portion of TA-54. Because of its weak matrix properties, this unit likely has few fractures.

The Tsankawi Pumice Bed is fairly thin (i.e., less than 0.30 m or 1 ft) at TA-54. It consists of a layer of gravel-sized, vitric, nonwelded pumice. The bed is extensive on the Pajarito Plateau and marks the base of the Tshirege Member. Underlying this basal unit is the Cerro Toledo interval, which is composed of sedimentary deposits, including tuffaceous sandstones, siltstones, and gravel and cobbles of mafic to intermediate lavas. It also contains deposits of ash and pumice. The Cerro Toledo interval has a thickness of about 5 m (16 ft) in the southeastern portion of TA-54; it typically gets thinner to the east across the Pajarito Plateau.

The Otowi Member at Mesita del Buey is a massive, nonwelded, pumiceous rhyolite tuff. It has a fine-grained ash matrix that contains an unsorted mix of phenocrysts (e.g., quartz and sanidine), glass shards, mafic minerals, and various rock fragments (e.g., latite, rhyolite, quartz latite, and pumice). The unit is about 30-m (100-ft) thick in the southeastern portion of TA-54 and typically gets thinner to the east. It rests conformably on the Guaje Member, the basal unit of the Bandelier Tuff. The Guaje Member is composed of nonwelded pumice fragments that are silicified and brittle. The bed is about 3.7-m (12-ft) thick.

***Mesa Top Alluvium.*** Silts, sands, gravels, soils, and reworked pyroclastic deposits overlie the Bandelier Tuff in many mesa-top localities, including Mesita del Buey. These deposits generally sit on the erosional surface that cuts the upper units of the Tshirege Formation. Alluvial gravels, deposited by a fluvial system that predates the incision of canyons on the Pajarito Plateau, contain abundant pumice and dacite clasts. The age of these deposits has been estimated to be several hundred thousand years old.

***Canyon Alluvium.*** Canyon alluvium is derived from the weathering and erosion of rocks from the Sierra de los Valles and the Pajarito Plateau. The thickness of the alluvium varies but is typically less than 6 m (20 ft) and increases as it goes eastward. Alluvial deposits are composed of unconsolidated silty to coarse sands of quartz and sanidine (feldspar), crystal fragments, and fragments of pumice. Occasional fragments of latite or latite-composition lava and welded tuff are also present.

**8.1.2.1.4 Seismicity.** LANL is located in the Española Basin within the Rio Grande rift zone. The Rio Grande rift is a north-trending, active tectonic feature that extends from central Colorado to northern Mexico (Figure 8.1.2-5). Basins in the rift zone are bounded by normal faulting that occurs along the rift zone margins and within the basins. The Española Basin is a west-tilting half-graben bounded on the west edge by north-trending normal faults of the Pajarito fault zone, bounded on the north by northeast-trending transverse faults of the Embudo fault zone, and bounded on the south by northwest-trending transverse faults of the Bajada fault zone (LANL 2007; Broxton and Vaniman 2005; Gardner et al. 1999).

The seismicity of north central New Mexico is concentrated along the rift structures within the Rio Grande rift — stretching from Socorro to Albuquerque — and tends to be shallow (i.e., less than 20 km [12 mi]). It is absent in areas of high heat flow, as in the calderas in the Jemez Mountains, because of the increased ductility of rocks; this situation reduces the likelihood of brittle fracture and faulting even at shallow depths (Cash and Wolff 1984).

The main strand of the Pajarito fault system, a major structural element of the Rio Grande rift, lies along the western boundary of LANL (Figures 8.1.2-5 and 8.1.2-6). The fault system is a north-northeast trending series of en echelon faults; it consists of the Pajarito fault zone and the related Guaje Mountain and Rendija Canyon faults (Figure 8.1.2-6). Activity along the fault system has been recurrent, with abundant evidence at the surface showing that Quaternary vertical displacement has taken place (e.g., stream gradient discontinuities and topographic scarps of up to 125 m [410 ft] in the Bandelier Tuff). Horizontal movement is also evident, particularly along the segment north of LANL. For these reasons, the fault system is considered capable[1] and has the potential to generate earthquakes in the region (Dransfield and Gardner 1985; Gardner and House 1987; Wachs et al. 1988; Wong 1990). It is considered to be the primary source of seismic risk at LANL (LANL 2007; DOE 2008c).

As many as 37 faults with vertical displacements of 5 to 65 cm (0.5 to 25 in.) have been observed in the surge beds of the Tshirege Member in outcrops of Mesita del Buey along Pajarito Canyon. Fault planes are steeply dipping, indicating normal displacement, and most displacements are down to the west. Lateral movement may also have occurred along these faults. Faults are thought to be no more than 1.2 million years old. Fracture studies have characterized the fractures in Unit 2 of the Tshirege Member in TA-54 (Area G) as steeply dipping, with preferential dips to the north and east. Fractures become more closely spaced with depth (Reneau and Vaniman 1998; Reneau et al. 1998; DOE 2008c). These faults are likely secondary effects associated with large earthquakes in the main Pajarito fault system, and the principal faults likely experience small amounts of movement during earthquakes (DOE 2008c).

The record of earthquakes in the vicinity of LANL goes back only to the 1940s when the town of Los Alamos was first established. Reports of earthquakes felt before 1950 are rare. Earthquakes of particular note that were felt in Los Alamos occurred on August 17, 1952 (magnitude estimate of 4); February 17, 1971 (magnitude estimate of 3.4); December 5, 1971

1 The NRC defines a capable fault as a fault with demonstrable historic macroseismicity, recurrent movements within the last 500,000 years, and/or one movement within the last 35,000 years (10 CFR Part 100, Appendix A).

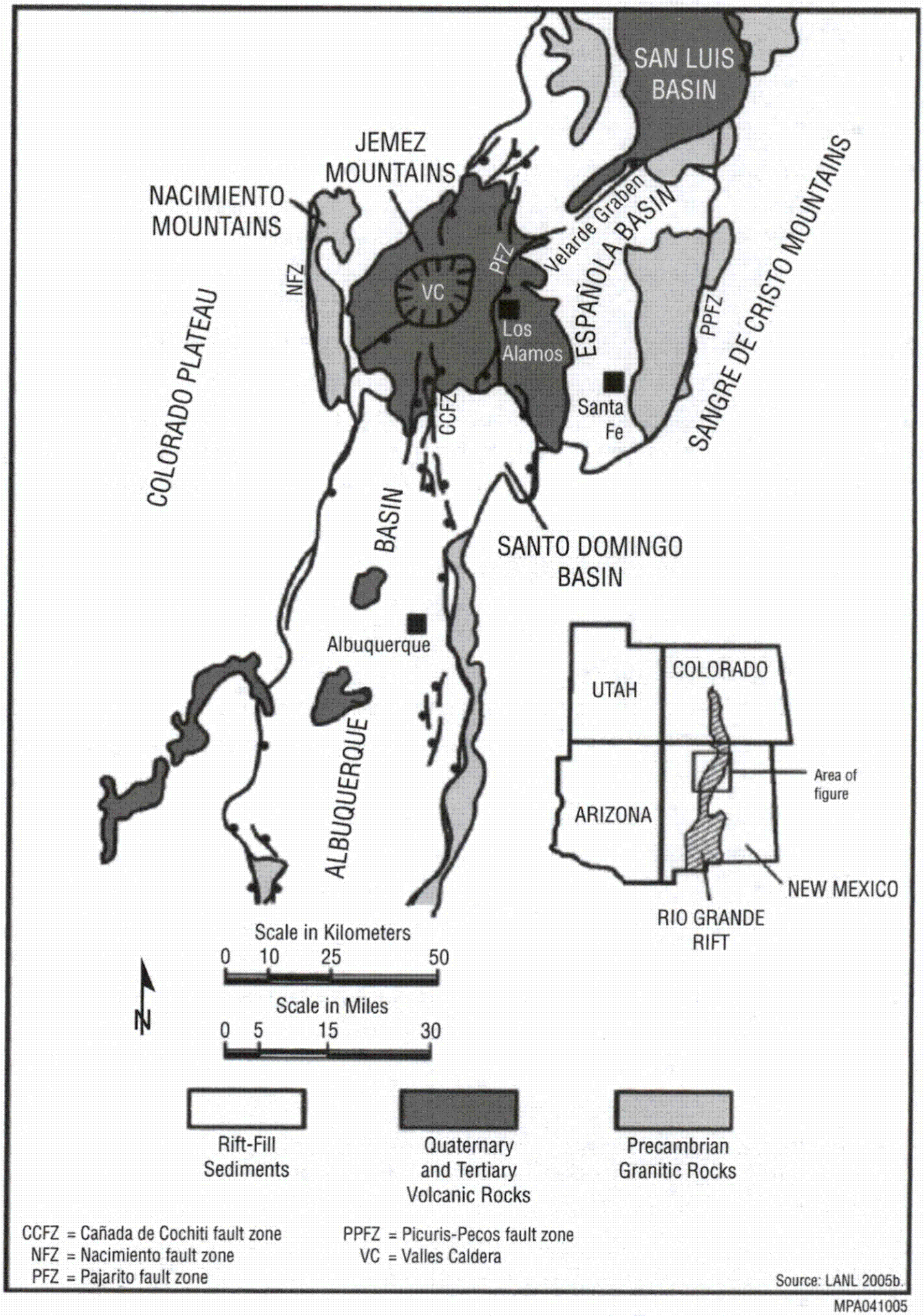



**FIGURE 8.1.2-5 Structural Elements of the Rio Grande Rift Zone (Source: DOE 2008c)**

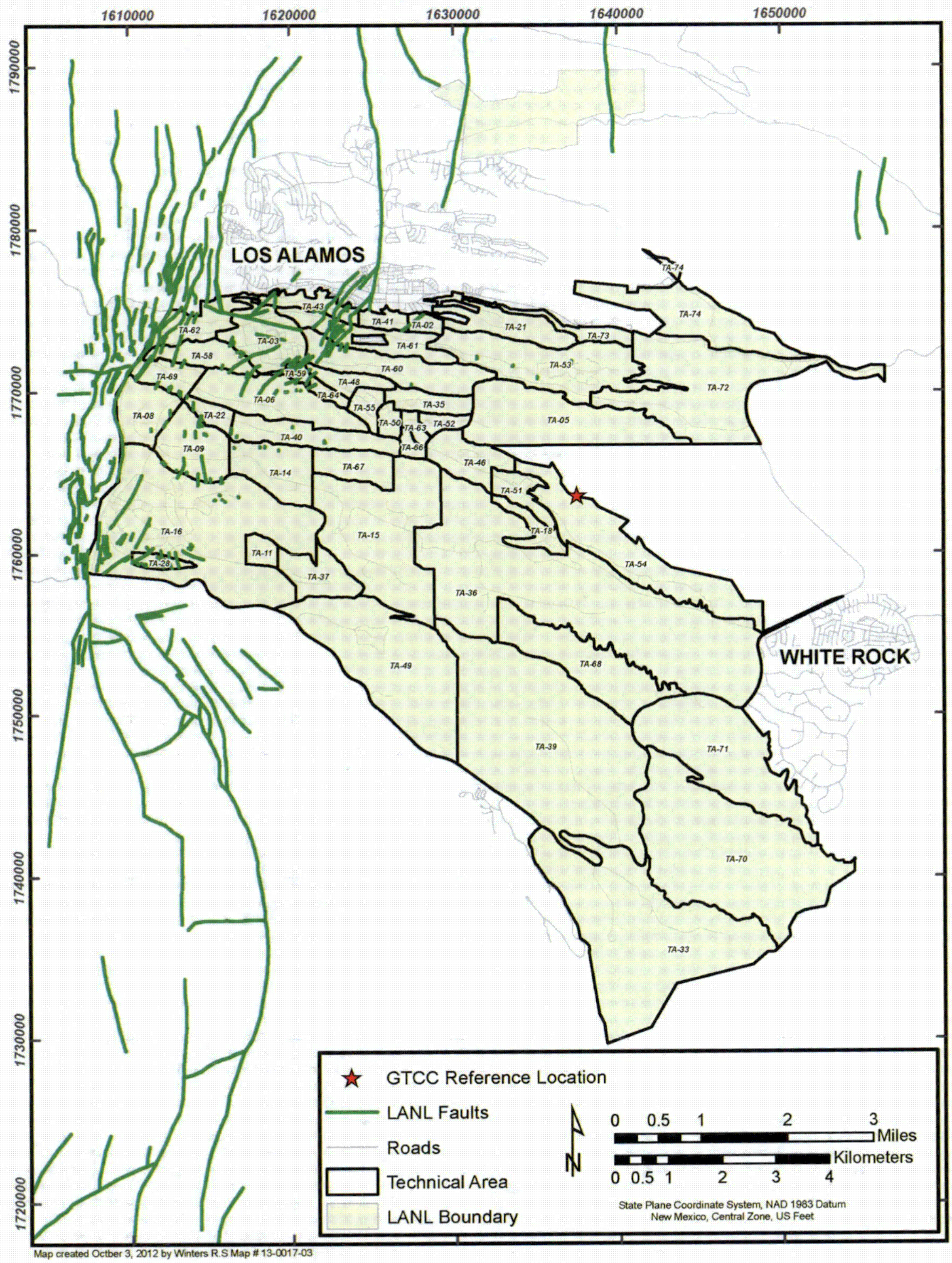



FIGURE 8.1.2-6 Mapped Faults in the LANL Area (Source: DOE 2008c)

(magnitude estimate of 3.3); and March 17, 1973 (magnitude estimate of 3.3). The largest reported earthquake in the region occurred in Cerrillos in 1918, about 50 km (31 mi) to the southeast of LANL; it had an estimated Richter local magnitude (ML) of about 5.3 (House and Cash 1988; DOE 1999a).

As many as 2,000 earthquakes have been recorded since the inception of the Los Alamos Seismograph Network in 1973. The largest event occurred in 1976, about 60 km (37 mi) to the west of LANL (near Gallup, New Mexico), with a magnitude of 5.2 (Cash and Wolff 1984; House and Cash 1988). A catalog of earthquakes occurring in the vicinity of LANL from 1893 to 1991 has been compiled by Wong et al. (1995). The latest SWEIS (DOE 2008c) documents more recent seismic events. Since 1991, five small earthquakes (with magnitudes of 2 or less on the Richter scale) have been recorded along the Pajarito fault (DOE 2008c).

A seismic hazard study, conducted in 2007, was based on more recent geological studies that characterize the faults within the Pajarito fault system and their relationships in the LANL area. The study determined that a 0.0004-per-year earthquake (with a return frequency of 2,500 years) would produce peak horizontal accelerations of about 0.47 to 0.52g for a surface facility in technical areas to the west of TA-54 (where the principal faults, and thus the principal seismic risks at LANL, are located). A 0.001-per-year earthquake (with a return frequency of 1,000 years) would produce peak horizontal accelerations of about 0.25 to 0.27g (DOE 2007; DOE 2008c).

An updated seismic hazard study was completed in 2009 to refine estimates of the 2007 study (DOE 2009b). The 2009 study used the new set of empirical ground motion attenuation models, available as part of the Pacific Earthquake Engineering Research Center's Next Generation Attenuation (NGA) Models for the Western United States Project (based on the latest geologic data published in Lewis et al. [2009] and documented in DOE [2007]). It refined estimates made in the 2007 study, finding that horizontal and peak acceleration values for a 0.0004-per-year earthquake (with a return frequency of 2,500 years) were 0.47g and 0.51g, respectively, a reduction from the 2007 study. The dominant earthquake was determined to be in the range of moment magnitude (M) 6.0 to 7.0 at close distances (DOE 2009b).

Facilities near a cliff edge or in a canyon bottom are potentially susceptible to slope instability, rock falls, and landslides. Slope stability studies have been performed at LANL facilities where a mass movement hazard has been identified. The potential for seismically induced land subsidence at LANL is considered low; the potential for soil liquefaction is considered negligible (DOE 2003).

American Indian Text

The Pueblo people are aware of the occurrence of major earthquakes in the GTCC study area (up to 2000 have been recorded in recent times). These cause vertical displacements, large fissures, and small fractures. Water seeps into these fissures and plant roots follow them to great depths (up to 66 feet). Pueblo people believe that plant roots will eventually penetrate the GTCC facility.

**8.1.2.1.5 Volcanic Activity.** Most of the volcanic activity in the vicinity of LANL has occurred in the Jemez Mountains, just to the west of the Pajarito Plateau (Figure 8.1.2-1). Volcanic activity dates to 16.5 million years ago. The oldest activity was concentrated to the southwest of the plateau and was dominated by basaltic to andesitic lavas (with minor dacites and rhyolites). About 3 to 7 million years ago, the activity shifted to the north and became dominated by dacites and rhyolites. Two major eruptions about 1.6 to 1.2 million years ago produced the ash fall material making up the Otowi and Tshirege Members of the Bandelier Tuff and formed the Valles Caldera, about 8 km (5 mi) to the west of LANL. The most recent volcanic activity within Valles Caldera is estimated to have occurred about 150,000 years ago (although some suggest activity occurred as recently as 50,000 to 60,000 years ago), creating rhyolitic lava domes and minor pyroclastic deposits. Currently, the Jemez Mountains show little seismic or volcanic activity (DOE 1999a; Rosenberg and Turin 1993).

The low seismic activity is attributed to the adsorption of seismic energy deep in the subsurface due to elevated temperatures and high heat flow, thus masking the movement of magma and adding to the difficulty of predicting a volcanic event in the LANL area (although a large Bandelier-Tuff-type eruption would give years of warning, as regional uplift and doming occurred). The Jemez Mountains continue to be considered a zone of potential volcanic activity (DOE 1999a, 2008c).

The Cerros del Rio basaltic field to the southeast of the Pajarito Plateau represents other volcanic activity in the vicinity of LANL (Figure 8.1.2-1). These basalts range in age from 1.1 to 1.4 million years (Rosenberg and Turin 1993).

**8.1.2.1.6 Slope Stability, Subsidence, and Liquefaction.** Steep canyon walls within LANL are susceptible to rock falls and landslides. The potential for these processes to occur is related to wall steepness, canyon depth, and stratigraphy. At greatest risk are facilities near a cliff edge or in a canyon bottom. Slope instability may be triggered by excessive rainfalls, erosion, and seismic activity (DOE 1999a). However, a study conducted for TA-3 indicated that rock spalling near canyon walls was determined not to be of concern even in an earthquake (Bradley et al. 2007). Fires, such as the Cerro Grande fire that occurred in 2000, also contribute to slope instability because they cause a loss of vegetative cover and the formation of hydrophobic soil, increasing soil erosion in localized areas. This risk is reduced as vegetation returns (DOE 2008c).

Subsidence and soil liquefaction are less likely to affect areas within LANL than are rock falls or landslides. The potential for subsidence is reduced by the firm rock beneath LANL. The potential for liquefaction is minimal, since bedrock, soils, and other unconsolidated materials at LANL tend to be unsaturated (DOE 1999a).

#### 8.1.2.2 Soils

The undisturbed soils within the study area were formed from material weathered from tuff on the nearly level surface (with slopes of 1% to 5%) of Mesita del Buey. These soils are shallow to moderately deep and well drained, with low to moderate permeability and a small to moderate erosion hazard. At the surface (to a depth of 10 cm [4 in.]), soils are predominantly brown loam to sandy loam. They become clay loam to clay with increasing depth (up to 50 cm [20 in.]). The substratum is a gravelly sandy loam, containing up to 30% pumice, with a thickness of about 40 cm (16 in.). The depth to tuff bedrock is from 30 to 100 cm (12 to 40 in.) (DOE 1999a; Nyhan et al. 1978).

#### 8.1.2.3 Mineral and Energy Resources

Mineral resources at LANL consist of rock and soil that are excavated for use as backfill or borrow material for construction of remedial structures, such as waste unit caps. Most borrow materials are taken from sedimentary deposits of the Santa Fe Group and Pliocene-age volcanic rocks (e.g., the Bandelier Tuff) and from Quaternary alluvium along stream channels (in limited volumes). The only borrow pit currently in use at LANL is the East Jemez Road Borrow Pit in TA-61 to the northwest of TA-54. The pit is cut into the Bandelier Tuff and is used for soil and rubble storage and retrieval. There are at least 11 commercial borrow pits and quarries within 48 km (30 mi) of LANL; these produce mostly sand and gravel (DOE 2008c). Pumice has been mined on U.S. Forest Service (USFS) land in Guaje Canyon (DOE 1999a).

LANL has conducted extensive research on geothermal energy systems throughout the United States (including the Valles Caldera in New Mexico) and in other countries. This research involves both conventional and dry hot rock geothermal energy. There are currently seven experimental geothermal (gradient) wells at LANL. Currently, there are no geothermal production wells on-site.

American Indian Text

The Pueblo people who visited the proposed GTCC disposal site note the likelihood of traditionally used minerals occurring there. They assess that this is a medium to high probability. There is a need for a cultural mineral assessment and study to identify the existence of minerals of cultural significance and use.

Although there is no current Pueblo ethnogeology studies for the LANL, one was recently developed for Bandelier National Monument. That study, which was approved by the participating pueblos, documented that 96 geological resources were found to have specific uses by Pueblo people, which is estimated to be the bulk of the occurring minerals in Bandelier NM. The following are the ten most frequently cited mineral resources, presented in order of frequency of reference. Included also is the number of pueblos that were documented to have used the named resource (1) Clay 17 times mentioned for 7 pueblos; (2) Turquoise 15 times mentioned for 7 pueblos; (3) Basalt 15 times mentioned for 5 pueblos; (4) Obsidian 9 times mentioned for 4 pueblos; (5) Gypsum 8 times mentioned for 5 pueblos; (6) Rock Crystal 8 times mentioned for 5 pueblos; (7) Salt 7 times mentioned for 4 pueblos; (8) Mica 6 times mentioned for 5 pueblos; (9) Sandstone 6 times mentioned for 5 pueblos; and (10) Hematite 6 times mentioned for 4 pueblos. Just as there are certain minerals that are more frequently documented, certain pueblos were more often the subject of observations and ethnographies.

### 8.1.3 Water Resources

#### 8.1.3.1 Surface Water

**8.1.3.1.1 Rivers and Streams.** LANL covers 100 $km^2$ (40 $mi^2$) of the Pajarito Plateau in north-central New Mexico, approximately 56 km (35 mi) northwest of Santa Fe. The surface of the Pajarito Plateau is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. There are about 140 km (85 mi) of drainage courses within LANL boundaries, of which only about 3.2 km (2 mi) are naturally perennial. About 5 km (3 mi) of streams flow perennially because they are supplemented by wastewater discharge. Most streams, however, are dry for most of the year and flow only in response to storm runoff or snowmelt.[2] Surface water also flows from shallow groundwater discharging as springs into canyons. Figure 8.1.3-1 shows the 16 watersheds in the vicinity of LANL; 12 of them cross LANL boundaries. The watersheds are named for the canyons that receive their runoff. TA-54 is situated on Mesita del Buey, between Pajarito Canyon to the south and Cañada del Buey to the north (LANL 2005; DOE 2008c). The GTCC reference sites at LANL are situated on Mesita del Buey.

Stream flow is monitored at six locations in Pajarito Canyon and three locations in Cañada del Buey (Figure 8.1.3-2; Table 8.1.3-1). Gauges monitoring the Pajarito Canyon during water year 2006 were dry for most of the year, with recorded average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 12 cms (425 cfs) on August 25. Similarly, gauges monitoring Cañada del Buey were dry for most of the year, with average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 6.4 cms (228 cfs) on August 25 (Table 8.1.3-1).

