V. Environmental Radiological Program Information

A major component of the Laboratory's environmental surveillance program includes monitoring for potential exposures to the public from Laboratory-related radiation sources and assessing the risk associated with that exposure. Air effluents are routinely monitored at approximately 90 release points on Laboratory property. In addition, air sampling is conducted on Laboratory property, along the Laboratory perimeter, and in more distant areas that serve as regional background stations. Atmospheric concentrations of tritium, uranium, plutonium, americium, radioiodine, and gross alpha and beta are measured. During 1994, the largest airborne release of radioactive material was 50,200 Ci (1,860 Tbq) of short-lived (8-s to 20-min half-life) air activation products from the Los Alamos Meson Physics Facility (LAMPF). Water effluent from the liquid waste treatment plant is sampled to determine the release of radionuclides. Total releases increased in 1994. No radioactive contribution in foodstuffs posed a threat to the health or safety of the public. The maximum individual effective dose equivalent (EDE) to a member of the public from 1994 Laboratory operations is estimated to be 3.5 mrem/yr (0.035 mSv/yr). The average doses to individuals in Los Alamos and White Rock were 0.27 and 0.06 mrem (0.0027 and 0.0006 mSv), respectively. These doses are estimated to add lifetime risks of less than one chance in one million to an individual's risk of cancer mortality.

A. Introduction

Many of the activities that take place at the Los Alamos National Laboratory (LANL or the Laboratory) involve handling radioactive materials and operating radiation-producing equipment. A major aspect of the Laboratory's environmental surveillance program is monitoring the environment for ionizing radiation from Laboratory-related sources. Ionization is the process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. Only ionizing radiation is considered in this chapter.

Alpha and beta particles and x-rays and gamma rays are different types of ionizing radiation. These radiation types can penetrate matter and be absorbed in living tissues to varying degrees potentially causing cellular damage. Alpha radiation penetrates poorly; a piece of paper or the outer layer of dead skin can stop it. Beta radiation has low-to-moderate penetrating ability and can be stopped by the equivalent of a few sheets of paper. X-rays and gamma radiation have much greater penetrating ability but can be reduced greatly by dense material, such as lead or concrete.

Radiation is emitted both by naturally occurring and man-made materials. LANL background radiation is composed of the natural component and man-made radiation exclusive to Laboratory operations. Examples of natural background radiation sources include naturally occurring radon gas and naturally occurring uranium and thorium in regional rock and soil. An example of man-made background radiation is radioactive fallout from historical nuclear weapons testing programs around the world. Ionizing radiation is also produced by medical diagnostic and treatment procedures, and accounts for the largest radiation dose to the American public from man-made radiation. Consumer products such as tobacco products, smoke detectors, and television sets may also be sources of ionizing radiation. Other sources of exposure to ionizing radiation include radiological occupations, the processing and storing of nuclear fuels, and scientific research at facilities such as LANL.

B. Radiological Emissions

1. Measurement of External Penetrating Radiation.

a. Introduction. Natural external penetrating radiation originates from terrestrial and cosmic sources. The terrestrial component results primarily from naturally occurring ^{40}K and radionuclides in the decay chains of naturally occurring thorium and uranium. Terrestrial radiation varies diurnally, seasonally, and geographically.

External radiation levels can vary from 15% to 25% at a given location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation due to topographical and geological variations (ESG 1978).

Natural ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding. At sea level, cosmic sources yield between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 75 mrem/yr (unshielded) from cosmic sources. However, different locations in the region range in elevation from about 1.7 km (1.1 mi) at Española to 2.7 km (1.7 mi) at Fenton Hill, resulting in a corresponding range of 45 to 90 mrem/yr from cosmic sources. This component can vary ±10% because of solar modulations (NCRP 1987a).

Fluctuations in natural background ionizing radiation make it difficult to detect an increase in radiation levels from man-made sources, especially when the increase is small relative to the magnitude of natural fluctuations.

b. Monitoring Network and Results. Levels of external penetrating radiation (including x-rays and gamma rays and charged-particle contributions from cosmic, terrestrial, and man-made sources) are measured with thermoluminescent dosimeters (TLDs), pressurized ionization chambers, and high-purity germanium (HPGe) detectors. LANL's environmental monitoring of external penetrating radiation is made up of three networks. These networks are used to measure natural and man-made radiation exposures (1) on site (the Laboratory) and off site (perimeter and regional), (2) at the Laboratory boundary north of the LAMPF, and (3) at on-site low-level radioactive waste management areas. These three networks are known, respectively, as TLDNET, LAMPFNET, and WASTENET.

Results from the environmental monitoring networks are presented below. In summary, the TLD measurements indicate no detectable radiological impact to humans or the environment due to external penetrating radiation from LANL operations.

Laboratory and Regional Areas (TLDNET). This environmental network consists of 53 stations divided into three groups. The off-site regional group has 7 locations ranging 28 to 117 km (17 to 73 mi) from the Laboratory boundary. The regional stations are located at Fenton Hill and in the neighboring communities of Española, Pojoaque, and Santa Fe. The Pueblos of San Ildefonso, Jemez, and Taos are also part of this network. The off-site perimeter group consists of 24 stations within 4 km (2.5 mi) of the Laboratory boundary; the on-site group includes 23 locations on Laboratory grounds (Figure V-1). Table V-1 contains the TLD measurements obtained at off-site regional, off-site perimeter, and on-site monitoring stations. The current minimum detection limit of the TLD system is 3 mrem. TLD network sampling methodology is explained in Section VIII.B.1. Station #52 at Taos Pueblo was discontinued in the fourth quarter of 1993 and not used in 1994 because of the repeated loss of TLDs from the station. Changes in administrative procedures will allow for data to be collected from this location in 1995. Some of the other TLD stations are lacking one or more quarters of data. Vandalism, animal predation, processing error, new TLD mid-year placement, and removal requests by the public all can result in loss of data for a given quarter.

The range of values observed in each network of stations is consistent with the expected variability in natural background radiation and is consistent with the range of results observed in 1993. Of the stations having a complete set of data, the 1994 annual dose at off-site regional stations ranged from 110 to 153 mrem. Annual measurements at off-site perimeter stations ranged from 101 to 165 mrem.

Technical Area (TA) 53 Network (LAMPFNET). This network monitors external penetrating radiation from airborne gases, particles, and vapors resulting from LAMPF operations at TA-53. Air emissions from the LAMPF linear accelerator constitute the largest Laboratory source of off-site external penetrating radiation. The network consists of 24 TLD stations. Twelve monitoring TLD stations are directly across from TA-53 to measure LAMPF emissions. The stations are 800 km (0.5 mi) north and downwind from LAMPF. The other 12 TLDs are background sites and are located about 9 km (5.5 mi) from TA-53, near the southern boundary of the Laboratory (Figure V-1). Both monitoring and background TLD stations are placed at approximately the same elevations. The use of a t-test to statistically compare data determined no statistical difference between the TLD results observed at LAMPF and those observed at the background locations. In addition to the TLDs, there is a network of three HPGe detector systems installed on the north side of Los Alamos Canyon and located north of, north-northeast of, and northeast of LAMPF (Figure V-2). At each site, a photon energy spectrum is collected hourly and analyzed for various radionuclides and the resulting exposure rate. In addition to providing for rapid data analysis, these systems have a very low detection level and are quite sensitive to changes in ambient exposure levels. Along with

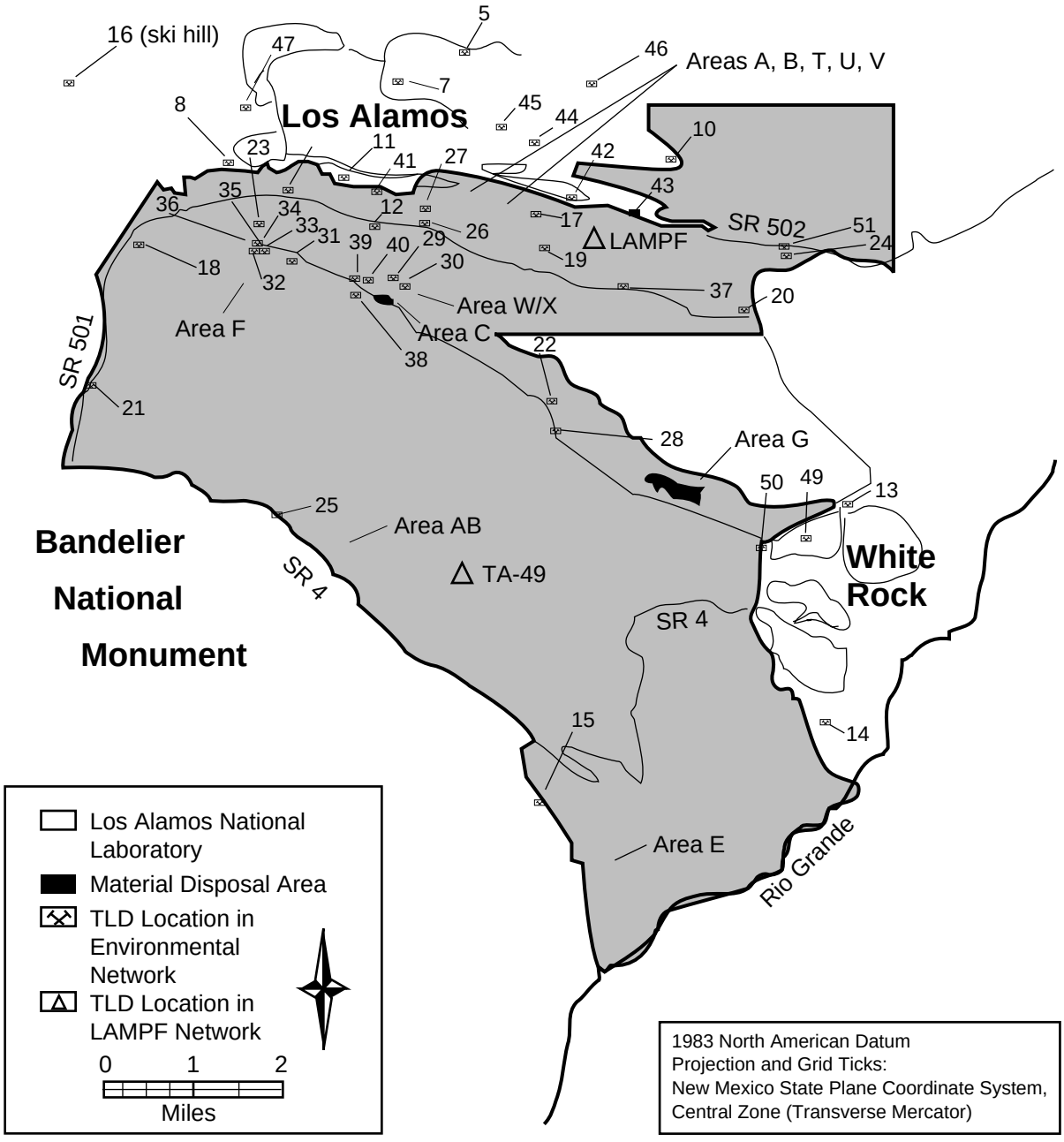

Figure V-1. Off-site perimeter and on-site Laboratory TLD Locations. (Does not show off-site regional stations.)

Table V-1. TLD Measurements for 1994

Station ID #	Location	1994 Annual Dose (mrem)[a]	1993 Annual Dose mrem)[a]
REGIONAL			
1.	Española	76[b] (± 13)	105 (± 12)
2.	Pojoaque	118 (± 13)	82[b] (± 10)
3.	Santa Fe	122 (± 12)	109 (± 12)
4.	Fenton Hill	152 (± 13)	157 (± 12)
52.	West Taos Pueblo	out of service	27[c] (± 6)
53.	San Ildefonso Pueblo	113 (± 13)	50[d] (± 10)
54.	Jemez Pueblo	110 (± 13)	66[d] (± 8)
PERIMETER			
5.	Barranca School, Los Alamos	118 (± 13)	112 (± 12)
7.	Cumbres School, Los Alamos	125 (± 10)	124 (± 9)
8.	48th Street, Los Alamos	132 (± 10)	126 (± 9)
9.	Los Alamos Airport	110 (± 10)	79[b] (± 7)
10.	Bayo Canyon, Los Alamos	145 (± 13)	148 (± 12)
11.	Shell Station, Los Alamos	140 (± 10)	174 (± 9)
12.	Royal Crest Trailer Court, Los Alamos	133 (± 13)	117 (± 12)
13.	White Rock	124 (± 10)	113 (± 11)
14.	Pajarito Acres, White Rock	122 (± 14)	126 (± 12)
15.	Bandelier Nat'l Monument Lookout Station	143 (± 11)	138 (± 9)
16.	Pajarito Ski Area	118 (± 13)	120 (± 12)
20.	Well PM-1 (SR4 and Truck Rt.)	148 (± 13)	154 (± 12)
41.	McDonald's Restaurant, Los Alamos	128 (± 10)	121 (± 9)
42.	Los Alamos Airport-South	123 (± 13)	116 (± 12)
43.	East Gate Business Park, Los Alamos	114 (± 13)	104 (± 12)
44.	Big Rock Loop, Los Alamos	165 (± 13)	147 (± 12)
45.	Cheyenne Street, Los Alamos	160 (± 13)	139 (± 12)
46.	Los Pueblos Street, Los Alamos	139 (± 13)	82[b] (± 11)
47.	Urban Park, Los Alamos	135 (± 13)	82[b] (± 10)
48.	Los Alamos County Landfill	122 (± 13)	116 (± 12)
49.	Piñon School, White Rock	124 (± 13)	103 (± 12)
50	White Rock Church of the Nazarene	101 (± 13)	81 (± 12)
51.	Bayo Canyon Well, Los Alamos	103 (± 12)	112 (± 13)
ON-SITE			
17.	TA-21 (DP West)	152 (± 10)	139 (± 9)
18.	TA-6 (Two Mile Mesa)	134 (± 10)	82 (± 11)
19.	TA-53 (LAMPF)	152 (± 10)	142 (± 12)
21.	TA-16 (S-Site)	99[b] (± 12)	129 (± 11)
22.	Booster P-2	144 (± 13)	117 (± 12)
23.	TA-3 East Gate of SM 43	132 (± 13)	109 (± 12)
24.	State Highway 4	98[b] (± 11)	147 (± 12)
25.	TA-49 (Frijoles Mesa)	119 (± 10)	113 (± 9)
26.	TA-2 (Omega Stack)	135 (± 13)	121 (± 11)
27.	TA-2 (Omega Canyon)	159 (± 13)	201 (± 12)
28.	TA-18 (Pajarito Site)	127 (± 13)	128 (± 12)
29.	TA-35 (Ten Site A)	114 (± 13)	91[b] (± 11)
30.	TA-35 (Ten Site B)	140 (± 13)	119 (± 12)
31.	TA-59 (Occupational Health Lab)	138 (± 13)	119 (± 9)
32.	TA-3-16 (Van de Graaff)	145 (± 13)	123 (± 12)

Table V-1. TLD Measurements for 1994 (Cont.)

Station ID #	Location	1994 Annual Dose (mrem)[a]		1993 Annual Dose mrem)[a]	
ON-SITE					
33.	TA-3-316 (Ion Beam Bldg.)	142	(± 13)	130	(± 12)
34.	TA-3-440 (CAS)	129	(± 13)	110	(± 12)
35.	TA-3-420 (CMR Bldg. West Fence)	115	(± 13)	109	(± 12)
36.	TA-3-102 (Shop)	119	(± 13)	116	(± 12)
37.	TA-72 (Pistol Range)	146	(± 13)	135	(± 12)
38.	TA-55 (Plutonium Facility South)	133	(± 13)	143	(± 12)
39.	TA-55 (Plutonium Facility West)	140	(± 14)	107	(± 10)
40.	TA-55 (Plutonium Facility North)	135	(± 13)	150	(± 12)

[a]The uncertainty of each measurement, shown in parentheses, is the propagated error of the quarterly measurements.
[b]Annual dose is the sum of three quarters.
[c]Only 4th quarter data available.
[d]Annual dose is the sum of two quarters.

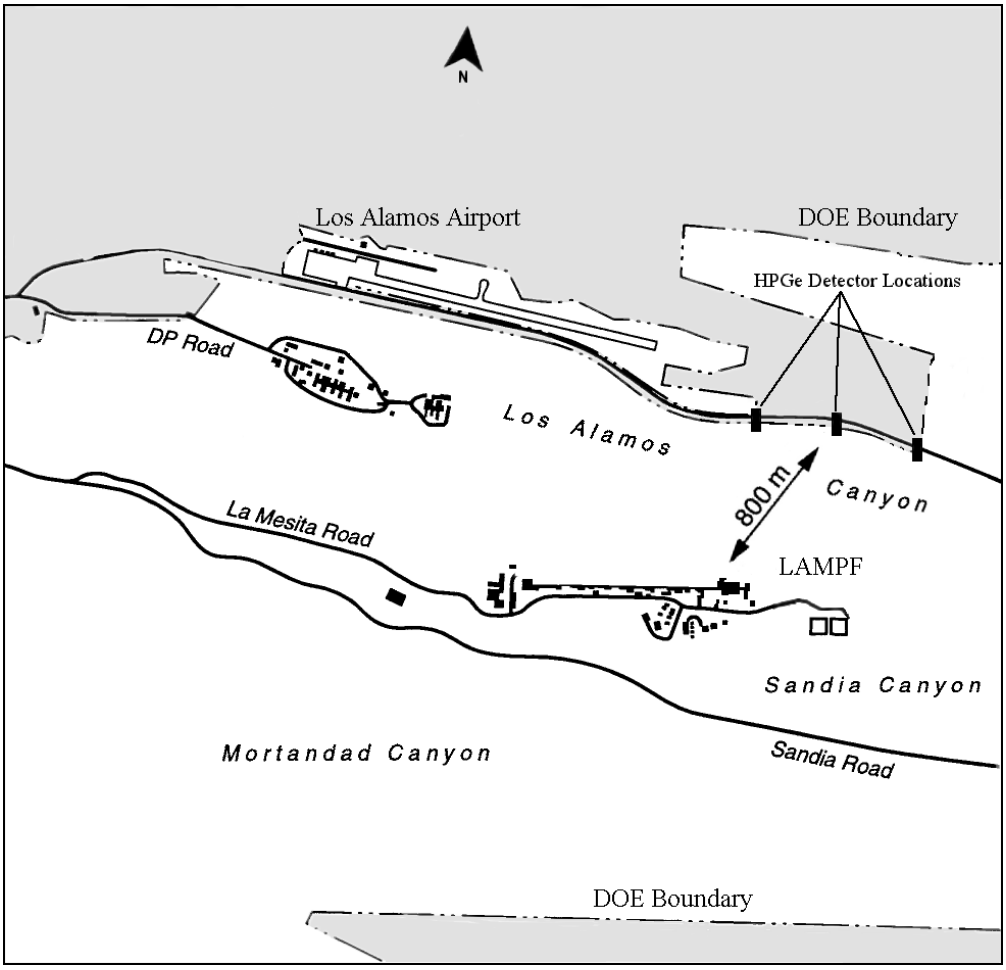

Figure V-2. High-Purity Germanium Detector Monitoring network at LAMPF, TA-53.

the HPGe systems, a high-pressure ion chamber is present as a backup system at the center north-northeast station. Figure V-3 presents an example of the hourly dose rate measured during a typical month of the 1994 LAMPF facility operating cycle. Figure V-4 presents summary data on the contribution of external penetrating radiation to the maximum individual dose and the maximum Laboratory boundary dose. The maximum Laboratory boundary dose assumes continued occupancy at the site, whereas the maximum individual dose incorporates adjustments for occupancy and shielding.

Low-Level Radioactive Waste Management Areas Network (WASTENET). Environmental TLDs are placed at 86 locations at LANL to monitor external penetrating radiation at 11 low-level radioactive waste management areas. Only one of these areas was active in 1994. The waste management areas are controlled-access areas and are not accessible to the general public. The average annual dose at each location is calculated from a set of TLDs located at each site. Annual doses at the waste management areas are presented in Table V-2. The annual average doses at all waste management areas during 1994 ranged from 105 to 160 mrem. Exposure data for Waste Area F at TA-6 are not available for 1994. Extensive and detailed geophysical sampling and characterization of the site disrupted the monitoring program for the year. Monitoring of Waste Area F will resume in 1995 upon completion of the site characterization study. The highest WASTENET annual average dose for 1994 was measured at TA-54, Area G, LANL's only active low-level radioactive waste area. The 25 TLDs of Area G are located within the waste site and along the perimeter fence. The highest dose was measured close to TRU waste storage areas. These areas were uncovered and the contents retrieved during 1994 in conjunction with a plan to build new domes for the temporary storage of TRU waste materials. The higher exposures measured near the mounds are attributed to contaminated dirt particles, which became airborne when the mounds were disturbed. Since the other TLDs placed around Area G received exposures similar to those observed at the regional stations, the exposure due to the active storage area is deemed to be highly localized within Area G.

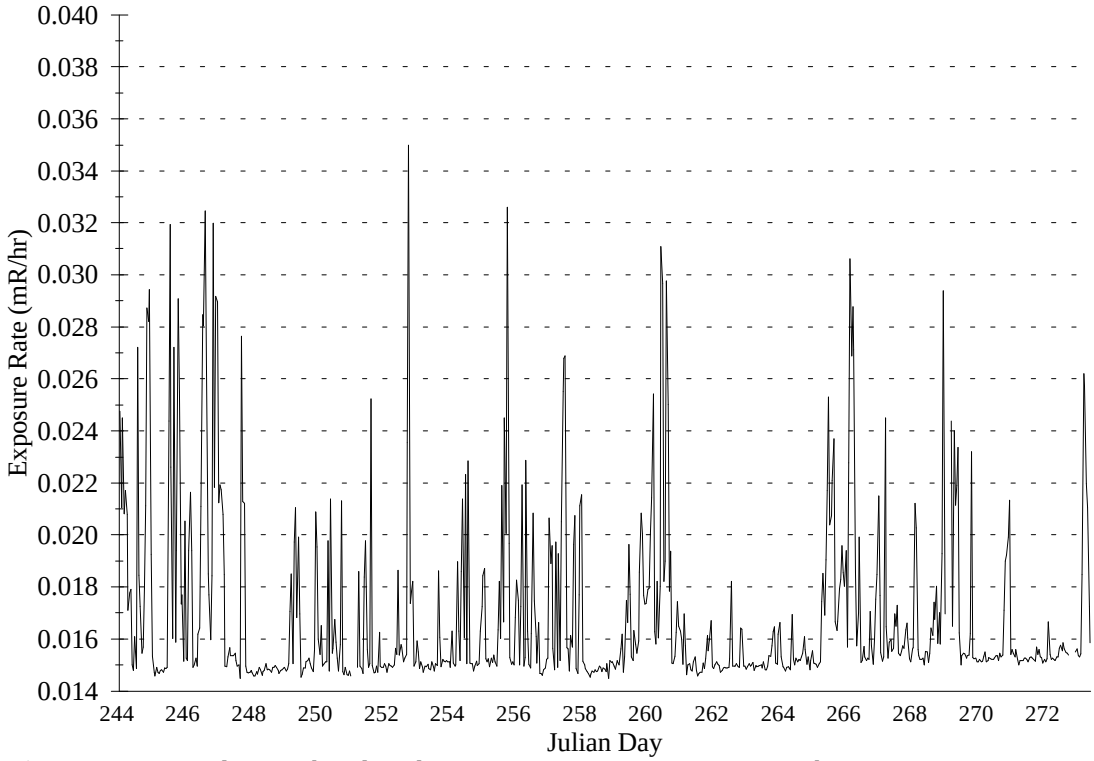

Figure V-3. Typical TA-53 hourly radiation exposure rate at East Gate with LAMPF in operation.

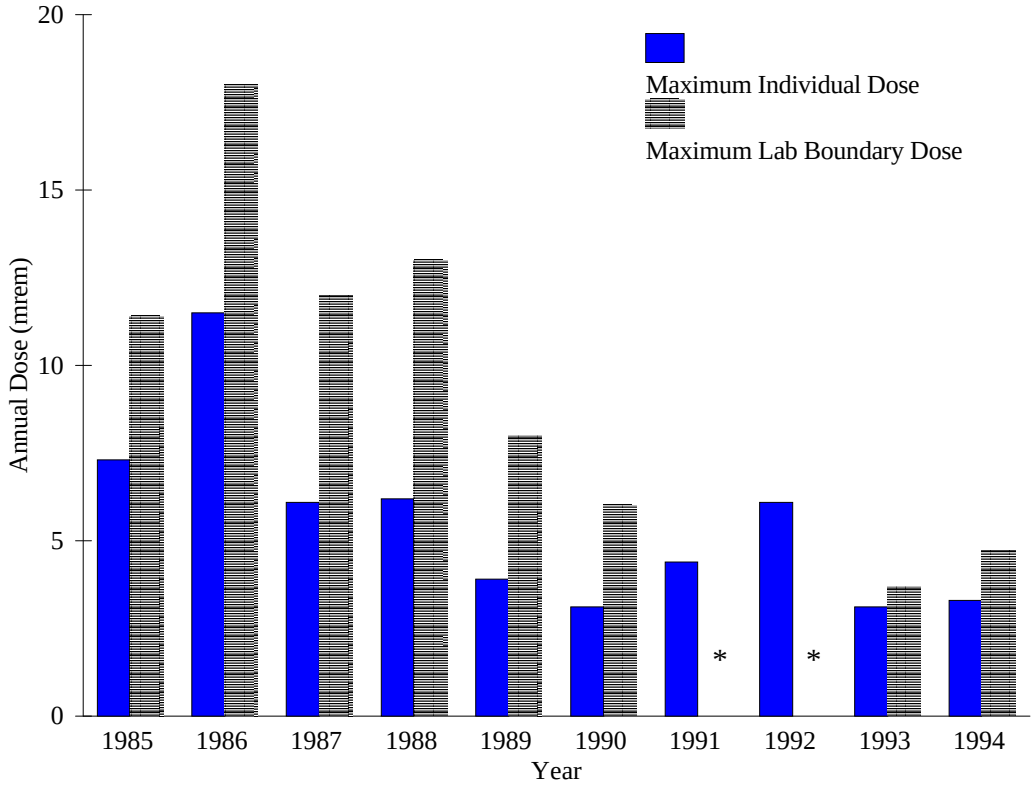

Figure V-4. Summary of estimated maximum individual and maximum Laboratory boundary doses from external penetrating radiation generated by Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources). Maximum individual dose calculated with DOE-approved modeling and measurement methods that take building shielding and occupancy into account.
*No above background Laboratory boundary doses as measured by TLDs were recorded during 1991 or 1992.

Table V-2. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1994

Waste Disposal Area	Number of TLD Locations	Annual Doses (mrem) Mean	Minimum	Maximum	Uncertainty[a]
TA-21, Area A	5	129	123	135	13
TA-21, Area B	14	135	120	145	13
TA-50, Area C	10	113	163	136	13
TA-33, Area E	4	139	149	146	13
TA-6, Area F	N/A[b]	N/A	N/A	N/A	—
TA-54, Area G	25	160	36	370	13
TA-21, Area T	7	159	123	275	14
TA-21, Area U	4	131	125	141	14
TA-21, Area V	4	105	89	131	12
TA-35, Area W	3	110	105	113	13
TA-49, Area AB	10	126	80	160	13

[a]Uncertainty is the propagated error of the quarterly measurements.
[b]Not monitored in 1994 because of geophysical study.

2. Airborne Radioactivity Monitoring.

a. Introduction. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made during the Laboratory's air sampling program. Worldwide background airborne radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests by several countries, natural radioactive constituents from the decay of thorium and uranium attached to dust particles, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Levels of background radioactivity in the atmosphere, which are useful in interpreting air sampling data, are summarized in Table V-3. Note that the measurements taken in Santa Fe by the Environmental Protection Agency (EPA) are similar to or lower than those taken by the Laboratory as regional background values and are significantly lower than DOE Derived Air Concentration (DAC) guides for uncontrolled areas.

The radiological air sampling network at the Laboratory is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include microcurie quantities of plutonium and americium, millicurie quantities of uranium, and curie (Ci) quantities of tritium and activation products.

Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on current meteorological conditions. Windy, dry days can increase the soil resuspension, whereas precipitation (rain or snow) can wash particulate matter out of the air. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing meteorological conditions. The measured airborne concentrations (Table V-3) are less than 1% of the DAC guide for uncontrolled areas. The DAC guide represents a concentration that would result in an annual dose of 100 mrem (1 mSv).

The quantities of airborne radioactivity released depend on the types of research activities and can vary markedly from year to year (Figures V-5 to V-7). During 1994, emissions reported from Laboratory stacks amounted to 51,300 Ci (1,900 TBq). These emissions include 50,200 Ci (1,860 TBq) of air activation products from LAMPF. A list of 1994 emissions is provided in Tables V-4 and V-5, and a comparison of emissions during 1993 and 1994 is provided in Table V-6.

Table V-3. Average Background Concentrations of Radioactivity in the Regional Atmosphere

Radioactive Constituent	Units	Santa Fe[a] 1988–1993	New Mexico[b] 1994	DOE DAC Guide for Uncontrolled Area[c]
Gross beta	10^{-15} µCi/mL[d]	12.0 (8.0)[e]	3.0 (4.2)	9,000
Tritium	10^{-12} µCi/mL	NA	1.3 (8.4)	100,000
Uranium (natural)	1 pg/m^3	54.6 (38.9)	74.2 (127)	100,000
^{234}U	10^{-18} µCi/mL	20.7 (5.3)	16.8 (20.6)	90,000
^{235}U	10^{-18} µCi/mL	0.8 (0.7)	1.4 (2.4)	100,000
^{238}U	10^{-18} µCi/mL	18.2 (13.0)	16.7 (20.6)	100,000
^{238}Pu	10^{-18} µCi/mL	0.2 (0.3)	2.4 (6.1)	30,000
^{239,240}Pu	10^{-18} µCi/mL	0.2 (0.3)	4.2 (6.6)	20,000
^{241}Am	10^{-18} µCi/mL	NA	4.9 (5.1)	20,000

[a]EPA (1989–1993), Reports 53 through 73. Data are from the EPA Santa Fe, New Mexico, sampling location and were taken from January 1988 through March 1993. Data for 1994 were not available at time of publication.

[b]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken by the Laboratory during CY94.

[c]See Appendix A. These values are presented for comparison.

[d]1 µCi/mL = 37 kBq/mL

[e]Uncertainties (2s) are in parentheses.

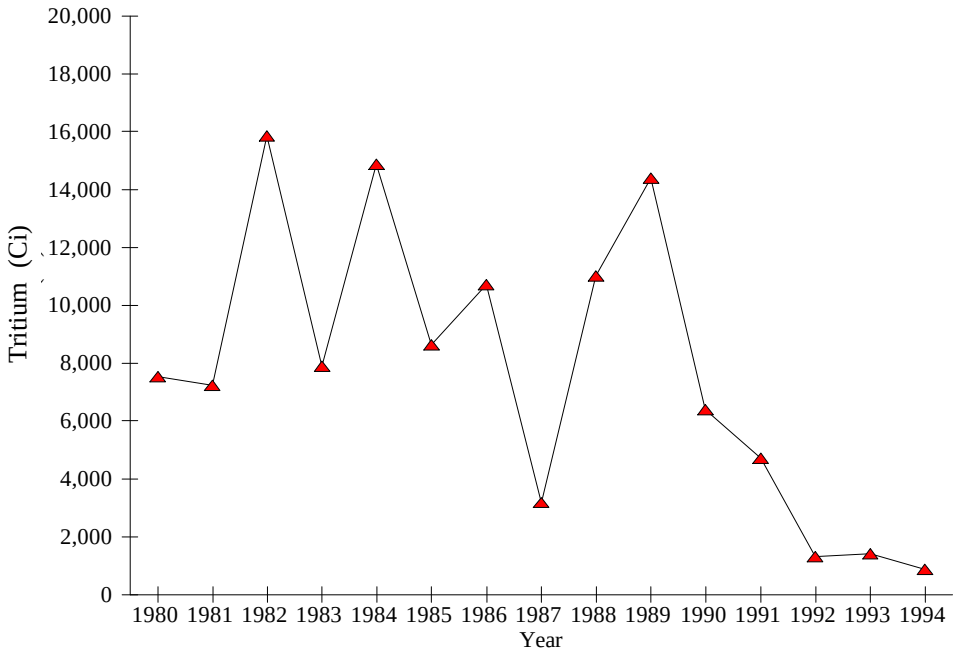

Figure V-5. Tritium in airborne stack effluents.

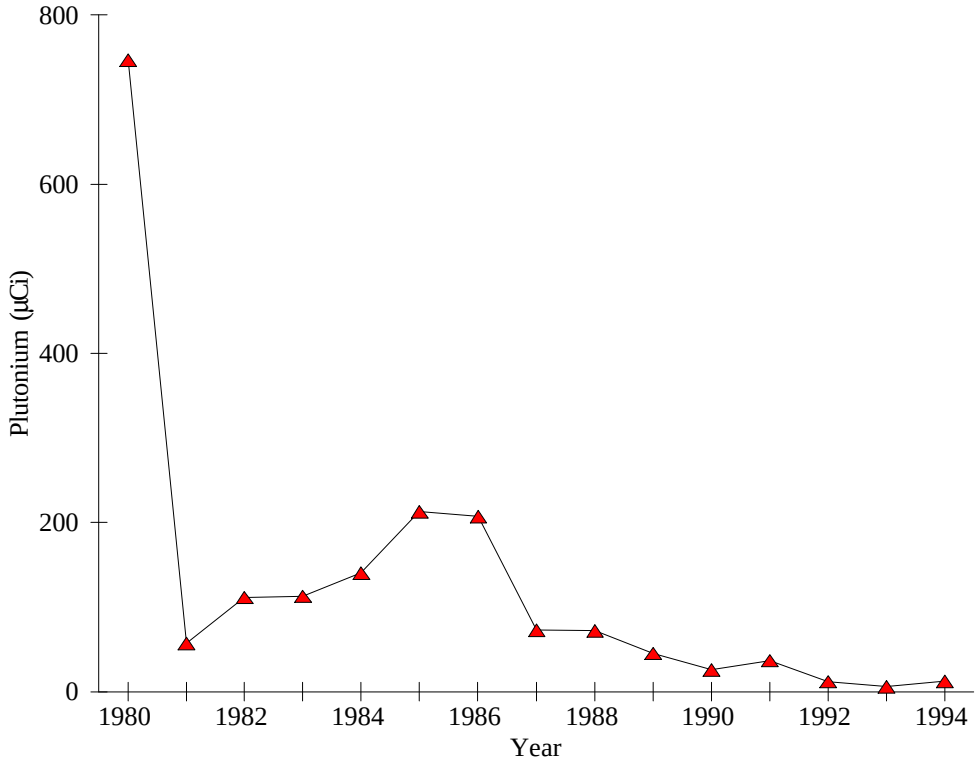

Figure V-6. Plutonium in airborne stack effluents.