American Indian Text

Pueblo people know that drainages in LANL flow during major runoff and storm events. These flows, though at times low in volume, have a potential to reach the Rio Grande and lower water bodies. In 1996, the Pueblo of Cochiti conducted a cooperative sediment study with LANL and the USGS in which Pre-1960s Legacy Waste was identified using the Thermal Ionization Mass Spectroscopy (TIMS) method. This Pre-1960s Legacy Waste has been recorded on the up-river portion of the Cochiti Reservoir, which is on the Rio Grande as it passes through the Cochiti Reservation.

There exists high potential for continuing pollution flows as indicated in the GTCC text above, and now the Cerro Grande fire has increased the potential for constituent movement as indicated in the Site-Wide EIS. Evidence of radioactivity and hazardous waste (PCBs) movement from LANL has led to fish consumption warnings on eating fish from the Rio Grande.

2 Environmental surveillance reports distinguish between streams that are ephemeral (always above the water table) and those that are intermittent (sometimes below the water table) because of the different biological communities they support.

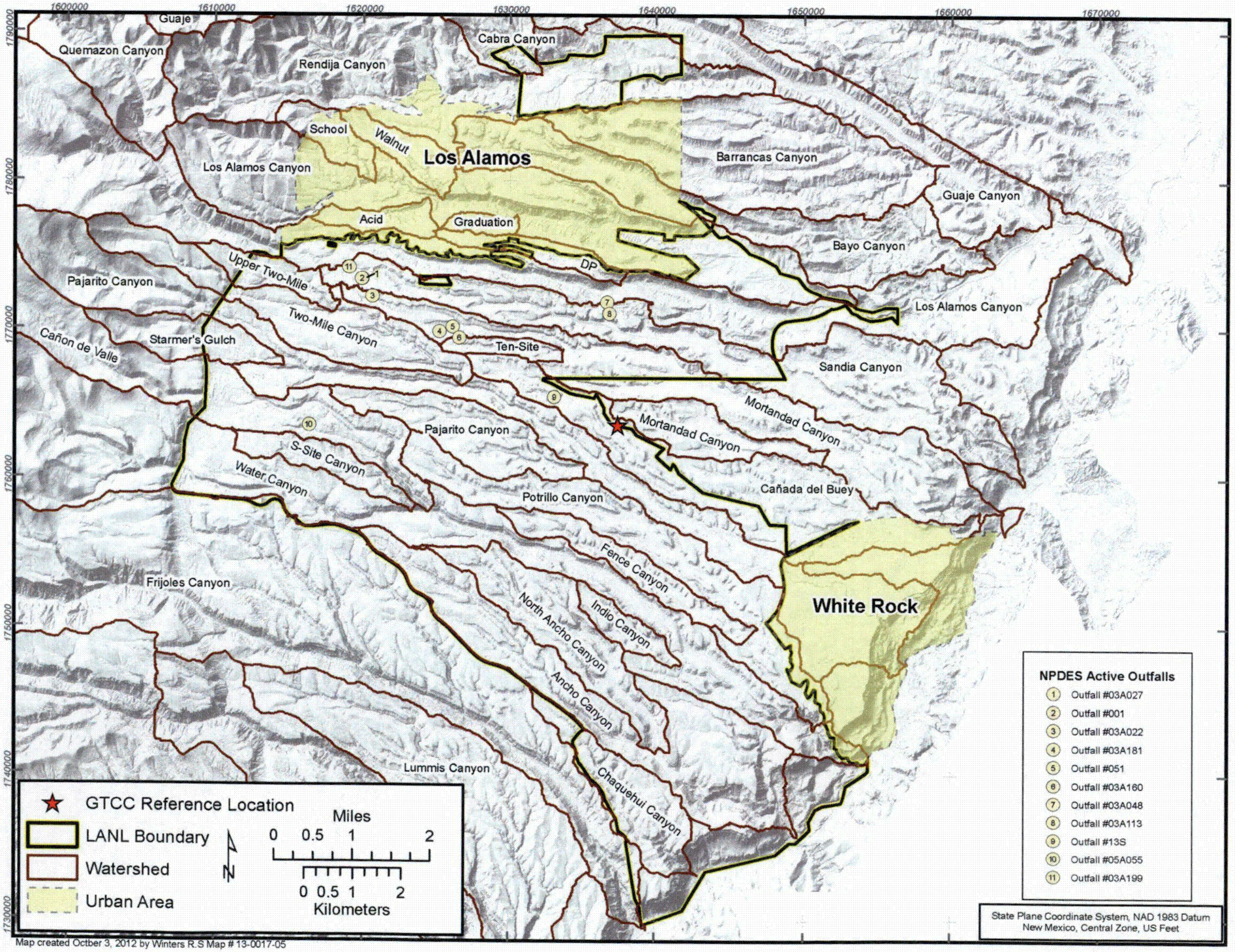



**FIGURE 8.1.3-1 Watersheds in the LANL Region (Source: DOE 2008c)**

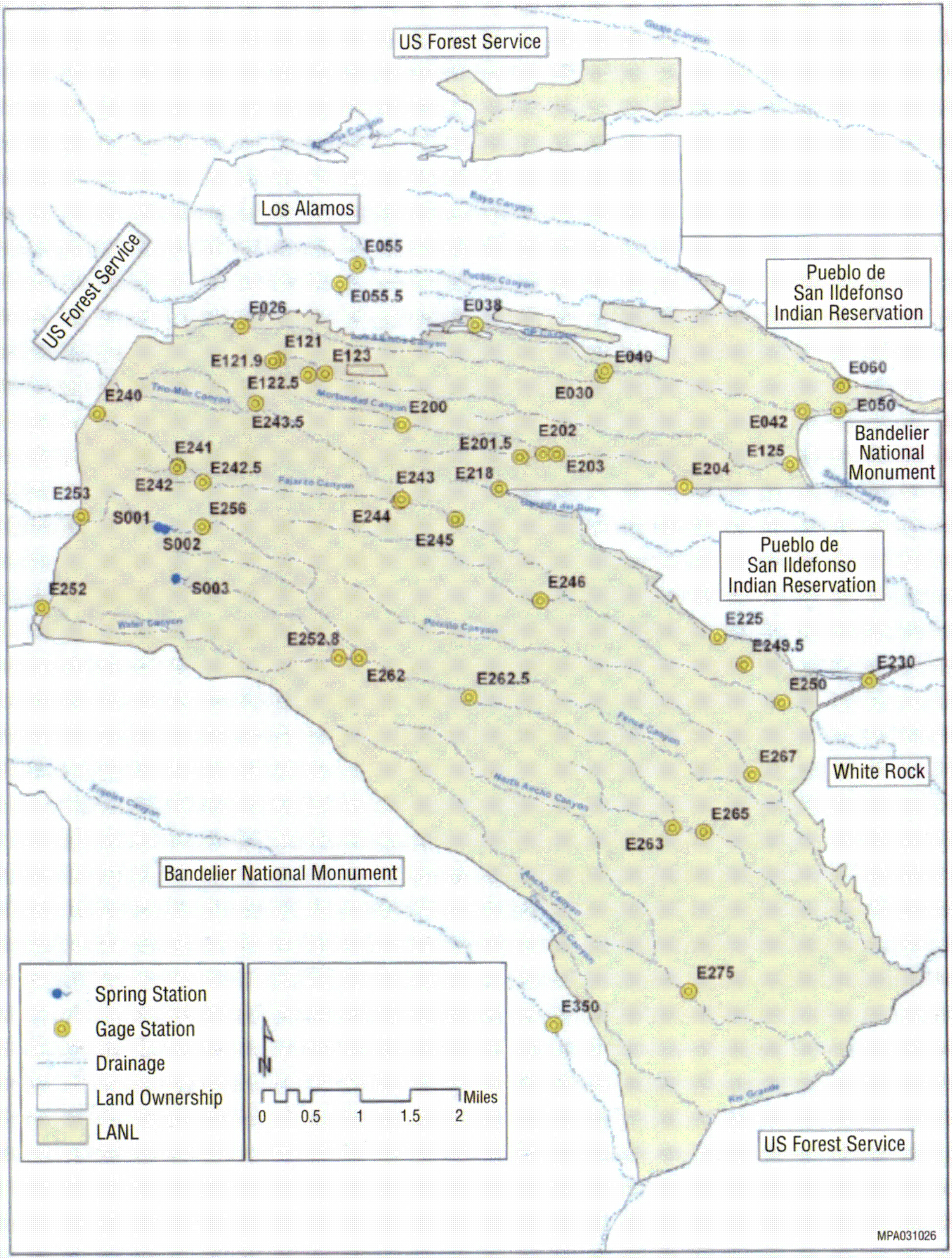



**FIGURE 8.1.3-2 LANL Stream Gauging Stations (Source: Romero et al. 2007)**

**TABLE 8.1.3-1 Stream Flow at U.S. Geological Survey Gauging Stations Monitoring Pajarito Canyon and Cañada del Buey in Water Year 2006[a]**

| Gauge Station | Maximum Stream Flow in cfs (Date) | Annual Mean |
|---|---|---|
| Pajarito Canyon | | |
| E240 | 16 (Aug. 8) | 0.0030 |
| E241 | 20 (Aug. 8) | 0.014 |
| E242.5 | 12 (Aug. 25) | 0.024 |
| E243 | 101 (Aug. 8) | 0.081 |
| E245 | 425 (Aug. 25) | 0.16 |
| E250 | 206 (Aug. 25) | 0.043 |
| Cañada del Buey | | |
| E218 | 228 (Aug. 25) | 0.028 |
| E225 | 0.49 (Aug. 8) | 0 |
| E230 | 54 (Aug. 6) | 0.0090 |

[a] Water year 2006 is from Oct. 2005 through Sept. 2006.

Source: Romero et al. (2007)

At LANL, perennial streams are not a source of municipal, industrial, irrigation, or recreational water; however, they have the designated uses of coldwater aquatic life use and wildlife habitat use (secondary contact). None of LANL perennial streams have been designated as Wild and Scenic. Ephemeral and intermittent streams, such as those within the Pajarito Canyon and Cañada del Buey, have designated uses of limited aquatic life use and wildlife habitat use (secondary contact). Beyond the site boundaries, water is used by tribal members of the Pueblo de San Ildefonso for traditional or ceremonial purposes. Water may discharge to the Rio Grande, which lies just to the east of the Pajarito Plateau (DOE 2008c; LANL 2007).

**8.1.3.1.2 Other Surface Water.** There are approximately 14 ha (34 ac) of wetlands within LANL boundaries. Most wetlands are associated with canyon stream channels; some are located on mesas and are associated with springs, seeps, and effluent outfalls. A 2005 survey found that about 45% of the site's wetlands are located in Pajarito Canyon. The acreage of wetlands at LANL has decreased since 1999 as effluent outfalls have been closed or rerouted. About 3.6 ha (9 ac) of wetlands were transferred to Los Alamos County and the DOI to be held in trust for the Pueblo de San Ildefonso and are no longer under DOE's control (DOE 2008c).

**8.1.3.1.3 Surface Water Quality.** Potential sources of surface water contamination at LANL include industrial effluents discharged through NPDES permitted outfalls, stormwater runoff, dredge and fill activities, isolated spills, former photographic processing facilities, highway runoff, residual Cerro Grande fire ash (the fire occurred in May 2000), and sediment transport (DOE 2008c). LANL samples surface water within the major canyons that cross the site and at locations along the site perimeter. Stormwater runoff is sampled along the site boundary and at discreet mesa-top sites (including two near North Site at TA-54). Sediment samples are also collected at stations along the canyons and from drainages downstream of two material disposal areas (MDAs), including nine stations just outside the perimeter fence of MDA G at TA-54. Exceedances between 2000 and 2005 were generally of excess total residual chlorine (LANL 2007).

Although every major watershed at LANL shows some effect from site operations, the overall quality of surface water is considered good. Environmental monitoring at NPDES-permitted outfalls indicates that levels of dissolved solutes are low and that levels of most analytes are below regulatory standards or risk-based levels (LANL 2007).

Past discharges of radioactive liquid effluents into Pueblo Canyon (including its tributary in Acid Canyon), and Los Alamos Canyons and current releases from the Radioactive Liquid Waste Treatment Facility into Mortandad Canyon have introduced Am-241, Cs-137, Pu-238, Pu-239, Pu-240, Sr-90, and tritium into both surface waters and canyon sediments. Table 8.1.3-2 summarizes radionuclide concentrations in Pueblo and Mortandad Canyons (DOE 2008c).

**TABLE 8.1.3-2 Summary of Surface Water Radionuclide Concentrations in Pueblo and Mortandad Canyons in 2005**

| Radionuclide | DOE 100-mrem Derived Concentration Guide for Public Exposure (pCi/L)[a] | Biota Concentration Guide (pCi/L) | Concentration in Lower Pueblo Canyon at SR (pCi/L) 502 | Concentration in Mortandad Canyon below TA-50 Radioactive Liquid Waste Treatment Facility Outfall (pCi/L) |
|---|---|---|---|---|
| Am-241 | 30 | 400 | 0.4 | 5.1 |
| Cs-137 | 3,000 | 20,000 | ND[b] | 20 |
| Tritium | NR[b] | 300,000,000 | ND | 237 |
| Pu-238 | 40 | 200 | ND | 2.1 |
| Pu-239 and Pu-240 | 30 | 200 | 11 | 2.9 |
| Sr-90 | 1,000 | 300 | 0.4 | 3.4 |
| U-234 | NR | 200 | 1.7 | 2.0 |
| U-235 and U-236 | NR | 200 | 0.1 | 1.1 |
| U-238 | NR | 200 | 1.6 | 1.9 |

a Source for the Derived Concentration Guide: DOE (2006).

b NR means not reported and ND means not detected.

Source: DOE (2008c)

During New Mexico's summer rainy season, a large volume of stormwater runoff can flow over LANL facilities and construction sites, picking up pollutants. The most common pollutants transported in stormwater flows are radionuclides, polychlorinated biphenyls (PCBs), and metals. Recent data from stormwater runoff monitoring detected some contaminants on and off-site, but the exposure potential for these contaminants is limited. Radionuclides have been detected in runoff at higher-than-background levels in Pueblo, DP, Los Alamos, and Mortandad Canyons, with sporadic detections extending off-site in Pueblo and Los Alamos Canyons. Stormwater runoff has exceeded the wildlife habitat standard for gross alpha activity of 15 pCi/L since the Cerro Grande fire that occurred in nearly all of the canyons in 2000. Los Alamos Canyon and Sandia Canyon runoff and base flows contain PCBs at levels above New Mexico human health stream standards. Dissolved copper, lead, and zinc have been detected above the New Mexico acute aquatic life stream standards in many canyons, and these metals were detected off-site in Los Alamos Canyon. Some of these PCB and metal detections were upstream of LANL facilities, indicating that non-LANL urban runoff was one source of the contamination. Mercury was detected slightly above wildlife habitat stream standards in Los Alamos and Sandia Canyons (DOE 2008c).

Dissolved aluminum concentrations exceeded the acute aquatic life standard for some locations in 2006; however, it is thought that these concentrations resulted from particulate (colloidal) aluminum passing through the filter, because LANL surface waters, which are slightly alkaline, rarely contain aluminum in solution. Selenium levels, which had been high following the Cerro Grande fire in 2000 (likely due to ash from the fire), were found to be below the wildlife habitat standard in 2006.

PCBs have also been detected in streams and sediment at LANL. Surface water was analyzed for PCBs in 14 water courses, and PCBs were detected in 6 of them. Consistent with previous years, multiple PCB detections were reported in Sandia, Los Alamos, and Mortandad Canyons. Sandia Canyon accounted for about half of the detections, and Los Alamos Canyon accounted for an additional one-third.

In Los Alamos Canyon, PCBs were detected in sediments throughout the watershed and extending to the confluence with the Rio Grande near Otowi. The highest sediment concentration for total PCBs in Los Alamos Canyon, approximately 0.5 μg/g, occurred at the confluence with DP Canyon. PCB concentrations tend to decrease with distance from the source; at the LANL boundary, the maximum total PCB sediment concentration was about 0.2 μg/g. The main sources of PCBs on LANL lands are probably from past spills and leaks of transformers rather than from current effluent discharges (LANL 2007).

PCBs were detected throughout the Sandia Canyon watershed from near LANL's main technical area at TA-3 to LANL's downstream boundary at SR 4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. Although most PCBs were detected in stormwater samples, they were also detected in three base flow samples collected near the Sandia Canyon wetlands. Sediment samples collected in the upper portion of Sandia Canyon contained PCB concentrations. The highest PCB concentration was approximately 7 μg/g. Concentrations of PCBs in downstream sediment decline quickly with distance and usually are not detected at the site's boundary (LANL 2007).

In 2006, approximately 50 surface water samples were collected from water-course and hillside sites and analyzed for PCBs within Mortandad Canyon and its tributaries: Cañada del Buey, Ten Site Canyon, and Pratt Canyon. In only two samples were concentrations of PCBs detected; both were from middle Mortandad Canyon. These results indicate that PCB concentrations in the drainage are occasionally detected but are relatively small (LANL 2007).

#### 8.1.3.2 Groundwater

**8.1.3.2.1 Unsaturated Zone.** Groundwater occurs in both the unsaturated (vadose) and saturated (phreatic) zones at LANL. Groundwater was encountered in characterization Well R-22 (located near MDA G on Mesita del Buey to the southeast of the North Site and Zone 6 in TA-54) at a depth of 270 m (890 ft). However, intermediate-depth perched groundwater also occurs within the vadose zone beneath wet canyons (e.g., within the more-porous breccia zones in basalt) and along the western portion of the site. The unsaturated zone varies in thickness from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing in thickness with increasing distance down the canyon to the southeast.

**8.1.3.2.2 Aquifer Units.** Saturated groundwater at LANL occurs in three hydrologic settings. It is perched at shallow depths in canyon bottom alluvium; it is perched at intermediate depths below canyon bottoms; and it is found at greater depths within units that make up the regional aquifer beneath the Pajarito Plateau. Figure 8.1.3-3 shows the hydrogeologic units at LANL and their relationship to the lithologic units of the Pajarito Plateau described in Section 8.1.2.1.3.

The following descriptions are taken from the SWEIS (DOE 2008c), Birdsell et al. (2005b), and LANL (2005, 2007) and include information specific to characterization Well R-22 and municipal water supply Wells PM-2 and PM-4. Well R-22, on the mesa above Pajarito Canyon, penetrates the Bandelier Tuff and Cerros del Rio lavas and is completed in the lower Puye Formation. Wells PM-2 and PM-4 are more than 451-m (1,500-ft) deep. Table 8.1.3-3 lists the hydrostratigraphic data for Well R-22.

**Perched Alluvial Groundwater.** Alluvial aquifers at the bottoms of canyons are made up of fluvial deposits interbedded with deposits of alluvial fans and colluvium from the adjacent mesas. The primary source of sediment is the Bandelier Tuff and other units, such as the Tschicoma Formation. The Bandelier Tuff produces sand-sized alluvium; colluvial deposits are more coarse-grained. The interbedded units range in thickness from a few meters (feet) to up to 30 m (100 ft) and serve as conduits for groundwater movement both laterally and with depth. The alluvial aquifers are perched on top of the less permeable Bandelier Tuff (Figure 8.1.3-4).

Many of the canyons are dry, with little surface water flow and little or no alluvial groundwater. In wet canyons, surface water flows along the canyon bottoms and infiltrates downward until it hits the less permeable tuff or other rocks, creating shallow zones of perched

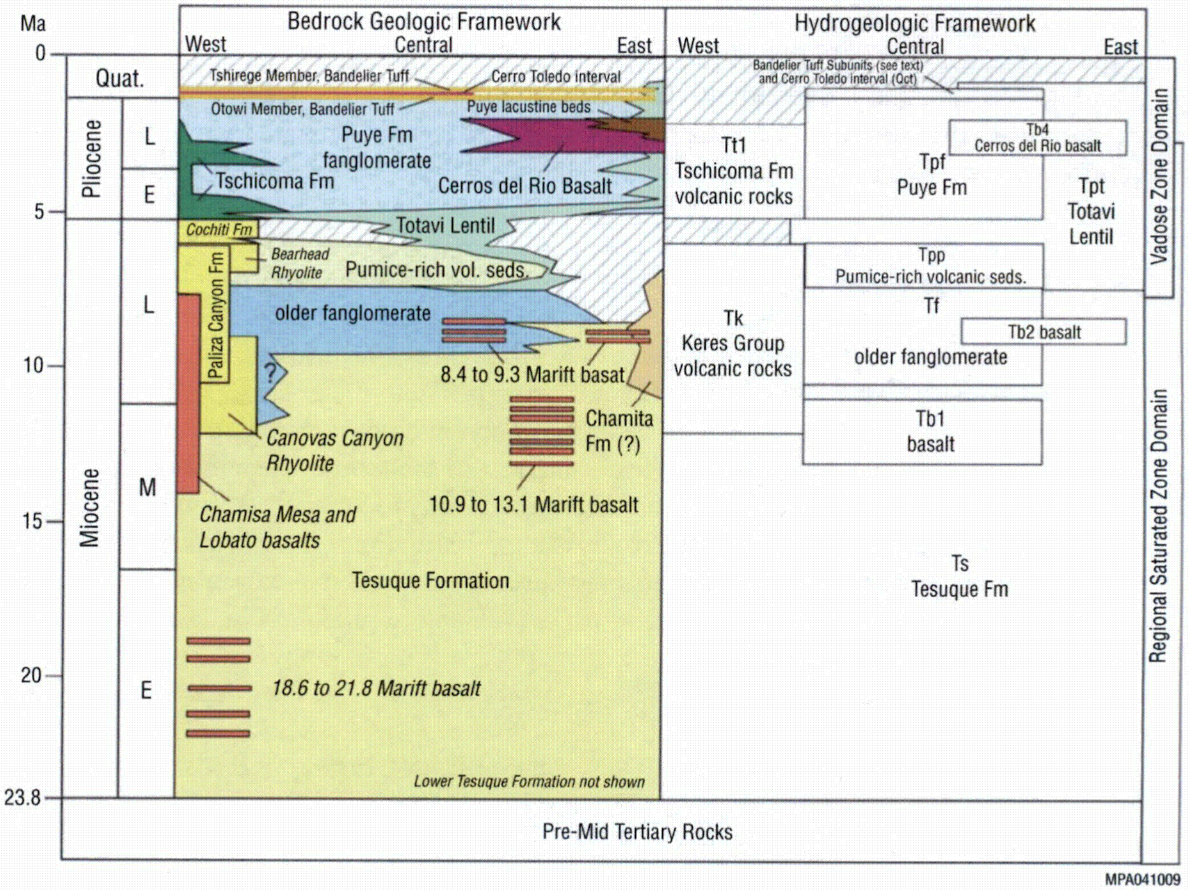



**FIGURE 8.1.3-3 Hydrogeologic Units at LANL (Source: Birdsell et al. 2005b)**

**TABLE 8.1.3-3 Hydrostratigraphic Data from Well R-22 at LANL[a]**

| Hydrostratigraphic Unit | Top Depth | Base Depth | Top Elevation | Unit Thickness |
|---|---|---|---|---|
| Depth to groundwater/vadose zone | 0 | 883 | 6,650.5 | 883 |
| Tshirege ash flows | 0 | 128 | 6,650.5 | 128 |
| Otowi ash flows | 128 | 179 | 6,522.5 | 51 |
| Guaje pumice bed | 179 | 190 | 6,471.5 | 11 |
| Cerros del Rio lavas | 190 | 1,173 | 6,460.5 | 983 |
| Upper Puye Formation | 1,173 | 1,338 | 5,477.5 | 165 |
| Older basalt unit (Santa Fe Group) | 1,338 | 1,406 | 5,312.5 | 68 |
| Lower Puye Formation | 1,406 | 1,489[b] | 5,244.5 | >83 |

[a] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[b] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Ball et al. (2002)

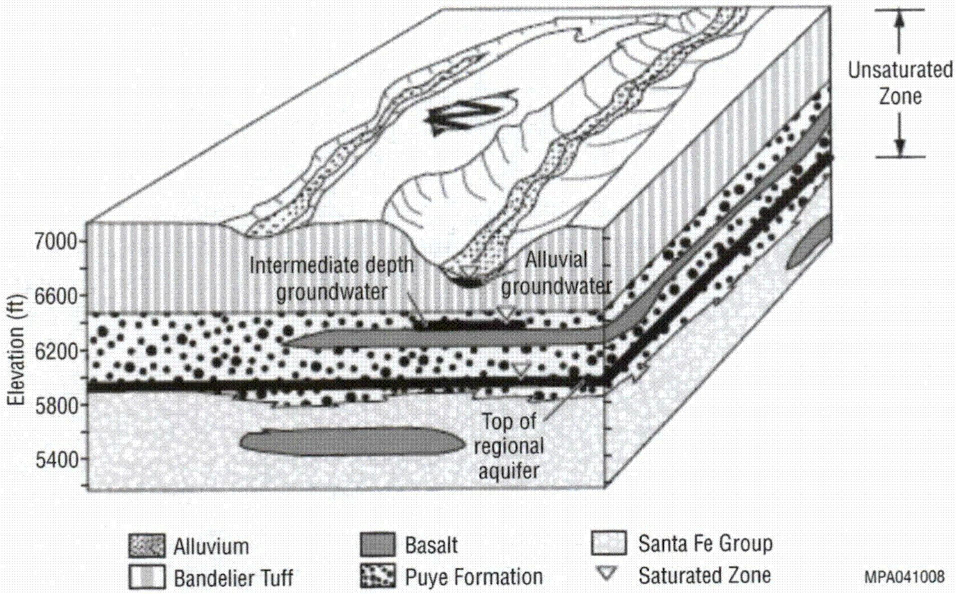



**FIGURE 8.1.3-4 Three Modes of Groundwater Occurrence at LANL (Source: DOE 2008c)**

groundwater within the alluvium. Infiltration rates beneath the alluvial systems of wet canyons are estimated to be the highest across the plateau, approaching several meters per year. The water table slopes toward the east, as do the canyon floors. Because of water losses due to evapotranspiration and infiltration, alluvial groundwater is generally not sufficiently extensive for domestic use.

**Intermediate-Depth Perched Groundwater.** Intermediate-depth perched groundwater aquifers are associated with wet canyons. These systems occur within the unsaturated portion of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 8.1.3-4) and are recharged by the overlying perched alluvial groundwater. Depths vary among canyons, ranging from 36.6 m (120 ft) in Pueblo Canyon to 230 m (750 ft) in Mortandad Canyon. It has been estimated that the rate of movement of the intermediate perched groundwater is about 18 m/d (60 ft/d), or about 6 months from recharge to discharge (LANL 2003a).

**Regional Aquifer.** The regional aquifer (known as the Española Basin aquifer system) is the only aquifer in the LANL vicinity that can serve as a municipal water supply. It is a major source of drinking and agricultural water for northern New Mexico, and, in January 2008, it was designated by EPA Region 6 as a sole source aquifer (EPA 2008c). The regional aquifer extends throughout the Española Basin and consists of both sedimentary and volcanic units that have vastly different hydrologic properties. Sedimentary units include the Puye Formation, pumice-rich volcaniclastic rocks, Totavi Lentil, older fanglomerate rocks, Santa Fe Group sands, and sedimentary deposits between basalt flows. These units are highly heterogeneous and strongly anisotropic, with lateral conductivity (parallel to the sedimentary beds) as much as 100 to 1,000 times higher than vertical conductivity.

Correlation (and therefore lateral continuity) between individual beds in the Puye Formation is difficult to find because of the complex arrangement of channel and overbank deposits in the alluvial fans that make up this unit. Pumice-rich volcaniclastic rocks are expected to have high porosity, which may, in turn, translate into high permeability, depending on the degree of clay alteration. The Totavi Lentil is thought to be the most transmissive of the sedimentary units, since it consists of unconsolidated sands and gravels. It also contains fine-grained sediments.

Volcanic rocks on the plateau include the lavas of the Tschicoma Formation and various basalt units (Cerros del Rio, Bayo Canyon, and the Miocene basalts within the Santa Fe Group). These rocks consist of stacked lava flows separated by interflow zones of highly porous breccias, clinker, cinder deposits, and sedimentary deposits. Lava flow interiors are made up of dense impermeable rock with varying degrees of fracture. Beneath Mesita del Buey, the Cerros del Rio basalt is 300-m (1,000-ft) thick, indicating fill within a paleocanyon (Ball et al. 2002).

North-south trending fault zones on the Pajarito Plateau — including the Pajarito fault zone and the Guaje Mountain and Rendija Canyon faults — may facilitate or impede groundwater flow in the north-south direction, depending on whether they are open or clay-filled.

Elevations of the regional aquifer water table decrease to the east-southeast and range from 1,780 m (5,850 ft) MSL near North Site to about 1,750 m (5,750 ft) MSL at Area G on Mesita del Buey (Figure 8.1.3-5). Vadose zone thickness ranges from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing with increasing distance down canyon (to the east-southeast). Groundwater was encountered at a depth of 269 m (883 ft) in characterization Well R-22 when it was installed in 2000 (Ball et al. 2002). Intermediate-depth perched aquifers occur within the vadose zone beneath major (wet) canyons (e.g., within the more porous, breccia zones in basalt) and along the western portion of the LANL site. In the vicinity of TA-54, the thickness of the saturated zone (Cerro del Rio basalts saturated zone) is about 37 m (120 ft).

**8.1.3.2.3 Groundwater Flow.** Unsaturated flow is through the welded and nonwelded units of the Bandelier Tuff and the basalt flow interior and interflow units of the Cerros del Rio lavas. Flow within the densely welded tuffs (which occur on the western edge of the plateau) and the dense, basalt flow interiors of the Cerros del Rio basalt is predominantly through fractures. Downward movement is thought to be more rapid in the basalt than through moderately welded tuff (Birdsell et al. 2005b). Matrix flow likely occurs within the nonwelded and moderately welded tuffs (with porosities of 40% to 50%) and within the more porous brecciated interflow zones in the basalt (Birdsell et al. 2005a).

Groundwater takes decades to move from the surface to perched groundwater zones. Movement within perched zones is not well characterized, but it is, in general, controlled by factors such as the topography of the perching layer, bedding features, and the orientation of interconnected fractures (LANL 2005; Birdsell et al. 2005b).

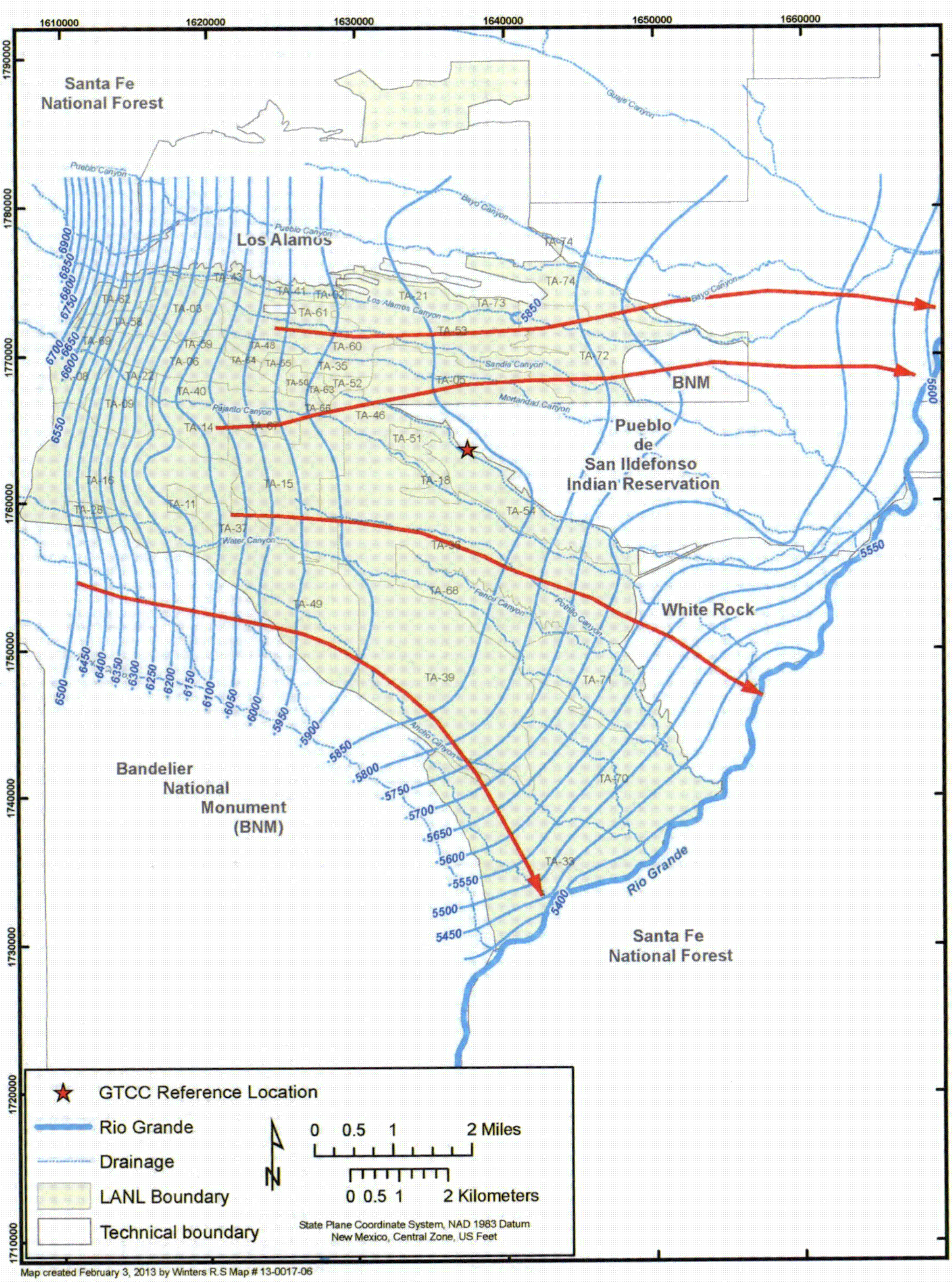



**FIGURE 8.1.3-5 Water Table Elevation of LANL Regional Aquifer (Source: Birdsell et al. 2005b)**

Saturated flow in the upper 90 m (300 ft) of the regional aquifer beneath Mesita del Buey (at Well R-22) is within the fractures and interflow zones of the Cerros del Rio basalt. Flow direction in the perched alluvial and regional aquifer systems is to the east-southeast, toward the Rio Grande; the direction of groundwater flow in the intermediate perched zones is less certain. Flow within deeper parts of the regional aquifer (i.e., deeper than 150 m [500 ft]) is currently unknown, but it could be different than the flow occurring at shallower depths. Groundwater flow is anisotropic, with preferential flow parallel to bedding planes.

The Rio Grande is the principal discharge point for the alluvial and regional aquifers. Discharge to the river may occur as lateral flow or upward flow or as flow from springs in White Rock Canyon (LANL 2005; Birdsell et al. 2005b).

**8.1.3.2.4 Groundwater Quality.** Natural groundwater chemistry at LANL varies with the acidity of the water and the chemistry of local rock. Natural constituents, including uranium, silicon, and sodium, are common in the volcanic rocks of the region. Since the 1940s, liquid effluents from operations at LANL have degraded the water quality in the perched alluvial groundwater beneath the floor of several canyons. In some cases, impacts extend to the intermediate perched aquifers (particularly below wet canyons). Water quality impacts on the regional aquifer are minimal, since several hundred feet of dry rock separate the regional aquifer from the shallow perched groundwater. Although there is evidence that some contaminants (tritium, perchlorate, cyclonite or RDX, trinitrotoluene or TNT, perchloroethylene or PCE, and trichloroethylene) are reaching the regional aquifer, none of the drinking water wells in the regional aquifer have been contaminated to date. Table 8.1.3-4 lists the major contaminants found in groundwater sampled beneath Pajarito Canyon and Cañada del Buey in 2006. Details of

**TABLE 8.1.3-4 Summary of Groundwater Contamination in Pajarito Canyon and Cañada del Buey at LANL in 2006**

| | | Groundwater Contaminants[a] | | |
|---|---|---|---|---|
| Canyon | Contaminant Sources | Alluvial | Intermediate | Regional |
| Pajarito Canyon | Major dry sources, past major but minor present liquid sources | Chloride above and nitrate at 50% of NMGWS | 1,1-DCE and 1,1,1-TCA above NMGWS, RDX above EPA excess cancer risk level, TCE, 1,1-dichloroethane, 1,4-dioxane | Trace RDX |
| Cañada del Buey | Major dry, minor liquid sources | None, little alluvial groundwater | No intermediate groundwater | None |

[a] DCE = dichloroethene, NMGWS = New Mexico groundwater standards, RDX = the explosive cyclonite, TCA = trichloroethane, TCE = trichloroethene.

Source: LANL (2007)

the monitoring program at LANL can be found in the Laboratory's annual surveillance reports (DOE 2008c; LANL 2007).

Waste was disposed of in pits and shafts at MDA L, which is within TA-54, adjacent to pueblo sacred areas. As part of the monitoring program, MDA L has been monitored for vapor-phase contaminants in soil. A subsurface VOC vapor plume is present in the vadose zone at MDA L. The primary sources of subsurface VOC vapors are the two shaft fields at MDA L, and they appear to be a continuing source of VOC vapors (LANL 2011).

The lower Pajarito Canyon has a saturated alluvium that does not extend past LANL's east boundary. Past discharges to the canyon via its tributaries include small amounts of wastewater from TA-9. A nuclear materials experimental facility was located on the floor of the canyon at TA-18. Mesita del Buey, to the north of the canyon, is the site of several waste management areas, including MDA G, used for the disposal of LLRW. In 2006, several organic compounds (including chlorinated solvents) were detected in the intermediate-depth perched aquifer below the canyon. Traces of RDX were detected in the regional aquifer (LANL 2007).

Cañada del Buey has a shallow alluvial groundwater system of limited extent and is monitored by a network of five shallow wells and two moisture monitoring wells. Most of these wells are dry at any given time. Past discharges include accidental releases from experimental reactors and laboratories at TA-46. Treated effluent from LANL's sanitary wastewater system is also discharged to the canyon at times. As of 2006, no contamination had been detected in any of the aquifer systems below the canyon (LANL 2007).

**8.1.3.2.5 Groundwater Use.** All water used at LANL is derived from groundwater drawn from the regional aquifer (the Española Basin aquifer system) in three well fields: Otowi, Pajarito, and Guaje. The Guaje, Pajarito, and Otowi Well Fields are located in the mesas and canyons of the Pajarito Plateau. The 12 deep wells that supply water are all completed within the regional aquifer, located beneath the Pajarito Plateau. This sole source aquifer is the only local aquifer capable of supplying municipal and industrial water in the Los Alamos area. The piezometric surface of the regional aquifer ranges in depth from about 6 m (20 ft) above ground level (artesian water conditions) in portions of lower Los Alamos Canyon near the confluence with Guaje Canyon, to about 230 m (750 ft) bgs along the eastern edge of LANL property, to more than 375 m (1,230 ft) bgs near the center of the Pajarito Plateau (LANL 2003b). Water levels in the wells are declining by 30 to 60 cm/yr (1 to 2 ft/yr) (LANL 2003a).

Potable groundwater is pumped from the wells into the distribution system. Yields from individual production wells ranged from about 1,400 to 5,600 L/min (370 to 1,480 gpm) from 1998 through 2001 (LANL 2003a). Booster pumps lift the water to terminal storage for distribution to LANL and the community. The entire water supply is disinfected with mixed-oxidant solution before it is distributed to Los Alamos, White Rock, Bandelier National Monument, and LANL areas. Potable water storage tanks at Los Alamos have a combined terminal storage of 132 to 150 million L (35 to 40 million gal). Under drought-like conditions, daily water production alone may not be sufficient to meet water demands, and Los Alamos

County relies on the terminal storage supply to make up the difference. The firm rated capacity[3] of the Los Alamos water production system is 7,797 gpm (42 million L/d or 11 million gal/d) (LANL 2003b).

Water use by LANL between 1998 and 2001 ranged from 1,430 million L (380 million gal) in 2000 to 1,745 million L (460 million gal) in 1998. LANL water use in 2001 was 1,490 million L (390 million gal), or 27% of the total water use at Los Alamos. Water use by Los Alamos County ranged from 3,300 million L (870 million gal) in 1999 to 4.2 billion L (1.1 billion gal) in 2000, and it averaged 3.8 billion L/yr (1.0 billion gal/yr) (LANL 2003b).

In September 1998, DOE leased the Los Alamos water supply system to Los Alamos County, and in September 2001, ownership of the water supply system was officially transferred to Los Alamos County. The water rights owned by DOE from all permitted sources (surface water and groundwater) in 1998 were about 5,500 ac-ft/yr or about 6.8 billion L/yr (1.8 billion gal/yr). In September 1998, these water rights were leased to Los Alamos County. DOE retained ownership of 30% of the water rights; this amount of water has been established as a maximum "target quantity" for water use by LANL. Transfer of ownership of the water supply system and water rights was completed in September 2001. LANL now purchases water from Los Alamos County. Water meters were installed at all delivery points to LANL, and water now provided to LANL is metered for documentation and billing (LANL 2003b).

Current water use in Los Alamos County falls into five categories: residential, commercial/institutional, industrial, public landscape irrigation, and other (e.g., firefighting, main flushing, swimming pools, construction projects, schools). In 2004, total water deliveries were estimated to be 3,920 million L (1,035 million gal). The greatest demand was for single-family use (62% or 2,400 million L [630 million gal]). The net per capita use was 572 L/d (151 gal/d). Water demand is expected to be about 8,285 million L (2,189 million gal) in 2020 (Daniel B. Stephens and Associates, Inc. 2006).

Water demand by LANL as a percentage of the total diversions varied from 34% in 1999 to 21% in 2002. Demand at LANL increases about 35% in the summer months because of its increased use of water in its cooling towers. In 2004, its per capita demand was 191 L/d (50 gal/d) (Daniel B. Stephens and Associates, Inc. 2006).

### 8.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of LANL would be only a very small fraction of the dose limit of 100 mrem/yr set by DOE to

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3 The firm rated capacity is the maximum amount of water that can be pumped immediately to meet peak demand.

American Indian Text

Pueblo people know that extensive work has been completed to map and determine flow rates, direction, and quality of groundwater systems. There are independent studies published which challenge these findings. These other studies maintain that monitoring at sites is inadequate and that the drilling practices influence the results.

Santa Clara Pueblo is concerned that their groundwater is being contaminated by LANL – especially from TA 54 waste deposits. Even though Santa Clara Pueblo is upstream when only surface water is considered, known faults between LANL and SCP are suspected to connect reservation groundwater and TA 54 wastes in LANL groundwater. Current investigations by Santa Clara Pueblo science teams and funded by the Pueblo are on-going to determine if Santa Clara Pueblo groundwater is connected through water bearing faults.

protect the public from the operations of its facilities (DOE Order 458.1). The pathways of potential exposure include ingestion of contaminated soil, groundwater, and fish and respiration of air emissions. In 2014, the dose from each of these pathways was estimated to be less than 1 mrem/yr (LANL 2015), as shown in Table 8.1.4-1.

In 2014, the highest dose to a member of the general public was determined to be along Jemez Road as it passes TA-53 (LANL 2015). The occupancy factor at this location is less than 1% resulting in a dose of <0.01 mrem/yr (LANL 2015). The location of the individual receiving the highest dose from airborne emissions was determined to be at the East Gate, and the dose at this location was reported to be 0.24 mrem/yr. Potential radiation exposure from airborne emissions is expected to remain low in the future. The collective dose for the 343,000 people living within 80 km (50 mi) around the LANL site was estimated to be 0.284 person-rem, which is less than 0.00013% of the collective dose that the same population would receive from natural background and man-made sources.

Among all the on-site workers who were monitored for radiation exposure, 1,335 had measurable doses in 2014. (The total number of monitored workers at LANL was 9,666.) The collective total dose was 95.4 person-rem (DOE 2015), which gives an average individual dose of 94 mrem/yr to the radiation workers at the site. The collective dose decreased by 31% from the previous year, and most of it was incurred by workers performing operational activities at the TA-55 Plutonium Facility. In addition to workers at TA-55, workers at the radioactive solid waste facilities in TA-50 and TA-54, and workers at the TA-53 Los Alamos Neutron Science Center also registered higher radiation exposures than the average (DOE 2015). Among the workers who registered measurable doses, most received only external radiation; only 17 workers had measurable internal doses. The collective internal dose was 0.143 person-rem;

**TABLE 8.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at LANL**

| Receptor | Radiation Source | Exposure Pathway | Dose to Individual (mrem/yr) | Dose to Population (person-rem/yr) |
|---|---|---|---|---|
| On-site workers | Radioactive materials handled in operations | Inhalation and ingestion | 8[a] | 0.14 [a] |
| | Radioactive materials handled in operations | Direct radiation | 68[b] | 95.4[b] |
| General public | Airborne release | Submersion, inhalation, ingestion of plant foods (contaminated through deposition), direct radiation from deposition | 0.24[c] | 0.284[d] |
| | Groundwater contamination | Water ingestion | < 0.1[e] | |
| | Soil contamination | External radiation, dust inhalation, soil ingestion | < 0.1[f] | |
| | Surface water contamination | Fish ingestion | ~0[g] | |
| | On-site waste storage and shipment | Direct radiation | <0.01[h] | |
| Worker/public | Natural background radiation and man-made sources | | 620[i] | 213,000[j] |

[a] In 2014, among the workers monitored for internal exposure, 17 had measurable doses. A collective dose of 0.14 person-rem was recorded, which would give an average internal dose of 8 mrem per worker (DOE 2015).

[b] In 2014, 1,401 workers monitored for radiation exposures received measurable doses (DOE 2015). The total collective dose for these workers was 95.4 person-rem (DOE 2015). When the collective dose for internal exposure is subtracted from the total collective dose, and the remainder is distributed evenly among the workers, an average individual external dose of 68 mrem/yr is obtained.

[c] The radiation dose was conservatively estimated as the sum of the dose calculated with CAP88-PC for airborne emissions from the Los Alamos Neutron Science Center and the dose calculated for ambient air monitoring data. In 2014, the location of the highest-exposed individual was determined to be at East Gate (LANL 2015). The potential maximum dose from airborne emissions is expected to remain low.

[d] The collective dose was estimated with CAP88-PC for the population residing within 80 km (50 mi) of LANL. The population size is about 343,000 (LANL 2015).