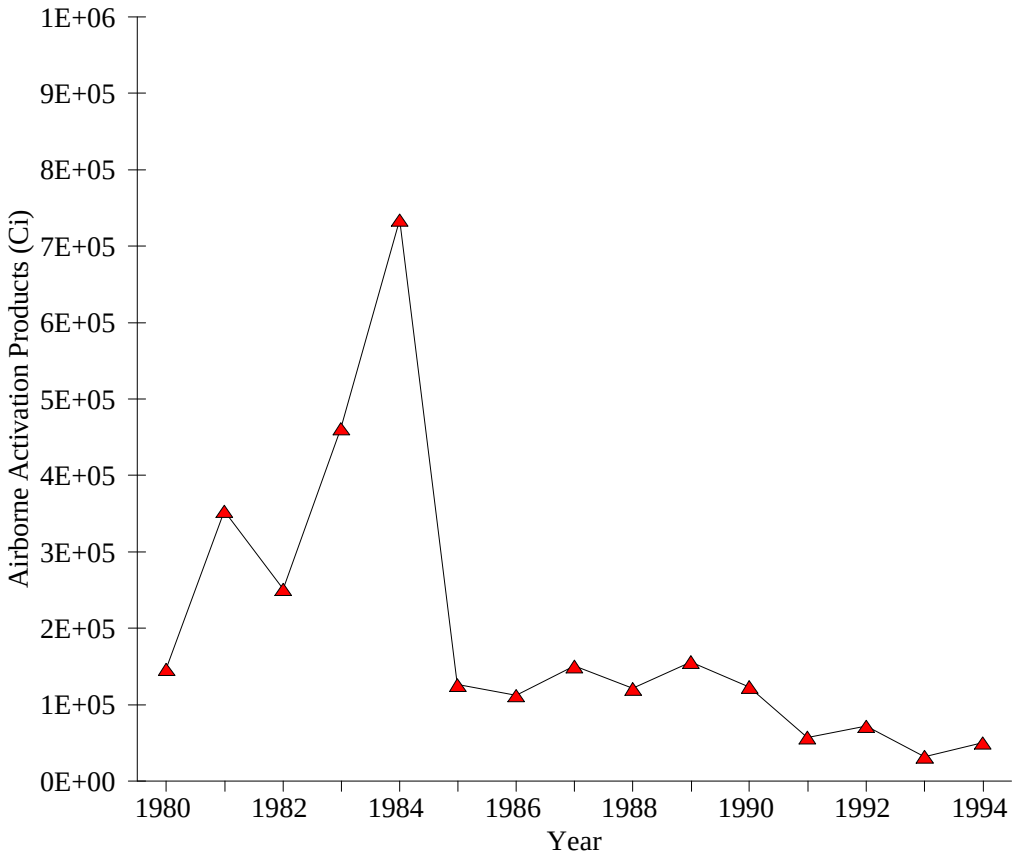

Figure V-7. Emissions of airborne gaseous mixed activation products (principally ^{10}C, ^{11}C, ^{13}N, ^{16}N, ^{14}O, ^{15}O, and ^{41} Ar) from LAMPF.

Table V-4. Airborne Radioactive Emissions from Laboratory Operations in 1994 (in Ci)

Radionuclide	TA-3	TA-15[a]	TA-16	TA-21	TA-33	TA-35
Tritium[b]	5.38×10^{1}		2.46×10^{1}	3.32×10^{2}	4.56×10^{2}	
^{10}C						
^{11}C						
^{13}N						
^{16}N						
^{14}O						
^{15}O						
UBE[c]						
^{41}Ar						
MFP[d]	3.84×10^{-5}			5.00×10^{-8}		
^{234}U		4.0×10^{-3}				
^{235}U	1.34×10^{-4}	1.7×10^{-4}		1.82×10^{-4}		
^{238}U	6.20×10^{-5}	3.7×10^{-3}				
Pu[e]	6.00×10^{-6}			2.40×10^{-6}		3.90×10^{-7}
P/VAP[f]						

Radionuclide	TA-41	TA-43	TA-48	TA-50	TA-53	TA-54	TA-55	Totals
Tritium[b]	1.72×10^{2}				1.46×10^{1}		2.26×10^{1}	1.08×10^{3}
^{10}C					2.12×10^{3}			2.12×10^{3}
^{11}C					1.41×10^{4}			1.41×10^{4}
^{13}N					6.93×10^{3}			6.93×10^{3}
^{16}N					1.80×10^{3}			1.80×10^{3}
^{14}O					7.29×10^{2}			7.29×10^{2}
^{15}O					2.43×10^{4}			2.43×10^{4}
UBE		9.61×10^{-6}						9.61×10^{-6}
^{41}Ar					2.84×10^{2}			2.84×10^{2}
MFP			3.90×10^{-4}	6.79×10^{-6}				4.35×10^{-3}
^{234}U								4.00×10^{-3}
^{235}U			4.00×10^{-7}					4.87×10^{-4}
^{238}U								3.76×10^{-3}
Pu	2.00×10^{-8}		3.22×10^{-6}	3.10×10^{-7}		1.00×10^{-8}	1.20×10^{-7}	1.25×10^{-5}
P/VAP			8.13×10^{-2}		3.14×10^{-1}			3.96×10^{-1}

[a]For dose calculation purposes, emissions from both TA-15 and TA-36 are conservatively considered to be released from TA-15.

[b]1994 tritium releases reported from TA-16, TA-21, and TA-53 were 51%, 52%, and 100% tritium oxide respectively. All remaining tritium releases were of indeterminate form.

[c]UBE = Unidentified beta emitters.

[d]MFP = mixed fission products.

[e]Plutonium includes ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am.

[f]P/VAP = particulate/vapor activation products. These include 13 radionuclides at TA-53 dominated by ^{82}Br, ^{7}Be, ^{54}Mn, and ^{77}Br; and 7 radionuclides at TA-48 dominated by ^{72}As, ^{75}Se, and ^{77}Br. Individual radionuclide totals for 1994 emissions are shown in Table V-5.

Table V-5. Detailed Listing of Activation Products from Laboratory Operations in 1994 (in Ci)

Mixed Activation Products	Radionuclide	Location	
		TA-53	TA-48
Particulate/Vapor (P/VAP)	^{72}As		1.11×10^{-2}
	^{73}As		1.90×10^{-2}
	^{74}As		3.75×10^{-3}
	^{68}Ge		1.70×10^{-3}
	^{7}Be	2.53×10^{-2}	7.67×10^{-6}
	^{77}Br	1.17×10^{-2}	2.37×10^{-2}
	^{75}Se	4.83×10^{-4}	2.21×10^{-2}
	^{82}Br	2.52×10^{-1}	
	^{60}Co	6.28×10^{-5}	
	^{195}Hg	9.69×10^{-4}	
	^{195}Hg	4.02×10^{-3}	
	^{54}Mn	1.83×10^{-2}	
	^{185}Os	2.39×10^{-4}	
	^{44}Sc	1.62×10^{-4}	
	^{48}Sc	6.03×10^{-5}	
	^{182}Ta	1.13×10^{-3}	
	^{48}V	1.94×10^{-4}	
Gaseous Mixed (GMAP)	^{41}Ar	2.84×10^{2}	
	^{10}C	2.12×10^{3}	
	^{11}C	1.41×10^{4}	
	^{83}Kr	1.50×10^{2}	
	^{13}N	6.93×10^{3}	
	^{16}N	1.80×10^{3}	
	^{14}O	7.29×10^{2}	
	^{15}O	2.43×10^{4}	

Another source of airborne radioactivity at the Laboratory is diffuse emissions, or emissions that do not come from a discrete location such as a stack or vent. In 1994, the following emissions were estimated from diffuse sources.

Tritium (as water vapor):	86 Ci
Plutonium:	0.55 µCi
Uranium:	4.3 mCi
Americium-241	0.12 µCi
Mixed fission products:	4.4 nCi
Gaseous mixed activation products:	1,000 Ci
Particulate/vapor activation products:	0.01 µCi

In 1994, 98% of LANL's emissions were gaseous mixed activation products that diffused from several buildings through the Laboratory, primarily from TA-53. Reductions in diffuse emissions from TA-53 were accomplished through the use of engineering controls, including sealing migration pathways throughout the facility. A list of selected nuclides and their half-lives is given in Table D-11.

Radioactive air emissions at the Laboratory are monitored according to DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991a) and 40 CFR (Code of Federal Regulations) Part 61, Subpart H, "National Emission Standards for Emissions of

Table V-6. Comparison of 1993 and 1994 Release of Radionuclides from Laboratory Operations

Airborne Emissions[a]

Radionuclide	Units	Activity Released 1993	Activity Released 1994	Ratio 1994:1993
Tritium	Ci	2,100	1,100	0.5
Uranium	μCi	270[b]	380[b]	1.4
Plutonium	μCi	6	13	2.2
Gaseous mixed activation products	Ci	32,100	50,200	1.6
Mixed fission products	μCi	1,360	450	0.3
Particulate/vapor activation products	Ci	13	0.4	0.03
Total	Ci	34,200	51,300	

Liquid Effluents

Radionuclide	Units	Activity Released 1993	Activity Released 1994	Ratio 1994:1993
Tritium	mCi	2,660.00	2,230.00	.84
$^{82,85,89,90}Sr$	mCi	7.64	37.00	4.84
^{137}Cs	mCi	8.17	8.5	1.04
^{234}U	mCi	0.12	.12	1
$^{238,239,240}Pu$	mCi	1.08	3.25	3.01
^{241}Am	mCi	11.20	3.06	.273
Total	mCi	2,688.21	2,281.93	

[a]Detailed data are presented in Tables V-4 and V-5 for airborne emissions.
[b]Does not include dynamic testing.

Radionuclides Other than Radon from DOE Facilities" (EPA 1989b). Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses are less than the 10 mrem/yr standard given in 40 CFR 61.92.

On July 17, 1990, LANL notified the DOE that the Laboratory met the 10 mrem/yr standard but did not meet the monitoring requirements (40 CFR 61.93) with its existing sampling program. On November 27, 1991, EPA Region 6 issued the DOE a notice of noncompliance (NON) with 40 CFR 61, Subpart H, specifically stating the following:

1. Every release source from an operation that uses radionuclides has not been evaluated using the approved EPA computer model to determine the dose received by the public, as required by 40 CFR 61.93(a).
2. DOE has failed to comply with 40 CFR 61.93(b)(4) because it has not determined each release point that has the potential to deliver more than 1% of the EDE standard.
3. The facility has not installed stack monitoring equipment on all its regulated point sources in accordance with the above analysis and 40 CFR 61.93 (b)(2)(ii) and (iii).
4. The facility has not conducted, and is not in compliance with, the appropriate quality assurance programs pursuant to 40 CFR 61.93 (b)(2)(iv).
5. The facility is in violation of 40 CFR 61.94 "Compliance and Reporting" because it has not calculated the highest EDE in accordance with the regulations cited above.

As a result of the NON, the DOE is negotiating a Federal Facility Compliance Agreement (FFCA) with EPA Region 6. The FFCA will include schedules that the Laboratory will follow to come into compliance with the Clean Air Act. A revised action plan was submitted by DOE Los Alamos Area Office (LAAO) to EPA in March 1993. Until the FFCA is completed, the Laboratory will continue to address the issues raised in the 1991 NON. The FFCA is expected to be signed before the end of 1995.

b. Monitoring Network. The sampling network for ambient airborne radioactivity consists of 52 continuously operating air sampling stations with 3 stations added and 2 stations discontinued in 1994. Three regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory are located in Española, Pojoaque, and Santa Fe. The data from these stations are used as reference points for determining regional background and fallout levels of atmospheric radioactivity. There are currently 13 perimeter stations located within 4 km (2.5 mi) of the Laboratory boundary.

Thirty-three on-site stations are within the Laboratory boundary (Figure V-8, Table D-12). Two samplers are collocated or replicate samplers, one at Station #27 at TA-54 and one at Station #26 at TA-49, for quality assurance purposes. In addition to the various networks or groups mentioned, stations can also be classified as being inside or outside a controlled area. A controlled area is where radioactive materials or elevated radiation fields may be present and are clearly posted as such (DOE 1988). The active waste site, TA-54, Area G, is an example of a controlled area.

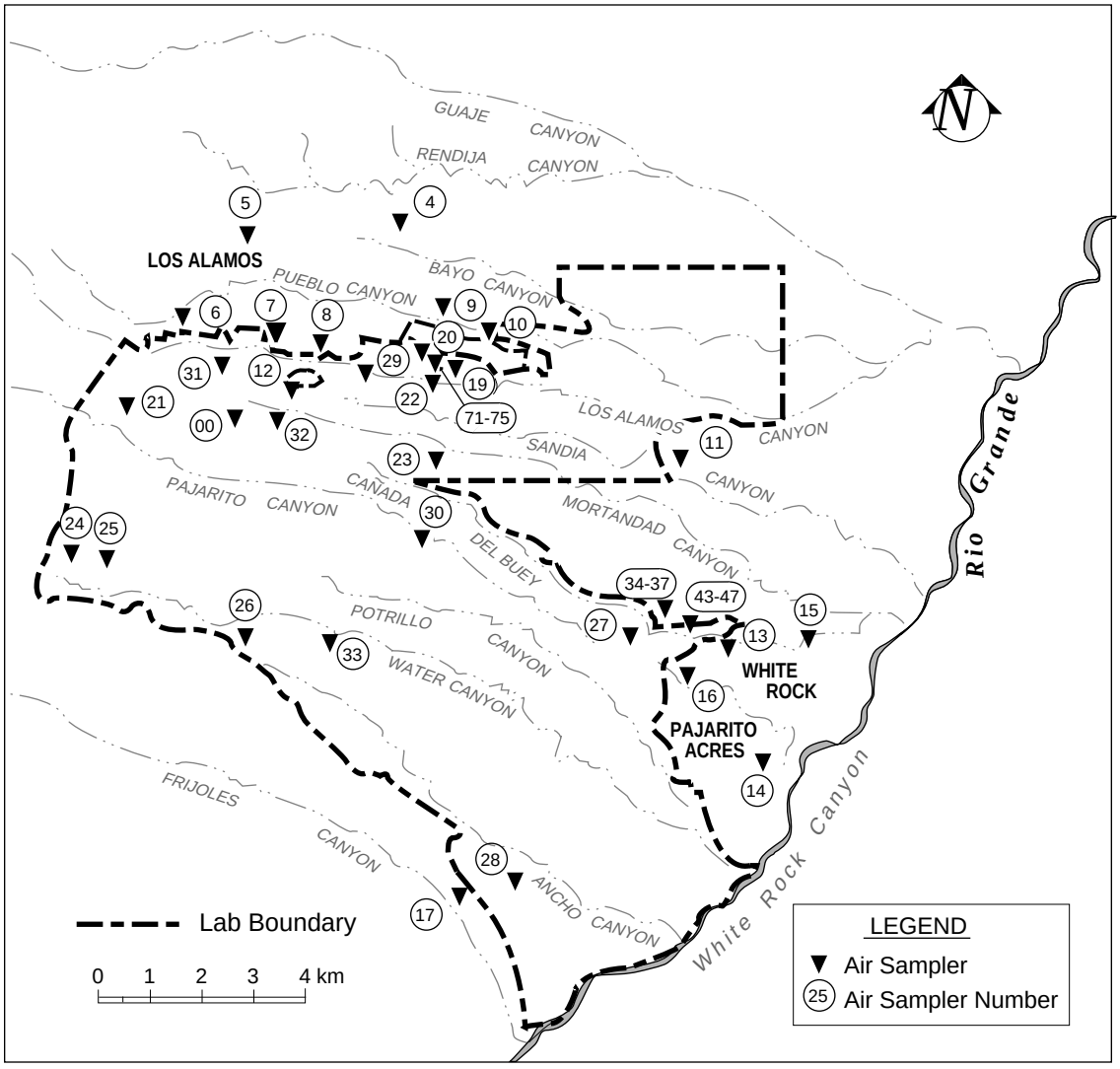

Figure V-8. Approximate locations for off-site perimeter and on-site Laboratory stations for sampling airborne radionuclides. (Does not show Regional Stations; see Table D-12 for specific locations.)

History of Changes in Sampling Stations. In addition to Station #27, which is part of the routine air sampling network, four site-specific stations were located at the active radioactive waste disposal site at TA-54, Area G in October 1984. In August 1992, five stations for sampling ^{131}I in air were added to the air monitoring network, with an additional station being added in January 1993. These ^{131}I stations are collocated with other stations. In October 1992, five new stations were established at TA-21 to monitor potential emissions resulting from the demolition and removal of a decommissioned nuclear facility, as part of the DOE's Environmental Restoration (ER) Project. In May 1993, five additional stations were established at TA-54, Area G to monitor potential emissions from the waste remediation project known as the Transuranic Waste Inspectable Storage Project (TWISP). Also during 1993, the Laboratory installed stations at the northern New Mexico Pueblos of Jemez, San Ildefonso, and Taos at the request of the respective tribal governments. In 1994, three stations were installed to monitor potential emissions from the PHERMEX and R-306 firing sites. The station located on the roof of the TA-59 Occupational Health Laboratory was discontinued in 1994, and at the request of residents of the area, Station #14, Pajarito Acres, was discontinued in 1994. Station #1, Española, was moved to an alternate location in the City of Española during 1994 because of a change in property ownership.

c. Analytical Results.

Gross Alpha and Beta Radioactivity. Gross alpha and beta analyses are used in evaluating general radiological air quality and identifying potential trends in the data. Alpha or beta activity for any single radionuclide cannot be present in greater quantity than the total gross concentration found on a filter. If gross activity in a sample is consistent with past observations and background, special analyses for specific radionuclides are not required. If the sample analytical results appear to be elevated, then analyses for specific radionuclides are required to confirm or deny a problem such as an unplanned release. Gross beta activity in air exhibits considerable environmental variability, as shown in Figure V-9, which plots the results from one regional and one perimeter station. The National Council on Radiation Protection and Measurements (NCRP) estimated average concentration of long-lived gross alpha activity in air to be 2.0×10^{-15} µCi/mL (74 µBq/m^3). The primary alpha activity is due to polonium-210 (a decay product of radon gas) and other naturally occurring radionuclides (NCRP 1987a). The NCRP also estimated average concentration levels of long-lived gross beta activity in air to be 20.0×10^{-15} µCi/mL

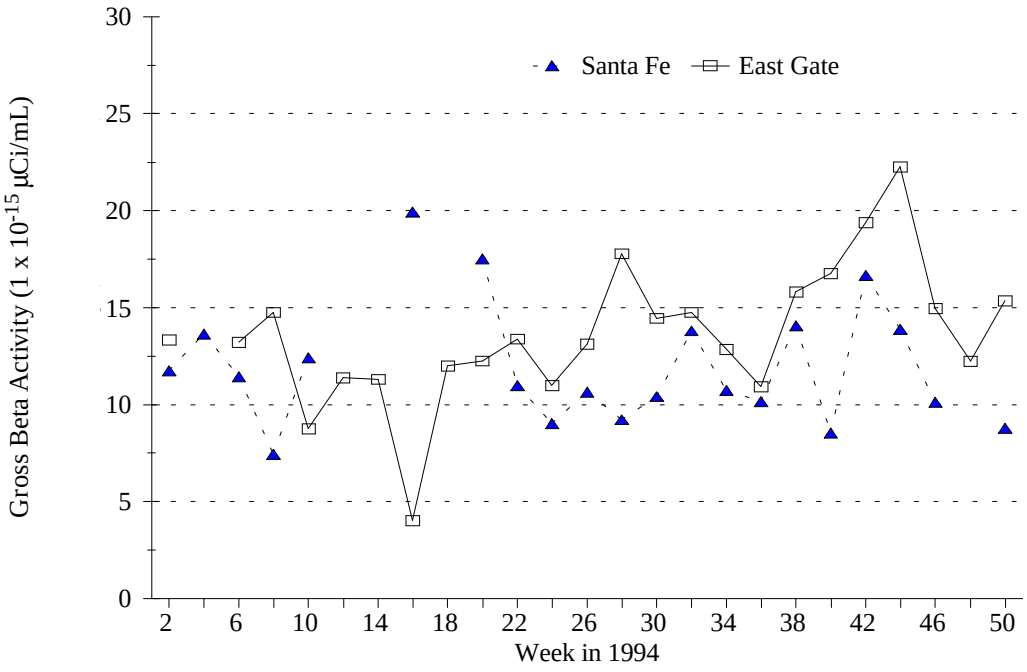

Figure V-9. Gross beta activity in air at one regional and one perimeter location.

(740 μBq/m^3). This activity is primarily due to the presence of ^{210}Pb and ^{210}Bi (decay products of radon), and other naturally occurring radionuclides. There were more than 1,000 air samples collected in 1994 and analyzed for gross alpha and gross beta activity (Table V-7 and Table V-8 respectively). No unusual above-background average annual results were observed in 1994.

Tritium. Tritium is released by the Laboratory in Ci (Gbq) amounts. In addition, tritium is present in the environment as the result of nuclear weapons tests and is also produced naturally by the cosmogenic process (Kathren 1984). Sampling results are presented in Table V-9. About 5% of the off-site samples were above the upper limit background (ULB) or the regional samplers' mean plus two standard deviations value of 9.7 x 10^{-12} mCi/mL (0.36 Bq/m^3). The maximum off-site concentration was recorded at Station #16, the Nazarene Church. The calculated tritium dose based on local mean air concentration at Station #16 was 0.19% of the EPA's public dose limit (PDL) of 10 mrem (0.1 mSv) per year. Elevated concentrations were observed by Station #35, G-2, at the TA-54, Area G waste site near shafts where tritium-contaminated waste is disposed. However, the maximum concentration observed at Station G-2 is less than 0.001% of the DOE DAC for controlled areas. All annual mean concentrations were well below the applicable EPA and DOE guidelines.

Plutonium. Plutonium is released by the Laboratory in μCi (kBq) amounts. In addition, plutonium is present in the environment because of fallout from past nuclear weapons testing, and in some isolated cases, from natural sources (Kathern 1984). Sampling results for ^{238}Pu are presented in Table V-10. Although 1% of the off-site sample results above the ULB value of 8.5 x 10^{-18} μCi/mL (0.31 μBq/m^3) were recorded in 1994, none of the annual means for on-site or off-site exceeded the UBL. Sampling results for ^{239,240}Pu are presented in Table V-11. About 3% of the off-site sample results were above the ULB value of 10.6 x 10^{-18} μCi/mL (0.392 μBq/m^3). The maximum on-site value of ^{239,240}Pu was recorded during the second quarter at Station #36, G-3, TA-54, Area G, and is less than 0.02% of the DOE DAC for controlled areas. All annual mean concentrations were well below the applicable EPA and DOE guidelines.

Americium. Since americium often occurs along with plutonium, a subset of plutonium samples is also submitted for this analysis; results are presented in Table V-12. Seven percent of the off-site sampling results were above the ULB value of 10.0 x 10^{-18} μCi/mL (0.37 μBq/m^3). The highest off-site concentrations occurred at Station #10, East Gate, and Station #16, Nazarene Church. The ^{241}Am doses at Stations #10 and #16 were 0.37% and 0.32%, respectively, of the EPA's PDL of 10 mrem (0.1 mSv)/year. All other annual mean concentrations were also well below the applicable EPA and DOE guidelines.

Uranium. Uranium is released from the Laboratory in mCi (μBq) amounts and is naturally occurring in rocks and soil; please refer to a general discussion regarding uranium in the environment in a previous annual report (EARE 1995b). Tables V-13 to V-15 present radioisotopic results for ^{234}U, ^{235}U, and ^{238}U respectively. About 6% of the off-site samples for ^{234}U were greater than the ULB value of 37.5 x 10^{-18} μCi/mL (1.39 μBq/m^3). The maximum off-site value was recorded at Station #15; White Rock Fire Station. The ^{234}U dose at Station #15 was 0.16% of the EPA's Public Dose Limit (PDL). About 4% of the off-site samples for ^{235}U exceeded the ULB value of 3.8 x 10^{-18} μCi/mL (0.14 μBq/m^3). The maximum off-site value was also recorded at Station #15; the corresponding ^{235}U dose was 0.065% of the EPA's PDL. The elevated reading for Station #42, Taos Pueblo, is unexplained at this time. Seven percent of the off-site sampling results for ^{238}U were above the ULB value of 39.2 x 10^{-18} μCi/mL (1.45 μBq/m^3). The highest off-site values were observed in the White Rock townsite. Stations #13, #15, and #16 had ^{238}U doses rates that are respectively 0.021%, 0.020%, and 0.019% of the EPA's PDL. All annual mean concentrations were well below the applicable EPA and DOE guidelines. Total uranium concentrations, in terms of mass, can be calculated using the conversion factors provided in Table V-16 for comparison with uranium data from previous environmental surveillance reports.

In addition to releases of enriched uranium from some Laboratory facilities, depleted uranium (consisting of primarily ^{238}U is dispersed by experiments that use conventional high explosives. About 111 kg (246 lb) of depleted uranium containing about 0.08 Ci (3 Gbq) of radioactivity was used in such experiments in 1994 (Table V-17). Most of the debris from these experiments was deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the uranium becomes airborne in a high-explosive test (Dahl 1977). Dispersion calculations indicate that resulting maximum airborne concentrations would be greater than concentrations attributable to the natural abundance of uranium that is resuspended in dust particles; however, the predicted values were not detected at on-site stations or off-site stations. The actual amount released is likely to be smaller than the values given in Table V-17. Additional air sampling conducted near the active firing sites supports this conclusion.

Table V-7. Airborne Long-Lived Gross Alpha Concentrations for 1994

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Regional Stations							
1 Española	33,800	15	0	4.8	2.2	3.4	1.7
2 Pojoaque	57,100	42	1	4.4	0.2	2.7	1.9
3 Santa Fe	57,700	23	2	4.9	0.0	2.4	2.6
Group Summary		62	3	4.9	0.0	2.8	2.3
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	24	0	5.6	0.8	2.8	2.1
42 Taos Pueblo	6,900	3	1	6.1	-0.0	2.9	6.2
48 Jemez Pueblo	29,900	7	0	2.2	0.6	1.7	1.4
Group Summary		34	1	6.1	-0.0	2.6	2.6
Perimeter Stations							
4 Barranca School	59,700	25	0	4.8	0.8	3.0	2.2
5 Urban Park	53,800	22	1	4.6	0.2	2.4	1.8
6 48th Street	58,600	25	0	5.2	0.4	3.0	2.5
7 Los Alamos Shell	54,100	23	0	5.1	0.9	3.1	2.4
8 McDonald's	60,300	25	0	5.5	1.8	3.4	2.0
9 Los Alamos Airport	61,500	25	0	5.5	0.6	3.2	2.3
10 East Gate	59,500	25	1	4.7	0.0	3.0	2.0
11 Well PM-1	58,700	25	0	5.6	1.4	3.6	2.0
12 Royal Crest	57,800	25	0	5.6	1.6	3.4	2.2
13 Piñon School	56,900	23	0	5.0	1.1	3.1	2.2
15 White Rock Fire Station	60,200	25	0	5.3	1.8	3.3	1.8
16 Nazarene Church	56,700	25	0	7.5	0.7	3.2	2.9
17 Bandelier	49,200	23	0	5.7	1.6	3.5	1.9
Group Summary		316	2	7.5	0.0	3.2	2.2
On-Site Stations							
19 TA-21, DP Site	54,100	24	0	7.0	1.4	3.3	2.6
20 TA-21, Area B	56,000	22	0	5.1	0.4	3.2	2.5
21 TA-6	61,000	25	1	4.2	0.0	2.3	2.3
22 TA-53, LAMPF	55,300	24	0	7.2	1.2	3.6	2.6
23 TA-52, Beta	60,600	25	0	4.7	1.3	3.2	1.8
25 TA-16-450	56,900	24	2	8.8	-0.0	2.9	3.7
26 TA-49	56,900	25	2	8.8	-0.0	2.9	3.7
27 TA-54, Area G	59,000	19	2	5.2	0.1	2.8	2.6
28 TA-33 HP Site	48,900	18	2	8.3	0.0	2.3	3.7
29 TA-2, Omega	42,000	22	0	6.7	0.6	3.3	3.0
30 Booster P-2	55,000	25	0	5.9	1.6	3.1	2.3
31 TA-3	62,200	16	0	8.4	1.9	3.4	2.6
32 County Landfill	36,700	25	0	5.2	2.2	3.5	1.8
33 Area AB	60,100	13	0	3.7	0.6	2.0	1.7
Group Summary		307	9	8.8	-0.0	3.0	2.6

Table V-7. Airborne Long-Lived Gross Alpha Concentrations for 1994 (Cont.)

1 fCi/m3 = 1 x 10^{-15} µCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Area G Fenceline							
34 Area G-1	58,900	23	2	5.3	0.0	2.7	2.9
35 Area G-2	58,700	24	2	4.6	0.1	2.7	2.2
36 Area G-3	51,800	21	4	4.5	0.0	2.2	2.9
37 Area G-4	56,100	21	3	9.5	-0.0	2.7	4.1
Group Summary		89	11	9.5	-0.0	2.6	3.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	10	0	10.7	0.5	3.3	5.9
44 Area G (S Perimeter)	60,000	25	1	9.5	0.4	2.9	3.7
45 Area G (SE Perimeter)	59,700	25	1	9.5	0.2	3.0	3.8
46 Area G (E Perimeter)	60,000	25	0	9.5	0.6	3.3	3.3
47 Area G (N Perimeter)	59,600	25	1	10.5	0.3	3.4	4.5
Group Summary		110	3	10.7	0.2	1.6	4.0
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	25	0	5.5	0.8	3.4	2.3
72 TA-21.02	58,500	25	0	6.1	1.5	3.9	2.0
73 TA-21.03	58,400	25	0	8.8	1.4	3.8	3.0
74 TA-21.04	58,600	25	1	8.4	0.0	3.3	3.5
75 TA-21.05	56,500	24	1	5.2	0.0	3.0	2.5
Group Summary		124	2	8.8	0.0	2.3	2.7
TA-15 Firing Sites							
76 TA-15-NNW	51,500	19	0	8.5	1.6	4.0	2.4
77 TA-15-NNE	43,100	16	2	8.4	-0.0	3.1	3.9
78 TA-15-N	40,700	15	2	10.4	-0.0	4.2	6.3
Group Summary		50	4	10.4	-0.0	3.8	5.0

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000
Uncontrolled Area DOE Derived Air Concentration guide	2,000
LANL Minimum Detection Limit	0.4

The concentration guide for Plutonium-239 is used for gross alpha*.
Concentration guides are for above-background values.

Table V-8. Airborne Long-Lived Gross Beta Concentrations for 1994

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Regional Stations							
1 Española	33,800	15	0	18.8	8.7	12.2	4.6
2 Pojoaque	57,100	24	1	18.2	1.2	11.9	7.7
3 Santa Fe	57,700	23	2	19.9	0.1	10.9	9.1
Group Summary		62	3	19.9	0.1	11.6	7.6
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	24	0	35.5	2.7	14.0	12.5
42 Taos Pueblo	6,900	3	1	14.0	0.2	9.0	15.3
48 Jemez Pueblo	29,900	7	0	25.4	3.2	13.6	15.7
Group Summary		34	1	35.5	0.2	13.4	13.3
Perimeter Stations							
4 Barranca School	59,700	25	0	19.0	3.5	12.3	7.3
5 Urban Park	53,800	22	0	16.8	1.6	10.0	7.3
6 48th Street	58,600	25	0	22.7	2.7	11.8	8.2
7 Los Alamos Shell	54,100	23	0	20.9	4.7	11.9	6.1
8 McDonald's	60,300	25	0	20.9	9.3	13.6	6.1
9 Los Alamos Airport	61,500	25	0	20.5	2.2	12.8	8.0
10 East Gate	59,500	25	1	22.3	0.0	13.0	8.9
11 Well PM-1	58,700	25	0	20.0	6.6	13.9	6.1
12 Royal Crest	57,800	25	0	21.5	5.8	13.6	6.3
13 Piñon School	56,900	23	0	16.5	3.6	11.7	6.0
15 White Rock Fire Sta.	60,200	25	0	18.8	9.4	12.9	5.1
16 Nazarene Church	56,700	25	0	19.6	4.2	12.5	7.4
17 Bandelier	49,200	23	0	20.8	8.8	13.8	5.4
Group Summary		316	1	22.7	0.0	12.6	6.9
On-Site Stations							
19 TA-21, DP Site	52,300	24	0	28.9	7.4	12.6	8.7
20 TA-21, Area B	51,400	22	0	21.1	1.1	12.7	9.1
21 TA-6	61,000	25	1	16.2	0.0	10.1	8.0
22 TA-53, LAMPF	55,300	24	0	31.7	4.5	14.3	9.8
23 TA-52, Beta	60,600	25	0	18.5	8.4	12.5	5.0
25 TA-16-450	56,900	24	2	34.6	0.0	11.6	13.2
26 TA-49	59,000	25	2	20.1	-0.1	11.4	9.6
27 TA-54, Area G	48,900	19	1	25.3	1.2	12.4	10.8
28 TA-33, HP Site	42,000	18	0	19.5	2.0	12.9	7.5
29 TA-2, Omega	55,000	22	0	22.5	8.5	12.7	6.5
30 Booster P-2	62,200	25	1	30.6	6.2	13.6	9.1
31 TA-3	36,700	16	0	15.5	9.2	11.9	3.4
32 County Landfill	60,100	25	0	16.1	4.4	10.7	5.3
33 Area AB	49,000	13	0	34.6	7.4	15.2	14.1
Group Summary		307	7	34.6	-0.1	12.4	9.1

Table V-8. Airborne Long-Lived Gross Beta Concentrations for 1994 (Cont.)

1 fCi/m^3 = 1 x 10^{-15} μCi/mL = 3.7 x 10^{-5} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	2s
Area G Fenceline							
34 Area G-1	56,300	23	2	21.2	0.0	11.6	11.6
35 Area G-2	56,100	24	1	18.1	0.6	11.6	7.0
36 Area G-3	49,200	21	2	18.4	0.4	10.5	9.5
37 Area G-4	51,300	21	2	22.5	0.0	11.5	10.6
Group Summary		89	7	22.5	0.0	11.3	9.7
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	10	0	37.0	2.0	12.6	19.5
44 Area G (S Perimeter)	60,000	25	1	19.6	0.9	11.0	8.0
45 Area G (SE Perimeter)	59,700	25	1	19.6	1.0	12.2	9.0
46 Area G (E Perimeter)	60,000	25	2	18.2	-0.1	12.3	8.8
47 Area G (N Perimeter)	59,600	25	1	34.9	0.8	13.3	11.3
Group Summary		110	5	37.0	-0.1	12.2	10.5
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	25	0	19.2	3.9	12.4	6.8
72 TA-21.02	58,500	25	0	19.0	9.9	13.7	4.8
73 TA-21.03	58,400	25	0	28.0	7.6	14.1	8.4
74 TA-21.04	58,600	25	2	31.7	-0.3	12.5	11.2
75 TA-21.05	56,500	24	1	16.3	-0.2	11.9	7.6
Group Summary		124	3	31.7	-0.3	12.9	8.0
TA-15 Firing Sites							
76 TA-15-NNW	51,500	19	0	36.0	11.0	16.2	13.5
77 TA-15-NNE	43,100	16	1	27.4	-0.2	14.1	11.9
78 TA-15-N	40,700	15	1	37.4	0.0	19.1	19.4
Group Summary		50	2	37.4	-0.2	16.4	15.3

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	9,000
LANL Minimum Detection Limit	0.4

The concentration guide for Plutonium-239 is used for gross alpha*.
Concentration guides are for above-background values.