[e] The dose corresponds to drinking 730 L/yr (190 gal/yr) of water from the Otowi-4 well located in Upper Los Alamos Canyon.

**Footnotes continue on next page.**

**TABLE 8.1.4-1 (Cont.)**

[f] The dose was calculated on the basis of measured surface soil concentrations at off-site locations. The soil concentrations measured indicate the potential dose would be less than 0.1 mrem/yr (LANL 2015).

[g] The dose from ingesting fish from the Rio Grande downstream from the LANL site would be negligible because surface water concentrations were well within the background levels (LANL 2015).

[h] Dose corresponds to an occupancy factor less than 1% at the Jemez Road location (LANL 2015).

[i] Average dose to a member of the general public (NCRP 2009).

[j] Collective dose to the population of 343,000 within 80 km (50 mi) of the LANL site from natural background radiation and man-made sources.

if distributed evenly among the 17 workers, the average individual dose was 8 mrem/yr (DOE 2015, Exhibit B-4). According to LANL records (DOE 2015), no radiation worker received a dose greater than the DOE administrative control level of 2 rem/yr in 2014. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

American Indian Text

Standard calculations of human heath exposure as used for the General Public are not applicable to Pueblo populations. The concept General Public is an EPA term that is a generalization that derives from studies of average adult males. Residency time for the General Public tends to be a short period of an individual's lifetime and exposure is voluntary. Pueblo people live here in their Sacred Home Lands for their entire lives and will continue to reside here forever.

Pueblo people use their resources differently than average US citizens so standard dosing rates do not apply. For ceremonial purposes, for example, water is consumed directly from surface water sources and natural springs. Potters, for example, have direct and intimate contact with stream and surface clay deposits. Natural pigment paints, for example, are placed on people's bodies and kept there through long periods of time during which strenuous physical activities opens the pores.

### 8.1.5 Ecology

LANL consists of five vegetation zones: (1) grassland, (2) ponderosa pine (*Pinus ponderosa*) forest, (3) pinyon-juniper (*P. edulis-Juniperus monosperma*) woodland, (4) juniper savannah, and (5) mixed conifer forest (Douglas fir [*Pseudotsuga menziesii*], ponderosa pine, and white fir [*Abies concolor*]) (DOE 2008c). The GTCC reference location at LANL would be located mostly within the pinyon-juniper woodland, although a portion might be located within the ponderosa pine forest zone. More than 900 species of plants occur on LANL. About 150 of them are nonnative plants (DOE 1999a). Exotic plant species of concern on LANL include salt-cedar (*Tamarix ramosissima*), tree-of-heaven (*Ailanthus altissima*), cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) (DOE 1999a). The vegetation that is planted as disposal pits are closed includes native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002).

Most wetlands in the LANL area are associated with canyon stream channels or occur on mountains or mesas as isolated meadows containing ponds or marshes, often associated with springs or seeps (DOE 2008c). About 14 ha (34 ac) of wetlands have been identified within LANL, and about 6.1 ha (15 ac) of these occur within Pajarito Canyon (DOE 2008c). Lake-associated wetlands occur at Cochiti Lake and near LANL Fenton Hill site (TA-57), while spring-associated wetlands occur within White Rock Canyon (DOE 1999a). No wetlands occur in the TA-54 area, although wetlands and floodplains exist in the lower portion of Pajarito Canyon.

American Indian Text

A Pueblo Writers' GTCC site visit and a draft LANL LLRW study for Area G documented the presence of the following plants:

| Plants from LLRW Areas | Listed in Area G LLRW Study | Observed by Pueblo Writer's Group |
|---|---|---|
| Blue Grama (*Bouteloua gracilis*) | X | P |
| Indian Rice Grass (*Achnatherum hymenoides*) | | P |
| Cutleaf evening primrose (*Oenothera caespitosa* | X | |
| Mullein Amaranth (*Verbascum thapsus*) | X | P |
| Indian Paintbrush (*Castilleja* sp.) | | P |
| 4-o'Clock (*Mirabilis jalapa*) | | P |
| Narrowleaf Yucca (*Yucca angustissima*) | X | P |
| Penstemon spp. | | P |
| Prickly Pear (*Opuntia polyacantha*) | X | P |
| Small Barrel (*Sclerocactus*) | | P |
| Sunflower (*Helianthus petiolaris*) | X | P |
| Apache Plume (*Fallugia paradoxa*) | X | P |
| Big Sage (*Artemisia tridentada*) | X | P |
| Chamisa (*Ericamerica nauseosa* ssp. *nauseosa* var. *nauseosa*) | X | P |
| Four-Wing Saltbush (*Atriplex canescens*) | X | P |
| Mountain Mahogany (*Cercocarpus montanus*) | X | |
| New Mexico Locust (*Robinia neomexicana*) | X | |
| Oak (*Quercus* spp.) | X | |
| Snakeweed (*Guiterrezia sarathrae*) | X | |
| Squawberry (*Rhus trilobata*) | X | |
| Wax Currant (*Ribes cereum*) | X | |
| Wolfberry (*Lycium barbarum*) | | P |
| One-Seed Juniper (*Juniperus monosperma*) | X | P |
| Pinon Pine (*Pinus edulis*) | X | P |
| Ponderosa Pine (*Pinus ponderosa*) | X | P |

While a full list of the traditional use animals was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 76 Pueblo use animals there. The use animals represent 76% of the animals on the official animal inventory.

American Indian Text

Pueblo People know that they have many traditional plants and animals located on and near to the GTCC proposal area. During a brief visit to the proposed GTCC site, Pueblo EIS writers identified traditional use plants, which include medicinal, ceremonial, and domestic use plants. These plants were identified in a brief period and it was noted that many plants could be identified were a full ethnobotany of the site to be conducted. During this site visit the Pueblo EIS writers identified the presence of traditional animals, but noted that more could easily be identified during a full ethnozoological study.

While a full list of the traditional use plants was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 205 Pueblo use plants there. These use plants represent 59% of the known plants on the official plant inventory of Bandelier.

American Indian Text

A Pueblo GTCC site visit and a LANL LLRW study for Area G documented the presence of the following animals: Deer; Elk; Lizards; Harvester Ants; Rattlesnake; Cicadas; Mocking Bird; Pocket Mice and Kangaroo Rats; Pocket Gophers; Chipmunks and Ground Squirrels.

Only about 5% of LANL is developed and unavailable for use by wildlife (e.g., due to security fencing) (DOE 2008c). Within LANL, 57 species of mammals, 200 species of birds, and 37 species of reptiles and amphibians have been reported (DOE 2008c). Mammals that occur in the area of the GTCC reference location (e.g., Pajarito Plateau) include a number of rodent species (e.g., North American deermouse, pinyon mouse [*Peromyscus truei*], western harvest mouse [*Reithrodontomys megalotis*], brush mouse [*P. boylii*], silky pocket mouse [*Perognathus flavus*], Colorado chipmunk [*Tamias quadrivittatus*], and woodrats [*Neotoma* spp.]), mountain cottontail (*Sylvilagus nuttallii*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), American black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*). Common bird species include Cassin's kingbird (*Tyrannus vociferans*), cliff swallow (*Petrochelidon pyrrhonota*), ash-throated flycatcher (*Myiarchus cinerascens*), and brown-headed cowbird (*Molothrus ater)*. Common reptile species include fence lizard (*Sceloporus undulatus*), plateau striped whiptail (*Cnemidophorus velox*), gophersnake (*Pituophis catenifer*), and terrestrial garter snake (*Thamnophis elegans*) (DOE 1999a; Shuman et al. 2002).

The streams on LANL drain into the Rio Grande, the major aquatic habitat in the area of LANL. Many of the streams on LANL are intermittent and flow in response to precipitation or snowmelt. Of the 140 km (85 mi) of water courses on LANL, about 3.2 km (2 mi) are naturally occurring perennial streams and another 5 km (3 mi) are perennial waters supported by supplemental wastewater discharge flows (DOE 1999a). No fish species have been reported within LANL boundaries (DOE 2008c).

The federally and state-listed species identified on or in the immediate vicinity of LANL are listed in Table 8.1.5-1. DOE and LANL coordinate with the USFWS and New Mexico Department of Game and Fish to locate and conserve these species (DOE 2008c). LANL has developed a *Threatened and Endangered Species Habitat Management Plan* (LANL 1998) whose goals are to (1) develop a comprehensive management plan that protects undeveloped portions of LANL that are suitable or potentially suitable habitat for threatened or endangered species, while allowing current operations to continue and future development to occur with a minimum of project or operational delays or additional costs related to protecting species or their habitats; (2) facilitate DOE compliance with the Endangered Species Act and related federal regulations by protecting and aiding in the recovery of threatened or endangered species; and (3) promote good environmental stewardship by monitoring and managing threatened and endangered species and their habitats using sound scientific principles. The plan identifies areas of environmental interest for federally listed species that have suitable habitat within LANL. In 1998, these species included the peregrine falcon (*Falco peregrinus*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), and

**TABLE 8.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on or in the Immediate Vicinity of LANL**

| Common Name (Scientific Name) | Status[a] Federal/State |
|---|---|
| **Plants** | |
| Santa Fe stickyleaf *(Mentzelia springeri)* | -/SSC |
| Sapello Canyon larkspur *(Delphinium sapellonis)* | -/SSC |
| Wood lily (*Lilium philadelphicum* L. var. *anadinum*) | -/SE |
| Yellow lady's slipper orchid (*Cyripedium parviflorum* var. *pubescens*) | -/SE |
| **Insects** | |
| New Mexico silverspot butterfly (*Speyeria nokomis nitocris*) | SC/- |
| **Fish** | |
| Rio Grande chub (*Gila pandora*) | -/SS |
| **Amphibians** | |
| Jemez Mountain salamander (*Plethodon neomexicanus*) | SC/ST |
| **Birds** | |
| American peregrine falcon (*Falco peregrinus anatum*) | SC/ST |
| Arctic peregrine falcon (*Falco peregrinus tundrius*) | SC/ST |
| Bald eagle (*Haliaeetus leucocephalus*) | -/ST |
| Gray vireo (*Vireo vicinior*) | -/ST |
| Loggerhead shrike (*Lanius ludovicianus*) | -/SS |
| Mexican spotted owl (*Strix occidentalis lucida*) | T/SS |
| Northern goshawk (*Accipiter gentilis*) | SC/SS |
| Southwestern willow flycatcher (*Empidonax traillii extimus*) | E/SE |
| Yellow-billed cuckoo (*Coccyzus americanus*) | C/SS |
| **Mammals** | |
| Big free-tailed bat (*Nyctinomops macrotis*) | -/SS |
| Black-footed ferret (*Mustela nigripes*) | E/- |
| Fringed myotis (*Myotis thysanodes*) | -/SS |
| Goat Peak pika (*Ochotona princeps saxatilis*) | SC/SS |
| Long-eared myotis (*Myotis* evotis) | -/SS |
| Long-legged myotis (*Myotis volans*) | -/SS |
| New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) | SC/ST |
| Ringtail (*Bassariscus astutus*) | -/SS |
| Spotted bat (*Euderma maculatum*) | -/ST |
| Townsend's big-eared bat (*Plecotus townsendii*) | SC/SS |
| Western small-footed myotis (*Myotis ciliolabrum*) | -/SS |
| Yuma myotis (*Myotis yumanensis*) | -/SS |

**Footnote on next page.**

**TABLE 8.1.5-1 (Cont.)**

[a] C (candidate): A species for which the USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

E (endangered): A species in danger of extinction throughout all or a significant portion of its range.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to a need for listing as threatened or endangered. Such species receive no legal protection under the Endangered Species Act, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SE (state endangered): An animal species or subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy; or a plant species that is listed as threatened or endangered under the Endangered Species Act, or is considered proposed under the Act, or is a rare plant across its range within New Mexico, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in New Mexico.

SS (state sensitive): Species that, in the opinion of a qualified New Mexico Department of Game and Fish biologist, deserve special consideration in management and planning and are not listed as threatened or endangered by the state of New Mexico.

SSC (state species of concern): A New Mexico plant species that should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

ST (state threatened): A native species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its New Mexico range.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

-: Not listed.

Source: DOE (2008c)

bald eagle (*Haliaeetus leucocephalus*). (The peregrine falcon and bald eagle have since been delisted.) These areas of environmental interest consist of core areas that contain important breeding or wintering habitat and buffer areas that protect the core area from disturbance (LANL 1998).

### 8.1.6 Socioeconomics

The socioeconomic data for LANL describe an ROI surrounding the site composed of three counties: Los Alamos County, Rio Arriba County, and Santa Fe County in New Mexico. More than 85% of LANL workers reside in these counties (DOE 2008c).

### 8.1.6.1 Employment

In 2011, total employment in the ROI stood at 97,095 (U.S. Department of Labor 2012). Employment grew at an annual average rate of –0.1% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing more than 91% of all employment (see Table 8.1.6-1). LANL is one of the largest institutions in northern New Mexico and has more than 12,500 employees, including laboratory, protective force, and support contractor personnel (LANL 2012).

### 8.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 8.1.6-2). Over the 10-year period 2002–2011, the average rate in Rio Arriba County was 6.4%, with lower rates in Santa Fe County (4.5%) and Los Alamos County (2.7%). The average rate in the ROI over this period was 4.7%, lower than the average rate for the state of 5.7%. Unemployment rates for 2011 were slightly lower than rates for 2010; in Los Alamos County, the unemployment rate fell from 3.3% to 3.2%, while in Santa Fe County, the rate declined from 6.5% to 6.0%. However, in Rio Arriba County, the unemployment rate increased slightly from 8.2% to 8.3% from 2010 to 2011. The ROI fell from 6.5% to 6.2%, and in the state, it fell from 7.9% to 7.4% during this period.

**TABLE 8.1.6-1 LANL: County and ROI Employment by Industry in 2009**

| | New Mexico | | | | |
|---|---|---|---|---|---|
| Sector | Los Alamos County | Rio Arriba County | Santa Fe County | ROI Total | % of ROI Total |
| Agriculture[a] | 0 | 1,231 | 429 | 1,660 | 2.3 |
| Mining | 10 | 32 | 60 | 102 | 0.1 |
| Construction | 183 | 413 | 2,874 | 3,470 | 4.8 |
| Manufacturing | 40 | 175 | 764 | 979 | 1.4 |
| Transportation and public utilities | 10 | 810 | 652 | 1,472 | 2.0 |
| Trade | 493 | 1,467 | 10,668 | 12,628 | 17.5 |
| Finance, insurance, and real estate | 452 | 452 | 2,930 | 3,686 | 5.1 |
| Services | 16,277 | 16,277 | 28,005 | 48,260 | 67.0 |
| Other | 0 | 0 | 2 | 2 | 0.0 |
| Total | 17,465 | 8,202 | 46,393 | 72,060 | |

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

**TABLE 8.1.6-2 LANL: Average County, ROI, and State Unemployment Rates (%) in Selected Years**

| Location | 2002–2011 | 2010 | 2011 |
|---|---|---|---|
| Los Alamos County | 2.7 | 3.3 | 3.1 |
| Rio Arriba County | 6.4 | 8.2 | 8.3 |
| Santa Fe County | 4.5 | 6.5 | 6.0 |
| ROI | 4.7 | 6.5 | 6.2 |
| New Mexico | 5.7 | 7.9 | 7.4 |

Source: U.S. Department of Labor (2012)

### 8.1.6.3 Personal Income

Personal income in the ROI stood at almost $8.9 billion in 2009, having grown at an annual average rate of growth of 2.4% over the period 2000–2009 (Table 8.1.6-3). ROI personal income per capita also rose over the same period and reached $43,195 in 2009, compared to $38,241 in 2000. Per-capita incomes were much higher in Los Alamos County ($62,842 in 2009) than elsewhere in the ROI.

### 8.1.6.4 Population

The population of the ROI in 2010 stood at 202,366 (U.S. Bureau of the Census 2012b) and was expected to reach 205,277 by 2012 (Table 8.1.6-4). In 2010, 144,170 people were living in Santa Fe County (71% of the ROI total), and 40,246 people resided in Rio Arriba County. Over the period 2000–2010, the population in the ROI as a whole grew slightly, with an average growth rate of 0.7%, with moderate growth occurring in Santa Fe County (1.1%) and slight declines in population elsewhere. The population in New Mexico as a whole grew at a rate of 1.2% over the same period.

### 8.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 1.7% over the period 2000–2010 (Table 8.1.6-5). A total of 18,605 new units were added to the existing housing stock in the ROI between 2000 and 2010. There were 13,865 vacant housing units in the ROI in 2010, of which 3,923 were rental units that could be available to construction workers at the GTCC proposed facility.

**TABLE 8.1.6-3 LANL: County, ROI, and State Personal Income in Selected Years**

| Income | 2000 | 2009 | Average Annual Growth Rate (%), 2000–2009 |
|---|---|---|---|
| Los Alamos County | | | |
| Total personal income (2011 $ in billions) | 1.0 | 1.1 | 1.2 |
| Personal income per capita (2011 $) | 55,635 | 62,842 | 1.4 |
| Rio Arriba County | | | |
| Total personal income (2011 $ in billions) | 1.0 | 1.2 | 2.3 |
| Personal income per capita (2011 $) | 23,293 | 28,958 | 2.4 |
| Santa Fe County | | | |
| Total personal income (2011 $ in billions) | 5.2 | 6.6 | 2.6 |
| Personal income per capita (2011 $) | 40,535 | 44,713 | 1.1 |
| ROI total | | | |
| Total personal income (2011 $ in billions) | 7.2 | 8.9 | 2.4 |
| Personal income per capita (2011 $) | 38,241 | 43,195 | 1.4 |
| New Mexico | | | |
| Total personal income (2011 $ in billions) | 54.1 | 70.1 | 2.9 |
| Personal income per capita (2011 $) | 29,748 | 34,880 | 1.8 |

Source: DOC (2012)

**TABLE 8.1.6-4 LANL: County, ROI, and State Population in Selected Years**

| Location | 1990 | 2000 | 2010 | Average Annual Growth Rate (%), 1990–2006 | 2012[a] |
|---|---|---|---|---|---|
| Los Alamos County | 18,115 | 18,343 | 17,950 | –0.2 | 17,872 |
| Rio Arriba County | 34,365 | 41,190 | 40,246 | –0.2 | 40,060 |
| Santa Fe County | 98,928 | 129,292 | 144,170 | 1.1 | 147,345 |
| ROI | 151,408 | 188,825 | 202,366 | 0.7 | 205,277 |
| New Mexico | 1,515,069 | 1,819,046 | 2,059,179 | 1.2 | 2,110,883 |

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

**TABLE 8.1.6-5 LANL: County and ROI Housing Characteristics in Selected Years**

| Type of Housing | 2000 | 2010 |
|---|---|---|
| Los Alamos County | | |
| Owner occupied | 5,894 | 5,828 |
| Rental | 1,603 | 1,835 |
| Vacant units | 440 | 691 |
| Total units | 7,937 | 8,354 |
| Rio Arriba County | | |
| Owner occupied | 12,281 | 12,528 |
| Rental | 2,763 | 3,240 |
| Vacant units | 2,972 | 3,870 |
| Total units | 18,016 | 19,638 |
| Santa Fe County | | |
| Owner occupied | 35,985 | 42,878 |
| Rental | 16,497 | 19,085 |
| Vacant units | 5,219 | 9,304 |
| Total units | 57,701 | 71,267 |
| ROI total | | |
| Owner occupied | 54,160 | 61,234 |
| Rental | 20,863 | 24,160 |
| Vacant units | 8,631 | 13,865 |
| Total units | 83,654 | 99,259 |

Source: U.S. Bureau of the Census (2012b)

### 8.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and would be used to support additional local community services currently provided by each jurisdiction. Table 8.1.6-6 presents information on expenditures by the various jurisdictions and school districts.

### 8.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment in order to provide public safety, fire protection, and community and educational services in the counties, cities, and school districts likely to host

**TABLE 8.1.6-6 LANL: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]**

| Location | Jurisdiction | School District |
|---|---|---|
| Los Alamos County | 44.6 | 21.0 |
| Rio Arriba County | 13.5 | 32.7 |
| Santa Fe County | 102.1 | 68.0 |
| ROI total | 160.2 | 121.6 |
| New Mexico | 753.6 | 2,789 |

[a] Argonne National Laboratory projections.

relocating construction workers and operations employees. Additional demand could also be placed on local physician services. Table 8.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 8.1.6-8 provides data on staffing and levels of service for school districts. Table 8.1.6-9 does the same for the medical field.

### 8.1.7 Environmental Justice

Figures 8.1.7-1 and 8.1.7-2 and Table 8.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around LANL from Census data for the year 2010 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number includes individuals who also identified themselves as being part of one or more of the population groups listed in the table. The most affected population in the 80-km (50-mi) assessment area could be the adjacent Pueblos.

**TABLE 8.1.6-7 LANL: County, ROI, and State Public Service Employment in 2009**

| | Los Alamos County | | Rio Arriba County | | Santa Fe County | |
|---|---|---|---|---|---|---|
| Type of Service | No. | Level of Service[a] | No. | Level of Service[a] | No. | Level of Service[a] |
| Police protection | NA[b] | NA | 22 | 0.5 | 79 | 0.5 |
| Fire protection[c] | 117 | 6.5 | 1 | 0.0 | 165 | 1.1 |

| | ROI | | New Mexico[d] | |
|---|---|---|---|---|
| Type of Service | No. | Level of Service[a] | No. | Level of Service[a] |
| Police protection | 101 | 0.5 | 3,882 | 2.0 |
| Fire protection[c] | 283 | 1.4 | 2,121 | 1.1 |

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] NA: not available

[c] Does not include volunteers.

[d] 2006 data.