Table V-9. Airborne Tritium as Tritiated Water Concentrations for 1994

1 pCi/m^3 = 1 x 10^{-12} μCi/mL = 3.7 x 10^{-2} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (PCi/m^3)	Minimum (pCi/m^3)	Mean (PCi/m^3)	2s
Regional Stations							
1 Española	60	15	14	19.3	-0.5	1.7	9.8
2 Pojoaque	105	24	21	20.1	-1.0	1.3	8.5
3 Santa Fe	97	22	21	18.4	-0.5	1.1	7.8
Group Summary		61	56	20.1	-1.0	1.3	8.5
Pueblo Stations							
41 Pueblo of San Ildefonso	92	24	22	23.8	-0.9	1.5	9.6
42 Taos Pueblo	24	1	1	0.1	0.1	0.1	0.1
48 Jemez Pueblo	57	7	5	2.6	-0.4	0.6	2.5
Group Summary		32	28	23.8	-0.9	1.3	8.4
Perimeter Stations							
4 Barranca School	105	25	22	33.3	-0.6	1.9	13.2
5 Urban Park	91	21	18	6.3	-0.9	0.9	3.0
6 48th Street	99	24	19	35.8	-0.2	2.3	14.4
7 Los Alamos Shell	96	23	21	20.0	-0.3	1.5	8.1
8 McDonald's	102	24	15	32.3	0.0	3.2	13.1
9 Los Alamos Airport	101	23	19	16.8	-0.4	2.2	9.0
10 East Gate	105	25	19	15.0	0.0	2.1	6.8
11 Well PM-1	100	24	20	35.5	-2.5	2.4	14.3
12 Royal Crest	94	23	19	11.2	-0.1	1.5	5.1
13 Piñon School	89	20	15	25.3	-0.4	2.6	11.6
15 White Rock Fire Station	103	24	22	15.7	-0.2	1.4	6.2
16 Nazarene Church	94	23	16	36.2	-0.4	3.0	14.8
17 Bandelier	84	23	22	16.2	-0.9	1.4	6.6
Group Summary		302	247	36.2	-2.5	2.0	10.4
On-Site Stations							
19 TA-21, DP Site	95	25	7	42.1	-0.2	6.0	20.1
20 TA-21, Area B	99	24	16	14.5	-0.5	2.0	5.9
21 TA-6	108	25	23	25.7	-0.5	1.5	10.2
22 TA-53, LAMPF	93	23	17	15.5	-0.2	1.9	6.5
23 TA-52, Beta	103	24	19	6.9	0.2	1.5	2.9
25 TA-16-450	96	23	11	120.0	0.1	9.1	50.5
26 TA-49	104	25	20	19.4	-0.6	1.8	8.3
27 TA-54, Area G	95	22	7	26.4	0.3	9.7	17.2
28 TA-33, HP Site	85	20	14	7.0	0.2	1.8	3.5
29 TA-2, Omega	76	17	6	25.4	0.0	4.2	11.8
30 Booster P-2	96	22	20	41.6	-0.2	2.7	17.5
31 TA-3	61	15	11	9.1	-0.1	2.0	4.8
32 TA-48	102	24	20	11.6	-0.5	1.4	4.7
33 Area AB	90	14	13	6.7	0.0	1.1	3.3
Group Summary		303	204	120.0	-0.6	3.4	18.0

Table V-9. Airborne Tritium as Tritiated Water Concentrations for 1994 (Cont.)

1 pCi/m^3 = 1 x 10^{-12} μCi/mL = 3.7 x 10^{-2} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	2s
Area G Fenceline							
34 Area G-1	108	25	6	73.7	0.6	13.9	35.4
35 Area G-2	103	24	2	1140.0	0.6	250.0	650.0
36 Area G-3	100	24	16	420.0	-1.4	19.5	170.0
37 Area G-4	99	23	10	46.9	0.1	5.1	19.3
Group Summary		96	34	1140.0	-1.4	72.0	390.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	41	10	6	6.4	0.5	2.3	3.6
44 Area G (S Perimeter)	100	24	10	25.7	0.0	5.9	13.4
45 Area G (SE Perimeter)	101	24	9	28.4	0.0	4.4	12.1
46 Area G (E Perimeter)	106	25	7	31.0	0.4	8.2	15.5
47 Area G (N Perimeter)	105	25	4	45.6	0.7	11.7	23.3
Group Summary		108	36	45.6	0.0	7.1	16.9
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	99	24	18	21.6	0.0	2.9	10.4
72 TA-21.02	103	25	17	15.4	0.2	2.7	7.1
73 TA-21.03	103	25	14	13.5	-1.7	3.1	6.5
74 TA-21.04	100	24	14	10.2	0.3	2.8	5.8
75 TA-21.05	104	25	16	31.3	-0.1	4.3	13.6
Group Summary		123	79	31.3	-1.7	3.1	9.1
TA-15 Firing Sites							
76 TA-15-NNW	87	17	12	13.9	-0.2	2.3	7.6
77 TA-15-NNE	80	15	12	8.0	0.0	1.3	4.0
78 TA-15-N	68	14	12	8.6	0.2	1.6	5.5
Group Summary		46	36	13.9	-0.2	1.8	5.9

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	100,000
EPA 40 CFR 61 Concentration guide	1,500
LANL Minimum Detection Limit	2

Table V-10. Airborne Plutonium-238 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	2	6.1	-2.3	1.7	8.4
2 Pojoaque	59,200	4	3	3.3	1.0	1.9	2.0
3 Santa Fe	57,700	4	2	8.8	0.3	3.4	8.0
Group Summary		11	7	8.8	-2.3	2.4	6.1
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	4	2.2	0.1	1.2	1.8
42 Taos Pueblo	20,600	2	2	2.6	-0.1	1.2	3.9
48 Jemez Pueblo	32,500	3	3	0.9	-1.2	-0.1	2.1
Group Summary		9	9	2.6	-1.2	0.8	2.4
Perimeter Stations							
4 Barranca School	59,700	4	3	3.2	-1.0	1.4	3.7
5 Urban Park	53,800	4	3	3.1	-0.4	0.9	3.0
6 48th Street	58,600	4	4	0.9	-0.8	-0.0	1.6
7 Los Alamos Shell	54,100	3	2	3.5	-1.9	0.5	5.5
8 McDonald's	60,300	4	4	2.5	-4.5	-1.2	5.7
9 Los Alamos Airport	61,500	4	3	4.6	1.4	2.3	3.1
10 East Gate	59,500	4	2	5.9	0.1	2.5	5.1
11 Well PM-1	58,700	4	4	1.8	-0.5	0.8	1.9
12 Royal Crest	57,800	4	4	-0.1	-2.4	-1.0	2.3
13 Pinon School	56,900	4	4	0.0	-1.8	-0.7	1.5
15 White Rock Fire Station	60,200	4	4	1.9	-0.6	0.4	2.2
16 Nazarene Church	56,700	4	4	2.4	-1.1	0.3	3.0
Group Summary		51	44	5.9	-4.5	0.6	4.0
On-Site Stations							
19 TA-21, DP Site	54,100	4	3	3.1	-0.4	1.6	3.5
20 TA-21, Area B	56,000	4	3	4.7	-1.0	1.5	4.8
21 TA-6	61,000	4	4	-0.1	-0.8	-0.4	0.6
22 TA-53, LAMPF	55,300	4	3	4.0	-0.9	1.0	4.3
23 TA-52, Beta	60,600	4	4	1.1	-0.4	0.4	1.6
25 TA-16-450	56,900	4	4	1.0	-3.6	-0.9	4.0
26 TA-49	59,000	4	3	3.1	0.1	1.6	2.6
27 TA-54, Area G	53,900	4	3	4.1	0.4	2.5	3.1
28 TA-33, HP Site	48,000	4	3	3.1	-2.1	0.2	4.4
29 TA-2, Omega	56,800	4	4	1.3	-0.9	0.2	1.8
30 Booster P-2	62,200	4	4	2.0	-1.2	0.4	3.4
31 TA-3	36,700	3	3	1.4	-0.6	0.3	2.0
32 County Landfill	60,100	4	3	3.7	0.1	1.6	3.0
33 Area AB	51,100	4	4	1.8	-1.1	0.0	2.5
Group Summary		55	48	4.7	-3.6	0.7	3.3

Table V-10. Airborne Plutonium-238 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34Area G-1	61,300	4	3	8.7	0.0	3.1	7.7
35 Area G-2	58,700	4	4	2.9	-1.2	0.5	3.5
36 Area G-3	56,400	4	2	9.2	0.3	4.4	8.6
37 Area G-4	44,400	3	3	1.5	0.2	0.9	1.3
Group Summary		15	12	9.2	-1.2	2.3	6.5
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	3.9	-0.3	1.8	6.0
44 Area G (S Perimeter)	60,000	4	3	3.1	0.2	1.2	2.7
45 Area G (SE Perimeter)	59,700	4	4	0.8	-1.2	-0.2	1.8
46 Area G (E Perimeter)	60,000	4	1	6.0	3.4	4.8	2.3
47 Area G (N Perimeter)	59,600	4	3	7.5	0.6	2.7	6.4
Group Summary		18	12	7.5	-1.2	2.1	5.0
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	4	1.5	-0.2	0.5	1.5
72 TA-21.02	58,500	4	4	0.4	-2.6	-0.8	2.5
73 TA-21.03	58,400	4	1	8.2	1.1	4.4	6.0
74 TA-21.04	58,600	4	3	5.5	0.1	1.9	5.0
75 TA-21.05	58,700	4	4	3.0	-2.2	0.7	4.6
Group Summary		20	16	8.2	-2.6	1.3	5.2
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	3	4.2	-0.7	1.0	4.4
77 TA-15-NNE	43,100	4	2	8.4	-0.4	3.9	8.5
78 TA-15-N	40,700	4	3	4.1	-7.8	-0.3	10.4
Group Summary		12	8	8.4	-7.8	1.5	8.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	3,000,000
Uncontrolled Area DOE Derived Air Concentration guide	30,000
EPA 40 CFR 61 Concentration guide	2,100
LANL Minimum Detection Limit	4

Table V-11. Airborne Plutonium-239,240 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL= 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	1	10.9	0.7	5.2	10.4
2 Pojoaque	59,200	4	2	5.4	1.5	3.1	3.6
3 Santa Fe	57,700	4	3	9.3	2.1	4.3	6.8
Group Summary		11	6	10.9	0.7	4.1	6.5
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	2	5.2	-0.1	2.1	5.1
42 Taos Pueblo	20,600	2	1	5.0	0.0	2.5	7.0
48 Jemez Pueblo	32,500	3	2	3.7	-2.4	0.6	6.1
Group Summary		9	5	5.2	-2.4	1.7	5.3
Perimeter Stations							
4 Barranca School	59,700	4	4	2.6	1.8	2.3	0.8
5 Urban Park	53,800	4	4	1.5	-0.7	0.7	2.0
6 48th Street	58,600	4	3	3.2	0.9	2.0	2.3
7 Los Alamos Shell	54,100	3	3	2.6	0.4	1.9	2.5
8 McDonald's	60,300	4	3	10.2	0.5	3.3	9.3
9 Los Alamos Airport	61,500	4	2	4.6	0.1	2.5	4.4
10 East Gate	59,500	4	3	4.1	-0.3	1.4	3.9
11 Well PM-1	58,700	4	4	1.7	-0.3	0.9	1.9
12 Royal Crest	57,800	4	4	2.7	-0.7	0.9	3.0
13 Piñon School	56,900	4	4	1.9	-0.7	0.6	2.9
15 White Rock Fire Station	60,200	4	3	7.1	-0.9	2.1	7.0
16 Nazarene Church	56,700	4	3	4.3	-0.3	1.1	4.3
17 Bandelier	50,100	4	3	4.1	-1.9	1.0	5.0
Group Summary		51	43	10.2	-1.9	1.6	4.0
On-Site Stations							
19 TA-21, DP Site	54,100	4	2	4.5	0.0	2.6	3.9
20 TA-21, Area B	56,000	4	1	8.5	0.3	3.8	6.9
21 TA-6	61,000	4	4	2.5	-2.4	0.8	4.5
22 TA-53, LAMPF	55,300	4	3	3.2	-0.4	1.5	3.4
23 TA-52, Beta	60,600	4	4	2.8	-0.6	0.8	3.0
25 TA-16-450	56,900	4	4	1.0	-1.9	0.0	2.6
26 TA-49	59,000	4	2	5.1	0.5	2.7	4.0
27 TA-54, Area G	53,900	4	1	8.5	-0.7	5.7	8.5
28 TA-33, HP Site	48,000	4	3	4.1	-3.7	0.3	6.4
29 TA-2, Omega	56,800	4	2	5.9	0.5	2.9	4.5
30 Booster P-2	62,200	4	2	6.8	1.2	3.8	4.9
31 TA-3	36,700	3	2	5.9	0.9	2.9	5.4
32 County Landfill	60,100	4	3	7.7	1.4	3.4	5.8
33 Area AB	51,100	4	3	4.1	-0.4	0.9	4.3
Group Summary		55	36	8.5	-3.7	2.3	5.5

Table V-11. Airborne Plutonium-239,240 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} µCi/mL= 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	1	6.6	1.1	3.7	4.5
35 Area G-2	58,700	4	2	7.8	1.3	3.8	5.7
36 Area G-3	56,400	4	2	33.2	1.1	10.1	30.9
37 Area G-4	44,400	3	3	2.5	0.5	1.8	2.2
Group Summary		15	8	33.2	0.5	5.0	16.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	6.5	0.9	3.7	8.0
44 Area G (S Perimeter)	60,000	4	1	5.4	0.6	3.6	4.5
45 Area G (SE Perimeter)	59,700	4	2	5.1	1.0	3.0	4.4
46 Area G (E Perimeter)	60,000	4	2	12.1	0.2	4.6	10.6
47 Area G (N Perimeter)	59,600	4	2	6.3	1.9	3.4	4.1
Group Summary		18	8	12.1	0.2	3.6	5.9
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	9.0	0.6	4.4	7.0
72 TA-21.02	58,500	4	1	8.1	0.1	5.2	7.2
73 TA-21.03	58,400	4	2	10.0	2.6	5.3	6.8
74 TA-21.04	58,600	4	1	17.1	3.0	9.3	12.0
75 TA-21.05	58,700	4	1	15.0	2.5	6.8	11.2
Group Summary		20	6	17.1	0.1	6.2	8.9
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	4	0.7	-2.2	-0.6	2.5
77 TA-15-NNE	45,200	4	2	28.1	-0.3	7.8	27.2
78 TA-15-N	40,700	4	3	3.9	-4.1	0.7	6.8
Group Summary		12	9	28.1	-4.1	2.6	16.6

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	20,000
EPA 40 CFR 61 Concentration guide	2,000
LANL Minimum Detection Limit	3

Table V-12. Airborne Americium-241 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
3 Santa Fe	57,700	4	1	6.6	1.1	4.9	5.1
Perimeter Stations							
9 Los Alamos Airport	61,500	4	0	9.9	3.4	5.8	5.7
10 East Gate	59,500	4	1	13.5	1.8	7.1	10.3
12 Royal Crest	57,800	4	0	7.8	2.6	4.5	4.6
13 Piñon School	56,900	4	0	7.1	2.7	4.0	4.2
15 White Rock Fire Station	60,200	4	0	7.0	2.1	5.2	4.5
16 Nazarene Church	56,700	4	1	13.5	1.9	6.1	10.5
Group Summary		24	2	13.5	1.8	5.4	6.7
On-Site Stations							
19 TA-21, DP Site	54,100	4	0	12.1	2.3	7.3	9.9
20 TA-21, Area B	56,000	4	1	10.1	1.6	6.1	7.5
21 TA-6	61,000	4	1	6.6	1.6	4.1	4.6
22 TA-53, LAMPF	55,300	4	2	7.2	1.8	3.9	5.2
26 TA-49	59,000	4	2	12.3	0.7	4.6	10.7
27 TA-54, Area G	53,900	4	0	14.0	5.1	11.4	8.4
30 Booster P-2	62,200	4	1	4.1	1.9	3.0	1.9
31 TA-3	36,700	3	0	9.8	3.3	5.8	7.0
Group Summary		23	6	14.0	0.7	5.5	8.4
Area G Fenceline							
34 Area G-1	61,300	4	0	8.6	2.9	5.2	5.1
35 Area G-2	58,700	4	1	9.7	1.3	6.6	7.3
36 Area G-3	56,400	4	0	9.4	4.0	6.0	4.8
37 Area G-4	44,400	3	0	8.1	4.1	5.5	4.5
Group Summary		15	1	9.7	1.3	5.8	5.1
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	7.9	3.2	5.5	6.7
44 Area G (S Perimeter)	60,000	4	0	8.7	2.9	5.3	5.0
45 Area G (SE Perimeter)	59,700	4	0	10.9	2.2	6.2	7.2
46 Area G (E Perimeter)	60,000	4	1	7.4	1.5	5.6	5.5
47 Area G (N Perimeter)	59,600	4	1	10.2	0.3	5.4	8.3
Group Summary		18	2	10.9	0.3	5.6	5.8
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	3	0	7.5	5.0	6.7	2.9
72 TA-21.02	58,500	3	0	3.4	2.8	3.2	0.5
73 TA-21.03	58,400	3	0	13.9	3.2	8.0	10.8
74 TA-21.04	58,600	3	0	8.1	3.0	5.8	5.2
75 TA-21.05	58,700	3	0	5.2	3.4	4.6	2.0
Group Summary		15	0	13.9	2.8	5.6	5.8

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	2,000,000
Uncontrolled Area DOE Derived Air Concentration guide	20,000
EPA 40 CFR 61 Concentration guide	1,900
LANL Minimum Detection Limit	4

Table V-13. Airborne Uranium-234 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	0	9.9	5.9	8.4	4.4
2 Pojoaque	59,400	4	0	33.8	5.7	21.4	28.1
3 Santa Fe	57,700	4	0	26.9	8.7	18.2	15.3
Group Summary		11	0	33.8	5.7	16.7	20.8
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	0	48.2	16.5	26.4	29.7
42 Taos Pueblo	20,600	2	1	39.4	0.6	20.0	54.9
48 Jemez Pueblo	32,500	3	0	25.4	14.4	20.9	11.6
Group Summary		9	1	48.2	0.6	23.2	27.9
Perimeter Stations							
4 Barranca School	59,700	4	1	14.5	2.7	6.3	11.0
5 Urban Park	53,800	4	1	13.6	-0.2	6.1	12.0
6 48th Street	58,600	4	1	10.3	2.0	5.8	7.4
7 Los Alamos Shell	54,100	3	0	14.7	7.5	12.0	7.9
8 McDonald's	60,300	4	2	7.4	1.2	4.3	6.2
9 Los Alamos Airport	61,500	4	0	30.4	3.1	11.5	25.7
10 East Gate	59,500	4	0	23.1	5.7	12.1	15.2
11 Well PM-1	58,700	4	0	8.8	3.1	5.2	5.0
12 Royal Crest	57,800	4	1	6.5	3.1	4.6	3.1
13 Piñon School	56,900	4	0	21.5	4.2	9.3	16.4
15 White Rock Fire Station	60,200	4	0	97.8	4.2	28.8	92.1
16 Nazarene Church	56,700	4	1	18.6	0.9	7.1	15.8
17 Bandelier	50,100	4	2	44.1	1.7	14.2	40.2
Group Summary		51	9	97.8	-0.2	9.7	29.7
On-Site Stations							
19 TA-21, DP Site	54,100	4	1	13.6	3.2	6.2	9.9
20 TA-21, Area B	56,000	4	2	5.8	1.3	3.6	4.1
21 TA-6	61,000	4	0	34.7	3.3	12.4	29.8
22 TA-53, LAMPF	55,300	4	0	9.4	4.4	7.1	5.0
23 TA-52, Beta	60,600	4	2	12.8	1.3	5.7	11.1
25 TA-16-450	56,900	4	1	19.9	2.7	10.3	14.2
26 TA-49	59,000	4	2	8.8	1.4	4.0	6.6
27 TA-54, Area G	53,900	4	0	51.1	20.3	39.0	27.3
28 TA-33, HP Site	48,000	4	2	10.2	1.5	5.5	8.7
29 TA-2, Omega	56,800	4	0	10.1	3.5	7.3	5.7
30 Booster P-2	62,200	4	1	22.1	1.4	8.8	18.4
31 TA-3	36,700	3	0	20.5	5.6	12.7	15.0
32 County Landfill	60,100	4	0	24.4	14.9	20.8	8.2
33 Area AB	51,100	4	1	20.5	1.5	10.5	18.4
Group Summary		55	12	51.1	1.3	11.0	22.0

Table V-13. Airborne Uranium-234 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	0	58.9	6.8	26.2	45.4
35 Area G-2	58,700	4	0	37.1	4.1	17.3	29.8
36 Area G-3	56,400	4	0	780.0	29.5	230.0	740.0
37 Area G-4	44,400	3	0	19.1	6.7	12.9	12.4
Group Summary		15	0	780.0	4.1	76.5	390.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	41.3	19.2	30.3	31.4
44 Area G (S Perimeter)	60,000	4	0	32.1	14.8	23.9	16.6
45 Area G (SE Perimeter)	59,700	4	0	35.5	19.4	25.4	14.5
46 Area G (E Perimeter)	60,000	4	0	24.6	12.5	16.7	10.8
47 Area G (N Perimeter)	59,600	4	0	40.1	14.8	22.6	23.5
Group Summary		18	0	41.3	12.5	23.1	18.2
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	17.0	2.9	9.9	15.4
72 TA-21.02	58,500	4	0	300.0	12.6	85.8	280.0
73 TA-21.03	58,400	4	0	19.9	6.1	11.4	12.8
74 TA-21.04	58,600	4	0	25.3	8.9	14.2	15.3
75 TA-21.05	58,700	4	1	9.3	1.4	6.6	7.1
Group Summary		20	2	300.0	1.4	25.	130.0
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	1	12.0	1.2	7.5	9.2
77 TA-15-NNE	45,200	4	1	23.5	1.9	12.2	17.8
78 TA-15-N	40,700	4	0	30.0	4.2	18.0	25.7
Group Summary		12	2	30.0	1.2	12.6	19.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	90,000
EPA 40 CFR 61 Concentration guide	7,700
LANL Minimum Detection Limit	4

Table V-14. Airborne Uranium-235 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	3	2.8	0.6	1.5	2.4
2 Pojoaque	59,400	4	4	3.0	0.4	1.6	2.5
3 Santa Fe	57,700	4	4	2.2	-0.9	1.0	2.8
Group Summary		11	11	3.0	-0.9	1.4	2.4
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	4	2.0	0.3	1.0	1.4
42 Taos Pueblo	20,600	2	1	11.7	-1.5	5.1	18.6
48 Jemez Pueblo	32,500	3	3	1.5	-0.2	0.5	1.7
Group Summary		9	8	11.7	-1.5	1.7	7.7
Perimeter Stations							
4 Barranca School	59,700	4	4	0.6	-0.1	0.3	0.6
5 Urban Park	53,800	4	4	1.2	-0.2	0.6	1.2
6 48th Street	58,600	4	4	1.3	0.5	0.8	0.8
7 Los Alamos Shell	54,100	3	3	1.5	0.7	1.1	0.7
8 McDonald's	60,300	4	4	1.9	0.1	0.7	1.7
9 Los Alamos Airport	61,500	4	4	0.3	-1.3	-0.5	1.4
10 East Gate	59,500	4	4	0.2	-0.3	-0.0	0.5
11 Well PM-1	58,700	4	4	2.1	-0.6	0.8	2.3
12 Royal Crest	57,800	4	4	0.9	-0.4	0.3	1.4
13 Piñon School	56,900	4	4	1.8	-0.5	0.2	2.1
15 White Rock Fire Station	60,200	4	3	14.9	0.3	4.6	13.8
16 Nazarene Church	56,700	4	4	1.5	-1.2	0.3	2.4
17 Bandelier	50,100	4	2	7.7	0.6	3.0	6.6
Group Summary		51	48	14.9	-1.3	0.9	4.8
On-Site Stations							
19 TA-21, DP Site	54,100	4	4	1.5	-0.9	0.7	2.3
20 TA-21, Area B	56,000	4	4	2.4	-0.2	0.8	2.3
21 TA-6	61,000	4	4	0.1	-0.7	-0.3	0.7
22 TA-53, LAMPF	55,300	4	4	1.2	-0.3	0.5	1.3
23 TA-52, Beta	60,600	4	4	0.3	-0.6	-0.2	0.8
25 TA-16-450	56,900	4	4	0.6	-0.3	0.2	0.8
26 TA-49	59,000	4	4	0.1	-0.5	-0.2	0.6
27 TA-54, Area G	53,900	4	2	6.0	0.0	2.4	5.5
28 TA-33, HP Site	48,000	4	4	1.3	-0.2	0.7	1.3
29 TA-2, Omega	56,800	4	4	1.3	-1.2	0.2	2.2
30 Booster P-2	62,200	4	4	0.9	-0.1	0.4	1.1
31 TA-3	36,700	3	3	1.6	0.9	1.2	0.8
32 County Landfill	60,100	4	4	1.5	-0.2	0.6	1.8
33 Area AB	51,100	4	3	3.5	-0.2	1.2	3.2
Group Summary		55	53	6.0	-1.2	0.6	2.4

Table V-14. Airborne Uranium-235 Concentrations for 1994 (Cont.)

$1 aCi/m^3 = 1 \times 10^{-18}$ μCi/mL = 3.7×10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	4	1.9	-0.2	1.1	1.8
35 Area G-2	58,700	4	3	2.7	-0.3	1.8	2.8
36 Area G-3	56,400	4	3	23.4	1.5	7.5	21.3
37 Area G-4	44,400	3	3	2.5	-0.2	1.1	2.6
Group Summary		15	14	23.4	-0.3	3.0	11.5
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	1	3.0	0.5	1.7	3.6
44 Area G (S Perimeter)	60,000	4	4	1.9	0.0	0.7	1.7
45 Area G (SE Perimeter)	59,700	4	3	3.5	0.8	1.7	2.4
46 Area G (E Perimeter)	60,000	4	4	2.5	-0.5	1.0	2.5
47 Area G (N Perimeter)	59,600	4	4	2.5	1.3	1.8	1.2
Group Summary		18	16	3.5	-0.5	1.3	2.1
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	4	2.3	0.1	1.3	2.0
72 TA-21.02	58,500	4	3	7.9	0.8	2.9	6.7
73 TA-21.03	58,400	4	4	0.6	-0.4	0.2	0.9
74 TA-21.04	58,600	4	3	4.6	-0.5	1.3	4.5
75 TA-21.05	58,700	4	4	1.2	-0.5	0.4	1.5
Group Summary		20	18	7.9	-0.5	1.2	3.9
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	4	2.4	-0.4	1.1	2.3
77 TA-15-NNE	45,200	4	4	1.4	-0.8	-0.1	2.1
78 TA-15-N	40,700	4	4	1.2	-1.0	0.4	2.0
Group Summary		12	12	2.4	-1.0	0.5	2.2

Concentration Guidelines

Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	100,000
EPA 40 CFR 61 Concentration guide	7,100
LANL Minimum Detection Limit	4

Table V-15. Airborne Uranium-238 Concentrations for 1994

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Regional Stations							
1 Española	33,800	3	0	15.5	9.8	12.4	5.8
2 Pojoaque	59,400	4	0	41.2	5.4	23.4	31.1
3 Santa Fe	57,700	4	0	25.8	8.8	17.4	14.1
Group Summary		11	0	41.2	5.4	18.2	21.0
Pueblo Stations							
41 Pueblo of San Ildefonso	52,200	4	0	43.4	15.4	24.0	26.2
42 Taos Pueblo	20,600	2	1	24.8	1.5	13.1	33.0
48 Jemez Pueblo	32,500	3	0	27.7	17.0	21.4	11.1
Group Summary		9	1	43.4	1.5	20.7	22.5
Perimeter Stations							
4 Barranca School	59,700	4	0	9.5	3.2	6.0	6.2
5 Urban Park	53,800	4	2	14.2	2.9	7.6	11.2
6 48th Street	58,600	4	0	10.0	5.0	7.7	4.6
7 Los Alamos Shell	54,100	3	0	17.0	5.0	12.6	13.3
8 McDonald's	60,300	4	1	6.6	1.9	5.2	4.4
9 Los Alamos Airport	61,500	4	1	13.1	1.3	6.1	10.3
10 East Gate	59,500	4	0	14.5	7.6	9.9	6.4
11 Well PM-1	58,700	4	0	10.9	3.4	7.1	6.4
12 Royal Crest	57,800	4	1	8.4	2.5	5.1	4.9
13 Piñon School	56,900	4	2	60.0	2.2	16.3	50.0
15 White Rock Fire Station	60,200	4	0	49.9	3.3	15.8	45.5
16 Nazarene Church	56,700	4	2	50.0	1.1	15.0	50.0
17 Bandelier	50,100	4	1	15.3	2.4	6.9	11.8
Group Summary		51	10	60.0	1.1	9.3	23.5
On-Site Stations							
19 TA-21, DP Site	54,100	4	0	6.7	4.3	5.6	2.2
20 TA-21, Area B	56,000	4	2	5.2	1.0	3.1	3.5
21 TA-6	61,000	4	1	25.2	1.8	9.6	21.2
22 TA-53, LAMPF	55,300	4	1	18.7	2.1	8.7	14.2
23 TA-52, Beta	60,600	4	0	50.0	4.3	16.7	45.1
25 TA-16-450	56,900	4	1	20.6	1.9	11.0	17.9
26 TA-49	59,000	4	2	12.1	0.9	5.2	9.9
27 TA-54, Area G	53,900	4	0	140.0	18.4	70.0	110.0
28 TA-33, HP Site	48,000	4	0	8.1	4.9	6.3	2.7
29 TA-2, Omega	56,800	4	0	9.0	3.8	7.0	4.8
30 Booster P-2	62,200	4	1	70.0	2.2	22.4	70.0
31 TA-3	36,700	3	0	28.1	3.5	13.4	25.9
32 County Landfill	60,100	4	0	37.4	19.4	30.1	17.5
33 Area AB	51,100	4	0	19.9	3.9	13.0	13.7
Group Summary		55	8	140.0	0.9	16.2	49.4

Table V-15. Airborne Uranium-238 Concentrations for 1994 (Cont.)

1 aCi/m^3 = 1 x 10^{-18} μCi/mL = 3.7 x 10^{-8} Bq/m^3

Location	Total Air Volume (m^3)	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Area G Fenceline							
34 Area G-1	61,300	4	0	60.0	13.1	27.5	50.0
35 Area G-2	58,700	4	0	100.0	5.2	33.4	90.0
36 Area G-3	56,400	4	0	70.0	12.6	46.1	50.0
37 Area G-4	44,400	3	0	47.2	5.7	19.6	50.0
Group Summary		15	0	100.0	5.2	32.5	60.0
Area G TRU Waste Inspectable Storage Program							
43 Area G (S of Dome)	23,400	2	0	48.3	37.9	43.1	14.7
44 Area G (S Perimeter)	60,000	4	0	37.9	17.1	31.2	9.6
45 Area G (SE Perimeter)	59,700	4	0	43.8	22.5	28.4	20.5
46 Area G (E Perimeter)	60,000	4	0	31.0	11.2	21.9	21.2
47 Area G (N Perimeter)	59,600	4	0	75.0	13.8	24.9	21.0
Group Summary		18	0	75.0	11.2	28.5	21.7
TA-21 Decontamination and Decommissioning Project							
71 TA-21.01	58,400	4	1	8.2	2.1	5.7	5.7
72 TA-21.02	58,500	4	1	5.3	1.8	3.8	3.3
73 TA-21.03	58,400	4	1	14.3	2.8	6.6	10.5
74 TA-21.04	58,600	4	1	8.3	2.9	6.4	4.9
75 TA-21.05	58,700	4	1	10.5	1.2	5.7	7.7
Group Summary		20	5	14.3	1.2	5.6	6.4
TA-15 Firing Sites							
76 TA-15-NNW	51,500	4	0	39.6	9.0	19.5	28.1
77 TA-15-NNE	45,200	4	0	60.0	4.7	31.2	44.4
78 TA-15-N	40,700	4	0	170.0	4.6	80.4	170.0
Group Summary		12	0	170.0	4.6	43.7	110.0

Concentration Guidelines	
Controlled Area DOE Derived Air Concentration guide	20,000,000
Uncontrolled Area DOE Derived Air Concentration guide	90,000
EPA 40 CFR 61 Concentration guide	8,300
LANL Minimum Detection Limit	4

Table V-16. Airborne Uranium Concentrations Conversion Factors

Multiply # of	by	to obtain # of
μCi/mL ^{234}U	1.60×10^{14}	pg/m^3 ^{234}U
μCi/mL^{235}U	4.63×10^{17}	pg/m^3 ^{235}U
μCi/mL ^{238}U	2.98×10^{18}	pg/m^3 ^{238}U

Table V-17. Estimated Concentrations of Radioactive Elements Released by Dynamic Experiments

Element	1994 Total Usage	Fraction Released [a] (%)	Annual Average (4 km)[b]	Concentration (8 km)[b]	Applicable Standard[c]
^{234}U	3.96×10^{-2} Ci	10	5×10^{-17}	2×10^{-17}	9×10^{-14} μCi/mL
^{235}U	1.74×10^{-3} Ci	10	2×10^{-18}	7×10^{-19}	1 x 10-^{13} μCi/mL
^{238}U	3.72×10^{-2} Ci	10	4×10^{-17}	2×10^{-17}	1×10^{-13} μCi/mL

[a](Dahl 1977)
[b]Distance downwind.
[c](DOE 1990)

Iodine. With the shutdown of the Omega West research reactor in December 1992, the potential for ^{131}I emissions from LANL is practically eliminated. Data from all six ^{131}I sampling stations are presented in Table V-18. All concentrations measured in 1994 were below the minimum detection limit (MDL) of 10×10^{-12} μCi/mL (0.37 Bq/m^3).

d. Air Monitoring at TA-54, Area G. In addition to the routine air monitoring performed for the environmental surveillance program, four air samplers are operated within the controlled area at TA-54, Area G, the Laboratory's active waste management area. In May 1993, five new stations were established to monitor potential emissions resulting from the uncovering and repackaging of 16,500 barrels of TRU waste at the TWISP site. This recovery effort is expected to last through FY 2002. All samplers measure air concentrations of tritium, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239,240}Pu, and ^{241}Am. Samplers are located near active waste handling and disposal operations. The measured air concentrations reflecting operations for 1994 are given in Tables V-7 to V-15. Some air concentrations are slightly above background but are less than 0.02% of the DOE's radioactivity DAC guides for controlled areas. Although the DACs for uncontrolled areas do not apply to TA-54, Area G, the annual average air concentrations measured during 1994 also are less than these more restrictive DAC guides.

Tritium air concentrations at Station #35, G-2, were observed to be higher than readings from other samplers in the area; these sampling results are shown in Figure V-10. Analysis of the results showed the data to be lognormally distributed. For lognormal data distributions, the median or geometric mean of the distribution are more appropriate estimates of the true value (Gilbert 1987).