Sources: U.S. Bureau of the Census (2008 a,b; 2012b,c); FBI (2012); Fire Departments Network (2012)

**TABLE 8.1.6-8 LANL: County, ROI, and State Education Employment in 2011**

| Location | No. of Teachers | Level of Service[a] |
|---|---|---|
| Los Alamos County | 251 | 13.5 |
| Rio Arriba County | 436 | 14.3 |
| Santa Fe County | 977 | 16.3 |
| ROI | 1,665 | 15.4 |
| New Mexico | 22,457 | 14.8 |

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

**TABLE 8.1.6-9 LANL: County, ROI, and State Medical Employment in 2010**

| Location | No. of Physicians | Level of Service[a] |
|---|---|---|
| Los Alamos County | 71 | 4.0 |
| Rio Arriba County | 49 | 1.2 |
| Santa Fe County | 661 | 4.6 |
| ROI | 781 | 3.9 |
| New Mexico[b] | 4,421 | 2.3 |

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)


**FIGURE 8.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2012b)**

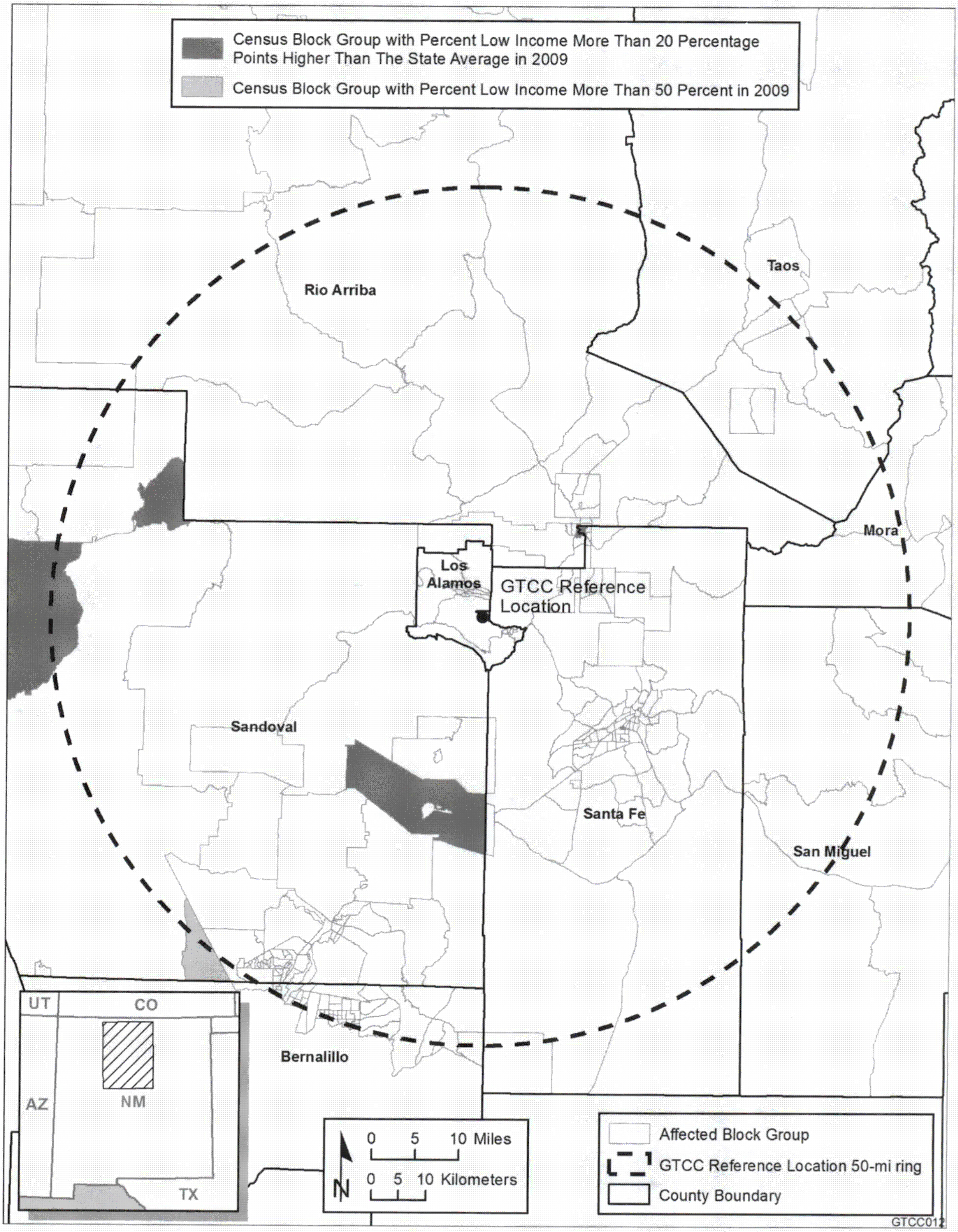


**FIGURE 8.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2012b)**

**TABLE 8.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of LANL**

| Population | New Mexico Block Groups |
|---|---|
| Total population | 454,879 |
| White, non-Hispanic | 210,995 |
| Hispanic or Latino | 196,394 |
| Non-Hispanic or Latino minorities | 47,490 |
| One race | 40,784 |
| Black or African American | 5,389 |
| American Indian or Alaskan Native | 25,509 |
| Asian | 8,499 |
| Native Hawaiian or other Pacific Islander | 269 |
| Some other race | 1,118 |
| Two or more races | 6,706 |
| Total minority | 243,884 |
| Percent minority in 80-km (50-mi) buffer | 53.6% |
| Percent minority in New Mexico | 59.5% |
| Low-income | 17,933 |
| Percent low-income in 80-km (50-mi) buffer | 10.6% |
| Percent low-income in New Mexico | 18.0% |

Source: U.S. Bureau of the Census (2012b)

American Indian Text

There are two major power transmission lines, the Norton and Reeves Power lines, which exist on both mesas that are considered by the proposed GTCC. One line goes through GTCC Zone 6 and the other through GTCC North Side and North Side Expanded. These major district power lines occupy the centers of both mesas and greatly reduce the potential areas of the GTCC. Along both lines are a series of Pueblo archaeology sites, which are currently signed as restricted access areas protected under the National Historic Protection Act.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius, 53.6% of the population is classified as minority, while 10.6% is classified as low income. Although the number of minority individuals does not exceed the state average by 20 percentage points or more, the number of minority individuals exceeds 50% of the total population in the area; that is, there is a minority population in the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the 50-mi (80-km) area around the reference location as a whole.

American Indian Text

As Indian peoples culturally affiliated with land currently occupied by LANL, the Pueblo people would like to expand the definition of Environmental Justice so that it reflects the unique burdens borne by them. This definition is defined more fully below.

Pueblo people and their lands have been encroached upon by Europeans since the 1500s. During this time they have experienced loss of control over many aspects of their lives including (1) loss of traditional lands, (2) damage to Sacred Home Lands, (3) negative health effects due to European diseases and shifting diet, and (4) lack of access to traditional places. Negative encroachments that occurred during the Spanish period were continued after 1849 under the United States of America's federal government. The removal of lands for the creation of LANL in 1942 were a major event causing great damage to Pueblo peoples. Resulting pollution to the natural environment and ground disturbances from LANL activities constitute a base-line of negative Environmental Justice impacts. The GTCC proposal needs to be assessed in terms how it would continue these Environmental Justice impacts and thus further increase the differential emotional, health, and cultural burdens borne by the Pueblo peoples.

The Congress of the United States recognized this violation of their human, cultural, and national rights when the American Indian Religious Freedom Act (AIRFA) was passed in 1978. In the AIRFA legislation Congress told all Federal agencies to submit plans which would assure they would no longer violate the religious freedom of American Indian peoples. Subsequent legislation like the Native American Graves Protection and Repatriation Act (NAGPRA) and Executive Order 13007 – Sacred Sites Access have further defined their rights to Sacred Home Lands and traditional resources. The Federal Government also has a Trust Responsibility to American Indian peoples which is recognized in the DOE American and Alaska Native policy (http://www.em.doe.gov/pages/emhome.aspx). Environmental Justice is one point of analysis where these concerns can be expressed by Pueblo peoples and the obligations addressed by Federal Agencies during the NEPA EIS process.

Pueblo people believe that their health has been adversely affected by LANL operations including different types of cancers. These concerns were publicly recorded in videos produced with Closing the Circle grants provided by the National Park Service and the DOE. Documentation of these adverse health affects is difficult because post-mortem analysis is not normal due to cultural rules regarding the treatment of the deceased and burial practices.

### 8.1.8 Land Use

The GTCC reference location is situated in three undeveloped and relatively undisturbed areas within TA-54 on Mesita del Buey: Zone 6, North Site, and North Site Expanded (Figure 1.4.3-6). Zone 6 is slightly less than 7 ha (17 ac) in area. It is not fenced, but access is controlled by staffed vehicle access portals on Pajarito Road. The total area of the North Site is about 16 ha (39 ac). The North Site Expanded section adds another 23 ha (57 ac). The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the Pueblo de San Ildefonso; its southeastern boundary borders the community of White Rock (LANL 2008).

LANL covers 10,360 ha (25,600 ac) and is divided into 48 technical areas or TAs. Developed areas make up only a small portion of LANL as a result of the physical constraints of the geological setting, such as steep slopes and canyons. No agriculture occurs on LANL (DOE 2008c). The GTCC reference location would be situated within TA-54 (Figure 8.1-1).

The land use categories at LANL include service and support, experimental science, R&D on high explosives, testing of high explosives, R&D on nuclear materials, physical and technical support, public and corporate interface, reserve (areas not otherwise included within other categories and that may include environmental core and buffer areas, vacant land, and proposed land transfer areas), theoretical and computational science, and waste management (DOE 2008c). The land use categories within TA-54 are (1) reserve and (2) waste management (areas that provide for activities related to handling, treatment, and disposal of all generated solid, liquid, and hazardous waste products [chemical, radiological, and explosive]). During the late 1950s, LANL, with the approval of the AEC and upon recommendation of the USGS, selected TA-54 for underground disposal of LANL-derived waste. Since that time, TA-54 has functioned as a major storage and disposal facility, with some treatment permitted for wastes generated by LANL operations (DOE 2008c).

LANL was designated as a NERP in 1977. The 405-ha (1,000-ac) White Rock Canyon Reserve, located on the southeast perimeter of LANL, was dedicated in 1999. The reserve is jointly managed by DOE and the National Park Service (NPS) for its significant ecological and cultural resources and research potential (DOE 2008c).

Communities in the region are generally small, supporting residential, commercial, light industrial, and recreational land uses. American Indian tribal communities also occur in the area, with the lands of the Pueblo de San Ildefonso sharing LANL's eastern border. The largest nearby city is Santa Fe, the state capital, which has a population of about 70,000 (2009).

Land stewards that determine the land uses within the LANL region include DOE, USFS, NPS, the county of Los Alamos, private land owners, the state of New Mexico, the Pueblos, the Bureau of Indian Affairs, and BLM (DOE 2008c). The Santa Fe National Forest lands adjacent to LANL support multiple activities. Bandelier National Monument has only a small portion that is developed for visitors; about 70% of the main unit, which is located immediately south of LANL, has been designated as a Wilderness Area.

### 8.1.9 Transportation

SR 502 and SR 4 are the only two major roads that access Los Alamos County, and the traffic volume on these two segments of highway is primarily associated with LANL activities. SR 502 passes along the northern border of the site, connecting to US 84 north of Santa Fe. SR 4 borders the eastern edge of LANL, starting from SR 502 going southward, passing through the community of White Rock and then eventually looping through the southern portion of the site, separating it from Bandelier National Monument. SR 4 passes along the site's southwestern border on its way to Jemez Springs and intersects the junction with West Jemez Road (S 501) near TA-16.

American Indian Text

Pueblo people note that all waste shipments move by highway. There are no local railroads. Pueblo people believe that GTCC waste shipments will adversely impact natural resources, reservation communities, tribal administration activities, public schools, day schools, and businesses located along Highway 502 and Highway 84/285.

The Pueblo of Nambe is located on Highway 84/285 between the Pueblos of Pojoaque and Tesuque. The Pueblo of Nambe is located on the Rio Nambe, which joins the Rio Grande a few miles downstream. The Rio Nambe is the major water source for the Pueblo. Nambe Falls is on the reservation is an eco-tourism destination. Also on the reservation is Nambe Lake, which is used for irrigation of fields (crops) and recreation. Nambe has established several businesses on Highway 84/285, such as the Nambe Pueblo Development Corporation, Nambe Falls Travel Center, Hi-Tech, and many more businesses are planned for this location. New businesses include a water bottling factory, a housing complex, and solar and wind energy projects.

The Pueblo of Nambe raises the issue of security. The Pueblo government wants to know when radioactive waste is being transported past the reservation lands. We have a “need to know” and this information should be provided to appropriate tribal authorities such as First Responders and Emergency Managers. The tribes with Indian Land on transportation routes should be funded by the DOE to train their own radiation monitor teams, to maintain capability for their own safety and to protect sovereign immunity of Native American Tribes as independent Nations within the United States. This would enable tribes to be effective participants in handling hazards and threats as mandated by US. Department of Homeland Security in the “Metrics for Tribes” to be compliant with NIMS. Tribes should be able to participate in the preparations of waste materials for transportation at DOE sites. This participation/observation would give Tribes confidence that proper packing techniques and guidelines are adhered to. Currently Tribes are expected to “trust” that State and Federal authorities are doing this phase properly. The Indian people will feel more comfortable if we have some role in observing the process/procedures particularly if our observers are properly trained to understand the scientific reasons associated with packaging methodology.

The Pueblo of Nambe wants to monitor the transportation of GTCC materials in the same way that transuranic waste is monitored on its route from LANL to WIPP site at Carlsbad.

The Pueblo of Santa Clara is traversed by NM 30. Near this road are tribal residential areas, tribal businesses, schools, and economic developments. This highway is not an alternate route for radioactive waste hauling. A violation of this rule occurred in 2006 when three semi-trailer trucks loaded with radioactive soils from LANL were seen using NM30 as a short-cut route (they should have remained on NM 502) Drivers had disregarded tribal regulations. A tribal representative caught up with them nearby and recorded the violation.

Other Pueblo people have business and tribal resources along potential transportation routes. The Pueblo de San Ildefonso, for example, is concerned about radioactive waste transportation along Highway 502. The Totavi Business Plaza, is an area that was traditionally occupied, and is now a restaurant and gas station and may be a location for new tribal housing. The Pueblo de San Ildefonso youth attend a Day School, a District High School, Middle School, and Elementary Schools along 502. Pojoaque has a business park and two gas stations along 502 and 84/285 as well as their youth attend these schools.

Hazardous and radioactive material shipments leave or enter LANL from East Jemez Road to SR 4 to SR 502. East Jemez Road, as designated by the State of New Mexico and governed by 49 CFR 177.825, is the primary route for the transportation of hazardous and radioactive materials. The average daily traffic flows at LANL's main access points are presented in Table 8.1.9-1.

The primary route designated by the State of New Mexico to be used for radioactive and other hazardous material shipments to and from LANL is the approximately 64-km (40-mi) corridor between LANL and I-25 at Santa Fe (DOE 2006). This route passes through the Pueblo de San Ildefonso, and the Pueblos of Pojoaque, Nambe, and Tesuque and is adjacent to the northern segment of Bandelier National Monument. This primary transportation route bypasses the city of Santa Fe on SR 599 to I-25. SR 599, the Santa Fe bypass, was built and funded by DOE primarily to convey LANL WIPP trucks around Santa Fe.

Motor vehicles are the primary means of transportation to LANL. The nearest commercial rail connection is at Lamy, New Mexico, 83 km (52 mi) southeast of LANL. The New Mexico Rail Runner commuter rail service operates between Santa Fe and Albuquerque. It uses the ROW and new tracks where there was previously a spur into central Santa Fe (the spur is still used by the Santa Fe Southern Railway for some freight and a tourist railroad). LANL does not currently use rail transport for commercial shipments. However, a recently completed supplement analysis to the 2008 SWEIS evaluated rail for shipping wastes off-site to Clive, Utah (DOE 2009a).

Most commuter traffic originates from within or east of Los Alamos County (Rio Grande Valley and Santa Fe) because a large number of LANL employees live in these areas (DOE 2006). A small number of LANL employees commute to LANL from the west along SR 4. The average weekday traffic volumes at various points in the vicinity of SR 502 and SR 4 measured in September 2004 are presented in Table 8.1.9-2. The intersection that serves all of TA-54 on Mesita del Buey is substandard and needs to be improved to comply with modern traffic engineering safety standards and would not support the activities proposed in this EIS. Upgrades to this intersection would be required (Werdel 2010).

**TABLE 8.1.9-1 Main Access Points at LANL[a]**

| Location | Average No. of Daily Vehicle Trips |
|---|---|
| Diamond Drive across the Los Alamos Canyon Bridge | 24,545 |
| Pajarito Road at SR 4 | 4,984 |
| East Jemez Road at SR 4 | 9,502 |
| West Jemez Road at SR 4 | 2,010 |
| DP Road at Trinity Drive | 1,255 |
| Total | 42,296 |

[a] Source: DOE (2006)

**TABLE 8.1.9-2 Average Weekday Traffic Volumes in the Vicinity of State Routes 502 and 4**

| Location | Average No. of Daily Vehicle Trips |
|---|---|
| Eastbound on SR 502, east of the intersection with SR 4 | 10,100 |
| Westbound on SR 502, east of the intersection with SR 4 | 7,765 |
| Eastbound on SR 502, west of the intersection of SR 502 and SR 4 | 6,540 |
| Westbound on SR 502, west of the intersection of SR 502 and SR 4 | 4,045 |
| Westbound on SR 4, between East Jemez Road and the SR 502/4 intersection | 6,505 |
| Eastbound on SR 4, between East Jemez Road and the SR 502/4 intersection | 6,665 |
| Transition road from northbound SR 4 to eastbound SR 502 | 5,170 |
| Transition road from eastbound SR 502 to southbound SR 4 | 1,610 |

Source: DOE (2006)

Park-and-ride services are provided by a commercial corporation in conjunction with the New Mexico State Highway and Transportation Department. More than 80 daily departures between Santa Fe and Española, between Santa Fe and Los Alamos, between Española and Los Alamos, between Albuquerque and Santa Fe, and between Albuquerque and Los Alamos are provided for commuters (DOE 2006). Monthly passes are sold for use of most park-and-ride routes. Los Alamos County operates Atomic City Transit with five weekday no-fare routes. The transit center at LANL is located in TA-3.

## 8.1.10 Cultural Resources

LANL's foundation was associated with the development of the first atomic bomb during World War II. The Laboratory's mission continues to be national security. LANL also has a strong stewardship role over the facilities it has used for the last 60 years and is managing the contamination that resulted from years of experiments. Management of cultural resources at LANL is the ultimate responsibility of DOE's NNSA. Since 2006, operations at LANL have been managed for DOE by Los Alamos National Security LLC.

The management of cultural resources at LANL is guided by several documents and plans. The first is a PA among DOE, the ACHP, New Mexico SHPO, and Los Alamos County. In addition, a mitigation action plan was developed as part of the 1999 SWEIS to aid in the future operation of LANL. This plan outlines the process and procedures for considering cultural resources during operations. LANL developed an integrated natural and cultural resources management plan in 2002. In 1992, LANL and DOE signed accords with four pueblos (Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo) to facilitate communication on cultural issues.

Evidence of prehistoric people goes back to 9500 B.C. in north central New Mexico. Archaeological evidence at LANL shows extensive use of the region beginning in the Archaic period (roughly 5500 B.C.) through the Ancestral Pueblo Classic period (around A.D. 1600). There is no archaeological evidence for agriculturalists on the LANL Plateau during the Archaic period (5500 B.C. to A.D. 600). Between A.D. 900 and A.D. 1150, agriculturalists expanded up the Rio Grande Valley. Pithouses persisted in some places, but sites are typically small adobe and masonry structures that are found at a wide range of elevations. There are only about 10 sites that date to this time period at LANL. These sites consist of artifact scatters, one- to three-room structures (jacal and masonry), and small masonry roomblocks. The sites appear to represent an initial attempt by agriculturalists to colonize the Pajarito Plateau. However, it appears that this strategy was not a success until about A.D. 1150 (Ancestral Pueblo Coalition period) when higher-yielding varieties of 12- to 14-row maize were available for planting in these upland settings. The plateau was presumably being used by both foragers and farmers during this time period.

Between A.D. 1150 and A.D. 1325, there was a substantial increase in the number, size, and distribution of above-ground habitation sites, with year-round settlements expanding into upland areas on the Pajarito Plateau. Early sites contained adobe and masonry rectangular structures with 10 to 20 rooms. These small rubble mound sites are the most common sites at LANL. In contrast, later sites of this period consist of large masonry-enclosed plaza pueblos that contain more than 100 rooms.

Ancestral Pueblo settlements on the Pajarito Plateau between A.D. 1325 and A.D. 1600 (Classic period) are aggregated into three population clusters with outlying one- to two-room fieldhouses. The central site cluster consists of four temporally overlapping sites: Navawi, Otowi, Tsirege, and Tsankawi. Only Tsirege is located on LANL land. The initial occupation of these pueblos occurred during the 14th century. Tsirege, Tsankawi, and Otowi continued to be occupied during the 15th century. Only Tsirege and Tsankawi remained by the 16th century. Oral traditions at Pueblo de San Ildefonso indicate that Tsankawi was the last of the plateau pueblos to be abandoned. As the result of a series of droughts, the Pajarito Plateau was eventually abandoned during the 1580s. New pueblos were occupied in the Rio Grande Valley.

There is evidence for American Indian, Hispanic, and Euro-American use of the area during the Historic period from A.D. 1600 to A.D. 1943. A.D. 1600 corresponds with the first Spanish settlement in New Mexico and the initiation of economic and political influence over the previously established Rio Grande populations. The Pueblo Indians revolted against the Spanish in 1680. Some pueblos were abandoned when the Spanish returned. Some sites on the plateau were reoccupied at the end of this refugee period (e.g., Nake'muu at LANL).

Mexico declared its independence from Spain in 1821. Trade between Mexico and Santa Fe along the Santa Fe Trail began soon after, and this trade dominated events in New Mexico for the next quarter-century. This trade introduced some comparatively inexpensive Euro-American goods to New Mexico; it is reflected in the increase of manufactured items found on sites from this period. New Mexico remained a part of Mexico until war broke out with the United States; New Mexico became part of the United States on August 18, 1846.

During the early 1900s in New Mexico, there was a continuation of traditional farming strategies, cattle grazing, timbering, and a wide variety of cultural practices. However, large-scale sheep herding, timbering, and mining activities during this period displaced some Hispanic communities. Seasonal homesteading continued to be prevalent on the plateau. Wooden cabins, corral structures, and rock or concrete cisterns characterize Hispanic and Anglo Homestead era sites. Many of the wooden structures burned during the May 2000 Cerro Grande fire. Artifact scatters, consisting of historic debris associated with household and farming/grazing activities, are also commonly found at this time period. The period 1890 to 1942 is typically referred to as the Homestead period at LANL. Most of the central Pajarito Plateau homestead patents were filed by Hispanic people who maintained permanent homes in the Rio Grande Valley, using the Pajarito Plateau sites for seasonal farming and resource gathering. Notable exceptions to this pattern included the establishment of a few permanent Anglo commercial concerns, such as the Anchor Ranch and Los Alamos Ranch School, the latter of which operated from 1918 until the late spring of 1943. The end of the Homestead period coincides with the appropriation of lands on the Pajarito Plateau for the Manhattan Project in 1943.

Manhattan Project personnel chose the LANL location in 1943 as the primary facility for research on developing an atomic bomb because it was remote and access could be controlled. The project proved a success when the first atomic bomb was detonated at the Trinity Site in July 1945. With the conclusion of World War II, research continued at LANL; it focused on new weapons. The first hydrogen bomb was successfully tested in 1951. By the late 1950s, research focused on reducing the size of bombs for use with intercontinental missiles. Weapons testing continued until the early 1990s, when the Test Ban Treaty was enacted. Environmental concerns began to be a major issue in the 1970s. Currently LANL focuses on its military and security missions as well as environmental stewardship.

Roughly 90% of the land at LANL has been surveyed for cultural resources. Cultural resource surveys at LANL have identified 1,915 archaeological sites. Of the 1,915 sites, 1,776 date to the prehistoric period. A total of 139 American Indian, Hispanic, and Euro-American historic sites represent populations that lived and/or worked in the region from the 1600s to the 1990s. The majority of these sites are structures or artifact scatters that date between 1600 and 1890. Researchers recommend that 400 of the sites identified be listed on the NRHP. The majority of the remaining sites have yet to be evaluated for their significance (DOE 2006). Archaeological remains include multiroom pueblos, field houses, talus houses, cavates, rock shelters, shrines, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, and limited-activity sites.

Historic buildings at LANL relate to both Manhattan Project and Cold War era research. A total of 510 buildings that date to this period remain. Of these, a total of 98 are considered eligible for listing on the NRHP, and 81 were determined ineligible. A small number of buildings at LANL that are less than 50 years old are considered eligible because of their exceptional importance to American history.

Several pueblos have expressed an interest in traditional cultural properties found on LANL. The Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo signed accords with DOE to facilitate communication about cultural resources on LANL.

Traditional cultural properties identified on LANL include 15 ceremonial archaeological sites, 14 natural features, 10 ethnobotanical sites, 7 artisan material sites, and 8 subsistence features.

Numerous cultural resources have been identified in TA-54, which includes both Zone 6 and the North Site (including North Site Expanded). Cultural resource surveys have been conducted for the proposed GTCC reference location. Eighteen archaeological sites are situated within the assessment area boundaries, including six in Zone 6, five in the North Site, and seven in the North Site Expanded area. These sites include large diffuse chipped and ground stone artifact scatters that, based on diagnostic projectile points, date back to the Archaic period. Ancestral Pueblo sites dating from A.D. 1150 to A.D. 1600 include numerous structural foundations and partial structures representing one- to three-room fieldhouses to multiroom (ranging from 4 to 50 rooms) pueblos; possible kivas (circular subterranean ceremonial structures); and lithic (stone tool) scatters containing thousands of artifacts (2,500 or more). Remains of the Pajarito Plateau Wagon Road from the Homestead era (1890–1942) were also found.

Section 106 of NHPA requires federal agencies to take into account the effect of any federal or federally funded undertaking on any district, site, building, structure, or object that is included in or is eligible for inclusion in the NRHP. Under NHPA, the SHPO is required to identify and inventory historic properties within the state and nominate eligible properties to the NRHP, and it is tasked to ensure that NRHP-eligible properties are taken into account during an undertaking's planning and development. Of the 18 archaeological sites located in the proposed GTCC reference location, four have SHPO concurrence with regard to their eligibility, and LANL has assessed all of the other sites as being NRHP eligible or having undetermined NRHP eligibility. A site with an undetermined eligibility is treated as eligible until a formal determination can be made. The site eligibility and potential effect determinations will involve any American Indian groups determined to be culturally affiliated with respect to the area proposed for development. Affiliated tribes will have to be consulted to determine if traditional cultural properties are present within the GTCC reference location.

American Indian Text

Pueblo oral histories document that they have lived in and used the entire area of LANL including the GTCC proposed site since the beginning of time. Because of this Pueblo people are the descendants of the people who have lived here throughout time and included time periods referred by LANL archaeologists by the terms (1) Paleo-Indian, (2) Archaic, (3) Ancestral Pueblo, (4) American Indian, and (5) Federal Scientific Laboratory. Pueblo people lived in the area before the Ancestral Pueblo period, which is dated at 1600AD. Pueblo people continue to know about and value lands, natural resources, and archaeological materials located on LANL.

Pueblo people continue to desire and have a culturally important role and responsibilities in the management of all of these traditional lands.

Recent cultural resource surveys have been conducted on LANL, which have identified some sites that were not identified when LANL was established after 1943. Pueblo people

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***Continued***

believe that these sites are connected with other much larger sites that were destroyed when the LANL facility was built and operated. The Pueblo people express concern that many early LANL developments destroyed culturally significant sites and that no effort has been made to conduct ceremonies that may alleviate the violations association with site destruction.

A known Sacred Area, primarily identified with Pueblo de San Ildefonso, is located on the next mesa to the north of the proposed GTCC waste site. It is spiritually connected to the surrounding area and is not bounded any federal boundaries. It is recognized as a Sacred Area on old USGS quads. The Sacred Area is continually monitored by Pueblo de San Ildefonso to constantly check on its cultural integrity. It has visual, auditory, and spiritual dimensions. Pueblo de San Ildefonso air quality program consistently monitors for tritium releases, which derive from nearby area G on TA 54 on LANL. Winds blow across this area from the Southwest from LANL on to the Sacred Area. The Cerro Grande fire brought ash debris which contained radionuclides to the Sacred Area. The Sacred Area is thus believed to have been contaminated by the ash from Cerro Grande fire. Dust contaminated from ongoing operations from area G has blown into the Sacred Area.

Although four American Indian pueblos, called by LANL the Accord Tribes: Santa Clara Pueblo, Pueblo de San Ildefonso, Jemez Pueblo, and Pueblo de Cochiti have been singled out during the GTCC consultation process as being both nearby and culturally connected with LANL, there is a widely recognized understanding that other American Indian tribes are also culturally connected with LANL. These include but are not limited to (1) all 8 northern pueblos including San Juan O'Hkayowingee, Nambe O-weenge, Pojoaque, Picuris; (2) Jicarilla Apache; (3) southern Pueblos like Santo Domingo; and (4) western pueblos like Zuni and Hopi. Important LANL actions like the GTCC EIS undergoing a major analysis should include all the culturally connected (affiliated) American Indian tribes.

The LANL NAGPRA consultation report includes the following statement "It is noted that since around 1994, LANL has consistently consulted with five tribes on issues relating to cultural resources management, or at least have informed them of proposed construction projects and other issues surrounding cultural resources management at LANL." These include the "Accord Pueblos" of San Ildefonso, Santa Clara, Cochiti, and Jemez, each of which has signed agreements with LANL, along with the Mescalero Apache Tribe. In addition, the Pueblo of Acoma and the Jicarilla Apache Nation have been recognized as having an active interest in cultural resources management at LANL. A draft version of that NAGPRA report was subsequently also sent in January 2002 to all New Mexico Pueblos and to the Pueblos of Hopi in Arizona and Ysleta del Sur in Texas, as well as to the Jicarilla Apache Nation, the Mescalero Apache Tribe, the Navajo Nation, and the Ute Mountain and Southern Ute Tribes. The pueblo writers find the patterns of consultation by LANL to be confusing and not clearly grounded in a formal policy based on an agreed to Cultural Affiliation study.

Meaning of Artifacts, Places, and Resources – There is a general pueblo concern for pre-agricultural period Indian artifacts and the places where they were left. These include the role of ceremony itself as an act of sanctifying places, such as has been conducted and occurred near Sacred Area over the past thousands of years. Pueblo people believe they have been in the area since the beginning of time. This connection back in time thus connects them to all places, artifacts, and resources in the area.

American Indian Text

The Pueblo people would like to point out a direct conflict in current LANL policy and the GTCC proposal. Today LANL is officially remediating contaminated areas. These actions result in the waste being moved to new sites such as WIPP. Some of this may be transported past Pueblo communities and economic business along transportation routes. LANL has already agreed to remove radioactive waste from Area G to WIPP. Currently LANL is shipping most kinds of radioactive and TRU waste off-site. This current LANL policy is in conflict with the GTCC proposal, which would place radioactive waste and TRU waste on LANL and near Area G. In addition, the Pueblos along the transportation routes will now be exposed twice – once to current LANL waste leaving for elsewhere like the WIPP site, and secondly to new GTCC waste shipments that are arriving from elsewhere.

The Pueblo people note that one of the potential GTCC sites, indicated as Zone 4, that is being considered in the EIS appears to have been withdrawn (June 2009) from consideration for GTCC waste because LANL is continuing to dispose of LLRW waste there. This is LLRW that has been or will be produced by LANL. These additional LANL wastes add to perceived contamination risks by the Pueblo people.

The Pueblo people note that the potential site for the GTCC waste disposal is already leaking radioactive contaminants around the perimeter of Area G and DARHT. GTCC waste could only increase the contamination of this area and add to the off-site flow of contaminants.

There is a known Sacred Area on the next ridge next to the existing LANL Area G radioactive waste isolation facility and also across from the proposed GTCC site. This Sacred Area is spiritually connected to the surrounding area and is not bounded any federal boundaries (it is even recognized as a sacred area on old USGS quads). Area is constantly monitored by Pueblo de San Ildefonso to check on its integrity. The Sacred Area has visual, auditory dimension, which are consistently monitoring for tritium from nearby areas. Winds blow across this area. The Cerro Grande fire brought ash debris, which contained radionuclides to the Sacred Area, thus the area is believed to have been contaminated by the ash from Cerro Grande fire. Radioactive Dust has blown away from Area G and has been recorded near Sacred Area. The Pueblo de San Ildefonso and other pueblo people believe that locating a GTCC facility in this area will further diminish the spiritual integrity of the Sacred Area.

Radioactivity studies using the TIMS (Thermo Ionization Mass Spectrometry) method have been fingerprinted and thus identified the source (1996) of radioactivity found in the sediments of Cochiti Reservoir as coming from LANL. This is a major concern for the Cochiti people. Storm and snow run off bring LANL radioactivity downstream to places where clay is deposited. There has even been a 100-year runoff event since the Cerro Grande fire. Automated recorders have documented radioactivity being recently brought down as far as the Pueblo de San Ildefonso. Jemez Pueblo potters also express concerns they these radioactive movement will impact them when they dig through these deposits while collecting clay for pottery and minerals for other uses.

### 8.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

## 8.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area in Section 8.1.

### 8.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of each of the disposal facilities (borehole, trench, and vault) at LANL. Noise impacts are discussed in Section 5.3.1.

#### 8.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., $SO_2$, $NO_x$, CO, $PM_{10}$, and $PM_{2.5}$), VOCs, and the primary greenhouse gas $CO_2$ would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and $CO_2$ from construction activities are estimated for the peak year when site preparation and the construction of support facility and some disposal cells would take place. The estimates for $PM_{10}$ and $PM_{2.5}$ include the diesel particulate emissions from engine exhaust. These estimates are provided in Table 8.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). Peak-year emissions for all criteria pollutants (except $PM_{10}$ and $PM_{2.5}$) and VOCs would be the highest for the vault method because it would consume more materials and resources for construction than would the other two methods. Construction for the borehole method would disturb a larger area, so it is estimated that fugitive dust emissions would be the highest. Peak-year emissions of all pollutants would be the lowest for the trench method, which would also involve the smallest disturbed area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of $SO_2$ for the vault method would be the highest, about 0.75% of the two-county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would each be 0.43% or less of the two-county emissions total.

**TABLE 8.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at LANL**

| Pollutant | Total Emissions (tons/yr)[a] | Construction Emissions (tons/yr) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Trench (%) | | Borehole (%) | | Vault (%) | |
| $SO_2$ | 429 | 0.90 | (0.21)[b] | 3.0 | (0.70) | 3.2 | (0.75) |
| $NO_x$ | 7,210 | 8.1 | (0.11) | 26 | (0.36) | 31 | (0.43) |
| CO | 65,596 | 3.3 | (0.01) | 11 | (0.02) | 11 | (0.03) |
| VOCs | 8,423 | 0.90 | (0.01) | 2.7 | (0.03) | 3.6 | (0.05) |
| $PM_{10}$[c] | 55,674 | 5.0 | (0.01) | 13 | (0.02) | 8.6 | (0.02) |
| $PM_{2.5}$[c] | 6,303 | 1.5 | (0.02) | 4.1 | (0.07) | 3.6 | (0.06) |
| $CO_2$ | | 670 | | 2,200 | | 2,300 | |
| County[d] | $5.28 \times 10^6$ | | (0.01) | | (0.04) | | (0.04) |
| New Mexico[e] | $6.50 \times 10^7$ | | (0.001) | | (0.003) | | (0.004) |
| U.S.[e] | $6.54 \times 10^9$ | | (0.00001) | | (0.00003) | | (0.00004) |
| World[e] | $3.10 \times 10^{10}$ | | (0.000002) | | (0.000007) | | (0.000007) |

a Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties).

b Numbers in parentheses are percent of total emissions.

c Estimates for GTCC construction include diesel particulate emissions.

d Emission data for the year 2005. Currently, data on $CO_2$ emissions at the county level are not available, so county-level emissions were estimated from available state total $CO_2$ emissions on the basis of population distribution.

e Annual $CO_2$ emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

Background concentration levels for $PM_{10}$ and $PM_{2.5}$ at LANL are below the standards (less than 80%) (see Table 8.1.1-3). Construction at LANL could occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, it is expected that high concentrations of $PM_{10}$ or $PM_{2.5}$ could occur and could exceed the standards at the site boundary, although such exceedances would be rare. Construction activities would not contribute much to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Construction activities would be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. In so doing, where appropriate, fugitive dust would be controlled by following established standard dust control practices (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles), as stipulated in the construction permits.

Levels of $O_3$ in Santa Fe, about 29 km (18 mi) southwest of the GTCC reference location, are below the standard (about 84%) (see Table 8.1.1-3). Los Alamos and Santa Fe Counties are currently in attainment for $O_3$ (40 CFR 81.332). $O_3$ precursor emissions from the possible GTCC LLRW and GTCC-like waste disposal facility for all methods would be relatively small, less than 0.43% and 0.05% of two-county total $NO_x$ and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are transported and formed into $O_3$. Accordingly, potential impacts of $O_3$ precursor releases from construction on regional $O_3$ would not be of concern.

The major air quality concern with respect to emissions of $CO_2$ is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes $CO_2$ the most widely emitted greenhouse gas worldwide. $CO_2$ concentrations in the atmosphere increased continuously from about 280 ppm in preindustrial times to 379 ppm in 2005 (a 35% increase), and most of this increase occurred in the last 100 years (IPCC 2007).

The climatic impact of $CO_2$ does not depend on the geographic location of the sources because $CO_2$ is stable in the atmosphere and is essentially uniformly mixed; that is, it is the global total that is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether $CO_2$ emissions from the site are significant with respect to global warming. As shown in Table 8.2.1-1, the highest peak-year amounts of $CO_2$ emissions from construction would be 0.04%, 0.004%, and 0.00004% of 2005 county, state, and U.S. $CO_2$ emissions, respectively. In 2005, $CO_2$ emissions in the United States were about 21% of worldwide emissions (EIA 2008). Emissions from construction would be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would be extended over more years, and thus emissions for nonpeak years would be lower than peak-year emissions, as shown in the table. In addition, construction activities would likely occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the LANL site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

#### 8.2.1.2 Operations

Criteria pollutants, VOCs, and $CO_2$ would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Annual emissions of criteria pollutants, VOCs, and $CO_2$ at the facility are estimated in Table 8.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is provided in Appendix D. As shown in the table, for the borehole and vault methods, annual emissions from operations are estimated to be lower than those from construction. Annual

**TABLE 8.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at LANL**

| Pollutant | Total Emissions (tons/yr)[a] | Operation Emissions (tons/yr) Trench (%) | | Borehole (%) | | Vault (%) | |
|---|---|---|---|---|---|---|---|
| $SO_2$ | 429 | 3.3 | (0.7)[b] | 1.2 | (0.28) | 33 | (0.77) |
| $NO_x$ | 7,210 | 27 | (0.37) | 10 | (0.14) | 27 | (0.37) |
| CO | 65,596 | 15 | (0.02) | 6.7 | (0.01) | 15 | (0.02) |
| VOCs | 8,423 | 3.1 | (0.04) | 1.2 | (0.01) | 3.1 | (0.04) |
| $PM_{10}$[c] | 55, 674 | 2.5 | (<0.01) | 0.91 | (<0.01) | 2.5 | (<0.01) |
| $PM_{2.5}$[c] | 6,303 | 2.2 | (0.03) | 0.81 | (0.01) | 2.2 | (0.03) |
| $CO_2$ | | 3,200 | | 1,700 | | 3,300 | |
| County[d] | $5.28 \times 10^6$ | | (0.06) | | (0.03) | | (0.06) |
| New Mexico[e] | $6.50 \times 10^7$ | | (0.005) | | (0.003) | | (0.005) |
| U.S.[e] | $6.54 \times 10^9$ | | (0.00005) | | (0.00003) | | (0.00005) |
| World[e] | $3.10 \times 10^{10}$ | | (0.00001) | | (0.00001) | | (0.00001) |

[a] Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). See Table 8.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on $CO_2$ emissions at the county level are not available, so county-level emissions were estimated from available state total $CO_2$ emissions on the basis of population distribution.

[e] Annual $CO_2$ emissions in New Mexico, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

emissions for the trench and vault methods would be higher than those for the borehole. Compared with annual emissions for counties encompassing LANL, annual emissions of $SO_2$ for the trench and vault methods would be about 0.77% of the county total, respectively, while annual emissions of other criteria pollutants and VOCs would be about 0.37% or less.

It is expected that except for particulates, concentration levels from operations would remain well below the standards. Estimates for $PM_{10}$ and $PM_{2.5}$ include diesel particulate emissions. However, the impacts of emissions from fugitive dust during emplacement would be lower than the impacts during construction activities, although fugitive dust emissions could exceed the standards under unfavorable meteorological conditions because of the proximity of the GTCC reference location to the site boundary. As discussed in the construction section, established fugitive dust control measures (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles) could be implemented to minimize potential impacts on ambient air quality.

With regard to regional $O_3$, precursor emissions of $NO_x$ and VOCs would be comparable to those resulting from construction activities (about 0.37% and 0.04% of the two-county total, respectively), and it is not anticipated that they would contribute much to regional $O_3$ levels. The highest emissions of $CO_2$ among the disposal methods would be comparable to the highest construction-related emissions; thus, the potential impacts of $CO_2$ emissions on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

### 8.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) for facility and other associated infrastructure construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

#### 8.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at LANL (Table 5.1-1). Of the three disposal methods, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth, 40 m (130 ft), with boreholes completed in unconsolidated mesa top alluvium and tuff.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault facility would require the most material since it involves the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at LANL, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures (e.g., siting the facility away from the cliff edge of the mesa) also would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. LANL is in a seismically active region, and earthquakes with magnitudes of more than 5 have been recorded in recent history. The annual probability of a volcanic event at LANL has not been determined; however, it is believed that volcanism would be detected years in advance by regional uplift and doming (in the event of a large eruption) or weeks in advance by the existing LANL seismographic network (in the event of smaller eruptions). Airborne ash could be deposited on-site, depending on the location of the eruption and the prevailing wind direction. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

#### 8.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase while waste was being delivered to the site for disposal over time. The potential for soil erosion would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining and geothermal energy development.

### 8.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) to water resources from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 8.2.4.2.

#### 8.2.3.1 Construction

Of the three land disposal methods considered for LANL, construction of a vault facility would have the highest water requirement (Table 5.3.3-1). Water demands for construction at LANL would be met by using groundwater from on-site wells completed in the regional aquifer in three well fields: Otowi, Pajarito, and Guaje. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources would be expected. The potential for indirect surface water impacts (in nearby canyons) related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

LANL uses about 1.4 billion L/yr (359 million gal/yr) of groundwater, about 21% of its water right of 6.8 billion L/yr (1.8 billion gal/yr). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) over the 20-year period that construction would occur. This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction, and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) is small relative to the LANL site.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at LANL (see Sections 5.3.11 and 8.2.11). The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

#### 8.2.3.2 Operations

Of the three types of land disposal facilities considered for LANL, a vault or trench facility would have the highest water requirement during operations (Table 5.3.3-1). Water demands for operations at LANL would be met by using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase annual water use at LANL by a maximum of about 0.39% (vault or trench method). This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at LANL. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

### 8.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations associated with the land disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal method, and these are presented in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the LANL GTCC reference location, since these impacts would be site dependent.

#### 8.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC LLRW and GTCC-like waste disposal facility at LANL are provided in Table 8.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the dose to the collective population shown in Table 8.2.4-1. External exposure was found to be negligible in all cases. All exposures are dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 160 person-rem, would be from a hypothetical release from an SWB caused by a fire in the Waste Handling Building (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 83,100 people living to the southeast of the facility, resulting in an average dose of approximately 0.002 rem per person. Because this dose would result from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 8.2.4-1, the maximum estimated dose to an individual, 12 rem, is for Accident 9 from inhalation exposure immediately after the postulated

**TABLE 8.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at LANL**

| | | Off-Site Public | | Individual[b] | |
|---|---|---|---|---|---|
| Accident Number | Accident Scenario | Collective Dose (person-rem) | Latent Cancer Fatalities[c] | Dose (rem) | Likelihood of LCF[c] |
| 1 | Single drum drops, lid failure in Waste Handing Building | 0.0035 | <0.0001 | 0.00025 | <0.0001 |
| 2 | Single SWB drops, lid failure in Waste Handing Building | 0.008 | <0.0001 | 0.00058 | <0.0001 |
| 3 | Three drums drop, puncture, lid failure in Waste Handling Building | 0.0063 | <0.0001 | 0.00045 | <0.0001 |
| 4 | Two SWBs drop, puncture, lid failure in Waste Handling Building | 0.011 | <0.0001 | 0.00081 | <0.0001 |
| 5 | Single drum drops, lid failure outside | 3.5 | 0.002 | 0.25 | 0.0001 |
| 6 | Single SWB drops, lid failure outside | 8 | 0.005 | 0.58 | 0.0003 |
| 7 | Three drums drop, puncture, lid failure outside | 6.3 | 0.004 | 0.45 | 0.0003 |
| 8 | Two SWBs drop, puncture, lid failure outside | 11 | 0.007 | 0.81 | 0.0005 |
| 9 | Fire inside the Waste Handling Building, one SWB assumed to be affected | 160 | 0.1 | 12 | 0.007 |
| 10 | Single RH waste canister breach | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| 11 | Earthquake affects 18 pallets, each with 4 CH drums | 100 | 0.06 | 7.2 | 0.004 |
| 12 | Tornado, missile hits one SWB, contents released | 32 | 0.02 | 2.3 | 0.001 |

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the south-southeast of the accident location. As discussed above, the estimated dose of 12 rem would be accumulated over a 50-year period after intake; thus, it is not expected to result in symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be approximately 0.07% on the basis of a total dose of 12 rem.

#### 8.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site members of the public after the closure of the disposal facility would be small. The RESRAD-OFFSITE calculation results (see Table 5.3.4-3) indicate that there would be no measurable radiation exposure for this pathway if a borehole facility was used, but small radiation exposures would result from either a trench or vault facility. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone of the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, $CO_2$ gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault facility.

Within 10,000 years, C-14, Tc-99, and I-129 could reach the groundwater table and a well installed by a hypothetical farmer at a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. All three of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater concentrations and subsequently a measurable radiation does to the resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC inventory at LANL was calculated to be 160 mrem/yr for the borehole method, 430 mrem/yr for the vault method, and 380 mrem/yr for the trench method. Exposure pathways related to the use of contaminated groundwater include ingestion of water, soil, plants, meat, and milk; external radiation; and inhalation of radon gas and its short-lived progeny. Except for the water ingestion pathway, all the pathways that contribute significantly to the dose to this hypothetical resident farmer are associated with the accumulation of radionuclides in agricultural fields due to the use of contaminated groundwater for irrigation.