The median air concentration at Station G-2 for 1994 was 147×10^{-12} μCi/mL (5.4 Bq/m^3). All other air samplers at TA-54, Area G measured tritium concentrations within the range of those observed elsewhere. Air sampler #35, G-2, is located south of shafts used to dispose of higher-activity waste containing tritium and reflects the air concentration close to the shafts.

e. TA-21 Decommissioning and Decontamination Project. Five stations were established in October 1992 to monitor potential emissions from facilities at TA-21 undergoing decommissioning. Stack emissions are also monitored during the project. The buildings TA-21-3 and TA-21-4 will be razed at the end of the decommissioning work. These structures were used mainly for nuclear chemistry involving uranium enriched in ^{235}U and may have

Table V-18. Airborne Iodine-131 Concentrations for 1994

$pCi/m^3 = 1 \times 10^{-12}$ μCi/mL = 3.7×10^{-2} Bq/m^3

Location	No. of Samples	No. of Samples <MDL	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	2s
Perimeter Stations						
8 McDonald's	32	32	1.3	-0.1	0.4	0.4
16 Nazarene Church	33	33	1.8	-0.4	0.5	0.6
On-Site Stations						
20 TA-21 Area B	35	35	1.8	-0.2	0.4	0.5
21 TA-6	27	27	1.5	-0.2	0.4	0.5
31 TA-3	24	24	2.2	-0.3	0.6	0.7
32 County Landfill	34	34	1.0	0.0	0.4	0.5
Concentration Guidelines						
Uncontrolled Area DOE Derived Air Concentration guide						400.0
EPA 40 CFR 61 Concentration guide						0.2
LANL Minimum Detection Limit						10.0

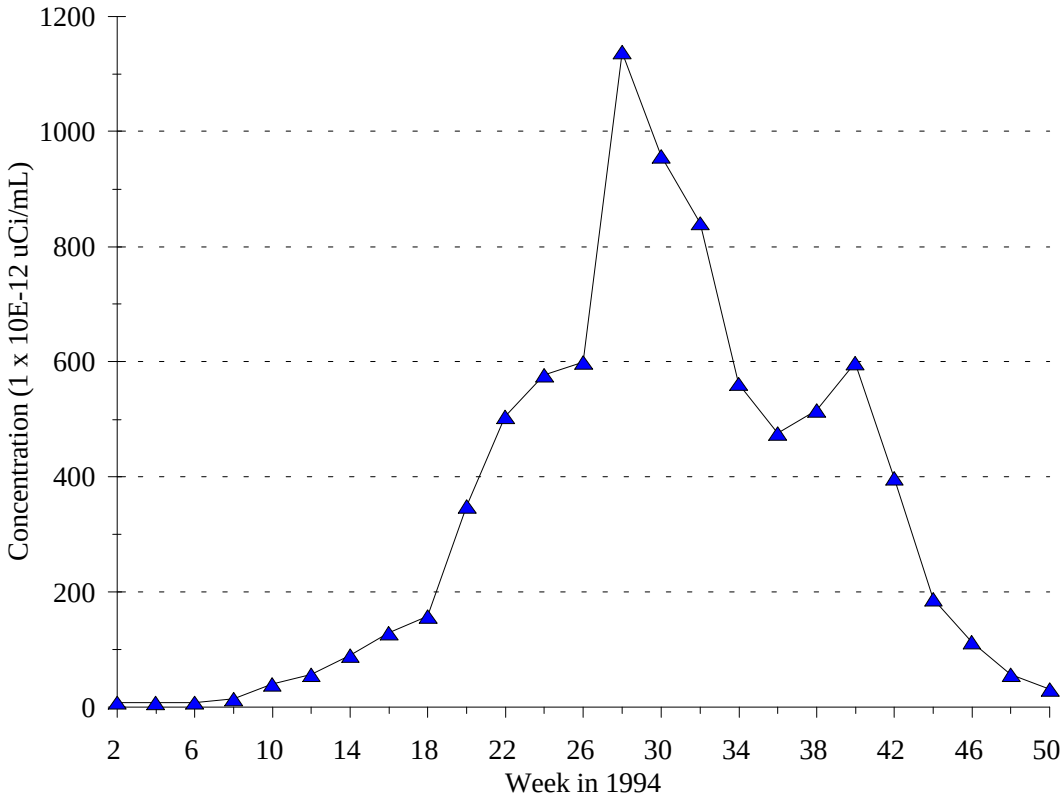

Figure V-10. Tritium in air at sampler #35, G-2.

work. These structures were used mainly for nuclear chemistry involving uranium enriched in ^{235}U and may have residual radionuclides. By combining the air sampling results with site-specific meteorology, an atmospheric dispersion model, and the measured stack emissions, an upper limit on the nonstack air emissions for 1994 can be calculated; these estimates are given in Table V-19.

Table V-19. 1994 Airborne Emissions from TA-21

Radionuclide	Stack Emissions (μCi)	Nonstack Emissions (μCi)
^{235}U	182	<100
^{239}Pu	2.40	<100

3. Surface Water Monitoring.

a. Introduction. Surface waters from off-site (regional and perimeter) and on-site (Laboratory and DOE lands) stations are monitored to routinely survey the environmental effects of Laboratory operations. As described in Section II.C, there are no perennial surface water flows that extend completely across the Laboratory in any of the canyons. Spring-fed flow originating on the flanks of the Jemez Mountains in Los Alamos Canyon continues into the Los Alamos Reservoir on US Forest Service lands west of the Laboratory. Discharge from the reservoir supports flow onto the western portion of the Laboratory for much of the year; during spring snowmelt, this flow is often sufficient to extend across the entire Laboratory for several weeks. Two canyons have perennial or intermittent spring-fed flows over short distances east of the Laboratory in White Rock Canyon: Pajarito Canyon (on Los Alamos County land) and Ancho Canyon (on DOE land).

Periodic natural surface runoff occurs in two modes: (1) spring snowmelt runoff that occurs over highly variable periods of time (days to weeks) at a low discharge rate and sediment load, and (2) summer runoff from thunderstorms that occurs over a short period of time (hours) at a high discharge rate and sediment load. None of the surface waters within the Laboratory are a source of municipal, industrial, or irrigation water. The waters are used by wildlife.

Most canyons receive discharges from some of the approximately 124 National Pollutant Discharge Elimination System (NPDES) permitted industrial and sanitary effluent outfalls, which support flows for varying distances in some of the canyons. The largest effluent-supported flow is in Sandia Canyon from the TA-46 Sanitary Wastewater Systems Consolidation (SWSC) Plant. In 1994, treated radioactive liquid waste effluents containing residual radioactivity were released only from the central Radioactive Liquid Waste Treatment Plant at TA-50 into the Mortandad Canyon drainage (Table V-6). In the past, Pueblo and Los Alamos Canyons also received effluents containing radioactivity.

Concentrations of radionuclides in environmental water samples, whether from within the DOE site boundaries or from off site, are compared with the ingested water Derived Concentration Guide (DCGs) for members of the public.

b. Monitoring Network. The locations of surface water monitoring stations are shown in Figures V-11 and V-12 and are listed in Table D-13.

Off-Site Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from six stations on the Rio Grande, the Rio Chama, and the Jemez River. The six water sampling stations are located at current or former US Geological Survey (USGS) gaging stations. These waters provide baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were at Embudo, Otowi, Cochiti, and Bernalillo (a former gaging station).

The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,037 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the periods of record (1895–1905 and 1909–1994) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 683 m^3/s (24,110 ft^3/s) in 1920. The discharge for water year 1994 (October 1993 through September 1994) ranged from 7.5 m^3/s (263 ft^3/s) in August to 242 m^3/s (8,543 ft^3/s) in May (USGS 1995).

The Rio Chama is a tributary of the Rio Grande upstream from Los Alamos. At Chamita, on the Rio Chama, the drainage area above the station is 8,140 km^2 (3,143 mi^2) in northern New Mexico, together with a small area in southern Colorado. Since 1971, some flow has been supplied by transmountain diversion water from the San Juan drainage. Flow at the Chamita gage is governed by release from several reservoirs. Discharge at Chamita during water year 1994 ranged from 7.3 m^3/s (257 ft^3/s) in August to 165 m^3/s (5,824 ft^3/s) in May.

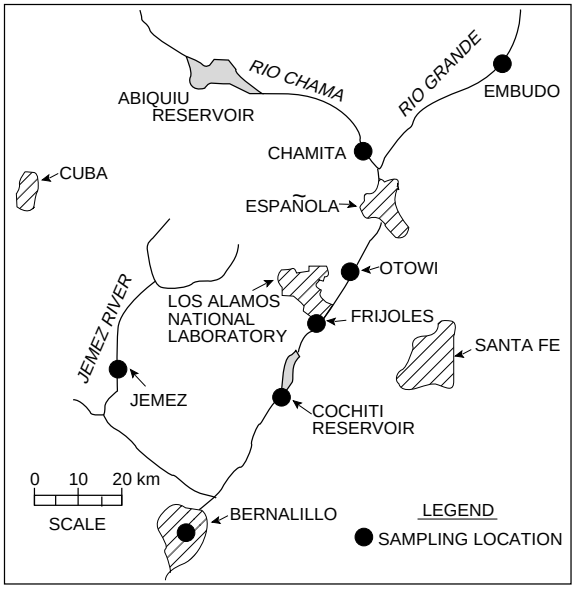

Figure V-11. Off-site regional surface water sampling locations. (Map denotes general locations only; see Table D-13 for specific coordinates.)

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The Fenton Hill Hot Dry Rock Geothermal Facility (TA-57) is located within this drainage. The drainage area is small, about 1,220 km^2 (471 mi^2). During water year 1994, discharge (as measured at the gage 3.5 mi north of Jemez) ranged from 0.2 m^3/s (7 ft^3/s) in July to 8.9 m^3/s (314 ft^3/s) in May. The river is a tributary of the Rio Grande downstream from Los Alamos.

Surface waters from the Rio Grande, the Rio Chama, and the Jemez River are used for irrigation of crops in the valleys, both upstream and downstream from Los Alamos. These rivers also run through recreational areas on state and federal lands.

Off-Site Perimeter Stations.

Radioactive Effluent Areas. Effluent-associated radionuclides occur off site in Pueblo and Los Alamos canyons. The residual contaminants are from past discharges and are predominantly associated with sediments in the canyons (see Section V.B.5 for further information). Some resuspension and redissolution occurs when surface flows move across these sediments, resulting in measurable concentrations in the surface waters.

Acid Canyon, a small tributary of Pueblo Canyon, is a former on-site release area for industrial effluents. Acid Canyon and the upper portion of Pueblo Canyon are on what is now Los Alamos County land about 1,190 m (3,900 ft) west of the Los Alamos-Santa Fe County Line. Acid-Pueblo Canyon received untreated and treated industrial effluent containing residual radionuclides from 1944 to 1964 (ESG 1981). Most of the residual radioactivity from these historical releases is now associated with the sediments in Pueblo Canyon with an estimated total inventory of about 600 mCi of Pu (ESG 1981). About two-thirds (400 mCi) of this total are in the DOE-owned portion of lower Pueblo Canyon. Pueblo Canyon presently receives treated sanitary effluent from the Los Alamos County Bayo sewage treatment plant in the middle reach of Pueblo Canyon. Increased discharge of sanitary effluent from the county treatment plant, starting in 1990, resulted in nearly continual flow during most days of all months except June and July in the lower reach of Pueblo Canyon and across the DOE land into the off-site lower reach of Los Alamos Canyon on Pueblo of San Ildefonso land. (See Section V.B.5.e for a discussion of the transport of radionuclides on sediments in surface runoff.)

This effluent flow from Pueblo Canyon into Los Alamos Canyon generally extends to somewhere between Totavi (just east of the DOE-Pueblo of San Ildefonso boundary) and the confluence of Guaje and Los Alamos canyons. During the peak irrigating season (mid-June through early August), the reduction in treatment plant discharge because of effluent diversion for golf course irrigation and higher evapotranspiration eliminates flow from Pueblo Canyon into Los Alamos Canyon.

The off-site surface water sampling stations are at Acid Weir (where Acid Canyon joins the main channel of Pueblo Canyon), Pueblo 1, and Pueblo 2. Flow is irregular at these locations and depends mainly on snowmelt and thunderstorm runoff and on return flow from the shallow alluvium. In the past, discharges from the Los Alamos County Pueblo Canyon sanitary sewage plant upstream from the confluence with Acid Canyon maintained more regular flow; however, discharges to the stream from this plant were permanently discontinued in 1991. In lower Los Alamos Canyon, off-site surface water samples are collected at its confluence with the Rio Grande.

Other Areas. Off-site perimeter stations within about 4 km (2.5 mi) of the Laboratory boundary include surface water stations at Los Alamos Reservoir, Guaje Canyon, and Frijoles Canyon. Los Alamos Reservoir, in upper Los Alamos Canyon on the flanks of the mountains west of Los Alamos, has a capacity of 51,000 m^3

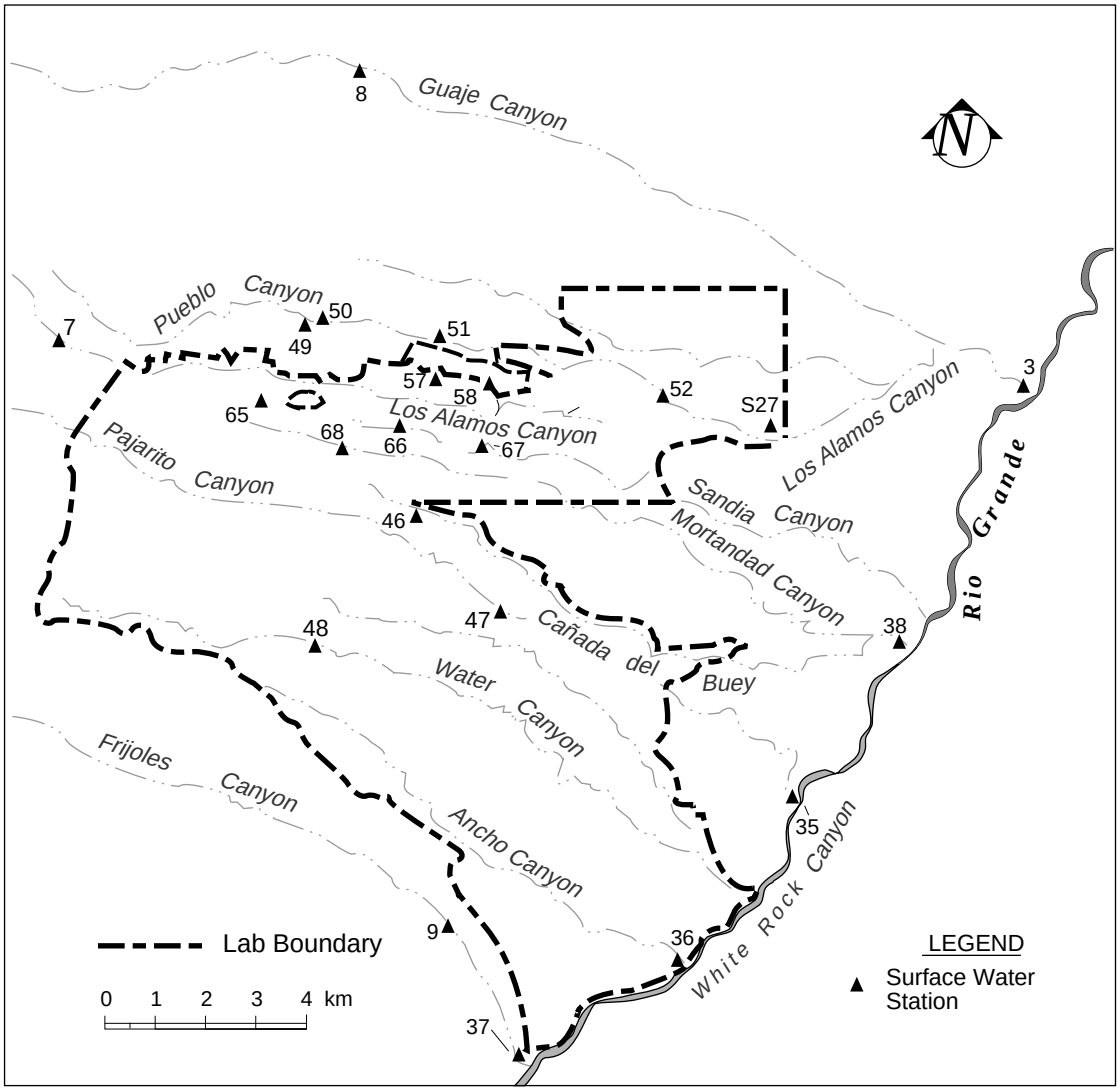

Figure V-12. Surface water sampling locations for off-site perimeter and on-site Laboratory sites. (Map denotes general locations only. See Table D-13 for specific locations.)

(41 ac ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for recreation and limited storage of water for irrigation of landscaping in the townsite.

The station in Guaje Canyon is below Guaje Reservoir, which is located in upper Guaje Canyon and has a capacity of 871 m^3 (0.7 ac-ft) and a drainage area above the intake of about 14.5 km^2 (5.6 mi^2). Flow into the reservoir is maintained by perennial springs. The stream and reservoir are used for recreation and for storing water used for landscape irrigation in the townsite.

Surface water flow in Frijoles Canyon is sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. The drainage area above the monument headquarters is about 44 km^2 (17 mi^2) (Purtymun 1980a). Surface flow in Frijoles Canyon is also sampled at the confluence with the Rio Grande.

There are two other off-site perimeter stations in White Rock Canyon along the Rio Grande just east of the Laboratory. These include the perennial reach of the stream in Pajarito Canyon (fed from Group I springs [see Section VII for additional information]), and the continual flow of treated sanitary effluent (from the community of White Rock) in Mortandad Canyon at its confluence with the Rio Grande.

On-Site Stations.

Radioactive Effluent Areas. On-site effluent release areas are canyons that receive, or have received, effluents containing radioactivity, including Pueblo, DP, Los Alamos, and Mortandad canyons (see Figure II-4 for location of on-site canyons).

As noted above in the section describing off-site radioactive effluent areas, the portion of lower Pueblo Canyon that is on DOE land contains sediments contaminated with residuals from past discharges into Acid Canyon. (See Section V.B.5 for related information.) Surface flow is presently maintained across the DOE land in Pueblo Canyon by discharge of effluent from the Los Alamos County Bayo sanitary sewage treatment plant located just west of the Los Alamos County-DOE boundary. Some of this effluent flow infiltrates the tuff and maintains a shallow body of perched alluvial water. (See Section VII for further information.) Pueblo Canyon discharges into Los Alamos Canyon at State Road 502 near the eastern Laboratory boundary. Surface water is sampled at Pueblo 3 and at State Road 502 (Figure V-12).

DP Canyon, a small tributary of Los Alamos Canyon, received treated radioactive liquid waste effluents between 1952 and 1984. Some residuals remain, primarily associated with sediments that are subject to resuspension and redissolution in surface flow. DP Canyon presently receives some sanitary effluent from the treatment plant at TA-21. Sampling stations consist of two surface water stations in DP Canyon, DPS-1 and DPS-4.

In the upper reach of Los Alamos Canyon (above Station LAO-1), there were releases of treated and untreated radioactive effluents during the earliest years of operations at TA-1 (late 1940s) and some release of water from the research reactor at TA-2. The Los Alamos Canyon drainage also received discharge containing some radioactivity in previous years from the sanitary sewage lagoon system at LAMPF (TA-53). (In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon.) There is normally some surface flow in the westernmost portion of Los Alamos Canyon within Laboratory boundaries that is maintained by discharge from the Los Alamos Reservoir. This flow generally infiltrates the shallow alluvium in the canyon and is depleted before it reaches the eastern margin of the Laboratory at State Road 4. Water quality in this portion of Los Alamos Canyon is monitored through samples taken of the alluvial water. (See Section VII for further information.) Snowmelt will often saturate the alluvium sufficiently to result in some surface flow beyond State Road 4 for varying periods in the spring. In the fall of 1991, the Laboratory resumed continuous operation of a stream flow gaging station a short distance upstream from State Road 4.

Mortandad Canyon has a small drainage area that heads at TA-3. Industrial liquid wastes containing radionuclides are collected and processed at the industrial waste treatment plant at TA-50, which began operating in 1963. After treatment, the effluents are released into Mortandad Canyon. Most of the residual contamination is now associated with the sediments in the canyon. The inventory of TRU contaminants (about 400 μCi) is entirely contained on site (Stoker 1991). Hydrologic studies in the canyon were initiated by the USGS in 1960. Since that time, there has been no known continuous surface water flow from the upper and middle reaches of the canyon down to or beyond the Laboratory's boundary; the small drainage area in the upper part of the canyon results in limited runoff and a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of runoff when it does occur. One surface water station, Gaging Station 1 (GS-1) is located in Mortandad Canyon a short distance downstream from the effluent release point. Most water quality observations in Mortandad

Canyon are made on the alluvial water. (See Section VII for further information.) Three sediment traps are located about 3 km (2 mi) downstream from the effluent discharge in Mortandad Canyon to dissipate the energy of major thunderstorm runoff events and settle out transported sediments. It is approximately another 2.3 km (1.4 mi) downstream to the Laboratory boundary with the Pueblo of San Ildefonso .

Other Areas. Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives water from the cooling tower at the TA-3 power plant and treated effluents from the TA-3 sanitary treatment plant. These effluents support a continuous flow in a short reach of the upper canyon, but only during summer thundershowers does stream flow reach the Laboratory boundary at State Road 4, and only during periods of heavy thunderstorms or snowmelt does surface flow from Sandia Canyon extend beyond Laboratory boundaries or reach the Rio Grande. Three surface water sampling stations, SCS-1, SCS-2, and SCS-3, are located in the reach of the canyon that contain flow maintained by the effluents.

Surface water samples are collected in three other on-site canyons: Cañada del Buey, Pajarito, and Water (at Beta Hole). The flows at these locations are primarily maintained by effluents but do include some natural flows. Spring-supported perennial flows in Water and Ancho canyons are sampled at the DOE boundary where these streams join the Rio Grande.

c. Radiochemical Analytical Results. The results of radiochemical analyses of surface water samples for 1994 are listed in Table V-20. All results are below the DOE DCGs that limit potential exposure to the public from ingestion of water to levels below the DOE public dose limit (PDL) (see Appendix A). The majority of the results are near or below the detection limits of the analytical methods used. Most of the measurements at or above detection limits are from locations with previously known contamination: Acid-Pueblo Canyon, DP-Los Alamos Canyon, and Mortandad Canyon.

A few of the measurements at or above detection limits were from locations that do not typically show detectable activity. This year, the ^{241}Am analyses for Chaquehui Canyon at the Rio Grande and for Frijoles at Rio Grande were slightly above detection limits. The tritium level in this year's sample from Frijoles Stream at the Rio Grande is slightly above detection limit levels, but several orders of magnitude below the DOE DCG.

Measurements of radioactivity in surface water runoff in Pueblo and Los Alamos canyons, as well as several additional locations, are presented in Table V-21. Samples collected on May 16, 1994, were analyzed for the dissolved concentrations of radioactivity in solution, while analyses of runoff waters collected on May 20, 1994, were additionally made on the suspended solids filtered from the water samples. (Radioactivity in solution refers to the filtrate that passes through a 0.45-μm-pore-size filter; radioactivity on suspended sediments refers to the residue retained by the filter.) This was done in order to estimate the fraction of activity associated with the liquid and suspended solid fractions.

Nearly all of the dissolved radioactity measurements of runoff are below detection limits. Runoff from Los Alamos and Pueblo Canyons are slightly elevated in the dissolved concentrations of tritium and ^{137}Cs, in comparison with the canyons that have not received radioactive effluent discharges (Frijoles, Pajarito and Sandia Canyons). Although the concentrations of ^{137}Cs downstream of radioactive effluent areas appear to be elevated approximately 10 times above-background levels, they are less than 25% of the DOE guide for ^{137}Cs for ingested water.

In recent years, treated effluents containing low levels of radioactivity have been released from the central liquid waste treatment plant (TA-50), from a smaller plant serving laboratories at TA-21, and from a sanitary sewage lagoon system serving LAMPF at TA-53 (Table V-6). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. In 1994, there were no releases from the TA-21 plant or the TA-53 total retention lagoons. Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon, where effluent affected surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

d. Long-Term Trends. Long-term trends of the concentrations of dissolved radionuclide (the portion of the sample that passes through a 0.45-micron membrane filter) in surface water in Pueblo Canyon (a former release area) are depicted in Figure V-13. These measurements were made on samples collected at station Pueblo 3, which is a short distance upstream of the confluence of Pueblo and Los Alamos canyons. This is taken to be representative of the surface water flow that moves off site into the lower reach of Los Alamos Canyon on Pueblo of San Ildefonso. In general, there has been a decrease in the combined levels of ^{238}Pu and ^{239,240}Pu (in solution) over three and a half decades. With continual improvements in detection limits, it is still possible for some

Table V-20. Radiochemical Analysis of Surface Water for 1994

LOCATION	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu (pCi/L)	^{239,240}Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
OFF-SITE STATIONS										
REGIONAL STATIONS										
Rio Chama at Chamita	0.0 (0.3)[a]	0.5 (0.7)	1.0 (0.5)	0.7 (0.1)	-0.019 (0.030)	-0.021 (0.020)	0.028 (0.030)	2 (2)	37 (4)	30 (50)
Rio Grande at Embudo	0.1 (0.3)	0.4 (0.7)	1.9 (0.7)	1.6 (0.2)	0.012 (0.030)	0.033 (0.020)	0.004 (0.030)	4 (1)	18 (2)	60 (50)
Rio Grande at Otowi	0.1 (0.3)	0.1 (0.7)	<0.6[b]	2.4 (0.2)	-0.014 (0.030)	0.035 (0.022)	N/A [c]	3 (1)	5 (1)	20 (50)
Rio Grande at Frijoles	0.2 (0.3)	-0.2 (0.7)	<0.8	0.2 (0.0)	0.012 (0.030)	0.042 (0.020)	0.054 (0.030)	-0 (0)	1 (0)	180 (50)
Rio Grande at Cochiti	0.0 (0.3)	0.3 (0.8)	1.9 (0.7)	1.6 (0.2)	-0.017 (0.030)	-0.014 (0.020)	0.017 (0.030)	3 (1)	11 (1)	10 (50)
Rio Grande at Bernalillo	-0.2 (0.3)	0.5 (0.7)	1.5 (0.8)	2.0 (0.2)	0.018 (0.030)	-0.006 (0.020)	0.011 (0.030)	3 (1)	10 (1)	30 (50)
Jemez River	0.1 (0.3)	0.7 (0.8)	<1.4	1.2 (0.1)	0.012 (0.030)	0.017 (0.020)	0.040 (0.030)	13 (3)	19 (2)	-10 (50)
PERIMETER STATIONS										
Acid-Pueblo Canyons										
Acid Weir	0.3 (0.3)	6.0 (0.7)	<1.3	0.8 (0.1)	0.037 (0.030)	1.962 (0.138)	0.170 (0.030)	2 (1)	7 (1)	10 (50)
Pueblo 1	0.4 (0.3)	0.5 (0.8)	0.7 (0.4)	0.0 (0.0)	-0.004 (0.030)	-0.005 (0.020)	N/A	2 (1)	4 (1)	-10 (50)
Los Alamos Canyon										
Los Alamos Canyon Reservoir	-0.2 (0.3)	0.0 (0.7)	<1.0	0.1 (0.0)	0.029 (0.019)	0.005 (0.012)	0.034 (0.014)	0 (0)	1 (0)	70 (50)
Other Areas										
Pajarito at Rio Grande	0.5 (0.3)	2.1 (8.5)	1.5 (0.6)	0.9 (0.2)	-0.005 (0.030)	0.010 (0.020)	0.037 (0.030)	0 (1)	3 (1)	40 (50)
Frijoles at Monument HQ	<0.0 (0.1)	N/A	<1.9	N/A	0.006 (0.007)	<0.002 (0.003)	N/A	2 (2)	0 (2)	N/A
Frijoles at Rio Grande	0.8 (0.3)	-0.2 (0.6)	1.7 (0.8)	1.0 (0.2)	0.010 (0.030)	-0.004 (0.020)	0.026 (0.030)	25 (5)	3 (0)	200 (50)
Chaquehui at Rio Grande	0.3 (0.3)	1.9 (0.8)	<1.1	1.4 (0.1)	0.020 (0.030)	0.029 (0.020)	0.060 (0.030)	2 (1)	2 (0)	0 (50)
ON-SITE STATIONS										
Mortandad Canyon										
Mortandad at GS-1	2.9 (0.5)	10.2 (0.7)	5.7 (1.4)	0.5 (0.1)	0.465 (0.052)	0.162 (0.030)	0.533 (0.059)	3 (1)	35 (4)	50 (50)
DP-Los Alamos Canyons										
DPS-1	0.2 (0.3)	6.5 (0.8)	1.4 (0.3)	0.2 (0.0)	0.028 (0.030)	0.054 (0.020)	0.525 (0.058)	2 (1)	20 (2)	20 (50)
DPS-4	0.3 (0.3)	0.4 (0.7)	1.2 (0.4)	1.1 (0.2)	0.009 (0.030)	0.044 (0.020)	0.070 (0.030)	0 (2)	46 (5)	80 (50)
Los Alamos at Gaging Station 1	0.6 (0.1)	N/A	<1.9	N/A	0.015 (0.012)	0.009 (0.010)	N/A	2 (3)	12 (4)	N/A
Los Alamos at SR 4	0.3 (0.1)	N/A	<1.6	N/A	0.005 (0.008)	0.005 (0.011)	N/A	3 (3)	15 (4)	N/A
Other Areas										
Cañada Del Buey	0.3 (0.3)	1.1 (0.8)	N/A	0.3 (0.1)	0.007 (0.030)	0.008 (0.020)	0.023 (0.030)	2 (1)	6 (1)	-10 (50)
Pajarito Canyon	<0.1 (0.1)	N/A	<1.7	N/A	0.001 (0.009)	0.001 (0.004)	N/A	1 (3)	3 (3)	N/A
Ancho at Rio Grande	0.3 (0.3)	0.9 (0.7)	<1.0	0.3 (0.1)	0.005 (0.030)	0.005 (0.020)	0.043 (0.030)	0 (0)	2 (0)	80 (50)

Table V-20. Radiochemical Analysis of Surface Water for 1994 (Cont.)

LOCATION	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu (pCi/L)	^{239,240}Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
ON-SITE STATIONS (Cont.)										
Sandia Canyon										
SCS-1	0.4 (0.3)	0.3 (0.9)	<0.8	0.5 (0.1)	0.006 (0.030)	0.012 (0.020)	0.017 (0.014)	-1 (1)	10 (1)	40 (50)
SCS-2	0.3 (0.3)	0.1 (0.7)	<1.0	0.8 (0.2)	0.017 (0.030)	0.002 (0.020)	0.066 (0.023)	1 (1)	10 (1)	0 (50)
SCS-3	0.0 (0.3)	0.1 (0.6)	<1.1	1.0 (0.1)	-0.001 (0.030)	0.028 (0.020)	0.062 (0.024)	1 (1)	9 (1)	-20 (50)
Sandia st SR4	0.1 (0.1)	N/A	<1.8	N/A	<0.002 (0.007)	0.002 (0.005)	N/A	0 (2)	1 (3)	N/A
Limits of Detection	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose [d]	2000	1000	3000	800	40	60	30			
DOE Drinking Water System DCG [d]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard [d]	20	8		20				15		
EPA Screening Level [d]									50	

[a]Radioactivity counting uncertainties are shown in parentheses.
[b]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[c]N/A means analysis not performed, lost in analysis or not completed.
[d]Standards given here for comparison only, see Appendix A.

Table V-21 Radiochemical Analysis of Spring Runoff Surface Water in 1994

Location Date	Tritium (nCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu Aqueous (pCi/L)	^{238}Pu Suspended (pCi/g)	^{239}Pu Aqueous (pCi/L)	^{239}Pu Suspended (pCi/g)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
OFF-SITE PERIMETER STATIONS										
Los Alamos Canyon										
Los Alamos Canyon Reservoir										
05/16	0.3 (0.3)[a]	1.3 (5.4)	0.1 (0.0)	0.001 (0.030)	N/A[b]	-0.001 (0.020)	N/A	1 (0)	3 (0)	50 (60)
DP-Los Alamos Canyons										
Los Alamos at Totavi										
05/16	0.6 (0.3)	28.5 (12.6)	0.8 (0.1)	0.003 (0.030)	N/A	0.011 (0.020)	N/A	1 (1)	11 (1)	20 (60)
Other Areas										
Frijoles at Monument HQ										
05/20	0.0 (0.1)	<1.9[c]	N/A	0.006 (0.007)	N/A	-0.002 (0.003)	N/A	2 (2)	0 (2)	N/A
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Pueblo Canyon at Gaging Station										
05/16	0.2 (0.3)	21.0 (13.3)	0.5 (0.1)	0.001 (0.030)	N/A	0.014 (0.020)	N/A	1 (1)	16 (2)	140 (60)
DP-Los Alamos Canyons										
Los Alamos At Gaging Station										
05/16	0.6 (0.3)	15.2 (11.8)	0.4 (0.1)	0.006 (0.030)	N/A	0.083 (0.020)	N/A	2 (1)	8 (1)	50 (60)
05/20	0.3 (0.1)	<1.0	<1.0	0.009 (0.95)	0.182 (0.019)	0.006 (0.085)	2.034 (0.077)	1 (4)	13 (7)	N/A
05/25	0.6 (0.1)	<1.9	N/A	0.015 (0.012)	N/A	0.009 (0.009)	N/A	2 (2)	12 (3)	N/A
Los Alamos at State Route 4										
05/20	0.3 (0.1)	<1.6 (0.0)	N/A	0.005 (0.008)	0.119 (0.006)	0.005 (0.011)	1.986 (0.075)	3 (3)	15 (4)	N/A
Other Areas										
Pajarito Canyon										
05/20	-0.05 (0.1)	<1.7	N/A	0.001 (0.009)	0.012 (0.016)	0.001 (0.004)	0.041 (0.022)	1 (3)	3 (3)	N/A
Sandia Canyon										
Sandia at State Route 4										
05/20	0.1 (0.1)	<1.8	N/A	-0.002 (0.007)	0.007 (0.002)	0.002 (0.005)	0.035 (0.003)	0 (2)	1 (3)	N/A

[a]Radioactivity counting uncertainties are shown in parentheses.

[b]N/A means analysis not performed, lost in analysis, or not completed.

[c]Less than (<) means measurement was below the specified unit of detection of the analytical method.

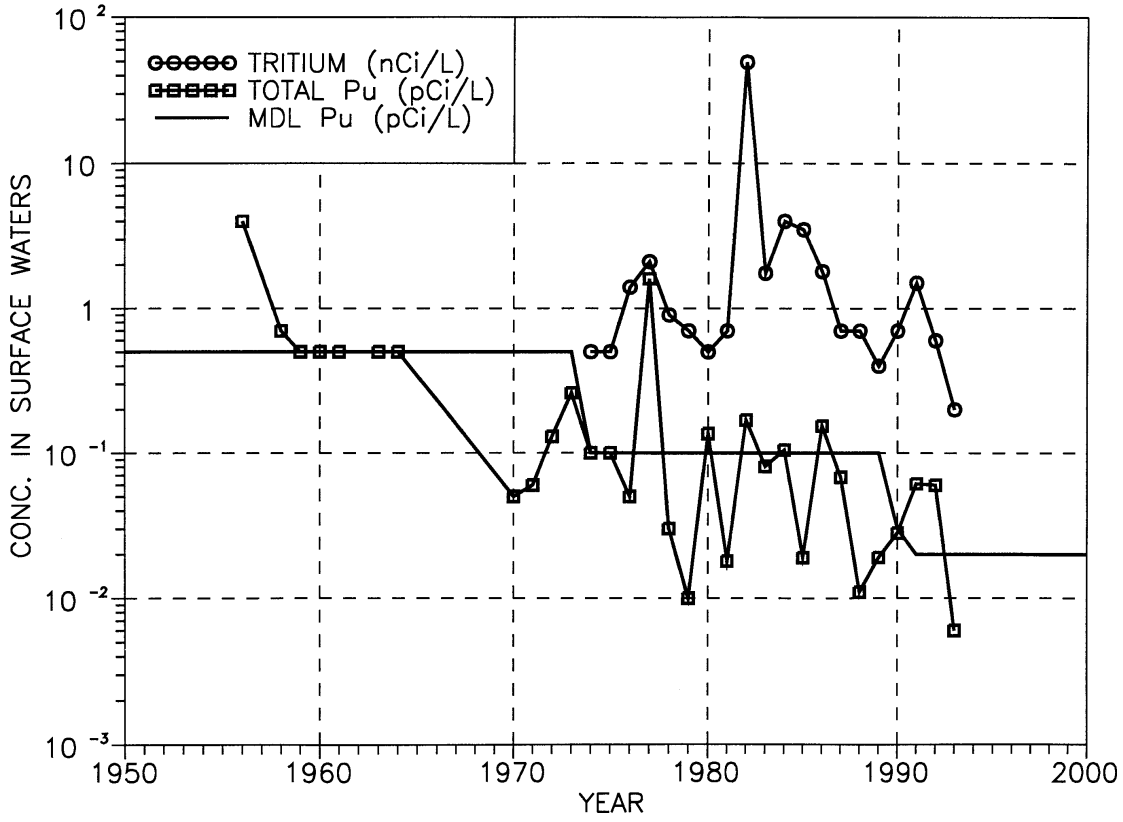

Figure V-13. Tritium and plutonium concentrations at the Pueblo-3 sampling station.

residuals to be detected. Except for an unexplained peak in 1982, tritium concentrations have fluctuated from near the detection limit of the analytical methods to several times the levels typically observed in regional surface waters. Transport of radioactivity occurs primarily as sediments are suspended and moved by the surface water flow. This aspect of off-site transport from Pueblo Canyon into Los Alamos Canyon is described in the following section covering sediment and soil monitoring.

4. Drinking Water.

This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems and from the Laboratory's water supply wellhead to ensure compliance with the federal Safe Drinking Water Act (SDWA) (40 CFR 141).

When gross alpha and beta activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations. In 1994 the concentrations of gross alpha activity were less than the screening level of 5 pCi/L, and the concentrations of gross beta activity measurements were less than the screening limit of 50 pCi/L. These results are summarized in Table V-22. It should be noted that gross alpha and beta monitoring of the water supply wells is also conducted by the Laboratory's Environmental Surveillance Program (See Table VII-1 of this report).

Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. In 1994, radon sampling was performed at wellheads and points of entry of water from the two well fields into the distribution system. This sampling was done to collect information before the issuance of final EPA regulations governing radon in drinking water. As shown in Table V-23, the radon concentrations ranged from 188 to

Table V-22. Radioactivity in Drinking Water (pCi/L)

Sample Location Calibration Standard	Gross Alpha Value	 (Uncertainty)	Gross Beta Value	 (Uncertainty)
ENTRY POINTS				
Pajarito Booster #2				
^{241}Am	0.50	(0.40)		
Natural U	0.50	(0.40)		
^{137}Cs			1.60	(1.00)
^{90}Sr, ^{90}Y			1.60	(1.00)
Guaje Booster #2				
^{241}Am	0.80	(0.40)		
Natural U	0.90	(0.40)		
^{137}Cs			2.40	(1.00)
^{90}Sr, ^{90}Y			2.40	(1.00)
Pajarito Well Field PM-1				
^{241}Am	2.60	(0.70)		
Natural U	3.00	(0.80)		
^{137}Cs			5.10	(1.20)
^{90}Sr, ^{90}Y			4.80	(1.10)
Pajarito Well Field PM-3				
^{241}Am	1.30	(0.50)		
Natural U	1.50	(0.60)		
^{137}Cs			3.50	(1.30)
^{90}Sr, ^{90}Y			3.20	(1.20)
WELLHEADS				
Pajarito Well Field PM-1				
^{241}Am	3.80	(1.20)		
Natural U	4.80	(1.40)		
^{137}Cs			3.80	(1.10)
^{90}Sr, ^{90}Y			3.70	(1.00)
Pajarito Well Field PM-2				
^{241}Am	0.70	(0.40)		
Natural U	0.70	(0.40)		
^{137}Cs			0.60	(0.80)
^{90}Sr, ^{90}Y			0.60	(0.80)
Pajarito Well Field PM-3				
^{241}Am	0.20	(0.50)		
Natural U	0.30	(0.60)		
^{137}Cs			3.40	(0.90)
^{90}Sr, ^{90}Y			3.20	(0.90)
Pajarito Well Field PM-4				
^{241}Am	0.20	(0.30)		
Natural U	0.20	(0.30)		
^{137}Cs			2.80	(1.00)
^{90}Sr, ^{90}Y			2.80	(0.90)
Pajarito Well Field PM-5				
^{241}Am	1.20	(0.50)		
Natural U	1.30	(0.50)		
^{137}Cs			2.10	(1.00)
^{90}Sr, ^{90}Y			2.10	(1.00)

Table V-22. Radioactivity in Drinking Water (pCi/L) (Cont.)

Sample Location	Gross Alpha		Gross Beta	
Calibration Standard	**Value**	**(Uncertainty)**	**Value**	**(Uncertainty)**
Guaje Well Field G-1				
^{241}Am	0.20	(0.20)		
Natural U	0.20	(0.30)		
^{137}Cs			2.70	(0.70)
^{90}Sr, ^{90}Y			2.60	(0.60)
Guaje Well Field G-1A				
^{241}Am	0.00	(0.30)		
Natural U	0.00	(0.40)		
^{137}Cs			1.90	(0.90)
^{90}Sr, ^{90}Y			1.90	(0.90)
Guaje Well Field G-2				
^{241}Am	1.00	(0.50)		
Natural U	1.20	(0.60)		
^{137}Cs			2.00	(1.10)
^{90}Sr, ^{90}Y			1.90	(1.00)
Guaje Well Field G-6				
^{241}Am	0.70	(0.40)		
Natural U	0.70	(0.40)		
^{137}Cs			2.40	(0.90)
^{90}Sr, ^{90}Y			2.40	(0.90)
Maximum Contaminant Level	15.00		[a]	
EPA Screening Action Limit	5.00		50.00	

[a]MCL for gross beta is a dose limit of 4 mrem/yr.

Table V-23. Radon in Drinking Water (pCi/L)

Sample Location	Value	(Uncertainity)
ENTRY POINTS		
Pajarito Booster #2	461.	19.
Guaje Booster #2	188.	14.
Pajarito Well Field PM-1	254.	17.
Pajarito Well Field PM-3	256.	17.
WELL HEADS		
Pajarito Well Field PM-1	262.	18.
Pajarito Well Field PM-2	629.	36.
Pajarito Well Field PM-3	293.	20.
Pajarito Well Field PM-4	529.	22.
Pajarito Well Field PM-5	499.	29.
Guaje Well Field G-1A	372.	16.
Guaje Well Field G-1	393.	23.
Guaje Well Field G-2	408.	24.
Guaje Well Field G-6	366.	22.
Proposed EPA Maximum Contaminant Level		300

629 pCi/L. If the MCL is finalized at the proposed 300 pCi/L level, waters from some well fields may need radon treatment by extended storage to allow radioactive decay or adsorption removal. Radon has a half-life of about 12 days; residence time in storage tanks will reduce radon concentrations before the water reaches consumers.

5. Sediment Monitoring.

a. Introduction. Sediments from off-site (regional and perimeter) and on-site (Laboratory and DOE land) locations are monitored to provide routine surveillance of environmental effects of Laboratory operations. One major mechanism of transport of contaminants is the hydrologic cycle, principally in sediments transported by surface waters. Sheet erosion of soils and the movement of suspended and bed load sediments in surface runoff or canyon stream channels are responsible for the transport of many substances. Many contaminants attach to soil and sediment particles by adsorption or ion exchange. Thus, contaminants from airborne deposition, effluent discharges, or unplanned releases often become associated with soils or sediments. Accordingly, soils are monitored at representative locations across the Laboratory, and sediments are sampled in all canyons, whether perennial or intermittent, that cross the Laboratory.

There are no standards directly applicable to radioactive contamination of soils or sediments. Instead, the levels of contaminants in soils or sediments must be interpreted by means of pathway analyses that determine the consequences in terms of dose to humans. These interpretations assume the contaminated particles are either ingested or inhaled. See Section V.C.2 (Methods for Dose Calculations) for further information. As an indication of environmental contamination levels attributable to Laboratory operations, the results of the annual sampling are compared to levels attributable to worldwide fallout or natural background. Results of analyses of radionuclides in soil and sediment samples from off-site regional stations routinely collected from 1974 through 1986 were used to establish statistical units for worldwide fallout levels of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$, and natural background levels of total uranium in northern New Mexico soils and sediments (Purtymun 1987a). The average concentration level in these samples plus twice the standard deviation of the mean was adopted as an indicator of an approximate upper limit for worldwide fallout or natural background concentration. Furthermore, the screening action levels (SALs) are used by the Laboratory's ER Project office to identify the presence of contaminants of concern at PRS. Both background concentration (i.e., mean plus twice the standard deviation as reported in Purtymun, 1987a) and SAL values for sediments are listed in tables summarizing analytical results for the environmental surveillance program. These values are intended for comparison to observed data and are provided as a convenience to the reader. Individual, media-specific, SAL values are derived from chemical-specific toxicity values and default exposure parameters using the most recently available data from the EPA Integrated Risk Information System (IRIS) database and Health Effects Assessment Summary Tables (HEAST) along with EPA guidance (EPA 1988) and the EPA's proposed computational methodology (EPA, 1990b). SALs for a variety of media are available for the Laboratory (IWP 1993) and some of the most recent updates are listed in Table V-24.

b. Monitoring Network. The sediment sampling locations are shown in Figure V-14 (off-site regional). Figure V-15 (off-site perimeter and on-site), and Figure V-16 a and b (solid waste management areas). These locations are also listed in Table D-14. The sediment stations are organized in the same groupings as the surface water sampling locations discussed in the surface water monitoring section, which provides the basic rationale for the groupings and related historic information.

Off-site Regional Stations. The regional stations for stream sediments are located in the three major drainages in northern New Mexico surrounding the Laboratory: the Rio Chama, the Rio Grande, and the Jemez River. Special samples of lake sediments are also collected from three different locations within each of three reservoirs. These reservoirs include Abiquiu Reservoir and Heron Lake on the Rio Chama upstream from Los Alamos, and Cochiti Reservoir on the Rio Grande downstream of Los Alamos. These three lakes are the nearest upstream and downstream lakes relative to the Laboratory. One kg samples of these sediments (100 times the mass usually employed) are used to obtain lower detection limits for ^{238}Pu and $^{239,240}Pu$ analyses. Large samples increase the sensitivity of the analyses and are necessary so that plutonium concentrations due to worldwide fallout from atmospheric tests can be effectively evaluated.

Off-site Perimeter Stations. Sediment sampling stations for the radioactive effluent release areas are located to monitor off-site drainages effected by transport of residuals from past releases, as discussed in the previous section. The off-site areas in Acid-Pueblo Canyons contain an estimated 150 mCi of plutonium from

Table V-24. Radioactivity in Sediments for 1994

Location	Tritium (nCi/L)		^{90}Sr (pCi/g)		^{137}Cs (pCi/g)		Total Uranium (mg/g)		^{238}Pu (pCi/g)		^{239,240}Pu (pCi/g)		^{241}Am (pCi/g)		Gross Alpha (pCi/g)		Gross Beta (pCi/g)		Gross Gamma (pCi/g)	
REGIONAL STATIONS																				
Regional																				
Chamita	0.2	(0.3)[a]	-1.7	(1.9)	0.1	(0.0)	1.0	0.4)	0.001	(0.030)	0.004	(0.020)	0.004	(0.030)	3	(1)	3	(0)	2	(0)
Rio Grande at Otowi	-0.3	(0.3)	0.2	(0.3)	7.7	(0.7)	1.5	(0.4)	0.000	(0.030)	0.001	(0.020)	0.004	(0.030)	2	(0)	1	(0)	-0	(0)
Rio Grande at Frijoles	0.3	(0.4)	0.4	(0.3)	0.0	(0.1)	2.0	(0.5)	0.005	(0.001)	0.005	(0.001)	0.008	(0.003)	2	(1)	1	(0)	3	(0)
Rio Grande at Bernalillo	-0.1	(0.3)	1.2	(0.2)	<0.0[b]		1.4	(0.3)	0.002	(0.030)	0.001	(0.020)	0.005	(0.030)	3	(1)	2	(0)	2	(0)
Jemez River	-0.6	(0.3)	0.1	(0.2)	<0.1		0.7	(0.1)	0.000	(0.030)	0.002	(0.020)	0.005	(0.030)	4	(1)	3	(0)	2	(0)
Rio Grande in White Rock Canyon																				
Rio Grande at Sandia	-0.4	(0.4)	0.0	(0.3)	0.0	(0.0)	2.7	(0.6)	0.008	(0.003)	0.011	(0.003)	0.003	(0.001)	4	(1)	3	(0)	4	(1)
Rio Grande at Pajarito	0.0	(0.4)	0.0	(0.4)	0.1	(0.0)	2.3	(0.4)	0.000	(0.001)	0.002	(0.001)	0.004	(0.001)	4	(1)	4	(1)	3	(0)
Rio Grande at Water	-0.1	(0.4)	0.2	(0.3)	0.1	(0.0)	3.3	(1.3)	0.001	(0.001)	0.009	(0.001)	0.004	(0.001)	7	(3)	6	(1)	4	(1)
Rio Grande at Ancho	-0.4	(0.4)	0.0	(4.1)	0.1	(0.0)	2.3	(0.7)	0.004	(0.001)	0.004	(0.001)	0.004	(0.001)	4	(1)	4	(1)	3	(0)
Rio Grande at Chaquehui	0.0	(0.4)	1.4	(3.5)	0.1	(0.0)	2.6	(0.5)	0.001	(0.001)	0.009	(0.001)	0.003	(0.001)	5	(1)	4	(1)	3	(0)
PERIMETER STATIONS (OFF SITE)																				
Acid-Pueblo Canyons																				
Acid Weir	0.3	(0.3)	0.4	(0.2)	0.3	(0.1)	1.6	(0.2)	0.054	(0.030)	11.800	(0.400)	0.330	(0.030)	11	(2)	3	(0)	1	(0)
Pueblo 1	-0.2	(0.3)	0.1	(0.2)	0.0	(0.0)	1.0	(0.1)	0.001	(0.030)	0.005	(0.020)	0.002	(0.030)	3	(1)	2	(0)	0	(0)
Pueblo 2	0.9	(0.7)	0.2	(0.3)	0.1	(0.0)	1.6	(0.4)	0.011	(0.002)	1.310	(0.060)	0.036	(0.004)	4	(1)	2	(0)	2	(0)
DP-Los Alamos Canyons																				
Los Alamos at Totavi	0.3	(0.3)	0.1	(0.2)	0.1	(0.0)	0.8	(0.1)	0.003	(0.030)	0.071	(0.020)	0.011	(0.030)	1	(0)	2	(0)	0	(0)
Los Alamos at LA-2	0.3	(0.3)	0.1	(0.4)	0.1	(0.0)	1.2	(0.1)	0.005	(0.030)	0.172	(0.020)	0.020	(0.030)	4	(1)	3	(0)	1	(0)
Los Alamos at Otowi	0.0	(0.0)	0.1	(0.2)	0.1	(0.0)	1.4	(0.2)	0.003	(0.030)	0.180	(0.020)	0.018	(0.030)	2	(1)	N/A[c]		1	(0)
Other Areas																				
Guaje At SR 4	0.1	(0.3)	0.1	(0.3)	<0.1		1.9	(0.2)	0.015	(0.030)	0.013	(0.020)	0.000	(0.030)	3	(1)	3	(0)	1	(0)
Bayo at SR 4	N/A		0.1	(0.1)	<0.0		2.2	(0.2)	0.008	(0.001)	0.005	(0.001)	0.003	(0.001)	2	(1)	2	(0)	2	(0)
Sandia at Rio Grande	-0.1	(0.4)	0.1	(0.3)	0.1	(0.0)	2.4	(0.8)	0.003	(0.006)	0.001	(0.006)	0.002	(0.001)	3	(1)	3	(0)	3	(0)
Cañada Ancha at Rio Grande	-0.1	(0.4)	0.1	(0.3)	0.0	(0.0)	2.2	(0.5)	0.004	(0.001)	0.001	(0.001)	0.000	(0.001)	4	(1)	4	(1)	3	(0)
Pajarito at Rio Grande	-0.1	(0.4)	0.0	(0.3)	0.0	(0.0)	1.3	(0.3)	0.001	(0.001)	0.002	(0.001)	0.003	(0.001)	1	(0)	1	(0)	2	(0)
Water at Rio Grande	-0.3	(0.4)	0.2	(0.3)	0.7	(0.1)	2.1	(0.7)	0.001	(0.001)	0.014	(0.003)	0.005	(0.003)	7	(3)	7	(1)	4	(1)
Ancho at Rio Grande	-0.3	(0.4)	0.8	(0.3)	0.2	(0.1)	4.8	(0.5)	0.023	(0.003)	0.010	(0.001)	0.004	(0.003)	17	(6)	10	(1)	4	(1)
Chaquehui at Rio Grande	3.3	(1.7)	0.2	(0.4)	0.1	(0.0)	1.4	(0.3)	0.004	(0.001)	0.006	(0.003)	0.003	(0.001)	3	(1)	3	(0)	3	(0)
Frijoles at Monument HQ	-0.2	(0.3)	0.1	(0.2)	0.1	(0.0)	1.5	(0.2)	0.004	(0.030)	0.006	(0.020)	0.003	(0.030)	4	(1)	5	(1)	2	(0)
Frijoles at Rio Grande	-0.2	(0.4)	0.1	(0.3)	0.0	(0.0)	1.5	(0.4)	0.000	(0.006)	0.007	(0.011)	0.000	(0.001)	2	(1)	1	(0)	2	(0)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
PERIMETER STATIONS (OFF SITE) (Cont.)										
Other Areas (Cont.)										
Sta 1 Sandia Can SI Seds	-0.1 (0.3)	-0.3 (0.6)	<0.0	1.4 (0.2)	0.001 (0.001)	0.002 (0.001)	0.006 (0.002)	3 (1)	2 (0)	1 (0)
Sta 2 Sandia Can SI Seds	1.9 (0.7)	0.3 (0.2)	0.0 (0.0)	2.4 (0.2)	<0.001	0.002 (0.004)	0.002 (0.001)	5 (1)	3 (0)	2 (0)
Sta 3 Sandia Can SI Seds	1.9 (0.7)	0.0 (0.2)	<0.0	1.7 (0.2)	0.002 (0.001)	0.002 (0.001)	0.003 (0.001)	3 (1)	2 (0)	1 (0)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	0.1 (0.4)	N/A	0.2 (0.1)	1.2 (0.1)	0.000 (0.000)	0.005 (0.001)	N/A	N/A	N/A	N/A
Mortandad A-7	-0.2 (0.3)	0.3 (0.2)	0.1 (0.0)	2.1 (0.2)	0.019 (0.003)	0.041 (0.004)	0.010 (0.002)	4 (1)	5 (1)	2 (0)
Mortandad A-8	1.1 (0.3)	0.3 (0.2)	0.2 (0.1)	3.6 (0.4)	0.025 (0.005)	0.013 (0.002)	0.005 (0.001)	8 (2)	6 (1)	3 (0)
Mortandad at SR-4 (A-9)	N/A	0.1 (0.4)	<0.0	2.1 (0.3)	0.003 (0.001)	0.002 (0.001)	0.004 (0.001)	3 (1)	3 (0)	2 (0)
Mortandad A-10	0.5 (0.3)	0.1 (0.2)	0.0 (0.0)	1.6 (0.2)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)	3 (1)	3 (0)	0 (0)
Mortandad at Rio Grande (A-11)	-0.3 (0.4)	0.2 (0.3)	0.1 (0.0)	2.3 (0.4)	0.006 (0.001)	0.007 (0.001)	0.003 (0.001)	4 (1)	3 (1)	2 (0)
Mortandad SI Sed										
Transect 94 COMP	0.3 (0.3)	0.8 (0.3)	0.3 (0.1)	3.8 (0.4)	0.001 (0.001)	0.015 (0.002)	0.005 (0.002)	10 (2)	8 (1)	3 (0)
ON-SITE STATIONS										
Acid-Pueblo Canyons										
Hamilton Bend Spring	0.0 (0.3)	0.2 (0.3)	0.1 (0.0)	1.1 (0.2)	0.015 (0.002)	0.852 (0.023)	0.043 (0.004)	3 (1)	2 (0)	2 (0)
Pueblo 3	-0.2 (0.3)	0.0 (0.2)	<0.1	1.3 (0.1)	0.008 (0.001)	0.257 (0.009)	0.010 (0.003)	2 (0)	2 (0)	1 (0)
Pueblo at State Route	0.2 (0.3)	5.0 (0.4)	<0.1	3.2 (0.7)	0.019 (0.004)	0.925 (0.022)	0.031 (0.005)	4 (1)	2 (0)	7 (1)
DP-Los Alamos Canyons										
DPS-1	0.1 (0.3)	1.0 (0.3)	1.9 (0.3)	1.0 (0.2)	0.043 (0.030)	0.155 (0.020)	0.250 (0.030)	2 (0)	5 (1)	3 (0)
DPS-4	-0.1 (0.3)	4.0 (0.6)	1.9 (0.3)	0.9 (0.1)	0.024 (0.030)	0.094 (0.020)	0.147 (0.030)	3 (1)	6 (1)	2 (0)
Los Alamos at Bridge	-0.4 (0.3)	0.2 (0.2)	0.0 (0.0)	1.7 (0.4)	0.002 (0.001)	0.003 (0.001)	0.005 (0.002)	2 (1)	2 (0)	1 (0)
Los Alamos at LAO-1	0.0 (0.0)	0.3 (0.2)	0.1 (0.0)	1.0 (0.2)	<0.000	0.063 (0.008)	0.187 (0.013)	2 (0)	1 (0)	1 (0)
Los Alamos at GS-1	0.0 (0.0)	0.2 (0.2)	1.1 (0.1)	0.8 (0.2)	0.016 (0.002)	0.110 (0.006)	0.101 (0.007)	2 (0)	2 (0)	2 (0)
Los Alamos at LAO-3	0.3 (0.4)	0.1 (0.2)	1.0 (0.1)	0.9 (0.2)	0.034 (0.003)	0.242 (0.009)	0.183 (0.009)	2 (1)	2 (0)	1 (0)
Los Alamos at LAO-4.5	0.0 (0.0)	0.1 (0.2)	1.2 (0.2)	1.1 (0.2)	0.024 (0.002)	0.164 (0.007)	0.187 (0.013)	3 (1)	3 (0)	2 (0)
Los Alamos at SR-4	N/A	0.2 (0.1)	0.6 (0.1)	1.9 (0.2)	0.014 (0.002)	0.091 (0.005)	0.072 (0.006)	4 (1)	4 (0)	3 (0)
Mortandad Canyon										
Mortandad Near CMR Bldg.	-0.1 (0.3)	0.1 (0.2)	<0.0	1.0 (0.2)	0.014 (0.030)	0.009 (0.020)	0.002 (0.030)	3 (1)	2 (0)	1 (0)
Mortandad West of GS-1	-0.1 (0.3)	0.1 (0.2)	0.1 (0.0)	0.9 (0.1)	0.005 (0.030)	0.004 (0.020)	0.002 (0.030)	1 (0)	1 (0)	0 (0)
GS-1	40.1 (2.0)	0.1 (0.2)	7.0 (0.6)	1.0 (0.1)	1.760 (0.042)	1.780 (0.043)	3.610 (0.360)	6 (1)	10 (1)	8 (1)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
ON-SITE STATIONS (Cont.)										
Mortandad Canyon (Cont.)										
Mortandad at MCO-5	22.7 (1.9)	1.7 (0.2)	14.2 (1.4)	1.0 (0.1)	2.770 (0.110)	7.800 (0.030)	7.990 (0.280)	22 (5)	24 (2)	14 (1)
Mortandad at MCO-7	9.4 (0.9)	1.0 (0.2)	12.0 (1.2)	1.2 (0.1)	1.390 (0.060)	4.330 (0.170)	5.190 (0.230)	17 (3)	18 (2)	14 (1)
Mortandad at MCO-9	-0.7 (0.4)	0.2 (0.2)	0.3 (0.1)	2.1 (0.2)	0.002 (0.001)	0.025 (0.002)	0.009 (0.002)	6 (1)	6 (1)	12 (1)
Mortandad at MCO-13 (A-5)[d]	-0.3 (0.4)	0.1 (0.3)	0.5 (0.1)	2.4 (0.3)	0.005 (0.002)	0.018 (0.003)	0.006 (0.003)	7 (1)	6 (1)	3 (1)
Other Canyons										
Sandia at SR-4	N/A	0.8 (0.2)	0.1 (0.0)	2.0 (0.2)	0.005 (0.001)	0.002 (0.001)	0.003 (0.002)	2 (1)	2 (0)	2 (0)
Cañada Del Buey at SR-4	N/A	0.1 (0.2)	<0.0	1.9 (0.2)	0.003 (0.001)	0.002 (0.001)	0.004 (0.001)	4 (1)	<3 (0)	2 (0)
Pajarito at SR-4	-0.1 (0.3)	0.2 (0.2)	0.2 (0.0)	2.7 (0.4)	0.010 (0.001)	0.009 (0.001)	0.004 (0.002)	5 (1)	7 (1)	3 (0)
Potrillo at SR-4	N/A	0.1 (0.2)	0.1 (0.0)	1.8 (0.2)	0.003 (0.001)	0.004 (0.001)	0.003 (0.002)	1 (0)	2 (0)	2 (0)
Fence at SR-4	-0.2 (0.3)	0.4 (0.2)	0.1 (0.0)	2.4 (0.2)	0.007 (0.001)	0.005 (0.001)	0.004 (0.002)	4 (1)	4 (0)	3 (0)
Water at SR-4	N/A	0.4 (0.2)	0.0 (0.0)	1.8 (0.2)	0.000 (0.001)	0.003 (0.001)	0.002 (0.002)	2 (1)	1 (0)	3 (0)
Indio at SR-4	0.1 (0.3)	0.3 (0.2)	0.2 (0.1)	1.2 (0.2)	0.002 (0.030)	0.004 (0.020)	0.002 (0.030)	3 (1)	3 (0)	3 (0)
Ancho at SR-4	N/A	0.1 (0.2)	<0.1	1.9 (0.2)	0.008 (0.002)	0.003 (0.001)	0.007 (0.003)	2 (0)	2 (0)	3 (0)
Ancho at Ancho Spring	N/A	0.1 (0.3)	0.0 (0.0)	2.1 (0.8)	0.003 (0.001)	0.005 0.003)	0.004 (0.001)	4 (1)	3 (1)	2 (0)
TA-54, Area G										
G-1	0.2 (0.3)	0.2 (0.2)	0.2 (0.1)	1.7 (0.2)	0.008 (0.030)	0.030 (0.020)	0.009 (0.002)	6 (1)	5 (1)	2 (0)
G-2	1.8 (0.4)	0.1 (0.2)	<0.1	0.6 (0.1)	0.002 (0.030)	0.003 (0.020)	0.002 (0.001)	3 (1)	3 (0)	1 (0)
G-3	0.8 (0.3)	0.4 (0.2)	0.4 (0.1)	1.6 (0.2)	0.011 (0.030)	0.016 (0.020)	0.009 (0.002)	6 (1)	5 (1)	2 (0)
G-4	4.3 (0.6)	0.2 (0.2)	0.1 (0.0)	0.8 (0.1)	0.007 (0.030)	0.019 (0.020)	0.014 (0.002)	3 (1)	3 (0)	2 (0)
G-5	2.0 (0.4)	0.0 (0.2)	0.2 (0.1)	1.4 (0.3)	0.009 (0.030)	0.067 (0.020)	0.023 (0.003)	4 (1)	3 (0)	2 (0)
G-6	0.8 (0.3)	0.5 (0.2)	0.6 (0.1)	1.5 (0.2)	0.014(0.030)	0.150 (0.020)	0.035 (0.003)	7 (1)	7 (1)	2 (0)
G-7	N/A	0.0 (0.2)	0.1 (0.0)	2.1 (0.2)	0.173 (0.030)	0.087 (0.020)	0.027 (0.003)	4 (1)	3 (0)	2 (0)
G-8	1.8 (0.6)	0.4 (0.2)	0.6 (0.1)	2.0 (0.2)	0.104 (0.030)	0.229 (0.020)	0.038 (0.003)	6 (1)	7 (1)	2 (0)
G-9	N/A	0.0 (0.2)	<0.1	0.4 (0.0)	0.003 (0.030)	0.004 (0.020)	0.003 (0.001)	2 (0)	2 (0)	-0 (0)
TA-49, Area AB										
AB-1	-0.2 (0.3)	0.4 (0.2)	0.3 (0.0)	2.4 (0.2)	0.003 (0.030)	0.017 (0.020)	0.011 (0.030)	7 (1)	6 (1)	2 (0)
AB-2	-0.1 (0.3)	0.4 (0.2)	<0.1	2.2 (0.3)	0.004 (0.030)	0.029 (0.020)	0.008 (0.030)	6 (1)	5 (1)	1 (0)
AB-3	0.0 (0.3)	0.3 (0.2)	0.3 (0.0)	2.6 (0.5)	0.031 (0.030)	1.606 (0.049)	0.420 (0.030)	4 (1)	5 (1)	2 (0)
AB-4	0.1 (0.3)	0.4 (0.3)	0.3 (0.0)	2.6 (0.3)	0.002 (0.030)	0.024 (0.020)	0.009 (0.030)	6 (1)	8 (1)	2 (0)
AB-4A	0.0 (0.3)	0.1 (0.2)	0.3 (0.3)	2.0 (0.2)	0.003 (0.030)	0.017 (0.020)	0.013 (0.030)	7 (1)	7 (1)	2 (0)
AB-5	-0.1 (0.3)	0.4 (0.2)	0.6 (0.0)	1.8 (0.2)	0.006 (0.030)	0.028 (0.020)	0.015 (0.030)	7 (2)	7 (1)	2 (0)

Table V-24. Radioactivity in Sediments for 1994 (Cont.)

Location	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
ON-SITE STATIONS (Cont.)										
Other Canyons (Cont.)										
AB-6	-0.3 (0.3)	0.1 (0.2)	0.3 (0.0)	2.2 (0.2)	0.004 (0.001)	0.013 (0.002)	0.007 (0.030)	8 (2)	7 (1)	2 (0)
AB-7	0.0 (0.3)	0.5 (0.2)	0.3 (0.0)	2.1 (0.2)	0.013 (0.002)	0.016 (0.002)	0.006 (0.030)	6 (1)	6 (1)	2 (0)
AB-8	0.1 (0.3)	0.1 (0.2)	<0.0	1.0 (0.1)	0.002 (0.001)	0.001 (0.001)	0.004 (0.030)	6 (1)	5 (1)	1 (0)
AB-9	-0.1 (0.3)	2.5 (0.2)	0.4 (0.0)	1.6 (0.2)	0.001 (0.001)	0.014 (0.002)	0.010 (0.030)	2 (0)	2 (0)	2 (0)
AB-10	0.0 (0.3)	0.2 (0.2)	0.4 (0.0)	1.9 (0.2)	0.002 (0.001)	0.013 (0.002)	0.008 (0.030)	7 (2)	7 (1)	2 (0)
AB-11	0.0 (0.3)	-0.3 (1.9)	0.3 (0.0)	1.9 (0.2)	0.006 0.030)	0.015 (0.020)	0.003 (0.030)	6 (1)	5 (1)	2 (0)
Background[e]		0.87	0.44	4.4	0.006	0.023				7.9
SAL[f]	20.0	5.9	4.0	95.0	20.0	18.0	17.0			

[a]Radioactivity counting uncertainties are shown in parentheses.

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

[c]N/A means analysis not performed, lost in analysis or not completed.

[d]Results averaged from more than one sample analysis

[e]W.D.Purtymun 1987a, standards given here for comparison only.

[f]Screening Action Level, Environmental Restoration Group 1994 FIMAD database; standards given here for comparison only.

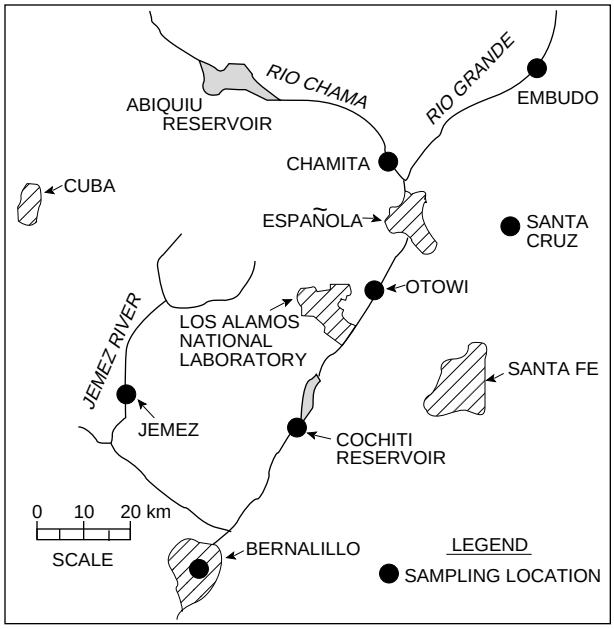

Figure V-14. Off-site regional sampling locations for sediments and soil. (Additional sediment samples are taken from the Rio Grande between Otowi and Cochiti, see Tables D-14 and D-15 and Figure V-15.)

effluent releases into Acid Canyon from 1944 through 1964 (ESG 1981). The three sampling stations include one in Acid Canyon at Acid Weir just above the confluence with Pueblo Canyon and two downstream in Pueblo Canyon at Stations Pueblo 1 and Pueblo 2.

The off-site portion of Los Alamos Canyon contains an estimated 30 mCi of plutonium. Table D-14 (See EARE 1995b) lists the three stations that are sampled routinely. Transport of contaminated sediments off-site is discussed in Section V.B.5.e (Transport of Radionuclides in Sediments for Surface Runoff). Canyons around the Laboratory, including those without perennial flow, have also been sampled.

Sediment samples have been collected in the off-site portion of Mortandad Canyon on Pueblo of San Ildefonso land so that conditions downgradient from the on-site residual contamination can be documented, as discussed in the surface water monitoring section. Also, sediment samples have been taken from the Rio Grande at confluences with major canyons that cross the Laboratory and adjacent public or Pueblo of San Ildefonso lands.

On-Site Stations. The on-site sediment stations are grouped into radioactive effluent release areas, solid waste management areas, and other areas.

The radioactive effluent release areas are the same as those used for the surface water stations. Transport of contaminated sediments off-site from Pueblo Canyon, transport of contaminated sediments within the on-site portion of Mortandad Canyon, and the sediment traps used for sampling are discussed in Section V.B.5.e (Transport of Radionuclides in Sediments from Surface Runoff). No off-site transport of contaminated sediments from Mortandad Canyon has ever been measured.

Sediments from natural drainages around two radioactive solid waste management areas are sampled to monitor transport of radioactivity from surface contamination. Nine sampling stations were established in 1982 outside the perimeter fence at TA-54, Area G (Figure V-16a), to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area. Some radionuclides are transported from the surface at TA-54, Area G in suspended or bed load sediments into channels that drain the area. This contamination is not related to the buried wastes in the pits and shafts; it is residual contamination on the land surface that occurred during earlier handling of the wastes.

From 1959 to 1961, hydronuclear experiments were conducted in underground shafts that ranged in depth from 15 to 36 m (49 to 118 ft) beneath the surface of the mesa at TA-49 (Purtymun 1987b, ESG 1988). The experiments involved a combination of conventional (chemical) high explosives usually in a nuclear weapons configuration. The quantity of fissile materials was kept far below the amount required for a nuclear explosion (Purtymun 1987b). The residuals of the experiments were confined in the shafts and left in place. The site is designated Solid Waste Management Area AB. A surface contamination incident occurred in 1960 during excavation of a shaft, and some erosional transport of radioactivity resulted (Purtymun 1987b, ESG 1988). Eleven sediment stations were established in 1972 to monitor surface sediments in natural drainages surrounding the experiment area. Another station (AB-4A) was added in 1981 as the drainage changed (Figure IV-16b). These sediment monitoring stations are sampled annually.