In Tables 8.2.4-2 and 8.2.4-3, the peak annual doses and LCF risks to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) are those associated with the disposal of the entire GTCC

**TABLE 8.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]**

| | GTCC LLRW | | | | GTCC-Like Waste | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Disposal Technology/ Waste Group | Activated Metals | Sealed Sources | Other Waste - CH | Other Waste - RH | Activated Metals | Sealed Sources | Other Waste - CH | Other Waste - RH | Peak Annual Dose from Entire Inventory |
| Borehole | | | | | | | | | 160[b] |
| Group 1 stored | 3.0 | - | 0.0 | 0.065 | 0.33 | 0.0 | 0.74 | 67 | |
| Group 1 projected | 46 | 0.0 | - | 0.0 | 0.81 | 0.0 | 0.21 | 0.18 | |
| Group 2 projected | 22 | 0.0 | 0.35 | 13 | - | - | 0.42 | 0.96 | |
| Vault | | | | | | | | | 430[b] |
| Group 1 stored | 60 | - | 0.0 | 0.22 | 0.45 | 0.0 | 1.8 | 230 | |
| Group 1 projected | 64 | 0.0 | - | 0.0 | 1.1 | 0.0 | 0.52 | 0.62 | |
| Group 2 projected | 30 | 0.0 | 0.87 | 40 | - | - | 1.0 | 3.1 | |
| Trench | | | | | | | | | 380[b] |
| Group 1 stored | 5.2 | - | 0.0 | 0.21 | 0.55 | 0.0 | 2.2 | 210 | |
| Group 1 projected | 78 | 0.0 | - | 0.0 | 1.4 | 0.0 | 0.63 | 0.58 | |
| Group 2 projected | 37 | 0.0 | 1.1 | 38 | - | - | 1.2 | 2.9 | |

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 160 mrem/yr for boreholes, 430 mrem/yr for vaults, and 380 mrem/yr for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. The primary contributors to the dose in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this dose would be C-14, Tc-99, and I-129.

**TABLE 8.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]**

| | GTCC LLRW | | | | GTCC-Like Waste | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Disposal Technology/ Waste Group | Activated Metals | Sealed Sources | Other Waste - CH | Other Waste - RH | Activated Metals | Sealed Sources | Other Waste - CH | Other Waste - RH | Peak Annual LCF Risk from Entire Inventory |
| Borehole | | | | | | | | | 9E-05[b] |
| Group 1 stored | 2E-06 | - | 0E+00 | 4E-08 | 2E-07 | 0E+00 | 4E-07 | 4E-05 | |
| Group 1 projected | 3E-05 | 0E+00 | - | 0E+00 | - | - | 1E-07 | 1E-07 | |
| Group 2 projected | 1E-05 | 0E+00 | 2E-07 | 8E-06 | 0E+00 | 0E+00 | 3E-07 | 6E-07 | |
| Vault | | | | | | | | | 3E-04[b] |
| Group 1 stored | 4E-05 | - | 0E+00 | 1E-07 | 3E-07 | 0E+00 | 1E-06 | 1E-04 | |
| Group 1 projected | 4E-05 | 0E+00 | - | 0E+00 | 7E-07 | 0E+00 | 3E-07 | 4E-07 | |
| Group 2 projected | 2E-05 | 0E+00 | 5E-07 | 2E-05 | - | - | 6E-07 | 2E-06 | |
| Trench | | | | | | | | | 2E-04[b] |
| Group 1 stored | 3E-06 | - | 0E+00 | 1E-07 | 3E-07 | 0E+00 | 1E-06 | 1E-04 | |
| Group 1 projected | 5E-05 | 0E+00 | - | 0E+00 | 8E-07 | 0E+00 | 4E-07 | 3E-07 | |
| Group 2 projected | 2E-05 | 0E+00 | 6E-07 | 2E-05 | - | - | 7E-07 | 2E-06 | |

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 9E-05 for boreholes, 3E-04 for vaults, and 2E-04 for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of peak LCF risks. The primary contributors to the LCF risk in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this risk would be C-14, Tc-99, and I-129.

LLRW and GTCC-like waste inventory by using the land disposal methods evaluated. In these tables, the annual doses and LCF risks contributed by each waste type (i.e., dose and risk for each waste type at the time or year when the peak dose or risk for the entire inventory is observed) to the peak dose and risk are also tabulated. The doses and LCF risks presented for the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own.

For borehole disposal, it is estimated that the peak annual dose and LCF risks would occur at about 500 years, and calculations indicate that the peak annual doses and LCF risks would occur at about 1,100 years after disposal for vaults and at about 1,000 years for trenches. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The GTCC LLRW activated metals and GTCC-like Other Waste - RH would be the primary contributors to the doses in all cases. The doses from C-14 and Tc-99 would be largely attributable to the GTCC LLRW activated metal wastes and the doses from I-129 and Tc-99 would be largely attributable to GTCC-like Other Waste - RH.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 8.24-2 (although for some cases, those sums might be close to those presented in the site-specific chapters).

Figure 8.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a time period extending to 10,000 years, and Figure 8.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale is logarithmic in Figure 8.2.4-1 and linear in Figure 8.2.4-2. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 2,000 years after closure of the disposal facility.

Although C-14, Tc-99, and I-129 would result in measureable radiation doses for the first 10,000 years, the inventory in the disposal areas would be depleted rather quickly, and the doses would gradually decrease with time after about 2,000 years. After the depletion of these three radionuclides, there would be no other radionuclides reaching the groundwater table within 100,000 years. The lack of groundwater contamination from other radionuclides at the LANL site between 10,000 and 100,000 years would be attributable to a low water infiltration rate of 0.5 cm/yr (0.2 in./yr) and the relatively long distance to the groundwater table (about 270 m [890 ft]).

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

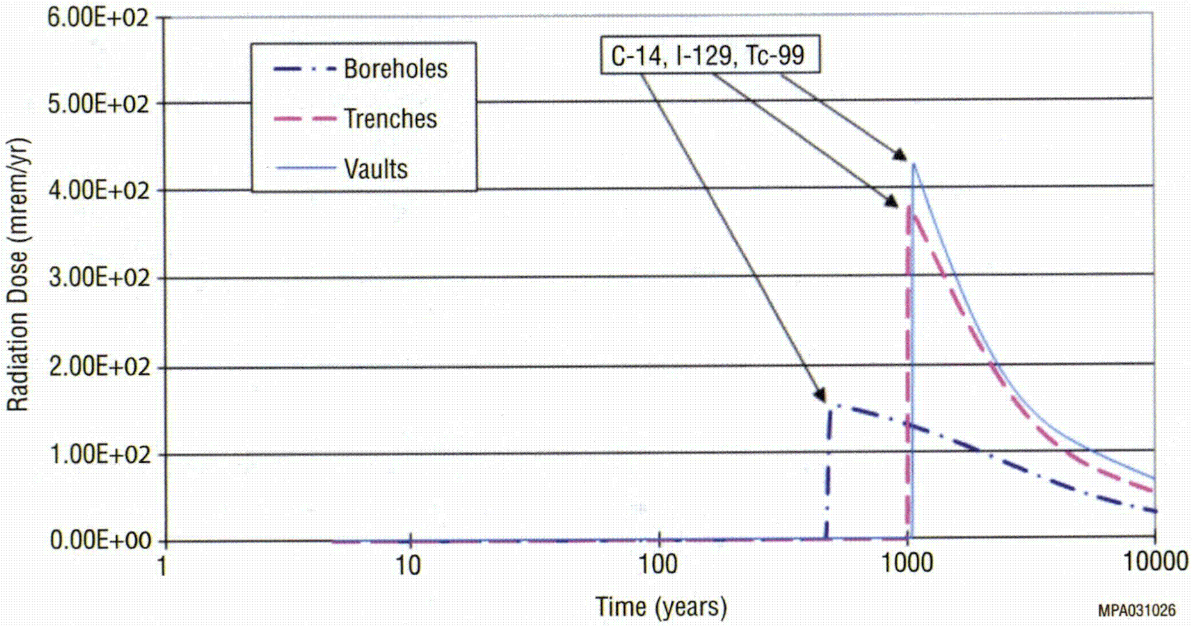


**FIGURE 8.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at LANL**

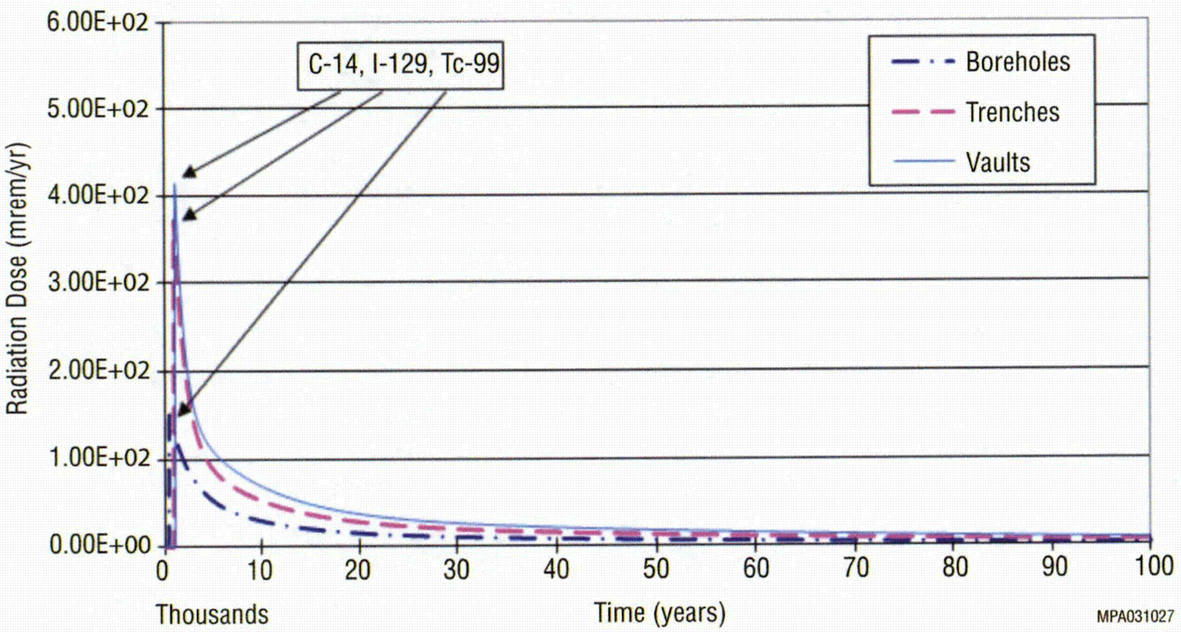


**FIGURE 8.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at LANL**

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in this EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because the engineered systems (including the disposal facility cover) are expected to last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, they would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure a good cover over the closed disposal units. Also, the doses (particularly for the GTCC-like Other Waste - RH) would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

### 8.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction and operations of the potential GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts of the GTCC LLRW and GTCC-like waste disposal facility on the ecological resources at LANL.

Habitat lost during construction would be mostly pinyon-juniper woodland. It is not expected that the initial loss of mostly pinyon-juniper woodland habitat, followed by eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal site, the cover would become vegetated with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site (EPA 1995). The vegetation that would be planted as the disposal facility was closed would include native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002). An aggressive revegetation program would be necessary so that nonnative species, such as cheatgrass and Russian thistle, would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because each year, they produce large amounts of seeds that remain viable for long periods of time (Blew et al. 2006).

Construction of the GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species that inhabit the TA-54 area (see Section 8.1.5). Small mammals, ground-nesting birds, and reptiles would recolonize the site once a vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would probably avoid the area. Species such as mule deer, coyote, and gray fox, which forage or hunt in early successional habitats, would be excluded from the GTCC LLRW and GTCC-like waste disposal facility because of the fencing (during the institutional control/monitored post-closure period). Nesting habitat would also be lost for raptors and other tree-nesting species.

Because no aquatic habitats or wetlands occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic or wetland biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. The GTCC LLRW and GTCC-like waste disposal facility retention pond would probably not become a highly productive aquatic habitat. However, depending on the amount of water and the length of time that the water was retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal and amphibian species that might enter the site.

Several federally and state-listed bird and mammal species occur within the area of the GTCC reference location. Localized impacts on these species might result from the construction and operations of the disposal facility. However, the area of pinyon-juniper woodland habitat that might be disturbed by construction would be small relative to the overall area of such habitat on the LANL site. Therefore, removal of pinyon-juniper woodland habitat would have a small impact on the populations of special-status species at LANL.

Among the goals of the waste management mission at DOE sites is to design, construct, operate, and maintain disposal facilities in a manner that protects the environment and complies with regulations. Therefore, impacts associated with the GTCC LLRW and GTCC-like waste disposal facility that could affect ecological resources (Section 5.3.3.6) would be minimized and mitigated.

## 8.2.6 Socioeconomics

### 8.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at LANL would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) and 145 people (vault method) in the peak construction year and an additional 64 indirect jobs (trench method) to 169 indirect jobs (vault method) in the ROI (Table 8.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.6 million in income (trench method) and $12.2 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 21 people (borehole method) and 64 people (vault method) would in-migrate to the ROI (Table 8.2.6-1) as a result of employment on the site. In-migration would have only a marginal effect on population growth and would require up to 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no more than one new public service employee would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

### 8.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be relatively small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually, and an additional 41 indirect jobs (borehole method) to 48 indirect jobs (vault method) in the ROI (Table 8.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $4.0 million in income (borehole method) and $5.0 million in income (vault method) annually during operations.

Two people would move to the ROI area at the beginning of operations (Table 8.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

**TABLE 8.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for LANL[a]**

| | Trench | | Borehole | | Vault | |
|---|---|---|---|---|---|---|
| Impact Category | Construction | Operation | Construction | Operation | Construction | Operation |
| Employment (number of jobs) | | | | | | |
| Direct | 62 | 48 | 47 | 38 | 145 | 51 |
| Indirect | 64 | 46 | 93 | 41 | 169 | 48 |
| Total | 126 | 94 | 140 | 79 | 314 | 99 |
| Income ($ in millions) | | | | | | |
| Direct | 2.3 | 3.2 | 2.0 | 2.6 | 6.2 | 3.4 |
| Indirect | 2.3 | 1.6 | 3.4 | 1.4 | 6.0 | 1.6 |
| Total | 4.6 | 4.8 | 5.4 | 4.0 | 12.2 | 5.0 |
| Population (number of new residents) | 27 | 2 | 21 | 2 | 64 | 2 |
| Housing (number of units required) | 14 | 1 | 10 | 1 | 32 | 1 |
| Public finances (% impact on expenditures) | | | | | | |
| Cities and counties[b] | <1 | <1 | <1 | <1 | <1 | <1 |
| Schools in ROI[c] | <1 | <1 | <1 | <1 | <1 | <1 |
| Public service employment (number of new employees) | | | | | | |
| Local government employees[d] | 1 | 0 | 0 | 0 | 1 | 0 |
| Teachers | 0 | 0 | 0 | 0 | 1 | 0 |
| Traffic (impact on current levels of service) | Small | Small | Small | Small | Moderate | Small |

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Los Alamos, Espanola, and Santa Fe and in Los Alamos, Rio Arriba, and Santa Fe Counties.

[c] Includes impacts that would occur in the Los Alamos, Chama, Dulce, Espanola, Jemez, Santa Fe, and Pojoaque school districts.

[d] Includes police officers, paid firefighters, and general government employees.

### 8.2.7 Environmental Justice

#### 8.2.7.1 Construction

No radiological risks and only a very low level of chemical exposure and risk are expected during construction of the trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, the impacts from the construction of each facility on the minority and low-income population would not be significant. The most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos.

#### 8.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations, and no adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. As was the case for the construction phase, the most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

#### 8.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.1 LCF for the population groups residing to the southeast of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the southeast of the site because of the prevailing wind condition in this case.

Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

### 8.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from a GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts from a GTCC LLRW and GTCC-like waste disposal facility on land use at LANL.

Siting the GTCC LLRW and GTCC-like waste disposal facility at LANL would alter portions of TA-54 that are currently reserve or experimental science areas to waste management areas. Addition of the GTCC LLRW and GTCC-like waste disposal facility within TA-54 would expand the amount of this technical area that is currently used for disposal of radioactive wastes. Land use areas surrounding LANL are considered sacred land and are sovereign lands of the Pueblo de San Ildefonso and the Santa Clara Pueblo. Future land use activities within LANL adjacent to the proposed GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize surrounding sacred and sovereign lands and would also be limited within LANL to those uses that would not jeopardize the integrity of the facility, create a security risk, or create a work or public safety risk.

### 8.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at LANL was evaluated. As discussed in Section 5.3.9, transportation of all cargo is considered for both truck and rail modes of transport as separate methods for the purposes of this EIS. Currently, there is no rail at LANL, and construction of a rail spur would have additional potential impacts. Upgrades on-site roads needed for truck transportation on the TA-54 area would also have additional impacts. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method chosen.

As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 8.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 8.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving the release of a radioactive or hazardous chemical material (Section 8.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to LANL are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

### 8.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 8.2.9-1 and 8.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments would result in about 36 million km (22 million mi) of travel and no LCFs among truck crew members or the public. One fatality directly related to accidents could result. For the rail option, it is estimated that no LCFs and potentially one physical fatality from accidents would occur, with about 5,010 railcar shipments resulting in about 14 million km (9 million mi) of travel. In addition, for the purpose of the analysis, no intermodal shipments were assumed.

### 8.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals in the vicinity of a shipment may be exposed to radiation. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation

**TABLE 8.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at LANL[a]**

| | | | Cargo-Related[b] Radiological Impacts | | | | | | | | Vehicle-Related Impacts[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dose Risk (person-rem) | | | | | | Latent Cancer Fatalities[d] | | |
| | | | | Routine Public | | | | | | | |
| Waste | No. of Shipments | Total Distance (km) | Routine Crew | Off-Link | On-Link | Stops | Total | Accident[e] | Crew | Public | Physical Accident Fatalities |
| **Group 1** | | | | | | | | | | | |
| **GTCC LLRW** | | | | | | | | | | | |
| Activated metals - RH | | | | | | | | | | | |
| Past BWRs | 20 | 63,900 | 0.66 | 0.025 | 0.1 | 0.12 | 0.24 | 0.00019 | 0.0004 | 0.0001 | 0.0015 |
| Past PWRs | 143 | 399,000 | 4.2 | 0.15 | 0.63 | 0.73 | 1.5 | 0.001 | 0.002 | 0.0009 | 0.0088 |
| Operating BWRs | 569 | 1,580,000 | 16 | 0.55 | 2.4 | 2.9 | 5.9 | 0.0031 | 0.01 | 0.004 | 0.036 |
| Operating PWRs | 1,720 | 4,350,000 | 45 | 1.5 | 6.7 | 8 | 16 | 0.0085 | 0.03 | 0.01 | 0.098 |
| Sealed sources - CH | 209 | 344,000 | 0.14 | 0.036 | 0.2 | 0.25 | 0.48 | 0.018 | <0.0001 | 0.0003 | 0.0087 |
| Cesium irradiators - CH | 240 | 396,000 | 0.17 | 0.041 | 0.23 | 0.28 | 0.56 | 0.0029 | <0.0001 | 0.0003 | 0.01 |
| Other Waste - CH | 5 | 5,750 | 0.0024 | 0.00052 | 0.0034 | 0.0041 | 0.008 | <0.0001 | <0.0001 | <0.0001 | 0.00014 |
| Other Waste - RH | 54 | 157,000 | 1.6 | 0.057 | 0.24 | 0.29 | 0.59 | <0.0001 | 0.001 | 0.0004 | 0.0036 |
| **GTCC-like waste** | | | | | | | | | | | |
| Activated metals - RH | 38 | 76,100 | 0.79 | 0.02 | 0.11 | 0.14 | 0.27 | <0.0001 | 0.0005 | 0.0002 | 0.0034 |
| Sealed sources - CH | 1 | 1,650 | 0.00069 | 0.00017 | 0.00096 | 0.0012 | 0.0023 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Other Waste - CH | 69 | 205,000 | 0.086 | 0.03 | 0.12 | 0.15 | 0.3 | 0.00099 | <0.0001 | 0.0002 | 0.0042 |
| Other Waste - RH | 1,160 | 3,330,000 | 34 | 1.2 | 5.1 | 6.1 | 12 | 0.0021 | 0.02 | 0.007 | 0.069 |

**TABLE 8.2.9-1 (Cont.)**

| Waste | No. of Shipments | Total Distance (km) | Cargo-Related[b] Radiological Impacts: Dose Risk (person-rem): Routine Crew | Routine Public: Off-Link | Routine Public: On-Link | Routine Public: Stops | Routine Public: Total | Accident[e] | Latent Cancer Fatalities[d]: Crew | Latent Cancer Fatalities[d]: Public | Vehicle-Related Impacts[c]: Physical Accident Fatalities |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Group 2** | | | | | | | | | | | |
| **GTCC LLRW** | | | | | | | | | | | |
| Activated metals - RH | | | | | | | | | | | |
| New BWRs | 202 | 432,000 | 4.5 | 0.12 | 0.65 | 0.79 | 1.6 | 0.00089 | 0.003 | 0.0009 | 0.01 |
| New PWRs | 833 | 2,040,000 | 21 | 0.7 | 3.2 | 3.8 | 7.6 | 0.0038 | 0.01 | 0.005 | 0.045 |
| Additional commercial waste | 1,990 | 6,050,000 | 63 | 2.3 | 9.3 | 11 | 23 | <0.0001 | 0.04 | 0.01 | 0.12 |
| Other Waste - CH | 139 | 423,000 | 0.18 | 0.063 | 0.26 | 0.3 | 0.62 | 0.003 | 0.0001 | 0.0004 | 0.0087 |
| Other Waste - RH | 3,790 | 11,400,000 | 120 | 4.3 | 18 | 21 | 43 | 0.00065 | 0.07 | 0.03 | 0.24 |
| **GTCC-like waste** | | | | | | | | | | | |
| Other Waste - CH | 44 | 118,000 | 0.05 | 0.016 | 0.071 | 0.085 | 0.17 | 0.00041 | <0.0001 | 0.0001 | 0.0025 |
| Other Waste - RH | 1,400 | 4,150,000 | 43 | 1.5 | 6.4 | 7.6 | 16 | 0.0021 | 0.03 | 0.009 | 0.086 |
| Total Groups 1 and 2 | 12,600 | 35,500,000 | 350 | 13 | 53 | 64 | 130 | 0.048 | 0.2 | 0.08 | 0.76 |

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of $6 \times 10^{-4}$ fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

**TABLE 8.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at LANL[a]**

| | | | Cargo-Related[b] Radiological Impacts | | | | | | | | Vehicle-Related Impacts[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dose Risk (person-rem) | | | | | | Latent Cancer Fatalities[d] | | |
| | | | | Routine Public | | | | | | | |
| Waste | No. of Shipments | Total Distance (km) | Routine Crew | Off-Link | On-Link | Stops | Total | Accident[e] | Crew | Public | Physical Accident Fatalities |
| **Group 1** | | | | | | | | | | | |
| **GTCC LLRW** | | | | | | | | | | | |
| Activated metals - RH | | | | | | | | | | | |
| Past BWRs | 7 | 20,400 | 0.17 | 0.054 | 0.0032 | 0.077 | 0.13 | 0.00035 | 0.0001 | <0.0001 | 0.0016 |
| Past PWRs | 37 | 101,000 | 0.84 | 0.28 | 0.017 | 0.39 | 0.69 | 0.0014 | 0.0005 | 0.0004 | 0.0054 |
| Operating BWRs | 154 | 422,000 | 3.5 | 1.1 | 0.062 | 1.7 | 2.9 | 0.0025 | 0.002 | 0.002 | 0.016 |
| Operating PWRs | 460 | 1,200,000 | 10 | 3.4 | 0.18 | 4.9 | 8.4 | 0.0091 | 0.006 | 0.005 | 0.052 |
| Sealed sources - CH | 105 | 190,000 | 0.53 | 0.16 | 0.0085 | 0.38 | 0.56 | 0.00095 | 0.0003 | 0.0003 | 0.0062 |
| Cesium irradiators - CH | 120 | 217,000 | 0.61 | 0.19 | 0.0097 | 0.44 | 0.64 | 0.00013 | 0.0004 | 0.0004 | 0.0071 |
| Other Waste - CH | 3 | 2,740 | 0.011 | 0.0025 | 0.00017 | 0.0083 | 0.011 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Other Waste - RH | 27 | 85,600 | 0.68 | 0.27 | 0.012 | 0.33 | 0.61 | <0.0001 | 0.0004 | 0.0004 | 0.0025 |
| **GTCC-like waste** | | | | | | | | | | | |
| Activated metals - RH | 11 | 23,400 | 0.21 | 0.051 | 0.0028 | 0.1 | 0.16 | <0.0001 | 0.0001 | <0.0001 | 0.0023 |
| Sealed sources - CH | 1 | 1,810 | 0.0051 | 0.0016 | <0.0001 | 0.0037 | 0.0053 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Other Waste - CH | 35 | 99,700 | 0.24 | 0.11 | 0.0066 | 0.18 | 0.29 | 0.00011 | 0.0001 | 0.0002 | 0.0036 |
| Other Waste - RH | 579 | 1,670,000 | 14 | 4.5 | 0.25 | 6.7 | 11 | 0.00024 | 0.008 | 0.007 | 0.061 |

**TABLE 8.2.9-2 (Cont.)**

| | | | Cargo-Related[b] Radiological Impacts | | | | | | | | Vehicle-Related Impacts[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Dose Risk (person-rem) | | | | | | Latent Cancer Fatalities[d] | | |
| | | | | Routine Public | | | | | | | |
| Waste | No. of Shipments | Total Distance (km) | Routine Crew | Off-Link | On-Link | Stops | Total | Accident[e] | Crew | Public | Physical Accident Fatalities |
| **Group 2** | | | | | | | | | | | |
| **GTCC LLRW** | | | | | | | | | | | |
| Activated metals - RH | | | | | | | | | | | |
| New BWRs | 54 | 119,000 | 1.1 | 0.3 | 0.018 | 0.52 | 0.84 | 0.0012 | 0.0006 | 0.0005 | 0.0051 |
| New PWRs | 227 | 587,000 | 5 | 1.7 | 0.082 | 2.4 | 4.2 | 0.0033 | 0.003 | 0.003 | 0.025 |
| Additional commercial waste | 498 | 1,450,000 | 12 | 3.8 | 0.23 | 6 | 10 | <0.0001 | 0.007 | 0.006 | 0.054 |
| Other Waste - CH | 70 | 203,000 | 0.49 | 0.23 | 0.014 | 0.36 | 0.6 | 0.00035 | 0.0003 | 0.0004 | 0.0076 |
| Other Waste - RH | 1,900 | 5,550,000 | 45 | 15 | 0.85 | 23 | 38 | <0.0001 | 0.03 | 0.02 | 0.2 |
| **GTCC-like waste** | | | | | | | | | | | |
| Other Waste - CH | 22 | 64,300 | 0.15 | 0.078 | 0.0039 | 0.11 | 0.19 | <0.0001 | <0.0001 | 0.0001 | 0.0023 |
| Other Waste - RH | 702 | 2,040,000 | 17 | 5.4 | 0.31 | 8.3 | 14 | 0.00022 | 0.01 | 0.008 | 0.076 |
| Total Groups 1 and 2 | 5,010 | 14,000,000 | 110 | 36 | 2.1 | 56 | 94 | 0.02 | 0.07 | 0.06 | 0.53 |

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of $6 \times 10^{-4}$ fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the LANL entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be $3 \times 10^{-7}$ or $6 \times 10^{-7}$ for truck or rail shipments, respectively.