The other canyon areas group contains eight sediment sampling stations, which are located where the canyons intersect State Road 4. All Laboratory facilities in or adjacent to these canyons are located upgradient of this highway.

c. Radiochemical Analytical Results. The results of radiochemical analyses of sediment samples collected during 1994 from off-site (regional and perimeter) and on-site locations, including solid waste management areas,

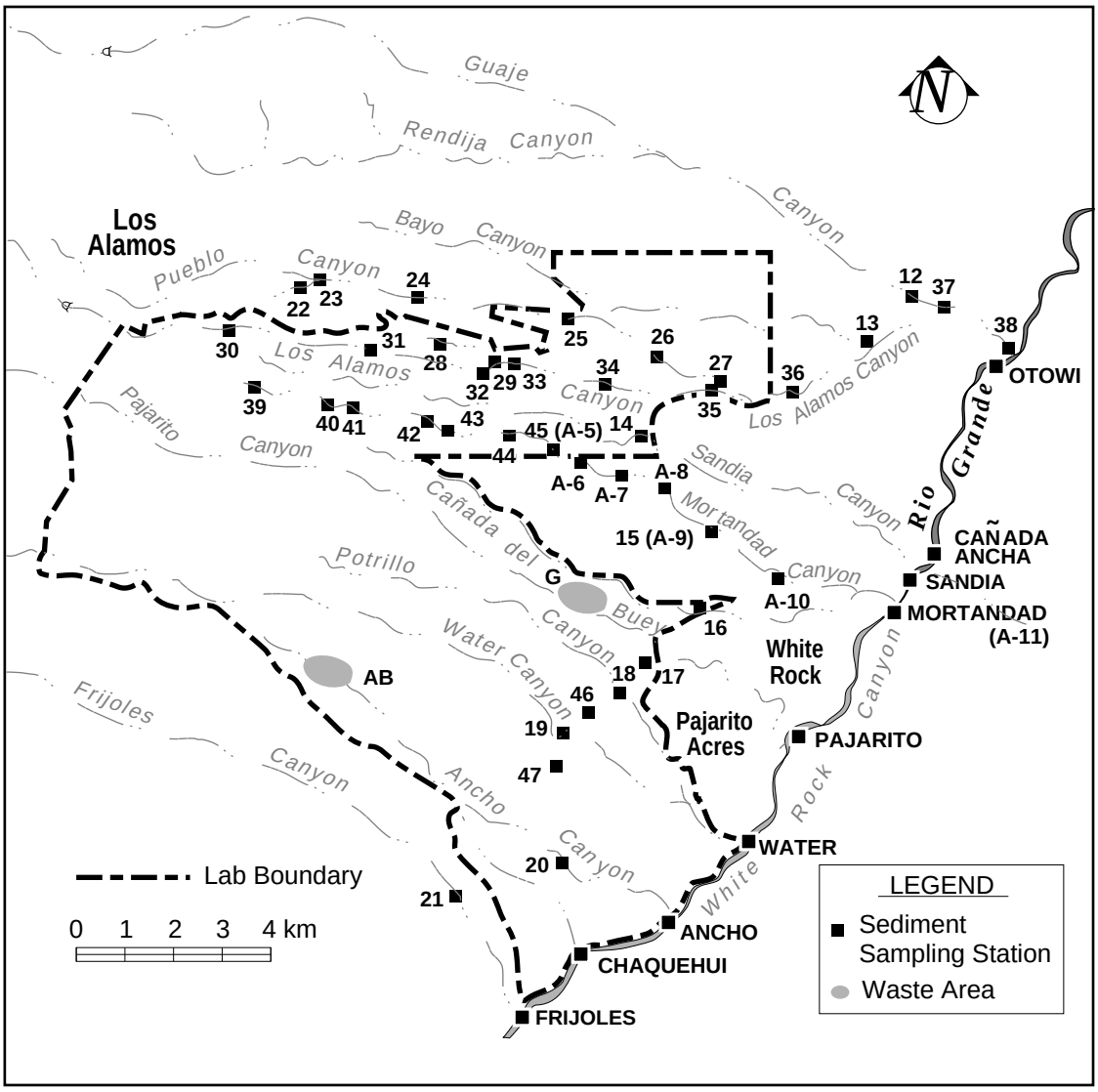

Figure V-15. Sediment sampling locations for off-site perimeter and on-site Laboratory stations. Solid waste management areas with multiple sampling locations are shown in Figure V-16. (Map denotes general locations only. See Table D-14 for specific coordinates).

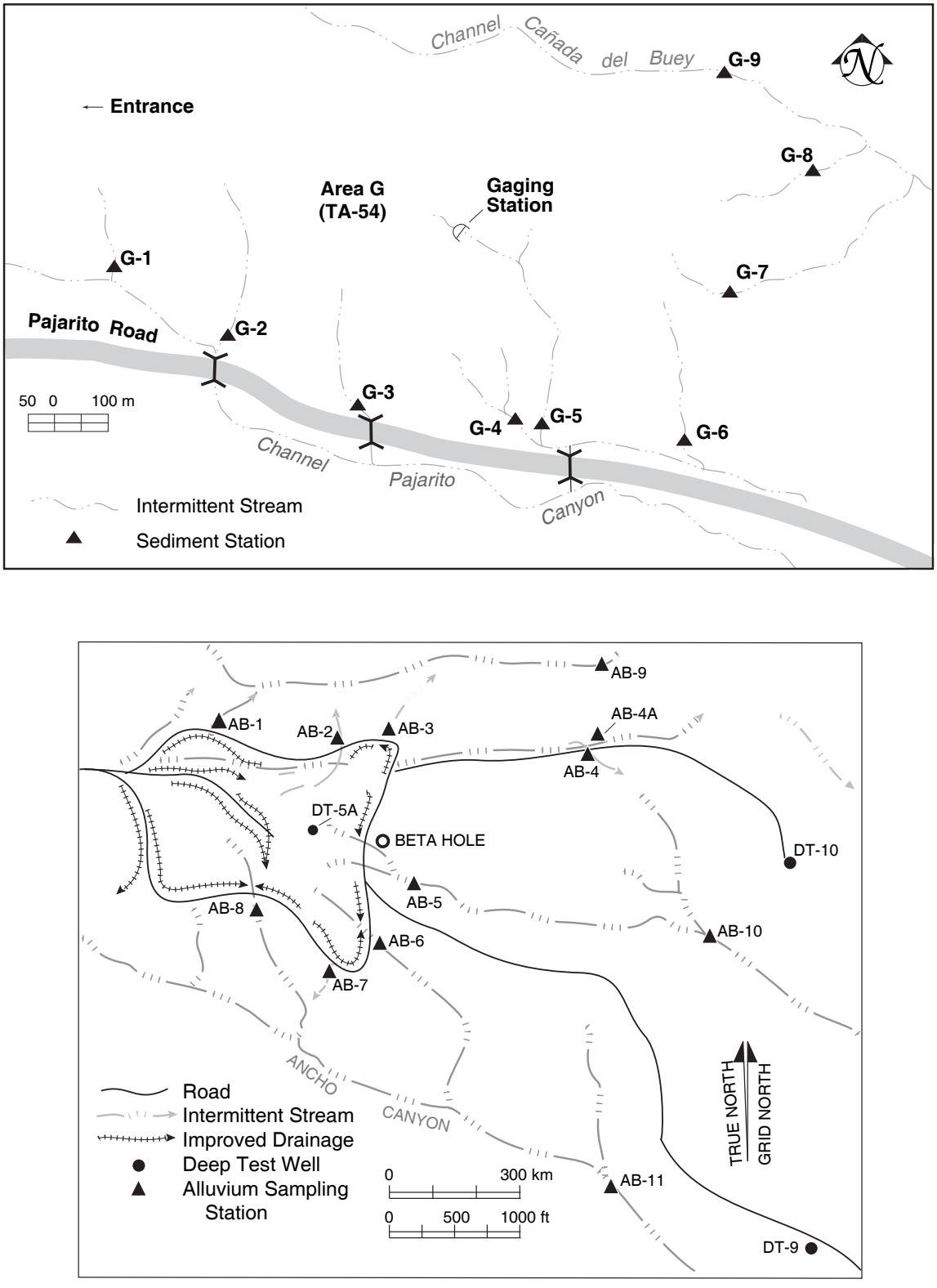

Figure V-16. Off-site perimeter and on-site sediment sampling locations on and near solid waste management areas.
a. Upper map shows the locations of alluvium sampling stations at TA-54, Area G.
b. Bottom map shows the location of sediment stations at TA-49, Area AB.

are listed in Table V-24. The majority of the sediment samples collected outside known radioactive effluent release areas were within the statistically derived reference levels that reflect activity attributable to worldwide fallout (Purtymun 1987a). These statistical limits are based on regional samples collected between 1974 and 1986, and are given as the level expected to be exceeded by about 1 in 40 samples taken from the same population. Each of these values is computed as the mean plus twice the standard deviation. These background reference levels, along with the respective SALs, are shown in Table V-24.

Many sediment samples from the known radioactive effluent release areas, both off-site and on-site, including Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons, exceeded worldwide fallout levels, as expected. The levels observed are consistent with previous data. However, none of the sediment samples collected in 1994 showed any concentration level that exceeded its respective SAL value.

Samples taken on San Ildefonso Pueblo land in Mortandad Canyon are discussed in detail in Section IV.C.4 (Environmental Studies at the Pueblo of San Ildefonso). As seen in Table V-24, only the samples from location A-7 and A-8 showed levels of ^{238}Pu and ^{239,240}Pu above the regional statistical reference levels for fallout.

For the regional stations, sediment samples from the Rio Grande at Bernalillo and Chaquehui showed ^{90}Sr somewhat above its background reference value. In addition, the sample from the Rio Grande at Otowi showed that ^{137}Cs was nearly 18 times larger than its background reference level. Finally, the ^{238}Pu value for the Rio Grande at Sandia slightly exceeded its background reference level. All of these variations, however, are consistent with data from previous years.

At the off-site perimeter stations, a number of sediment samples from Acid-Pueblo Canyon, DP-Los Alamos Canyon, and stations from other areas had ^{238}Pu and ^{239,240}Pu values above the background reference levels for these isotopes. Sediments from Water Canyon at the Rio Grande showed slightly elevated total uranium in comparison to its established background reference level. However, all of these values are consistent with historic data. In addition, several samples in this group had elevated ^{241}Am and gross alpha values, even though there are no established background reference levels for these parameters.

For the on-site stations, all of the sediment samples in Acid-Pueblo Canyons showed ^{238}Pu and ^{239,240}Pu values above the respective background reference levels. In DP-Los Alamos Canyons, a number of stations exceeded background reference levels for ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu. In addition, several of these samples showed elevated ^{241}Am values. In Mortandad Canyon, a number of stations exceeded background reference levels for ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu and gross gamma; furthermore tritium, ^{241}Am gross alpha, and gross beta levels were elevated, even though there are no established background reference levels for these parameters. At TA-54 Area G, a number of stations exceeded background reference levels for ^{137}Cs, ^{238}Pu and ^{239,240}Pu. In addition some of these stations also showed elevated tritium values. At TA-49 Area AB, several stations exceeded the ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu background reference levels, while station AB-3 showed slightly elevated ^{241}Am levels, even though there are no comparison standards for this isotope. In summary, all of the 1994 sediment samples appeared to be consistent with previous years results. Furthermore, no SALs were exceeded.

Nonradiological Analyses. Results of nonradiological analyses of sediment samples collected during 1994 are contained in Section VI.A.4 (Nonradiological Sediment Monitoring).

d. Long-Term Trends. The concentrations of radioactivity in sediments from Acid, Pueblo, and Los Alamos Canyons that are or may be transported off site were studied extensively about 15 years ago as part of the Formerly Utilized Sites Remedial Action Program and are fully documented (ESG 1981; Ferenbaugh 1994). Data gathered from selected locations as part of a routine monitoring program indicate that the concentrations of radionulclides in drainage sediments have been relatively constant at each location since 1980. The total plutonium concentrations, ^{238}Pu and $^{239, 240}$Pu observed since 1980 in sediments at four indicator locations are shown in Figure V-17. The first location is Acid Weir, the location of Acid Canyon near its confluence with Pueblo Canyon where the highest concentrations are typically observed. This location is on Los Alamos County property and effectively integrates the mobile sediments from all of Acid Canyon. The second location is Pueblo Canyon at State Road 502, just upstream of the confluence with Los Alamos Canyon. This location is on DOE land and reflects levels before off-site transport of sediments. The third location is Los Alamos Canyon at Totavi, located on the Pueblo of San Ildefonso, which represents the first off-site point. The fourth location is Los Alamos Canyon at Otowi, also located on the Pueblo of San Ildefonso, which reflects sediment concentrations at the point where they enter the Rio Grande.

e. Transport of Radionuclides in Sediments from Surface Runoff. The major transport mechanism for radionuclides from canyons that have received radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad

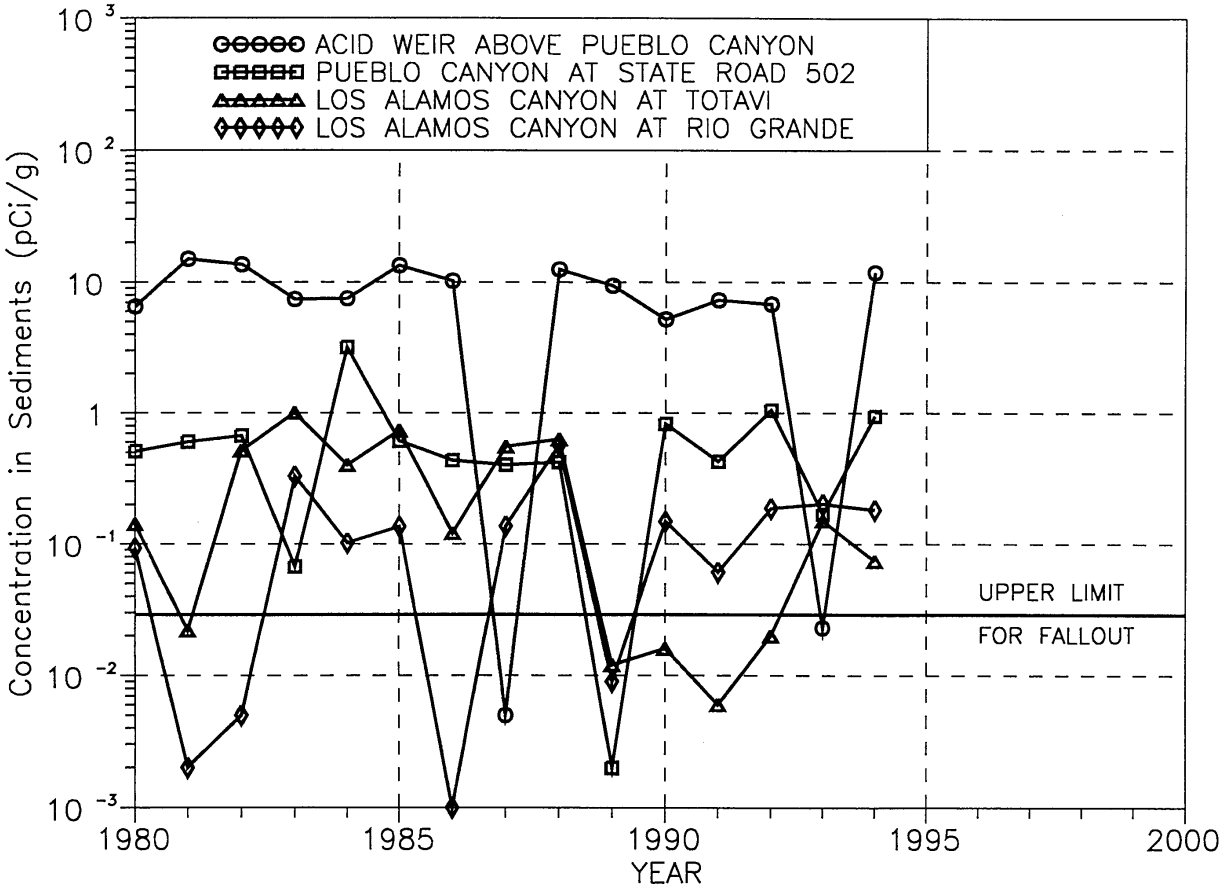

Figure V-17. Total plutonium concentrations in sediments.

Canyons) is by surface runoff. Residual radionuclides in the effluents may become adsorbed or attached to sediment articles in the stream channels. Concentrations of radioactivtiy in the alluvium are generally highest near the effluent outfall and decrease downstream in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and natural surface stormwater and snowmelt runoff.

Pueblo-Los Alamos Canyons. Residual radioactivity from past effluent releases into DP Canyon, upper Los Alamos Canyon, and Acid Canyon is present on sediments in those canyons and in Pueblo Canyon downstream from Acid Canyon. See Section V.B.3.b (Surface Water Monitoring Network) for additional historic information. Over the years, some of that radioactivity has been transported off site into lower Los Alamos Canyon largely by seasonal snowmelt and thunderstorm runoff.

Starting in 1990, increased effluent flow from the Los Alamos County Bayo sanitary sewage treatment plant resulted in flow during most of the year through the lower part of Pueblo Canyon and into Los Alamos Canyon. This flow transported some of the contaminated sediments out of Pueblo Canyon and into the lower reach of Los Alamos Canyon. This effluent-induced flow from Pueblo Canyon entered Los Alamos Canyon on most days in 1994 (except mid-June to early August) and typically extended to a location between Totavi (just east of the DOE-Pueblo of San Ildefonso boundary) down to the confluence of Guaje and Los Alamos Canyons.

Periodic grab samples of effluent and runoff collected from Pueblo Canyon above the confluence with Los Alamos Canyon, near State Road 502, were analyzed for radioactivity in solution and in suspended sediments. Radioactivity in solution refers to the filtrate that passes through a 0.45-micron pore-size filter. Radioactivity on suspended sediments refers to the residue retained by the filter. The samples collected from runoff contained above

background amounts of cesium, strontium, and plutonium in solution, which was expected in light of the residuals from historical releases into Pueblo Canyon. The levels of plutonium detected are shown in Table V-24, and the levels for other radioactive constituents are shown in Table V-25. These tables also show results of grab samples of snowmelt runoff from other canyons; results for these other canyons are discussed below.

Concentration of plutonium in the suspended sediments from Pueblo and Los Alamos Canyons were above background, although these levels were comparable to those seen in previous years. The increased transport of contaminated sediments from Pueblo Canyon is not having any significant effect on the concentrations of plutonium in sediments from lower Los Alamos Canyon (ESG 1981). Current measurements from throughout the region are given in Table V-24; measurements from locations in lower Los Alamos Canyon are shown in Figure V-17. Runoff from summer thunderstorms and extended periods of snowmelt periodically move accumulated sediments from lower Los Alamos Canyon into the Rio Grande (ESG 1981, Lane 1985).

The effluent-induced flow will slightly increase the rate at which contaminated sediments from historical discharges in Acid and Pueblo Canyons are moved through Los Alamos Canyon to the Rio Grande. Theoretical estimates and field measurements (ESG 1981; Graf 1993) demonstrate that the incremental contributions to radioactivity on sediments in Cochiti Reservoir resulting from Laboratory operations are small (approximately 10%) relative to the contributions from worldwide fallout. The incremental doses accumulated through food pathways are well below DOEs applicable PDLs. See Section V.C.3.e (Doses to Individuals from Ingestion of Foodstuffs) for additional details.

Radionuclides in Water and Sediment from Snowmelt Runoff. During the spring snowmelt season, grab samples of runoff were collected from several other canyons. The analytical results are shown in Tables V-20 and V-21. These results are for unfiltered samples and represent total concentrations, including both dissolved and suspended solid components.

Radionuclides in Water and Sediment from Mortandad Canyon. Residual radionuclides are released in effluent from the treatment plant at TA-50 into Mortandad Canyon (see Table V-6). The liquid infiltrates and recharges a shallow body of groundwater in the alluvium. This shallow aquifer is of limited extent and lies completely within Laboratory boundaries (see Section V.B.3.b (Surface Water Monitoring Network) and Section VII.B (Monitoring Network) for additional information. Most of the radionuclides in the effluent are adsorbed or bound to the sediments in the channel.

The sediments and radionuclides in the stream channel alluvium may be transported when additional effluent releases or storm water runoff enters the channel. The canyon's small drainage area and the capacity of the thick unsaturated alluvium to store runoff have prevented transport to the Laboratory's boundaries. To further ensure containment of sediment transport by major runoff events within Laboratory boundaries, a series of canyon sediment traps was installed in the early 1970s. These traps are located in Mortandad Canyon approximately 2.3 km (1.4 mi) upstream of the eastern facility boundary. The traps are excavated below the prevailing grade of the stream channel so that runoff water flows in and is retained temporarily, letting the heavier sediments settle out. When one trap is filled up to the level of the stream channel, the water flows on to the next trap. Runoff from several large thunderstorms in late July and early August 1991 filled all three sediment traps to capacity. Results from special sediment sampling conducted after these storms were reported in the 1991 surveillance report(EPG 1993). The three sediment traps were excavated during 1992 so that their original sediment retention volumes could be restored.

Since no significant thunderstorm runoff events occurred in Mortandad Canyon during 1994, only routine samples were collected. Furthermore, very little sediment in-filling of the sediment traps occurred during 1994.

Radionuclides in Wastewater. In recent years, treated effluents containing low levels of radioactivity have been released from the central liquid waste treatment plant (TA-50), from a smaller plant serving laboratories at TA-21, and from a sanitary sewage lagoon serving LAMPF at TA-53 (Table V-6 and Figures V-6 and V-7). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. In 1994, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

f. Special Reservoir Sediment Studies. Analytical results of the large (1 kg) sediment samples collected in 1994 from Abiquiu, Heron, and Cochiti reservoirs are presented in Tables V-25 and V-26. Results are similar to those from past years. The ^{238}Pu level from the lower station in Heron Reservoir exceeded the statistically established regional fallout reference level (Purtymun 1987a). Furthermore, ^{239,240}Pu levels from Heron and

Table V-25. Radioactivity in Sediments from Reservoirs on the Rio Chama and Rio Grande for 1994

	Tritium (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (mg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
Abiquiu Lake										
Upper	-0.2 (0.3)[a]	0.1 (0.5)	<0.07[b]	3.6 (0.6)	0.0004 (0.0001)	0.0008 (0.0003)	0.002 (0.030)	4 (1)	4 (1)	2 (1)
Middle	-0.1 (0.3)	0.0 (0.2)	<0.07	1.9 (0.2)	0.0000 (0.0001)	0.0002 (0.0001)	0.000 (0.030)	8 (3)	6 (1)	1 (0)
Lower	-0.3 (0.3)	0.0 (0.2)	<0.08	2.4 (0.5)	0.0001 (0.0001)	0.0004 (0.0001)	-0.001 (0.030)	4 (1)	4 (0)	1 (0)
Cochiti Lake										
Upper	-0.1 (0.3)	0.1 (0.2)	0.21 (0.07)	1.7 (0.2)	0.0001 (0.0001)	0.0027 (0.0002)	0.002 (0.030)	4 (1)	4 (1)	1 (0)
Middle	-0.1 (0.3)	0.3 (0.2)	0.32 (0.10)	3.2 (0.4)	0.0006 (0.0001)	0.0128 (0.0004)	0.008 (0.030)	11 (3)	9 (1)	2 (0)
Lower	-0.2 (0.3)	0.2 (0.2)	0.28 (0.10)	2.9 (0.3)	0.0005 (0.0001)	0.0123 (0.0006)	0.005 (0.030)	70 (20)	13 1)	1 (0)
Heron Lake										
Upper	-0.2 (0.3)	0.1 (0.2)	0.14 (0.06)	3.2 (0.3)	0.0002 (0.0001)	0.0049 (0.0002)	0.002 (0.030)	7 (2)	6 (1)	2 (0)
Middle	0.0 (0.3)	0.3 (0.2)	0.14 (0.05)	2.8 (0.2)	0.0003 (0.0002)	0.0029 (0.0005)	0.006 (0.030)	8 (2)	7 (1)	2 (0)
Lower	0.1 (0.3)	0.5 (0.2)	0.30 (0.10)	3.2 (0.3)	0.0009 (0.0001)	0.0079 (0.0003)	0.006 (0.030)	8 (2)	6 (1)	2 (0)
Background [c]		0.87	0.44	4.4	0.006	0.023				7.9
SAL[d]	20.0	5.00	4.0	95.0	20.0	18.0	17.0			

[a]Counting uncertainties (± 1 standard deviation) are in parenthesis.
[b]Less than symbol (<) means measurement was below the specified limit of the detection of the analytical method.
[c]Background (Purtymun 1987a); background defined as mean plus two times standard deviation.
[d]Screening Action Level; Environmental Restoration Group, 1994 FIMAD database; standards for comparison only.

Table V-26. Plutonium Analyses of Sediments in Reservoirs on the Rio Chama and Rio Grande[a]

			^{238}Pu (fCi/g)		^{239,240}Pu (fCi/g)		Ratio (^{239,240}Pu/^{238}Pu)
Abiquiu Reservoir (Rio Chama)							
1984	Mean	(s)	0.7	(0.2)[b]	12.7	(1.1)	18.1
1985	Mean	(s)	0.7	(0.2)	8.8	(0.8)	12.6
1986	Mean	(s)	0.3	(0.1)	7.5	(0.3)	25.0
1987	Mean	(s)	0.2	(0.0)	3.7	(0.2)	18.5
1988	Mean	(s)	0.3	(0.1)	7.4	(0.3)	24.7
1989	Mean	(s)	0.4	(0.1)	3.7	(0.2)	9.2
1990	Mean	(s)	0.1	(0.1)	2.6	(0.2)	26.0
1991	Mean	(s)	0.3	(0.2)	7.2	(0.4)	24.0
1992	Mean	(s)	0.1	(0.0)	0.8	(0.0)	8.0
1993	Mean	(s)	0.2	(0.1)	5.1	(0.4)	25.5
1994	Upper		0.4	(0.1)	0.8	(0.3)	2.0
	Middle		0.0	(0.1)	0.2	(0.1)	
	Lower		0.1	(0.1)	0.4	(0.1)	4.0
	Mean	(s)	0.2	(0.1)	0.5	(0.2)	2.5
Cochiti Reservoir (Rio Grande)							
1984	Mean	(s)	0.7	(0.1)	19.7	(1.1)	28.1
1985	Mean	(s)	1.6	(0.3)	24.1	(0.8)	15.1
1986	Mean	(s)	1.3	(0.1)	21.6	(0.3)	16.6
1987	Mean	(s)	0.8	(0.1)	17.5	(0.2)	21.9
1988	Mean	(s)	1.7	(0.2)	12.1	(0.3)	7.1
1989	Mean	(s)	2.5	(0.2)	49.3	(0.2)	19.7
1990	Mean	(s)	3.2	(0.1)	17.6	(0.2)	5.5
1991	Mean	(s)	0.2	(0.1)	4.1	(0.4)	20.1
1992	Mean	(s)	1.9	(0.2)	13.4	(0.0)	7.1
1993	Mean	(s)	4.1	(0.4)	30.5	(0.4)	7.4
1994	Upper		0.1	(0.1)	2.7	(0.2)	27.0
	Middle		0.6	(0.1)	12.8	(0.4)	21.3
	Lower		0.5	(0.1)	12.3	(0.6)	24.6
	Mean	(s)	0.4	(0.1)	9.3	(0.4)	23.3
Background							
(1974–1986)[c]			6.0		23.0		

[a]Samples were collected August 3, 1994, at Abiquiu Reservoir and August 2, 1994, at Cochiti Reservoir.

[b]Counting uncertainties (±1 standard deviation) are in parentheses.

[c]Purtymun (1987a).

Cochiti Reservoirs in the samples from the upper, middle, and lower stations exceeded the statistically established regional fallout reference levels. However, none of the other samples exceeded any statistically derived background level for any other radionuclide listed in Table V-25.

The results of these analyses are best interpreted in conjunction with information from a special study, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," which provides a broader regional context for analyses of reservoir sediments (Purtymun 1990b). This study analyzed the radiochemical constituents of large (1 kg) samples of soils and sediments collected between 1979 and 1987 from locations in northern New Mexico and southern Colorado. The conclusions of greatest significance to interpreting the current samples from Abiquiu and Cochiti reservoirs are: (1) the average total Pu concentrations in Cochiti Reservoir are almost identical to the concentrations found in the Rio Grande Reservoir in Colorado; (2) reservoirs on the Rio Chama exhibit slightly lower radionuclide concentrations than those found in the Rio Grande Reservoir; and (3) the isotopic ratios of ^{239,240}Pu to ^{238}Pu are essentially the same, with nearly complete overlap of the statistical uncertainties, for all of the soil and sediment samples analyzed. These findings are consistent with the interpretation that the source of the Pu at all reservoir locations studied is predominantly from worldwide fallout.

The data from the 1994 Pu analyses are shown in a long-term context in Table V-26. The measurements in the samples from Cochiti Reservoir have some of the lowest long-term means for radionuclide concentration and the lowest isotope ratios. The samples from Abiquiu Reservoir had the lowest concentration ranges and isotopic ratios seen. The 1994 concentration averages have proportionately large standard deviations because of the great range of values in each data group. Thus, the average isotopic ratios also have large uncertainties. However, the isotopic ratios from Cochiti Reservoir are even lower than those typical for worldwide fallout, and therefore show no significant contribution of residual effluents from Laboratory operations in the Acid Canyon arm of Pueblo Canyon. Sediments from Acid-Pueblo Canyon exhibit a ratio of ^{239,240}Pu to ^{238}Pu that is much larger than values typical of worldwide fallout. This is consistent with the long term observation that the contributions of radionuclides from Los Alamos Canyon are a relatively small proportion of the total carried in the Rio Grande.

The contribution of total Pu carried by runoff from Los Alamos Canyon into the Rio Grande is estimated to be about 10% of the contribution from worldwide fallout (ESG 1981, Graf 1993). The range of Pu levels in sediments in the Rio Grande in the vicinity of Los Alamos indicate a variable mixing of the generally higher concentrations and isotopic ratios observed on soils and sediments farther north in the Rio Grande drainage and the generally lower concentrations and lower isotopic ratios found in the Rio Chama system reservoirs and soils of northern New Mexico. Thus, the significant variability with time and the uncertainty in measurements of at least 5% to 10% in even the 1 kg samples (the uncertainty can be as high as 50% in samples collected for routine monitoring) combine to make it generally impossible to distinguish the contribution of sediments from Los Alamos Canyon to the Rio Grande by measuring concentrations. Similarly, there is no distinguishable increase in the ^{239,240}Pu to ^{238}Pu isotopic ratio, which would be expected if the higher concentration, higher ratio sediments from Los Alamos Canyon were making a large contribution.

g. Special Rio Grande Sediment Study. A geomorphologic study completed in 1991, "Geomorphology of Plutonium in the Northern Rio Grande System," (Graf 1993) uses a historical perspective to evaluate the contributions of plutonium from Los Alamos to the Rio Grande. This study uses historical aerial photography and hydrologic data to study the movement and deposition of sediments over time. Among the study's conclusions regarding a regional plutonium budget for the 1948 to 1985 period accounting for both worldwide fallout and input from Los Alamos Canyon for the northern Rio Grande, three are particularly relevant to interpreting the surveillance data:

- Fallout accounts for more than 90% of the plutonium in the system; slightly less than 10% is from activity at the Laboratory.
- About half of the total plutonium (from fallout and the Laboratory) is estimated to be stored along the river, and the remainder has been carried to Elephant Butte Reservoir.
- Most of the contributions from the Laboratory are found along the river between Otowi and Peña Blanca (just downstream from Cochiti Dam); since 1973 the downstream transport of the contributions from the Laboratory has terminated in Cochiti Reservoir.

The study identified locations where sediments had been deposited during specific periods. A special sediment sample deposited sometime between 1941 to 1968 was collected from a floodplain near Buckman (just south of Cañada Ancha in Figure V-15). This sample was subjected to a very sensitive analysis (detection limits as little as 0.0001 pCi/g) of plutonium isotopes by the Isotope Geochemistry Group at the Laboratory. They found that the plutonium levels in sediments at the Buckman site contained a ratio of ^{239}Pu to ^{240}Pu consistent with approximately an equal weight amount of plutonium on sediments from worldwide fallout and from sediments originating in the Acid-Pueblo-Los Alamos canyon system. The total level of ^{239}Pu plus ^{240}Pu in the sample (0.017 pCi/g) was near the statistically derived fallout level (0.023 pCi/g). The precise analysis found that the deposit contained a substantial contribution from historical flows out of Los Alamos Canyon. Such techniques may be useful for research into other sediment transport processes.

6. Soil Monitoring.

a. Introduction. A soil sampling and analysis program provides the most direct means of determining the concentration, inventory, and distribution of radionuclides (and heavy metals) around nuclear facilities (DOE 1991a). Soil provides an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous effluents or indirectly from resuspension of on-site contamination, or through liquid effluents released to a stream that is subsequently used for irrigation. Hence, soil sampling and analysis is performed with the purpose of evaluating the long-term accumulation trends and to estimate environmental radionuclide and heavy metal inventories. In addition to radionuclides (and heavy metals) that are specific to a particular operation or facility, naturally occurring and/or fallout radionuclides and heavy metals can be expected in background soil samples.

b. Monitoring Network. Soil samples are collected annually from on-site, perimeter, and regional (background) locations. On-site stations are located mostly downwind from the major potential contaminant sources in an effort to intercept any contamination related to Laboratory operations. Perimeter stations are located on the north (two), south (one), east (two), and southwest (one) side of the Laboratory. All areas are compared to soils collected from regional (background) locations where radionuclides and radioactivity are due to natural and/or to worldwide fallout events.

Off-Site Regional (Background) Stations. The regional stations for soils are located in the three major drainages in northern New Mexico surrounding the Laboratory: Rio Chama, Embudo, and Otowi; Cochiti and Bernalillo; and Jemez. One additional soil station is located near Santa Cruz Lake, across the Rio Grande Valley to the northeast of the Laboratory (Figure V-14). All are over 15 km (9 mi) from the Laboratory (DOE 1991a) and are beyond the range of potential influence from normal Laboratory operations.

Off-Site Perimeter Stations. A total of six soil sampling stations are located within 4 km (2.5 mi) of the Laboratory (Figure V-18 and Table D-15). Four of these stations are located to reflect the soil conditions of the inhabited areas to the north and east of the Laboratory. The other two stations, one located on Forest Service land to the west and the other located on Park Service land (Bandelier) to the southwest, provide additional data.

On-Site Stations. Soil samples from 10 on-site stations are collected; they are mostly located near and downwind of Laboratory facilities that are the principal sources of airborne emissions or that could be potential contaminant sources (FigureV-18 and Table D-15).

c. Radiochemical Analytical Results. Table V-27 shows data from soils collected in 1994. The average concentrations of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu and gross beta activity in soils collected from perimeter stations were not significantly ($p < 0.05$) different than radionuclide concentrations and activity in soil samples collected from regional (background) locations. The average levels of uranium (3.16 μg/g) in perimeter soils were significantly higher than background soils (1.91 μg/g). Although the average levels of uranium in perimeter soils were significantly higher than background, it was still within the long-term regional statistical reference level (RSRL) of 3.4 μg/g. The RSRL is the average background concentration plus twice the standard deviation of the mean from data collected over a 13-yr period; data from 1974 through 1986 from regional background stations were used to establish long term regional statistical limits for worldwide fallout levels of tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu and total uranium (Purtymun 1987a).

The average levels of ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, total uranium, and gross alpha and beta activity in soils collected from on-site stations were not significantly ($p < 0.05$) different than radionuclide concentrations and

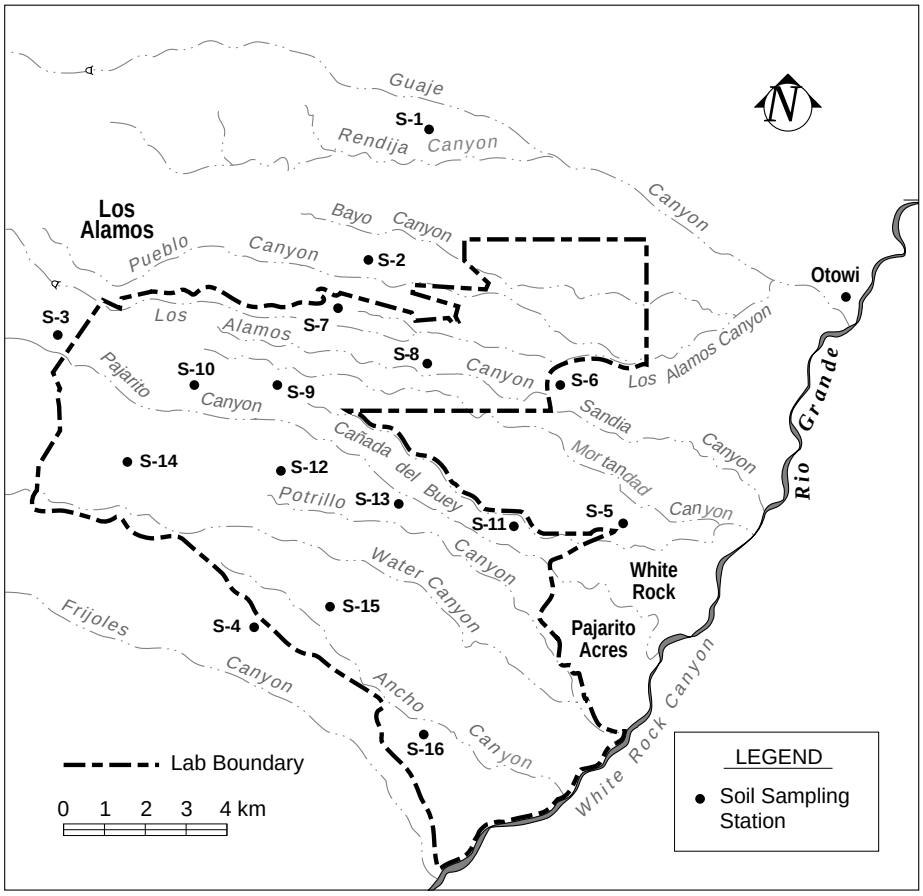

Figure V-18. Off-site perimeter and on-site Laboratory soil sampling locations. (Map denotes general locations only. Refer to Table D-15 for specific coordinates.)

activity in soil samples collected from regional (background) locations. Only tritium was found to be significantly higher in on-site soils (0.13 pCi/mL) versus off-site (background) soils (-0.59 pCi/mL), albeit by less than 1 pCi. On-site soils are still within the long-term background average of 7.2 pCi/mL of tritium, however, and were less than last year's tritium concentration (1.4 pCi/mL).

A comparison of individual radionuclide detectable values (where the analytical result was greater or equal to two sigma) in soils collected from on-site and perimeter stations versus the RSRL and SAL's (LANL SALs) show:

Tritium. No detectable tritium values were found in any of the soil samples collected, including on-site soils. Accordingly, all soil samples collected from either on-site and perimeter stations were far below the Laboratory's SAL (<820 pCi/g soil).

Cesium-137. One perimeter (TA-8/GT site) and two on-site soil samples (Two-Mile Mesa and near TA-33) contained detectable ^{137}Cs activity higher than the RSRL. All detectable values, however, were far below the SAL (<4.0 pCi/g).

Total Uranium. One perimeter (Tsankawi) and three on-site soil samples (TA-50, R-Site Road East, and near Test Well DT-9) contained detectable uranium activity higher than the RSRL. The highest value (114 μg/g) was detected at the R-Site Road East station and was over 33 times higher than last year's value and background. However, all uranium detectable values, including that detected at R-Site Road East, were far below the Laboratory's SAL of 185 μg/g.

Plutonium-238. Two perimeter (White Rock [East] and Tsankawi) and four on-site soil samples (TA-21 [DP Site], West of TA-53, TA-50, and near Test Well DT-9) contained detectable ^{238}Pu activity that exceeded the RSRL; the highest concentration (0.009 pCi/g) was only 0.003 pCi/g higher than the RSRL. All soil samples containing detectable ^{238}Pu activity were far below the Laboratory's SAL (<20 pC/g).

Table V-27. Radiochemical Analyses of Soils Collected in 1994

Location	Tritium (pCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
OFF-SITE REGIONAL (BACKGROUND) STATIONS										
Rio Chama	-0.10 (0.60)[ab]	0.50 (0.40)	0.19 (0.08)	1.54 (0.30)	0.001 (0.002)	0.008 (0.002)	0.006 (0.002)	3.8 (1.8)	5.4 (1.2)	2.0 (0.6)
Embudo	-1.50 (1.20)	0.40 (0.40)	0.38 (0.14)	1.34 (0.80)	0.004 (0.002)	0.023 (0.004)	0.008 (0.002)	4.3 (2.0)	5.1 (1.2)	2.4 (0.6)
Otowi	-0.60 (0.60)	0.70 (0.40)	0.17 (0.08)	2.51 (0.66)	0.003 (0.002)	0.009 (0.004)	0.008 (0.004)	3.4 (1.6)	3.2 (0.8)	3.3 (0.8)
Santa Cruz	-0.20 (0.60)	0.20 (0.40)	0.31 (0.12)	2.24 (0.44)	0.008 (0.002)	0.010 (0.002)	0.003 (0.002)	6.0 (2.0)	8.6 (1.8)	3.3 (0.8)
Cochiti	-0.60 (0.60)	0.40 (0.40)	0.22 (0.10)	1.92 (0.88)	0.003 (0.002)	0.009 (0.002)	0.004 (0.002)	5.0 (2.0)	5.7 (1.2)	3.0 (0.6)
Bernalillo	-0.30 (0.60)	0.80 (0.40)	0.03 (0.06)	1.32 (0.30)	0.003 (0.002)	0.006 (0.002)	0.001 (0.002)	2.5 (1.2)	2.1 (0.6)	1.5 (0.4)
Jemez	-0.80 (0.80)	0.40 (0.40)	0.33 (0.12)	2.51 (1.10)	0.010 (0.004)	0.013 (0.004)	0.006 (0.002)	4.0 (2.0)	4.7 (1.0)	3.6 (0.8)
Mean (+2SD)	-0.59 (0.95)	0.49 (0.41)	0.23 (0.24)	1.91 (1.05)	0.005 (0.006)	0.011 (0.011)	0.005 (0.005)	4.1 (2.3)	5.0 (4.1)	2.7 (1.6)
RSRL[c]	7.20	0.88	1.10	3.40	0.005	0.025	0.023			
SAL[d]	820.00[e]	5.90	4.00	185.10	20.000	18.000	17.000			
OFF-SITE PERIMETER STATIONS										
L.A. Sportsman Club	-0.20 (0.60)	0.30 (0.40)	0.26 (0.10)	3.40 (0.82)	0.004 (0.004)	0.018 (0.006)	0.005 (0.004)	6.0 (2.0)	6.7 (1.4)	3.3 (0.8)
North Mesa	-0.10 (0.60)	0.20 (0.40)	0.07 (0.06)	2.54 (1.38)	0.004 (0.002)	0.005 (0.002)	0.003 (0.004)	4.5 (2.0)	3.2 (0.8)	3.5 (0.8)
TA-8/GT Site	0.10 (0.60)	1.10 (0.40)[f]	0.75 (0.20)	3.30 (1.26)	0.000 (0.002)	0.000 (0.002)	0.010 (0.006)	6.0 (2.0)	6.3 (1.4)	3.6 (0.8)
TA-49	-0.10 (0.60)	0.50 (0.40)	0.42 (0.14)	2.45 (0.58)	0.002 (0.002)	0.020 (0.004)	0.008 (0.006)	6.0 (2.0)	5.8 (1.2)	3.4 (0.8)
White Rock (East)	-0.30 (0.60)	0.10 (0.40)	0.21 (0.10)	2.45 (0.54)	0.008 (0.002)[f]	0.011 (0.002)	0.003 (0.002)	6.0 (2.0)	5.1 (1.2)	3.4 (0.8)
Tsankawi	-0.50 (0.60)	0.70 (0.40)	0.10 (0.08)	4.83 (0.96)[f]	0.005 (0.002)[f]	0.006 (0.002)	0.002 (0.002)	3.8 (1.6)	3.4 (0.8)	5.1 (1.0)
Mean (+2SD)	-0.18 (0.41)	0.48 (0.74)	0.30 (0.51)	3.16 (1.85)[g]	0.004 (0.005)	0.010 (0.016)	0.005 (0.003)	5.4 (2.0)[g]	5.1 (3.0)	3.7 (1.4)[g]
ON-SITE STATIONS										
TA-21 (DP Site)	0.10 (0.60)	0.30 (0.40)	0.01 (0.02)	2.34 (0.46)	0.005 (0.002)[f]	0.009 (0.004)	0.001 (0.004)	6.0 (2.0)	4.2 (1.0)	3.5 (0.8)
West of TA-53	0.30 (0.60)	0.40 (4.20)	0.05 (0.04)	2.47 (0.50)	0.007 (0.002)[f]	0.019 (0.004)	0.002 (0.002)	5.0 (2.0)	4.4 (1.0)	3.7 (0.8)
TA-50	0.40 (0.60)	0.30 (0.40)	0.08 (0.06)	3.74 (1.58)[f]	0.009 (0.004)[f]	0.032 (0.006)[f]	0.016 (0.012)	4.0 (1.0)	5.0 (2.0)	3.4 (0.8)
Two-Mile Mesa	-0.20 (0.60)	0.90 (0.60)[f]	0.90 (0.24)	1.86 (0.64)	0.006 (0.002)[f]	0.039 (0.006)[f]	0.018 (0.008)	5.0 (2.0)	5.9 (1.2)	3.4 (0.8)

Table V-27. Radiochemical Analyses of Soils Collected in 1994 (Cont.)

Location	Tritium (pCi/mL)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (μg/g)	^{238}Pu (pCi/g)	^{239,240}Pu (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
ON-SITE STATIONS (Cont.).										
East of TA-54	0.60 (0.60)	0.20 (0.40)	0.10 (0.06)	2.16 (0.44)	0.003 (0.002)	0.005 (0.002)	0.004 (0.004)	4.1 (1.8)	4.0 (0.8)	3.4 (0.8)
R-Site Road East	0.10 (0.60)	0.70 (0.40)	0.31 (0.12)	114.00 (24.00)[f]	0.002 (0.002)	0.016 (0.004)	0.008 (0.004)	44.0(18.0)	67.0 (14.0)	4.3 (1.0)
Potrillo Drive	-0.40 (0.60)	0.50 (0.40)	0.20 (0.10)	2.78 (0.56)	0.002 (0.002)	0.009 (0.004)	0.005 (0.004)	6.0 (2.0)	4.5 (1.0)	3.3 (0.8)
S-Site (TA-16)	-0.10 (0.60)	0.50 (0.40)	0.15 (0.08)	2.96 (0.66)	0.002 (0.004)	0.007 (0.004)	0.001 (0.004)	5.0 (2.0)	4.5 (1.0)	3.2 (0.8)
Near Test Well DT-9	0.00 (0.60)	0.80 (0.40)	0.94 (0.24)	5.18 (1.04)[f]	0.007 (0.002)[f]	0.031 (0.006)[f]	0.013 (0.006)	9.0 (4.0)	8.1 (1.8)	3.8 (0.8)
Near TA-33	0.50 (0.80)	1.10 (0.40)[f]	0.61 (0.18)	2.57 (0.72)	0.003 (0.002)	0.022 (0.004)	0.011 (0.004)	6.0 (2.0)	5.9 (1.2)	3.5 (0.8)
Mean (+2SD)	0.13 (0.64)[g]	0.57 (0.59)	0.34 (0.71)	14.00 (70.30)	0.005 (0.005)	0.019 (0.024)	0.008 (0.013)	9.4(24.5)	11.4 (39.2)	3.6(0.6)[g]

[a]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[b](+2 counting uncertainty); values are the uncertainty of the analytical result at the 95% confidence level.
[c]RSRL (Regional Statistical Reference Level; this is the upper limit background concentration [mean + 2 std dev] from Purtymun 1987a).
[d]SAL (Los Alamos National Laboratory Screening Action Level).
[e]820 pCi/dry g soil; therefore, all values were evaluated on a dry weight basis and all were below the SAL. The highest tritium value in the data set (0.60 pCi/mL detected from East of TA-54, for example, contained approximately 12% moisture; thus, 0.60 x 0.12/1 x 0.88 = 0.08 pCi/dry g soil.
[f]Detectable value (where the analytical results is equal or greater than two sigma) and equal or higher than the RSRL.
[g]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Plutonium-239, 240. Three detectable ^{239,240}Pu values that were higher than the RSRL were observed in soils collected from on-site areas TA-50, Two-Mile Mesa, and near Test Well DT-9. Last year a soil sample collected from TA-54 exceeded the RSRL for ^{239,240}Pu by almost 90 times. This year ^{239,249}Pu concentrations at TA-54 were observed within background concentrations; this value was attributed as an outlier since there were no known atmospheric releases of plutonium and a check of past ^{239,240}Pu values collected at the TA-54 station showed no large quantities of ^{239,240}Pu. All soil samples, including detectable concentrations of ^{239,240}Pu, collected from on-site stations were far below the Laboratory's SAL for ^{239,240}Pu (<18 pCi/g).

Americium-241. No detectable amounts of ^{241}Am were detected in any of the soil samples collected from either perimeter or on-site areas. Accordingly, all soil samples were below the Laboratory's SAL of 17 pCi/g.

Soils were also analyzed for heavy metals; analytical results can be found in Table VI-18.

7. Foodstuffs Monitoring.

a. Introduction. As part of the Environmental Protection Program at LANL, samples of foodstuffs are collected annually from the Laboratory and surrounding communities to determine the impact of Laboratory operations on the human food chain, as per DOE Orders 5400.1 and 5400.5. The two main objectives of the Foodstuffs Monitoring Program are to (1) determine and compare radioactive constituents (and heavy metals) in foodstuffs between on-site LANL and off-site perimeter against regional areas and (2) calculate a total CEDE to area residents (Los Alamos townsite and White Rock/Pajarito Acres) who may consume such foodstuffs. Radiation doses to individuals from the ingestion of foodstuffs are presented in Section V.C.3.e. Information on trace and heavy metals in various foodstuffs (produce and fish) can be found in Section VI.A.5.

b. Monitoring Network.

Produce and honey. Fruits, vegetables, grains, and honey are collected each year from on-site (Laboratory), off-site perimeter (Los Alamos townsite and White Rock/Pajarito Acres), and off-site regional (background) locations (Figures V-19 and V-20, and Table D-17). Samples of foodstuffs were also collected from the pueblos of Cochiti and San Ildefonso, which are located in the general vicinity of LANL. Regional or background samples are collected from gardens >15 km (9 mi) from the Laboratory; these areas are located around the Española, Santa Fe, and Jemez areas. The regional sampling locations are sufficiently distant from the Laboratory to be unaffected by airborne emissions.

Fish. Fish are collected annually upstream and downstream of the Laboratory (Figure V-19). Cochiti Reservoir, a 10,690-acre flood and sediment control project, is located on the Rio Grande approximately five miles downstream from the Laboratory. Radionuclides in fish collected from Cochiti Reservoir are compared to fish collected from Abiquiu, Heron, and/or El Vado reservoirs. Abiquiu, Heron, and El Vado reservoirs are located on the Rio Chama, upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands.

Fish are separated into two categories for analysis: game (surface-feeders) and nongame (bottom-feeders). Game fish include Rainbow Trout (*Salmo gairdneri*), Brown Trout (*Salmo trutta*), Kokanee Salmon (*Oncorhynchus nerka*), Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieui*), White Crappie (*Pomixis annularis*), and Walleye (*Stizostedion vitreum*). Nongame fish include the White Sucker (*Catostomus commersone*), Channel Catfish (*Ictalurus penctatus*), Carp (*Cyprinus carpio*), and Carp Sucker (*Carpiodes carpio*).

Game animals. Road kills of elk are collected on an annual basis and the meat and bone are analyzed for various radionuclides. Three elk (*Cervus elaphus*) were collected during the winter of 1994/1995. Results of these animals, however, will be reported in the report "Environmental Surveillance at Los Alamos during 1995."

Milk. There are no milk production facilities within 15 km (9 mi) of the Laboratory; the closest working dairy, located in the Pojoaque Valley, is approximately 40 km (25 mi) away. However, because milk is considered one of the most important and universally consumed foodstuffs and because dairy animals may have consumed vegetation (hay) grown in the vicinity of the Laboratory, the analysis of milk may yield information as to the deposition of small amounts of radionuclides over a relatively large area. Accordingly, various radionuclides in milk from the Pojoaque Valley dairy were analyzed and compared to milk collected from a (background) dairy located in Albuquerque, NM.

c. Radiochemical Analytical Results.

Produce. Concentrations of radionuclides in produce collected from on-site, off-site perimeter, and off-site regional (background) locations during the 1994 growing season can be found in Table V-28. The average

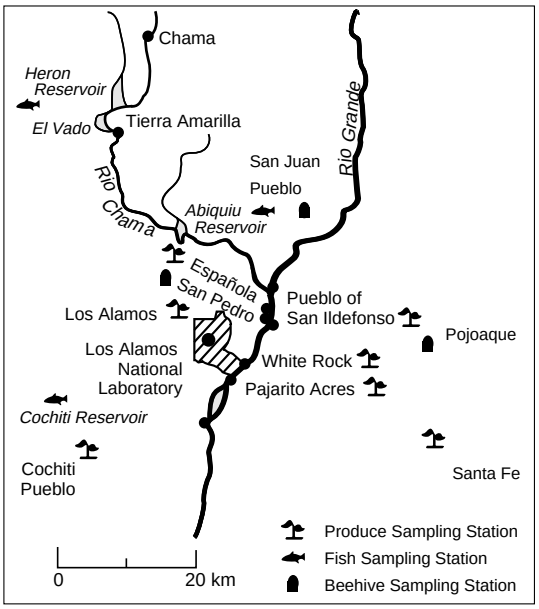

Figure V-19. Produce, fish, and beehive off-site (regional and perimeter) sampling locations. (Map denotes general locations only.)

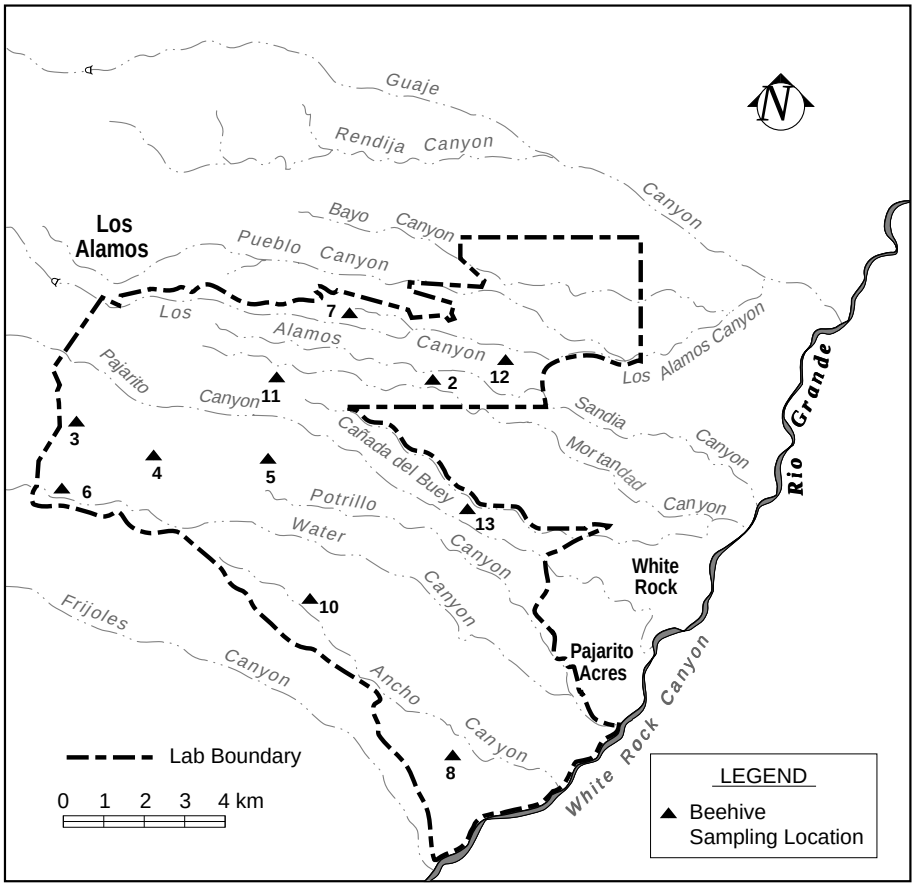

Figure V-20. Locations of beehives in on-site Laboratory areas. (Map denotes general locations. Specific locations are presented in Table D-17.)

Table V-28. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1994 Growing Season[a]

	Tritium (pCi/mL)		^{90}Sr (10^{-3} pCi/dry g)		U (ng/dry g)		^{238}Pu (10^{-5} pCi/dry g)		^{239,240}Pu (10^{-5} pCi/dry g)		^{137}Cs (10^{-3} pCi/dry g)	
OFF-SITE STATIONS												
Regional												
Espanola/Santa Fe/Jemez												
apples	0.2	(0.6)[b]	20.8	(20.8)	0.52	(1.04)	10.4	(312.0)	5.2	(208.0)	14.0	(107.2)
pears	0.0	(0.6)	15.5	(12.4)	0.93	(0.62)	0.0	(186.0)	0.0	(124.0)	1.5	(11.8)
squash	-0.4	(0.6)[c]	33.2	(33.2)	8.30	(1.66)	-8.3	(498.0)	8.3	(332.0)	11.6	(88.0)
apples	0.1	(0.6)	10.0	(20.0)	1.00	(1.00)	-5.0	(300.0)	0.0	(200.0)	-3.0	(23.0)
apricots	-0.1	(0.6)	79.8	(106.4)	5.32	(1.60)	0.0	(1,596.0)	0.0	(1,064.0)	23.9	(180.8)
corn	0.1	(0.6)	5.6	(11.2)	0.56	(0.56)	-2.8	(168.0)	2.8	(112.0)	-6.2	(47.0)
squash	0.1	(0.6)	124.0	(49.6)	9.92	(9.92)	24.8	(744.0)	24.8	(496.0)	50.8	(386.8)
apples	-0.1	(0.6)	11.2	(22.4)	1.68	(2.24)	0.0	(336.0)	0.0	(224.0)	-3.4	(25.8)
squash	-0.1	(0.6)	11.0	(44.0)	5.50	(2.20)	0.0	(660.0)	-11.0	(440.0)	25.3	(193.6)
squash	0.0	(0.6)	42.6	(56.8)	2.84	(2.84)	0.0	(852.0)	0.0	(568.0)	-7.1	(54.0)
Mean	-0.0	(0.4)[d]	35.4	(76.6)	3.66	(6.85)	1.9	(18.7)	3.0	(18.3)	10.7	(37.0)
RSRL[e]	16.9		75.6		38.20		35.4		67.9		690.1	
Perimeter												
Los Alamos												
cherries	0.8	(0.6)	25.2	(33.6)	1.68	(0.50)	0.0	(504.0)	0.0	(336.0)	7.6	(57.2)
apricots	0.2	(0.6)	26.8	(107.2)	5.36	(1.60)	0.0	(1,608.0)	0.0	(1,072.0)	24.1	(182.2)
squash	-0.1	(0.6)	95.9	(54.8)[f]	2.74	(2.74)	13.7	(822.0)	13.7	(548.0)	8.2	(63.0)
tomatoes	0.1	(0.6)	44.0	(44.0)	2.20	(2.20)	11.0	(660.0)	11.0	(440.0)	-9.9	(74.8)
Mean	0.3	(0.8)	48.0	(66.1)	3.00	(3.27)	6.2	(14.4)	6.2	(14.4)	7.5	(27.8)
White Rock/Pajarito Acres												
apples	-0.1	(0.6)	8.8	(8.8)	0.66	(0.88)	-6.6	(132.0)	4.4	(88.0)	-8.1	(62.0)
squash	0.2	(0.6)	46.2	(92.4)	4.62	(4.62)	-23.1	(1386.0)	23.1	(924.0)	-2.3	(18.4)
tomatoes	0.3	(0.6)	15.9	(63.6)	1.59	(1.28)	0.0	(954.0)	0.0	(636.0)	-6.4	(47.6)
squash	0.1	(0.6)	49.5	(66.0)	3.30	(6.60)	-33.0	(990.0)	-33.0	(660.0)	3.3	(26.4)
apples	-0.1	(0.6)	12.0	(12.0)	0.60	(1.20)	-6.0	(180.0)	3.0	(120.0)	-14.4	(109.8)
tomatoes	-0.1	(0.6)	36.0	(36.0)	2.70	(0.54)	-9.0	(540.0)	-9.0	(360.0)	-8.1	(61.2)
tomatoes	0.3	(0.6)	28.8	(38.4)	0.96	(1.92)	-28.8	(576.0)	0.0	(384.0)	-7.7	(57.6)
Mean	0.1	(0.4)	28.2	(33.0)	2.06	(3.06)	-15.2	(25.8)	-1.6	(33.8)	-6.2	(11.0)
Cochiti												
cucumbers	0.0	(0.6)	40.8	(54.4)	19.04	(5.44)	0.0	(816.0)	13.6	(544.0)	42.2	(321.0)
squash	-0.1	(0.6)	31.8	(63.6)	4.77	(3.18)	-15.9	(954.0)	0.0	(636.0)	39.7	(302.0)
corn	0.0	(0.6)	3.0	(12.0)	0.30	(0.24)	-3.0	(180.0)	-3.0	(120.0)	9.6	(73.2)
apples	-0.1	(0.6)	5.8	(11.6)	1.45	(0.58)	0.0	(174.0)	0.0	(116.0)	22.0	(168.2)
Mean	-0.0	(0.2)	18.0	(32.0)	5.38	(13.92)	-3.1	(12.8)	1.0	(14.0)	33.0	(28.8)[g]

Table V-28. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1994 Growing Season.[a] (Cont.)

	Tritium (pCi/mL)		^{90}Sr (10-3 pCi/dry g)		U (ng/dry g)		^{238}Pu (10-5 pCi/dry g)		^{239,240}Pu (10-5 pCi/dry g)		^{137}Cs (10-3pCi/dry g)	
OFF-SITE STATIONS (Cont.)												
San Ildefonso												
apples	0.2	(0.6)	0.0	(14.0)	0.70	(0.70)	-3.5	(210.0)	0.0	(140.0)	8.1	(61.6)
peaches	0.0	(0.6)	18.3	(73.2)	7.32	(3.66)	0.0	(1098.0)	0.0	(732.0)	22.0	(168.4)
squash	-0.3	(0.6)	87.6	(58.4)[f]	8.76	(2.92)	-29.2	(876.0)	14.6	(584.0)	87.6	(668.6)
apples	-0.2	(0.6)	9.6	(12.8)	1.60	(0.64)	6.4	(192.0)	-3.2	(128.0)	7.0	(53.8)
squash	0.0	(0.6)	34.0	(34.0)	18.70	(5.10)	0.0	(510.0)	-8.5	(340.0)	11.9	(90.2)
Mean	-0.1	(0.4)	29.9	(69.2)	7.42	(14.42)	-5.3	(27.8)	0.6	(17.2)	27.3	(68.4)
ON-SITE STATIONS												
LANL												
apples	0.4	(0.6)	31.0	(24.8)	1.24	(1.24)	0.0	(372.0)	0.0	(248.0)	1.2	(10.0)
peaches	0.4	(0.6)	8.0	(16.0)	0.80	(0.64)	0.0	(480.0)	0.0	(320.0)	-5.6	(43.2)
apples	0.3	(0.6)	11.9	(10.2)	1.36	(0.68)	5.1	(102.0)	-1.7	(68.0)	-0.2	(13.0)
peaches	3.5	(1.2)	18.0	(14.4)	3.60	(0.72)	-3.6	(216.0)	0.0	(144.0)	-5.8	(44.0)
cucumbers	0.3	(0.6)	-104.8	(655.0)	6.55	(7.86)	0.0	(786.0)	39.3	(524.0)	9.2	(70.8)
squash	0.5	(0.6)	40.0	(16.0)	5.60	(0.80)	-4.0	(240.0)	0.0	(160.0)	2.0	(15.2)
squash	0.3	(0.6)	32.9	(9.4)	1.88	(0.94)	4.7	(282.0)	4.7	(188.0)	-4.2	(32.0)
squash	0.2	(0.6)	54.0	(24.0)	3.60	(1.20)	-6.0	(360.0)	-6.0	(240.0)	-8.4	(64.8)
tomatoes	0.2	(0.6)	15.4	(13.2)	1.32	(1.32)	-11.0	(132.0)	4.4	(88.0)	-9.0	(24.6)
squash	2.7	(1.0)	59.0	(23.6)	4.72	(1.18)	5.9	(354.0)	5.9	(236.0)	4.1	(31.8)
Mean	0.9	(2.4)	16.5	(92.0)	3.07	(4.10)	-0.9	(10.8)	4.7	(25.4)	-1.7	(11.8)

[a]There are no concentration guides for produce; however, most mean radionuclide contents in produce collected from LANL and perimeter areas were not significantly different from regional background using a Student's t-test at the 0.05 probability level (Gilbert 1987).

[b](+2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.

[c]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[d](+2 standard deviation).

[e]Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1994d).

[f]Detectable value (where the analytical result was greater or equal to two sigma) and was equal or higher than than the RSRL.

[g]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

concentration of all radionuclides, including tritium, in produce collected from on-site and off-site perimeter locations were not significantly different than radionuclide concentrations in produce collected from background locations and were within values reported for these areas in past years (Fresquez 1994d). In past years, tritium in produce from on-site and off-site perimeter locations have almost always been higher than tritium concentrations in produce collected from background locations.

No significant differences were found in the levels of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs between produce collected from gardens at the Pueblo of San Ildefonso and produce collected from the Española/Santa Fe/Jemez areas (Table V-28). Similarily, no significant differences, with the exception of ^{137}Cs, were detected in produce collected from Cochiti area. Although the average level of ^{137}Cs was significantly higher in produce from Cochiti Pueblo as compared to background, it was still below the RSRL for similar foodstuffs collected over a 16-yr period from gardens located in northern New Mexico (i.e., <690 pCi/dry g) (Fresquez 1994d). In addition, none of the seven individual ^{137}Cs values in produce from the Cochiti area contained detectable activity (where the analytical result was higher or equal to two sigma).

Honey. Honey data collected during the 1994 season are presented in Table V-29. Most detectable radionuclides (where the analytical value is greater or equal to two sigma), particulary ^{90}Sr, ^{238}Pu, ^{239}Pu, ^{137}Cs, and uranium isotopes, in honey samples collected from on-site and perimeter areas were within the current year regional statistical reference level (CYRSRL) (mean + 2 std dev). Two detectable ^{239}Pu values—one of which occurred in a honey sample collected from the Los Alamos townsite (0.107 pCi/L)—were observed in higher concentrations than either the CYRSRL (0.055 pCi/L) and the long-term regional statistical reference level (LTRSRL) (0.103 pCi/L). Also, the highest detectable ^{90}Sr value (20.30 pCi/L) was found in honey collected from a beehive located in the Los Alamos townsite.

Tritium in honey collected from Laboratory beehives ranged from -0.30 (±0.60) pCi/mL at TA-16 to 1,300 (±1.00) pCi/mL at TA-53. Technical Area 53 and TA-54 (101.7 pCi/mL) contained the highest concentration of tritium in honey samples. Honey produced by the hives on Laboratory lands is not available for public consumption. The White Rock/Pajarito Acres/TA-36 hive contained higher detectable levels of tritium in honey (2.40 pCi/mL) than the CYRSRL which averaged 0.37 pCi/mL. The LTRSRL for honey is 21.22 pCi/mL.

Fish. Concentration of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory are presented in Table V-30.

The concentrations of most radionuclides, with the exception of uranium, were not significantly different in game fish collected from Cochiti Reservoir as compared to game fish collected from reservoirs located upstream of the Laboratory. These results compare well with radionuclide contents in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Wicker 1972, Nelson 1969). Similarily, concentrations of ^{90}Sr, ^{137}Cs, ^{238}Pu, and ^{239}Pu in nongame fish collected downstream of the Laboratory were not significantly different from nongame fish collected from background locations. One fish sample, a bottom-feeder from Cochiti Reservoir, contained elevated levels of ^{239}Pu (0.0235 pCi/dry g). Since the other eight fish samples from Cochiti did not contain ^{239}Pu, this high value was probably a result of processing (i.e., cleaning) or analytical anomalies and was not included in Table V-30.

Again, total uranium concentrations were found to be significantly higher in nongame fish from Cochiti as compared to background. Also, both game (6.64 ng/dry g) and non-game fish (20.42 ng/dry g) from Cochiti contained higher uranium concentrations than the RSRL's (Fresquez 1994a). Although both game and nongame fish from Cochiti Reservoir had higher concentrations of uranium than fish collected upstream of the Laboratory, the isotopic ratio of ^{235}U (1.197 ± 10^{-13} atoms/g ash) to ^{238}U (1.652 ± 10^{-15} atoms/g ash) in Cochiti Reservoir bottom-feeding fish were consistent with naturally occurring uranium (e.g., 0.0072) (Efurd 1995). In other words, there was no evidence of depleted uranium in these fish samples. Depleted uranium, a by-product of uranium enrichment processes, has been used in dynamic weapons testing at Laboratory firing sites since the mid-1940s (Becker 1992). There was also no evidence of ^{236}U; this isotope does not occur in nature, and it is indicative of the presence of anthropogenic (man-made) uranium. The uranium detected in fish samples from Cochiti Reservoir (as well as from Abiquiu, Heron, and El Vado reservoirs) was probably from common uranium-bearing minerals (Wicker 1982). The uranium concentrations from northern New Mexico and in Bandelier tuff around the Los Alamos area, for example, range from 1.3 to 3.9 μg/g (Purtymun 1987a) and from 4.0 to 11.4 μg/g (Crowe 1978), respectively. In addition to these sources, uranium may be entering Cochiti Reservoir via the Santa Fe River as it passes near an abandoned 25-acre uranium mine site approximately 9.7 km (6 mi) upstream of Cochiti Reservoir. The US Forest Service stated in an Environmental Assessment report that uranium, lead, and other materials may enter the Santa Fe River during a major storm event.