#### 8.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

### 8.2.10 Cultural Resources

The GTCC reference location is situated in the easternmost portion of the LANL site in TA-54. Most of TA-54 has been surveyed for cultural resources. Eighteen cultural resources (sites) are reported to be in or near the project area, and some of the sites in the GTCC reference location are considered eligible for listing on the NHRP. Several sites need evaluation. In addition, several traditional cultural properties are located in the area. If the location is chosen for development, the NHPA Section 106 process would be followed for considering the impact of the project on significant cultural resources. The Section 106 process requires that the project location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance. All resources present would be evaluated for historical significance. Impacts on significant resources would be assessed and mitigated during the project. DOE would consult with the New Mexico SHPO and the Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo, and any other appropriate American Indian tribes. The tribes would be consulted to ensure that no traditional cultural properties were located in the project area.

It is expected that the majority of the impacts on cultural resources would occur during the construction phase. The intermediate-depth borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench.

Unlike the other two methods being considered, the vault method requires large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, the amount of land disturbed to obtain the soil for the cover could exceed the land requirements for the boreholes. Impacts on culturally significant resources could result from the project. The appropriate tribes would be consulted to ensure that no traditional cultural properties were affected by the project. Most impacts on significant cultural resources could be mitigated through data recovery, but avoidance is preferred.

Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operational and post-closure activities.

### 8.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is expected that no impacts on waste management programs at LANL would result from the waste that could be generated from the construction and operations of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at LANL for the waste types generated.

## 8.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 to 5 are summarized by resource area as follows:

***Air quality.*** It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and $CO_2$ would be small. The highest construction emissions would be from the vault method and would be about 0.75% of the two-county emissions total for $SO_2$. The highest operational emissions would be from the trench and vault methods and would be about 0.76% and 0.77%, respectively, of the two-county emissions total for $SO_2$. $O_3$ levels in the two counties encompassing LANL are currently in attainment; $O_3$ precursor emissions from construction and operational activities would be relatively small, less than 0.43% and 0.05% of $NO_x$ and VOC emissions, respectively, and much lower than those for the regional air shed. During construction and operations, maximum $CO_2$ emissions would be negligible.

Some construction and operational activities might occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, high concentrations of $PM_{10}$ or

$PM_{2.5}$ would likely occur and could at times exceed the standards at the site boundary. However, these activities would not contribute significantly to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Fugitive dust emissions during construction would be controlled by following established standard dust control practices.

***Noise.*** The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from sources would be below the EPA guideline of 55 dBA as the $L_{dn}$ for residential zones. There are no residences within this distance; the nearest residence is in White Rock, about 3.5 km (2.2 mi) away. Noise generated from operations would be less than noise during the construction phase. No ground-borne vibration impacts are anticipated, since low-vibration generating equipment would be used and since there are no residences or vibration-sensitive buildings in the area.

***Geology.*** No adverse impacts from the extraction or use of geologic and soil resources are expected, nor would there be significant changes in surface topography or natural drainages. Boreholes (at depths of 40 m or 130 ft) would be completed in unconsolidated mesa top alluvium and tuff. The potential for erosion would be reduced by the low precipitation rates (although catastrophic rainfall events do occur) and would be further reduced by best management practices.

***Water resources.*** Construction of a vault facility would have the highest water requirement. Water demands for construction at LANL would be met using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) and 0.39% (vault or trench method), respectively. Since these increases are well within LANL's water right and would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could occur as a result of aquifer discharges to seeps, springs, and rivers.

***Human health.*** The worker impacts during operations would mainly be those from the radiation doses associated with handling of the wastes. It is expected that the annual radiation dose would be 2.6 person-rem/yr for boreholes, 4.6 person-rem/yr for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (2 rem/yr) for site operations. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem. The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for boreholes) to 2 (for trenches and vaults) and that no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur during any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire impacting an SWB) would be 12 rem and would not result in any LCFs. The collective dose to the affected population from such an event is estimated to be 160 person-rem. The peak annual dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resides 100 m (330 ft) from the disposal site is estimated to be 430 mrem/yr for the vault method. This dose would result mainly from the GTCC LLRW activated metal waste and GTCC-like Other Waste - RH and is projected to occur about 1,100 years in the future. The peak annual doses for the borehole and trench methods would be lower: 160 mrem/yr and 380 mrem/yr, respectively. These doses would occur at 500 years for the borehole method and 1,000 years for the trench method. These times represent the length of time after failure of the engineered barrier (including the cover), which is assumed to begin 500 years after closure of the disposal facility.

***Ecology.*** The initial loss of mostly pinyon-juniper woodland habitat, followed by the eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Construction of the GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species inhabiting TA-54; however, small mammals, ground-nesting birds, and reptiles would recolonize the site once vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would likely avoid the area. Foragers and hunters (e.g., mule deer, coyotes, and gray foxes) would be excluded by fences (during the institutional control/monitored post-closure period) around the facility. There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established. Several federally and state-listed bird and mammal species occur within the project area. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall area of such habitat at LANL.

***Socioeconomics.*** Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for a maximum of 145 people in the peak construction year and 169 indirect jobs in the ROI (vault method); the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce a maximum of $12.2 million in income in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating a maximum of 51 direct jobs annually and an additional 48 indirect jobs in the ROI (vault method). The disposal facility would produce up to $5.0 million in income annually during operations.

***Environmental justice.*** Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

***Land use.*** Portions of TA-54 that are currently designated as reserve or experimental science areas would need to be reclassified as waste management areas. The addition of the facility within TA-54 would expand the area that is currently used for disposal of radioactive waste. Land use in areas surrounding LANL would not be affected.

***Transportation.*** Shipment of all waste to LANL by truck would result in approximately 12,600 shipments involving a total distance of 36 million km (22 million mi). For shipment of all waste by rail, 5,010 railcar shipments involving 14 million km (9 million mi) would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

***Cultural resources.*** There are 18 cultural resources within TA-54. Some of these resources are considered significant and would require consideration under the NHPA. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources since no new ground-disturbing activities would occur during these phases. Section 106 of the NHPA would be followed to determine the impact of the project on significant cultural resources. Local tribes would be consulted to ensure no traditional cultural properties were impacted by the project.

***Waste management.*** The wastes that could be generated from the construction and operations of the land disposal methods are not expected to affect the current waste management programs at LANL.

## 8.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at LANL, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 8.1).

### 8.4.1 Reasonably Foreseeable Future Actions at LANL

Reasonably foreseeable future actions at LANL are summarized in the following sections. These actions were included in the cumulative impacts discussion presented in the 2008 SWEIS (DOE 2008c) and consist of the actions described under "expanded operations alternative" in the SWEIS, other DOE or NNSA actions, and actions planned by other agencies for the region surrounding LANL. The cumulative impacts analysis presented in the 2008 SWEIS is used as the baseline for the discussion of potential cumulative impacts at LANL from the proposed action discussed in this EIS. The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at LANL.

#### 8.4.1.1 Radioisotope Power Systems Project

In the RPS Project, radioactive power systems are developed for space exploration and national security missions. DOE is currently supporting RPS production, testing, and delivery operations for a national security mission and for the NASA Mars Science Laboratory mission launched in 2011.

#### 8.4.1.2 Plutonium Facility Complex

The production of pits (detonation device for a nuclear bomb) would be achieved by consolidating a number of plutonium processing and support activities (such as analytical chemistry and materials characterization at the Chemistry and Metallurgy Research Replacement Facility [DOE 2008c]). The *Final Supplemental Environmental Impact Statement for the Nuclear Facility Portion of the Chemistry and Metallurgy Research Building Replacement Project at Los Alamos National Laboratory, Los Alamos, New Mexico* (CMRR-NF SEIS), DOE/EIS-0350-S1, was issued in August 2011, with a Modified ROD issued in October 2011 selecting the Modified CMRR-NF Alternative described in the Final SEIS: to proceed forward with the design and construction of the nuclear facility at LANL. However, in the FY 2013 budget request decision, DOE was made to defer the construction of the facility for at least five years. NNSA has determined, in consultation with the national laboratories, that the existing infrastructure in the nuclear complex has the inherent capacity to provide adequate support.

#### 8.4.1.3 Biosafety Level-3 Facility

Construction on the Biosafety Level-3 (BSL-3) Facility was substantially completed in the fall of 2003, but the facility has not yet been put into operation. The facility is a windowless, single-story, 3,200-ft$^2$ building, housing one BSL-2 laboratory and two BSL-3 laboratories. DOE is preparing an EIS to evaluate the environmental consequences of operating the BSL-3 Facility, which was built upon fill material, including the ability of the facility to withstand seismic loads (LANL 2010).

#### 8.4.1.4 NNSA Complex Transformation

Under the NNSA Complex Transformation, the U.S. nuclear weapons complex would be modified to one that is smaller, more efficient, more secure, and better able to respond to changes in national security requirements. This action would be covered by the national stockpile, stewardship, and management program (DOE 2008b). The current NNSA Complex consists of sites located in seven states (California, Missouri, Nevada, New Mexico, South Carolina, Tennessee, and Texas). Possible alternatives are to restructure special nuclear materials manufacturing and R&D facilities; consolidate special nuclear materials throughout the NNSA Complex; consolidate, relocate, or eliminate duplicate facilities and programs and improve operating efficiencies; and identify one or more sites for conducting NNSA flight test operations (DOE 2008b). In the December 19, 2008, ROD for the Complex Transformation Supplemental Programmatic EIS (73 FR 245, page 77644), the NNSA stated its decision to continue conducting manufacturing and R&D activities involving plutonium at LANL.

#### 8.4.1.5 BLM Electrical Power Transmission Project

Under the BLM Electrical Power Transmission Project, DOE would construct and operate a 31-km (19-mi) electric transmission power line reaching from the Norton Substation, west across the Rio Grande, to locations within LANL TA-3 and TA-5. The construction of one electric substation at LANL would be included in the project, as would the construction of two line segments less than 366-m (1,200-ft) long that would allow for uncrossing a crossed portion of two existing power lines. In addition, a fiber-optic communications line would be included and installed concurrently as part of the required overhead ground conductor for the power line. The new power line would improve the reliability of electric service in LANL and Los Alamos County areas, as would the uncrossing of the crossed segments of the existing lines. In addition, installation of the new power line would enable the LANL and Los Alamos County electric grid, which is a shared resource, to be adapted to accommodate future increased power imports when additional power service becomes available in northern New Mexico (DOE 2000, 2008a).

#### 8.4.1.6 New Mexico Products Pipeline Project

The New Mexico Products Pipeline Project would involve the construction and operation of two additional segments for an existing petroleum products pipeline between distribution terminals in Odessa, Texas, and Bloomfield, New Mexico. Neither of the new segments would be within 80 km (50 mi) of LANL (DOE 2008a).

#### 8.4.1.7 Mid-America Pipeline Western Expansion Project

The Mid-America Pipeline Western Expansion Project would add 12 separate loop sections to the existing liquefied natural gas pipeline to increase system capacity. A 37-km (23-mi) segment would be placed in Sandoval County, 48 km (30 mi) from the LANL boundary. This segment would be constructed parallel to and 7.6 m (25 ft) away from the existing pipeline ROWs (DOE 2008a).

#### 8.4.1.8 Santo Domingo Pueblo-Bureau of Land Management Land Exchange

The Santo Domingo Pueblo-BLM land exchange involves an equal-value exchange of approximately 2,985 ha (7,376 ac) of BLM lands for 261 ha (645 ac) of Santo Domingo Pueblo land in Santa Fe and Taos Counties (BLM 2002).

#### 8.4.1.9 Land Conveyance and Transfer Program

Under P.L. 105-119, DOE, through the Los Alamos Site Office Land Conveyance and Transfer Project, has transferred over 840 ha (2,100 ac) to the Bureau of Indian Affairs in trust for the Pueblo de San Ildefonso and approximately 130 ha (330 ac) to the County of Los Alamos and the Los Alamos Public Schools. In continuation with this program, the Los Alamos Site Office is scheduled to convey an additional 690 ha (1,700 ac) in the next 10 years (DOE 1999b). Several RODs (65 FR 14952, 67 FR 45495, 70 FR 48378, 77 FR 3257) have been issued in support of these actions. To date, 16 tracts have been conveyed to Los Alamos County, 3 tracts have been conveyed to the Los Alamos School Board, and 3 tracts have been conveyed to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso.

#### 8.4.1.10 Treatment of Saltcedar and Other Noxious Weeds

The treatment of saltcedar and other noxious weeds is an ongoing adaptive management program for the control of exotic weeds at LANL. An environmental assessment prepared for this project resulted in a finding of no significant impact (FONSI). The project area is approximately 64 km (40 mi) from the LANL boundary (DOE 2008a).

#### 8.4.1.11 Buckman Water Diversion Project

The Buckman Water Diversion Project diverts water from the Rio Grande for use by the City of Santa Fe and Santa Fe County. The diversion project withdraws water from the Rio Grande approximately 5 km (3 mi) downstream from where SR 4 crosses the river. The pipelines for this project largely follow existing roads and utility corridors. Decreased water withdrawals from the Buckman Well Field benefit groundwater levels. Potential impacts on fish and aquatic habitats below the proposed project due to effects on water flow would be minimal (DOE 2008a).

#### 8.4.1.12 46-kV Transmission Loop System

Another project at LANL would upgrade the existing 46-kV transmission loop system that serves central Santa Fe County with a 115-kV system (DOE 2008a).

#### 8.4.1.13 Radioactive Liquid Waste Treatment Facility (RLWTF-UP)

The RLWTF-UP will replace the capabilities that are currently provided by the existing RLWTF, which is beyond its design life. The process systems are required to collect, store, treat, and dispose of up to 5.0 million L (1.3 million gal) per year of low-level waste and industrial waste and 0.029 million L (0.0077 million gal) per year of TRU liquid waste (acid and caustic) generated primarily by weapons manufacturing and R&D activities. The RLWTF-UP is currently being implemented in a phased approach due to budget and programmatic conditions. The overall project scope includes the following subprojects:

- *Zero Liquid Discharge Subproject*: This subproject involves evaporation tanks; transfer lines and pumping from existing and new (i.e., proposed) radioactive liquid waste facilities; and discharge capabilities for off-normal events. The subproject constitutes a "best management practice." This subproject is currently completing construction.

- *Low-Level Waste Subproject*: This subproject involves the construction of a less than Hazard Category 3 (HC-3) nuclear structure for treatment of this low-level waste. Specifically, the scope of this low-level waste treatment capability includes facility/infrastructure and low-level waste treatment process piping; secondary waste treatment (including storage, treatment, and packaging); treated effluent storage, reuse, and discharge; receipt and storage of chemicals; a laboratory for process sample analysis; secondary solid waste storage and handling; and electrical/control/data transmission and receipt of equipment associated with low-level waste influent storage, treatment processes, and effluent storage/discharge and shipment of solid waste. This subproject includes a Utility Building to support the low-level waste processes.

- *TRU Liquid Waste Subproject*: This subproject involves the construction of a new HC-3 nuclear structure for storage of the TRU liquid waste influent, treatment for the removal of TRU elements, and transfer to low-level waste treatment. Specifically, the scope of this TRU liquid waste treatment capability includes facility/infrastructure and TRU liquid waste treatment process piping; secondary waste treatment (including storage, treatment, and packaging); treated effluent transfer; receipt and storage of chemicals; secondary solid waste storage and handling; and electrical/control/data transmission and receipt of equipment associated with TRU liquid waste influent storage, treatment processes, and effluent transfer and shipment of solid waste.

#### 8.4.1.14 TRU Waste Facility

Existing capabilities to manage solid radioactive waste must be re-established outside Area G to allow closure of Area G and maintain compliance with the Consent Order. The proposed facility will handle only Defense Program newly generated solid TRU wastes. Newly generated solid TRU wastes are defined as those generated after 1999. The TRU Waste Facility Project will be located in the TA-63 site south of Puye Road and west of Pajarito Road. The project will be designed, permitted, constructed, and commissioned as an HC-2 nuclear facility, with a RCRA permit to store hazardous wastes. The facility will consist of multiple buildings for the storage of TRU waste to meet nuclear facility requirements for staging of newly generated solid TRU wastes in support of LANL programs and missions. A RCRA-permitted pad with power hook-up will be designed and constructed for the characterization and testing trailers required to certify whether containers meet the WIPP WAC. Other functions provided at the TRU Waste Facility will include intra-site shipping and receiving, operational support, and the provision of necessary utilities and services. The project is currently in the planning and design stage.

### 8.4.2 Cumulative Impacts from the GTCC Proposed Action at LANL

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at LANL are described in Section 8.2 and summarized in Section 8.3. These sections indicate that the potential impacts from the proposed action (construction and operations of a borehole, trench, or vault facility) for all the resource areas and the transportation of waste would be small. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 8.4.1) reported in the 2008 SWEIS (DOE 2008c), it is unlikely that the additional potential impacts from the GTCC proposed action would contribute substantially to cumulative impacts for the resource areas evaluated for LANL.

To provide perspective, the potential impacts from this EIS were compared to values provided in the *Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico* (DOE 2008c). For example, the maximum acreage of land affected by the disposal of GTCC LLRW and GTCC-like waste would be about 44 ha (110 ac). This is a small percentage of the total amount of land (10,360 ha or 40 $mi^2$ or 25,600 ac) that makes up the 48 contiguous TAs at LANL. The GTCC EIS socioeconomics evaluation indicates that about 51 additional (direct) jobs would be created by the operation of any of the facilities considered. This number is small relative to the 13,500 people who currently work at LANL and the 1,890 new direct jobs projected to be created for the expanded operations alternative at LANL by 2011. With regard to potential worker doses, the GTCC EIS estimate of about 5.2 person-rem/yr is low when compared to the 540 person-rem/yr estimated as the total for LANL from various other activities under the expanded operations alternative.

However, the estimated human health impacts from the GTCC proposed action could add an annual dose of up to 430 mrem/yr or result in an annual LCF risk of 3E-04 (based on the vault disposal method) 1,100 years after closure of the GTCC LLRW and GTCC-like waste disposal facility at LANL. The performance assessment and composite analysis for LANL TA-54 indicate that the peak mean dose incurred by members of the closest residential communities would be 4 mrem/yr over the compliance period of 1,000 years (LANL 2008). Final considerations regarding any cumulative impacts on human health should incorporate the actual design of the GTCC LLRW and GTCC-like waste disposal facility at LANL and use similar assumptions and a similar compliance period. Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at LANL would provide more detailed analyses of site-specific issues, including cumulative impacts.

## 8.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR LANL

A Compliance Order on Consent, involving DOE and LANL as respondents, was issued on March 1, 2005 (revised October 29, 2012) by the NMED. As a result, LANL agreed to a schedule for completion of cleanup at various locations on the LANL site. The purposes of the Consent Order are to (1) fully determine the nature and extent of releases of contaminants at or from LANL; (2) identify and evaluate, where needed, alternatives for corrective measures, including interim measures, designed to clean up contaminants in the environment and prevent or mitigate the migration of contaminants at or from LANL; and (3) implement such corrective measures. However, the Consent Order contains no requirements for radionuclides or the radioactive portion of mixed waste.[4]

In January 2012, DOE and the State of New Mexico issued a nonbinding Framework Agreement as a blueprint on cleanup at LANL. It specifically calls for the cleanup of TRU waste currently stored in aboveground containers on the LANL grounds at Area G. The Framework Agreement sets a deadline for disposal of more than 3,700 $m^3$ (4,800 $yd^3$) of TRU waste from Area G by June 30, 2014. That disposal involves physically packing the radioactive TRU waste into approved transportation containers that are then shipped by truck to WIPP in Carlsbad, New Mexico, for permanent underground emplacement. The Framework Agreement also includes a DOE/LANL commitment to complete the removal of all newly generated TRU waste, received at Area G during FY 2012 and FY 2013, by December 31, 2014. The Framework Agreement continues to prioritize groundwater and surface water monitoring to ensure protection of human health and the environment. The Order of Consent and Framework Agreement will be taken into consideration as part of the decision-making process for disposal of GTCC LLRW and GTCC-like waste.

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