Table V-29 Radionuclides in Honey Collected from Off-Site and On-Site Beehives during 1994

	Tritium (pCi/mL) [a]	^{90}Sr (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	^{137}Cs (pCi/L)	Uranium (μg/L)
OFF-SITE STATIONS						
Regional						
San Pedro	-0.10[b]	-1.700	.017	-0.006	-7.33	2.57
	(0.60)[c]	(17.00)	(0.048)	(0.040)	(22.00)	(0.88)
Pojoaque	-0.40	-1.50	0.032	0.035	18.89	0.35
	(0.60)	(15.80)	(0.038)	(0.044)	(56.68)	(0.12)
San Juan	0.10	-0.10	-0.006	-0.005	46.67	1.40
	(0.60)	(9.40)	(0.020)	(0.030)	(140.02)	(0.48)
Mean[d]	-0.13	-1.10	0.014	0.008	19.41	1.44
	(0.50)	(1.74)	(0.038)	(0.047)	(54.01)	(2.22)
CYRSRL[e]	0.37	0.64	0.052	0.055	73.42	3.66
LTRSRL[f]	21.22	6.00	0.121	0.103	327.47	6.46
Perimeter						
Los Alamos	0.20	20.30[g]	0.021	0.107[h]	38.87	1.97
	(0.60)	(18.60)	(0.048)	(0.102)	(31.96)	(0.40)
White Rock/Pajarito Acres/TA-36	2.40[h]	8.80	0.019	0.019	30.00	1.44
	(1.00)	(27.00)	(0.056)	(0.056)	(27.34)	(0.60)
ON-SITE STATIONS						
TA-5	-0.20	8.90	0.017	0.021	4.89	0.38
	(0.60)	(25.80)	(0.026)	(0.030)	(14.68)	(0.12)
TA-8	0.10	6.20	0.016	-0.011	4.44	0.28
	(0.60)	(11.20)	(0.026)	(0.018)	(13.32)	(0.14)
TA-9	0.70 [h]	5.40	0.003	0.030	15.71	0.22
	(0.66)	(14.20)	(0.020)	(0.034)	(47.14)	(0.12)
TA-15	-0.20	5.00	0.009	0.001	-12.00	0.24
	(0.60)	(11.80)	(0.022)	(0.020)	(32.00)	(0.08)
TA-16	-0.30	5.20	0.000	-0.004	20.54	0.12
	(0.60)	(8.60)	(0.024)	(0.012)	(61.62)	(0.06)
TA-21	2.00[h]	13.70[g]	0.014	0.013	19.33	0.15
	(0.80)	(8.60)	(0.018)	(0.020)	(58.00)	(0.06)
TA-33	21.30[g]	-3.00	-0.012	0.040	14.23	0.18
	(2.80)	(31.00)	(0.044)	(0.078)	(16.62)	(0.06)
TA-35	0.60[h]	5.00	-0.003	-0.022	9.56	0.27
	(0.60)	(9.20)	(0.024)	(0.032)	(28.68)	(0.10)
TA-49	0.30	8.90	0.014	0.013	-0.53	0.28
	(0.60)	(11.00)	(0.030)	(0.030)	(0.16)	(0.10)
TA-53	1,300.00[g]	2.70	0.091[h]	0.401[g]	-4.00	0.64
	(1.00)	(27.20)	(0.084)	(0.228)	(12.00)	(0.36)
TA-54	101.70[g]	-1.10	0.000	0.003	34.64	0.33
	(6.60)	(8.60)	(0.010)	(0.008)	(30.36)	(0.16)

[a]pCi/mL of honey moisture; honey contains approximately 18% water and has a density of 1860 g/L.
[b]See Section VIII.C.3, Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.
[c](± 2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.
[d](± 2 standard deviation).
[e]Current Year Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev]).
[f]Long-Term Regional Statistical Reference Level (this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1995a).
[g]Detectable value and higher than the LTRSRL.
[h]Detectable value (where the analytical result was greater or equal to two sigma) and higher than the CYRSRL.

Table V-30. Radionuclide Concentrations in Game (Surface-Feeding) and Nongame (Bottom-Feeding) Fish Upstream and Downstream of Los Alamos National Laboratory during 1994.

	^{90}Sr 10^{-2} pCi/dry g		^{137}Cs 10^{-2} pCi/dry g		Uranium ng/dry g		^{238}Pu 10^{-5} pCi/dry g		^{239}Pu 10^{-5} pCi/dry g	
GAME FISH (Surface-Feeders: Trout, Salmon, Crappie, Bass, Walleye).										
Upstream (Abiquiu, Heron, and El Vado)										
N[a]	10		10		10		10		10	
Min	0.0	(7.2)[b]	2.9	(2.4)	-0.04[c]	(0.12)	-17.0	(120.0)	-4.0	(80.0)
Max	10.2	(6.8)	18.5	(8.0)	4.05	(2.40)	15.0	(1,020.0)	0.0	(680.0)
Mean	4.4	(7.0)[d]	10.8	(11.6)	0.91	(2.80)	-0.4	(15.2)	-0.4	(2.6)
RSRL[e]	17.0		27.7		6.50		23.6		28.3	
Downstream (Cochiti)										
N	6		6		6		6		6	
Min	3.8	(7.6)	0.4	(1.2)	4.00	(0.36)	0.0	(960.0)	0.0	(640.0)
Max	13.3	(7.6)	9.0	(27.0)	9.88	(2.66)	18.0	(1,140.0)	0.0	(760.0)
Mean	8.4	(7.6)	3.2	(6.6)	6.64	(5.14)[f]	3.0	(14.6)	0.0	(0.0)
NONGAME FISH (Bottom-Feeders: Catfish, Suckers, Carp)										
Upstream (Abiquiu, Heron, and El Vado)										
N	10		10		10		10		10	
Min	1.2	(1.6)	0.0	(0.0)	1.30	(0.26)	-6.0	(360.0)	0.0	(160.0)
Max	9.1	(5.2)	18.1	(7.8)	18.60	(6.96)	13.0	(840.0)	0.0	(560.0)
Mean	4.2	(5.2)	12.2	(13.4)	7.48	(12.40)	2.8	(14.2)	0.0	(0.0)
RSRL[e]	13.2		26.9		16.20		9.8		19.2	
Downstream (Cochiti)										
N	9		9		9		9		8[g]	
Min	1.2	(2.4)	-2.7	(1.4)	6.42	(2.64)	-13.0	(360.0)	0.0	(240.0)
Max	10.4	(5.2)	3.5	(10.6)	43.89	(15.96)	0.0	(1,260.0)	0.0	(560.0)
Mean	4.9	(6.2)	0.4	(3.8)	20.42	(21.42)[f]	-2.6	(10.2)	0.0	(0.0)

[a]N = number of composite samples.

[b](+2 counting uncertainty); values are the uncertainty in the analytical results at the 95% confidence level.

[c]See Section VIII.C.3., Data Handling of Radiochemical Samples, for an explanation of the presence of negative values.

[d](+2 standard deviation).

[e]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 2 std dev) from Fresquez 1994a.

[f]Statistically significant from background using a Student's t-test at the 0.05 probability level.

[g]One sample was eliminated due to cross-contamination during sample preparation or analysis.

As expected, the bottomfeeders (nongame fish) from both downstream and upstream reservoirs contained higher average (weighted) uranium contents (14.00 ng/dry g) than the surfacefeeders (3.07 ng/dry g). The higher concentration of uranium in bottomfeeders as compared to surfacefeeders may be attributed to the ingestion of sediments on the bottom of the lake (Gallegos 1971). Sediments represent the accumulation or sink compartment for most radionuclides (Wicker 1982).

Game Animals. Analytical results of elk road kills collected during the winter of 1994/1995 will be reported in the FY95 Surveillance report. Two previous reports on elk collected on Laboratory land, however, are available for study (Meadows 1992, Fresquez 1995). The most current report includes data on total uranium ^{137}Cs, ^{90}Sr, ^{238}Pu, and ^{239}Pu concentrations detected in various tissue samples collected from on-site and off-site cow elk in 1992/1993. In general, no significant differences in the concentration of radionuclides were detected in any of the elk tissue samples collected from on-site and off-site locations.

Milk. Milk collected from the Pojoaque Valley and Albuquerque region are summarized in Table V-31. All radionuclides, with the exception of uranium, in milk collected from Pojoaque were within ULB concentrations (mean + 2 std dev). Tritium (0.10 pCi/mL) and ^{90}Sr (0.00 pCi/L) levels, in particular, compare well with tritium (ave. 0.16 pCi/mL) and ^{90}Sr levels (ave. 1.1 pCi/L) in milk from other states around the country (Nevada Test Site Annual Site Environmental Report 1993). Milk collected from both Pojoaque and Albuquerque dairies contained detectable uranium levels (where the analytical result was higher than two sigma). This is not unexpected as uranium is a natural element in all soils, and the degree to which it is found in milk depends on many factors including the geology, vegetation, and meterological (wind and rain) conditions of the area (Wicker and Schultz 1982). Although the uranium level in milk from the Pojoaque Valley (0.24 µg/L), was slightly higher than the uranium content in milk from Albuquerque (0.10 µg/L), it was still within (background) uranium concentrations found in milk from other parts of the country (e.g., 0.02 to 0.30 µg/L) (Fernald Environmental Restoration Management Corporation 1993).

8. Unplanned Releases.

a. Airborne Radioactivity. On January 25, 1994, an estimated 340 Ci (13 Tbq) of tritium was released during a pumping and sampling operation performed for a planned safe shutdown maintenance procedure at the high-pressure tritium laboratory (TA-33, Building 86). Potential doses were estimated using the meteorological conditions during the time of the release (PGL 1994). The estimated dose to the nearest public receptor was 3.3 x 10^{-4} mrem (3.3 x 10^{-6} mSv). The calculated dose to LANL's maximum exposed individual (MEI) location was 1.0 x 10^{-3} mrem (1.0 x 10^{-5} mSv).

On February 7, 1994, a HEPA filter was changed out of Building 4, FE-3, at the DP Site West (TA-21). The changeout resulted in a higher-than-normal stack release of ^{238}U. Approximately 160 µCi (5.9 MBq) were released during the week of February 4 to February 11, 1994 (LANL 1994). Potential doses were estimated using an EPA-approved dispersion code to be 3.44 x 10^{-2} mrem (3.44 x 10^{-4} mSv) to the nearest public receptor and 3.60 x 10^{-3} mrem (3.60 x 10^{-5} mSv) to the LANL MEI, (EPA 1990a).

Table V-31. Radionuclide Concentrations in Milk Collected in 1994[a]

	Pojoaque Valley		Albuquerque, NM	
^{238}Pu (pCi/L)	0.003	(0.060)[b]	0.000	(0.060)
^{239}Pu (pCi/L)	0.000	(0.040)	-0.013	(0.040)
^{90}Sr (pCi/L)	0.000	(0.200)	0.000	(0.200)
Total U (µg/L)	0.240	(0.040)	0.100	(0.020)
Tritium (pCi/mL)	0.100	(0.600)	-0.200	(0.600)
^{137}Cs (pCi/L)	3.100	(11.860)	2.410	(13.380)
^{131}I (pCi/L)	4.700	(11.600)	10.000	(15.760)

[a]All radionuclide contents in milk, with the exception of uranium, had non-detectable values (i.e., where the analytical result was less than two sigma).

[b](±2 counting uncertainties); values are the uncertainty in the analytical results at the 95% confidence level.

On December 5, 1994, during a process to recover ^{68}Ge from a target, containment of the distillation process was lost, resulting in a stack release of 1.18 mCi (44 MBq) from the radiochemistry site (TA-48, building 1) (LLNL 1994). Potential doses were estimated to be 3.03×10^{-6} mrem (3.03×10^{-8} mSv) to the nearest public receptor and 5.02×10^{-8} mrem (5.02×10^{-10} mSv) to the LANL MEI (LLNL 1994).

b. Radioactive Liquid Releases. There were no unplanned liquid releases at the Laboratory during 1994.

C. Radiological Doses

1. Introduction.

Radiological dose equivalents are calculated in order to measure the health impacts of any releases of radioactivity to the environment. Dose equivalent refers to the quantity of radiation energy absorbed per unit mass (the dose), multiplied by adjustment factors for the type of radiation absorbed. The effective dose equivalent (EDE) is the principal measurement used in radiation protection. The EDE is a hypothetical whole-body dose equivalent that would equal the same risk of cancer mortality and serious genetic disorder as the sum of the weighted dose equivalents of those organs considered to be most seriously affected by the radionuclide in question. The EDE includes the committed effective dose equivalent from internal deposition of radionuclides and the EDE due to penetrating radiation from sources external to the body.

Standards exist which limit the EDE to the public (DOE 5400.5, 40 CFR Part 61. The DOE's PDL is 100 mrem/yr (1mSv/yr) EDE received from all pathways (i.e., ways in which people can be exposed to radiation, such as inhalation, ingestion, and immersion in water or air containing radioactive materials), and the dose received by air is restricted by the EPA's effective dose standard of 10 mrem/yr (0.10 mSv/yr) ([40 CFR Part 61] Appendix A). These values are in addition to exposures from normal background, consumer products, and medical sources. The standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

2. Methods for Dose Calculations.

a. Introduction. Annual radiation doses are evaluated for three principal exposure pathways: external exposure (which includes exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation), inhalation, and ingestion. Estimates are made of the following exposures:

- maximum individual organ doses and the EDE to an individual at or outside the Laboratory boundary where the highest dose rate occurs and a person actually is present,
- average organ doses and EDEs to nearby residents,
- collective EDE for the population living within an 80 km (50 mi) radius of the Laboratory.

Two evaluations of potential airborne releases are conducted: one to satisfy 40 CFR Part 61 requirements and one for all pathways. Results of environmental measurements are used as much as possible in assessing doses to individual members of the public. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE 1991a, NRC 1977). If the impact of Laboratory operations is not detected by environmental measurements, individual and population doses attributable to Laboratory activities are estimated through computer modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-18. These factors are recommended by the DOE (1988b) and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP 1978).

Dose conversion factors for inhalation assume a particle size of 1 μm activity median aerodynamic diameter as well as the lung solubility category that will maximize the EDE (for comparison with DOE's 100 mrem/yr PDL). Similarly, the ingestion dose conversion factors are chosen to maximize the EDE for comparison with DOE's 100 mrem/yr PDL for all pathways.

These dose conversion factors give the 50-year dose commitment for internal exposure. The 50-year dose commitment is the total dose received by an organ during the 50-year period following the intake of a radionuclide.

External doses are calculated using the dose-rate conversion factors published by DOE (1988c) (Table D-19). These factors give the photon dose rate in millirems per year per unit radionuclide air concentration in microcuries

per cubic meter. If the conversion factor for a specific radionuclide of interest is not published in DOE 1988c, it is calculated with the computer program DOSFACTOR II (Kocher 1981).

Annual EDEs are estimated with the CAP-88 collection of computer codes published by the EPA if releases from Laboratory operations are so small that they are less than analytical detection limits. CAP-88 uses dose conversion factors generated by the computer program RADRISK. The 50-year dose commitment conversion factors from RADRISK were compared with the ICRP/DOE dose conversion factors and found to agree to within 5%. This agreement was judged more than adequate to justify RADRISK dose factors when CAP-88 is being used.

b. External Radiation. Environmental TLD measurements are used to estimate external penetrating radiation doses. The TLD measurements include background radiation and any external radiation contribution from Laboratory operations. Environmental background dose is subtracted from the environmental TLD measurements to determine the contribution from the Laboratory. Background radiation estimates at each site are based on historical data, consideration of other possible radioactive sources, and, if possible, values measured at locations of similar geology and topography. The estimated background value is subtracted from the total measured TLD value to yield the net annual dose. The net annual TLD dose is assumed to represent the dose from Laboratory activities that would be received by an individual who spent 100% of the year at the monitoring location.

The final individual dose is derived by reducing the measured exposure by 20% to account for building shielding and by 30% to account for the self-shielding of the body. (Note: these reductions are not used for demonstrating compliance to the EPA standard; see Section C.4.b below.)

Neutron generating facilities at TA-18 had the potential for resulting in exposures from direct penetrating radiation to the public along Pajarito Road. The TA-18 site policy strictly follows as low as reasonably achievable (ALARA) principles; specifically, daytime operations are limited to producing less than 1 mrem per operation or 10 mrem per month at the site boundary. During 1994, operations at TA-18 that had the potential of producing a dose in excess of 1 mrem per operation were limited to nighttime or weekend operations with minimum site occupation. In addition, public access was restricted by closing Pajarito Road from White Rock to TA-51 during these operations at TA-18, thus eliminating the potential for dose to the public.

c. Inhalation Dose. Annual average air concentrations of tritium, ^{238}Pu $^{239,240}Pu$, ^{234}U, ^{235}U, ^{238}U, and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. The net concentration is reduced by 10% to account for indoor occupancy (Kocher 1980). These net concentrations are then multiplied by a standard breathing rate of 8,400 m /yr (ICRP 1975) to determine total adjusted intake via inhalation, in microcuries per year, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50-year dose commitments. Following ICRP methods, doses are calculated for all organs that contribute more than 10% of the total EDE for each radionuclide. The dose calculated for inhalation of tritium is increased by 50% to account for absorption through the skin.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (8,760 h). This assumption is made for the boundary dose, dose to the MEI, and dose to the population living within 80 km (50 mi) of the site.

d. Ingestion Dose. Results from foodstuffs sampling are used to calculate organ doses and EDEs from ingestion for individual members of the public. The procedure is similar to that used in the previous section. Corrections for background are made by subtracting the average concentrations plus two standard deviations from sampling stations not affected by Laboratory operations. The radionuclide concentration in a particular foodstuff is multiplied by an estimated annual consumption rate to obtain total adjusted intake of that radionuclide. Multiplication of the adjusted intake by the radionuclide's ingestion dose conversion factor for a particular organ gives the estimated dose to the organ and the CEDE to the entire body (Table D-19).

To obtain the net positive difference for each radionuclide, the maximum CEDE (i.e., average + 2 sigma) at the regional stations is subtracted from the maximum CEDE at each monitoring location. Since one cannot receive a "negative exposure to radiation," all negative values are set to zero. The total net positive difference is the resulting CEDEs summed over all monitored radionuclides.

3. Estimation of Radiation Doses.

a. Doses from Natural Background. Published EDE values from natural background and from medical and dental uses of radiation are used to provide a comparison with doses resulting from Laboratory operations. Global fallout doses due to atmospheric testing of nuclear weapons are only a small fraction of total background doses (<0.3%, NCRP 1987a). Natural background radiation dose is due to exposure to the lungs from radon decay products and exposures from nonradon sources which affect the whole body.

External radiation comes from two sources of approximately equal magnitude: the cosmic radiation from space and terrestrial gamma radiation from radionuclides in the environment. Estimates of background radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b). The 1987 NCRP report uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation. The 30% protection factor is also applied to less energetic gamma radiation from LANL sources.

Whole-body external dose is incurred from exposure to cosmic rays, external terrestrial radiation from naturally occurring radioactivity in the earth's surface, and from global fallout. The EDE from internal radiation is due to radionuclides naturally present in the body and inhaled and ingested radionuclides of natural origin.

Annual external background radiation exposures for sources other than radon vary depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation in 1994 from nonradon sources are based on TLD measurements of 132 mrem (1.32 mSv) in Los Alamos and 118 mrem (1.18 mSv) in White Rock. These measured doses were adjusted for structural shielding by reducing the cosmic ray component by 20%. The measured doses were also adjusted for self-shielding by the body by reducing the terrestrial component by 30%. The neutron dose from cosmic radiation and the dose from self-irradiation were then included to obtain the whole-body background dose of 148 mrem (1.48 mSv) at Los Alamos and 136 mrem (1.30 mSv) at White Rock from sources other than radon. Inhalation of ^{222}Rn produced by decay of ^{226}Ra, a member of the uranium series, results in a dose to the lung, which also must be considered. Uranium decay products occur naturally in soil and building construction materials. The EDE from ^{222}Rn decay products is assumed to be equal to the national average, 200 mrem/yr (2 mSv/yr). This estimate may be revised if a nationwide study of background levels of ^{222}Rn in homes is undertaken. Such a national survey has been recommended by the NCRP (NCRP 1984, 1987a).

In 1994 the EDE to residents was 348 mrem (3.48 mSv) at Los Alamos and 336 mrem (3.36 mSv) at White Rock (Table V-32) from all natural sources. The individual components of the background dose for Los Alamos and White Rock, and the average EDE of 53 mrem/yr (0.53 mSv/yr) to members of the US population from medical and dental uses of radiation (NCRP 1987a) are listed in Table V-33.

b. Doses to Individuals from External Penetrating Radiation from Airborne Emissions. The major source of external penetrating radiation from LANL operations has been airborne emissions from LAMPF. Nuclear reactions with air in the beam target areas at LAMPF (TA-53) cause the formation of air activation products, principally ^{11}C, ^{13}N, ^{14}O, and ^{15}O. These isotopes are all positron emitters and have 20.4-min, 10-min, 71-s, and 122-s half-lives, respectively. These isotopes are sources of gamma photon radiation because of the formation of two 0.511-MeV photons through positron-electron annihilation. The ^{14}O also emits a 2.4-MeV gamma photon.

Because of questions concerning the event-to-dose conversion algorithm, a comprehensive dose figure is currently not available from the East Gate air monitoring stations. Several different methods were applied to derive a dose estimate, but the resulting data could not be statistically proven accurate compared with data from a pressurized ion chamber gamma photon detector. The pressurized ion chamber is considered a primary standard for radiation measurement (NCRP 1978). Although the HPGe system used in the East Gate system is thought to be more sensitive than the pressurized ion chamber, the sensitivity does not currently withstand statistical scrutiny.

c. Doses to Individuals from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring of off-site locations. On-site TLD measurements of external penetrating radiation reflected Laboratory operations; however, they did not represent any significant public exposure since these areas were closed to the public.

d. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual EDEs attributable to inhalation of airborne emissions (Table V-34) are below the EPA air pathway standard of 10 mrem/yr (0.1 mSv/yr). Exposures to airborne tritium (as tritiated water vapor), ^{238}Pu, ^{239,240}Pu, ^{241}Am, ^{234}U, ^{235}U, ^{238}U,

Table V-32. Summary of Annual Effective Dose Equivalents Attributable to 1994 Laboratory Operations

	Maximum Dose to an Individual[a]	Average Dose to Nearby Residents		Collective Dose to Population within 80 km of the Laboratory (234,000 persons)
		Los Alamos	White Rock	
Dose[b]	3.5 mrem[c]	0.27 mrem[b]	0.06 mrem[b]	4 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
Background	348 mrem	348 mrem	336 mrem	77,0000 person-rem[d]
DOE Public Dose Limit	100 mrem			[e]
Percentage of Public Dose Limit	3.5 %	0.27%	0.06%	
Percentage of Background	1.0%	0.077%	0.018%	0.006%

[a]Maximum individual dose is the dose to any individual at or outside the Laboratory where the highest dose rate occurs. Calculations take into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.
[b]Doses are reported at the 95% confidence level.
[c]1 mrem = 0.01 mSv.
[d]Based on the collective dose from the CAP-88 model
[e]There is no dose limit for the collective dose; however, a 100 person-rem value for the population is found in the proposed 10 CFR 834.

Table V-33. Calculation of Total Effective Dose Equivalent (mrem/yr)

	Los Alamos	White Rock
Radon	200	200
Self-irradiation	40	40
Total External[a]	108	96
Total Effective Background Dose	**348**	**336**
Medical	53	53

[a]Includes correction for shielding

Table V-34. Estimated Maximum Individual 50-Year Dose Commitments from 1994 Airborne Radioactivity

Isotope	Location	Estimated Dose (mrem/yr)[a]	Percentage of Public Dose Limit
Tritium	Nazarene Church	0.02	0.2%
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	Residence North of LAMPF	3.5	35%
^{241}Am, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$	White Rock Fire Station	0.022	0.22%

[a]1 mrem/yr = 0.01 mSv/yr.

and ^{131}I were determined by measurement. Correction for background was made by assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. The highest EDE measured off site for ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{234}U, ^{235}U, and ^{238}U occurred at the White Rock Fire station and was 0.022 mrem (0.022 mSv), or 0.022% of the DOE's PDL of 100 mrem/yr (1 mSv/yr), and 0.7% of the EPA's 10 mrem/yr (0.1 mSv/yr) standard for dose from the air pathway. Emissions of air activation products from LAMPF resulted in negligible inhalation exposures. The total EDE to a member of the public from all TA-54, Area G operations during 1994 was estimated using the atmospheric transport model, CAP-88, to be 2.0 μrem/yr (0.02 μSv/yr), or 0.02% of the EPA radiation limit of 10 mrem/yr for the air pathway. Exposure from all other atmospheric releases of radioactivity (Table V-5) was also evaluated by theoretical calculations of airborne dispersion. All potential inhalation doses from these releases were less than 1.3% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

e. Doses to Individuals from Ingestion of Foodstuffs. Data from samples of produce, fish, honey, and milk were used in 1994 to estimate the committed effective dose equivalents (CEDEs) from the ingestion of foodstuffs. The CEDE is the committed effective dose equivalents to individual tissues resulting from an intake multiplied by the appropriate weighting factors and then summed over all tissues (ICRP 1984). This value thus represents the EDE to the whole body for radionuclides taken into the body. Assuming one individual consumed the total quantity listed for each food grouping, the net difference for the CEDE between the regional background and the dose in food consumed for all food groups is 0.1% of the DOE's 100 mrem/yr (1 mSv/yr) public dose limit (PDL) (DOE 1990a), indicating that Laboratory operations do not result in significant radiation doses to the general public from consuming foodstuffs in the local area.

Produce. Produce (fruits, vegetables, and grains) are collected from on-site, perimeter (Los Alamos and White Rock/Pajarito Acres), and regional (Española, Santa Fe, and Jemez) locations, as well as pueblo lands (the Pueblo of San Ildelfonso and Cochiti) located in the general vicinity of the Laboratory. These samples are analyzed by the Environmental Chemistry Group (CST-9) for concentrations of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. The CEDE values are based on an annual consumption rate for produce of 160 kg/yr (352 lb/yr) (Table V-35).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from all sources in 0.514 mrem (5.1 μSv). The total net positive difference in the CEDE due to the consumption of 160 kg/yr (352 lb/yr) of produce from Cochiti, White Rock, Los Alamos, and the Pueblo of San Ildefonso is 0.016 mrem (0.16 μSv) (<0.02% of the DOE PDL), 0.001 mrem (0.01 μSv) (<0.002% of the DOE PDL), 0.006 mrem (0.06 μSv) (<0.007% of the DOE PDL) and 0.047 mrem (0.47 μSv) (<0.05%) of the DOE PDL) respectively. The total net positive difference between the CEDE for regional and on-site produce is 0.027 mrem (0.27 μSv). Ingestion of produce collected onsite is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs. The Student's t-test shows that there is no significant difference at the 95% level of confidence between the CEDEs from produce consumed from regional, perimeter, and on-site locations.

Table V-35. Total Committed Effective Dose Equivalent from the Ingestion of Produce Collected from Off-Site Areas during the 1994 Growing Season

Off-Site Stations	Total CEDE[a] (mrem/yr)	
Regional		
Española/Santa Fe/Jemez	0.149	(0.365)[b]
Perimeter Stations		
Cochiti Pueblo	0.091	(0.169)[b]
White Rock	0.061	(0.116)[b]
Los Alamos	0.147	(0.228)[b]
Pueblo of San Ildefonso	0.117	(0.300)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).

[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

Honey. Honey samples were collected from off-site regional stations (San Pedro, Pojoaque, and San Juan), off-site perimeter stations in Los Alamos and White Rock, and from 11 on-site locations in 1994. These samples were analyzed for tritium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{137}Cs, and uranium. The CEDE values are based on an annual consumption rate of 5 kg (11 lbs) (Table V-36). The water content of honey is estimated at 18% (Winston 1991).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from the ingestion of honey collected in Los Alamos and White Rock during 1994 is 0.027 mrem (0.27 μSv). To provide an assessment of the potential impact of Laboratory operations on this foodstuff, the net dose was determined by subtracting the regional background concentrations from the off-site perimeter stations. This total net positive difference for the Los Alamos and White Rock locations is 0.011 mrem (0.11 μSv) (0.01% of the DOE PDL) and 0.008 mrem (0.08 μSv) (0.01% of the DOE PDL), respectively. Honey that is collected from on-site Laboratory locations is not available for public consumption.

Fish. Fish samples were collected in 1994 from bottom and higher level feeders at locations upstream (Abiqui, Heron, and/or El Vado reservoirs) and downstream (Cochiti Reservoir) of the Laboratory. All samples collected are more than 10 km (6.2 mi) beyond Laboratory boundaries. These samples are analyzed by the Environmental Chemistry Group (CST-9) for the concentrations of uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. The CEDE values are based on an annual consumption rate of 21 kg (46 lbs) (Table V-37).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from bottom feeders is 0.153 mrem (1.5 μSv). The total net positive difference in the CEDE from the consumption of bottom feeders from these upstream and downstream locations using a 21 kg/yr (46 lb/yr) consumption rate is 0.017 mrem (0.17 μSv) (0.02% of the DOE

Table V-36. Total Committed Effective Dose Equivalent from the Ingestion of Honey Collected from Los Alamos and White Rock during 1994

Off-Site Stations	Total CEDE[a] (mrem/yr)	
Regional		
San Pedro	0.001	(0.010)[b]
Pojoaque	0.003	(0.014)[b]
San Juan	0.007	(0.023)[b]
Perimeter		
Los Alamos	0.015	(0.013)[b]
White Rock	0.008	(0.015)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).
[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

Table V-37. Total Committed Effective Dose Equivalent from the Ingestion of Fish Collected during 1994

Off-Site Sampling Location	Total CEDE[a] (mrem/yr)	
Bottom Feeders		
Upstream (Abiqui, Heron, El Vado)	0.068	(0.085)[b]
Downstream (Cochiti Reservoir)	0.038	(0.074)[b]
Higher Level Feeders		
Upstream (Abiqui, Heron, El Vado)	0.059	(0.084)[b]
Downstream (Cochiti Reservoir)	0.072	(0.077)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).
[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

PDL). Similarly for higher level feeders, the total net positive difference in the CEDE is 0.039 mrem (0.39 μSv) (0.04% of the DOE PDL). The Student's t-test shows that there is no significant difference at the 95% level of confidence between the CEDE from the consuming fish from these upstream and downstream locations.

Milk. Milk samples were collected from a dairy in Pojoaque Valley and a dairy in Albuquerque during 1994. All samples collected are more than 10 km (6.2 mi) beyond Laboratory boundaries. These samples were analyzed for ^{90}Sr, $^{239,240}Pu$, ^{137}Cs, tritium, ^{131}I, and uranium. The CEDE values are based on a maximum annual comsumption rate of 292 L (77 gal) (Table V-38).

The maximum annual CEDE (i.e., the total CEDE plus 2 sigma) from the two dairies is 0.771 mrem (7.7 μSv). The total net positive difference in the CEDE from the consumption of milk produced at these two locations is 0.014 mrem (0.14 μSv) (0.01% of the DOE PDL). Based on the sample results and plus 2 counting uncertainties, these data sets overlap indicating that there is no significant difference between the CEDEs from consuming milk collected from these two dairies.

4. Total Maximum Individual Dose to a Member of the Public from 1994 Laboratory Operations.

a. Maximum Individual Dose. The maximum individual EDE to a member of the public from 1994 Laboratory operations is estimated to be 3.5 mrem/yr (0.035 mSv/yr). This is the total EDE from all pathways. This dose is 3.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) EDE from all pathways (Table V-32) and 0.9% of the total annual dose contribution (Figure V-21). The maximum individual dose occurred at East Gate (the Laboratory boundary northeast of LAMPF) and was primarily due to external penetrating radiation from air activation products released by the LAMPF accelerator. The 1994 dose estimate is based on environmental measurements for doses. See Section V. B. for discussion of environmental dose measurements. The computer model CAP-88, which is discussed in more detail in the following section, was used to make the dose estimate for external radiation from airborne radioactivity for the Los Alamos and White Rock townsites. Doses from other exposure pathways were estimated using environmental monitoring results (see Sections V.C.3.d and V.C.3.f). Doses from liquid releases and direct radiation from LANL facilities did not impact the Los Alamos or White Rock townsites. The maximum EDE for external radiation from airborne emissions was estimated by CAP-88 using all measured releases from LANL facilities (Tables V-4 and V-17) and 1994 meteorological data. The dose estimate took into account shielding by buildings (30% reduction for submersion dose, 10% for inhalation dose) (Kocher 1980) and occupancy (100% for residences, 25% for businesses). The contribution to the maximum individual off-site dose via each pathway is presented in Figure V-22. The average EDE to residents in the Los Alamos townsite that is attributable to Laboratory operations in 1994 was 0.27 mrem (0.0027 mSv). The corresponding dose to White Rock residents was 0.06 mrem (0.0006 mSv). The doses are approximately 0.27% and 0.06% of DOE's PDL of 100 mrem/yr (1.0 mSv/yr) (Table V-32).

b. Estimate of Maximum Individual Dose from Airborne Emissions for Compliance with 40 CFR Part 61, Subpart H. As required by the EPA, compliance with regulation 40 CFR 61, Subpart H must be demonstrated with the CAP-88 version of the computer codes PREPAR2, AIRDOS2, DARTAB2, and RADRISK (EPA 1990a). These codes use measured radionuclide release rates and meteorological information to calculate transport and airborne concentrations of radionuclides released to the atmosphere. The programs estimate radiation exposures from inhalation of radioactive materials; external exposure to the radionuclides present in the atmosphere and deposited on the ground; and ingestion of radionuclides in produce, meat, and dairy products.

Table V-38. Total Committed Effective Dose Equivalent from the Ingestion of Milk Collected during 1994

Sampling Locations	Total CEDE[a] (mrem/yr)	
Dairy in the Pojoaque Valley	0.135	(0.490)[b]
Dairy in Albuqerque, NM	0.195	(0.576)[b]

[a]Based on DOE dose conversion factors (DOE 1988b).

[b] ± 2 sigma in parentheses; to convert to μSv, multiply by 10.

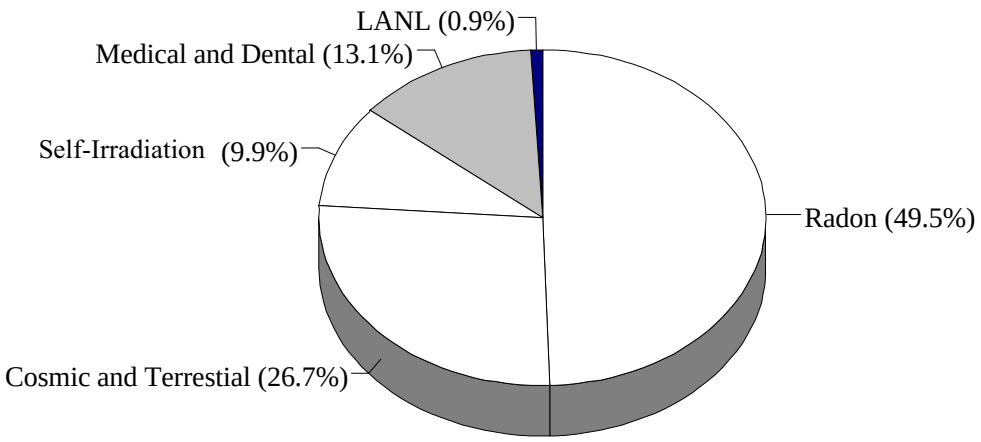

Figure V-21. Total contributions to 1994 dose at the Laboratory's maximum exposed individual location.

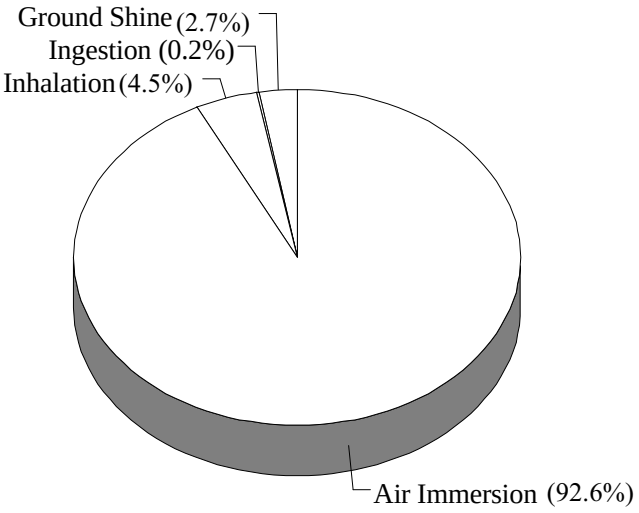

Figure V-22. The Laboratory's contribution to dose by pathway at the maximum exposed individual location.

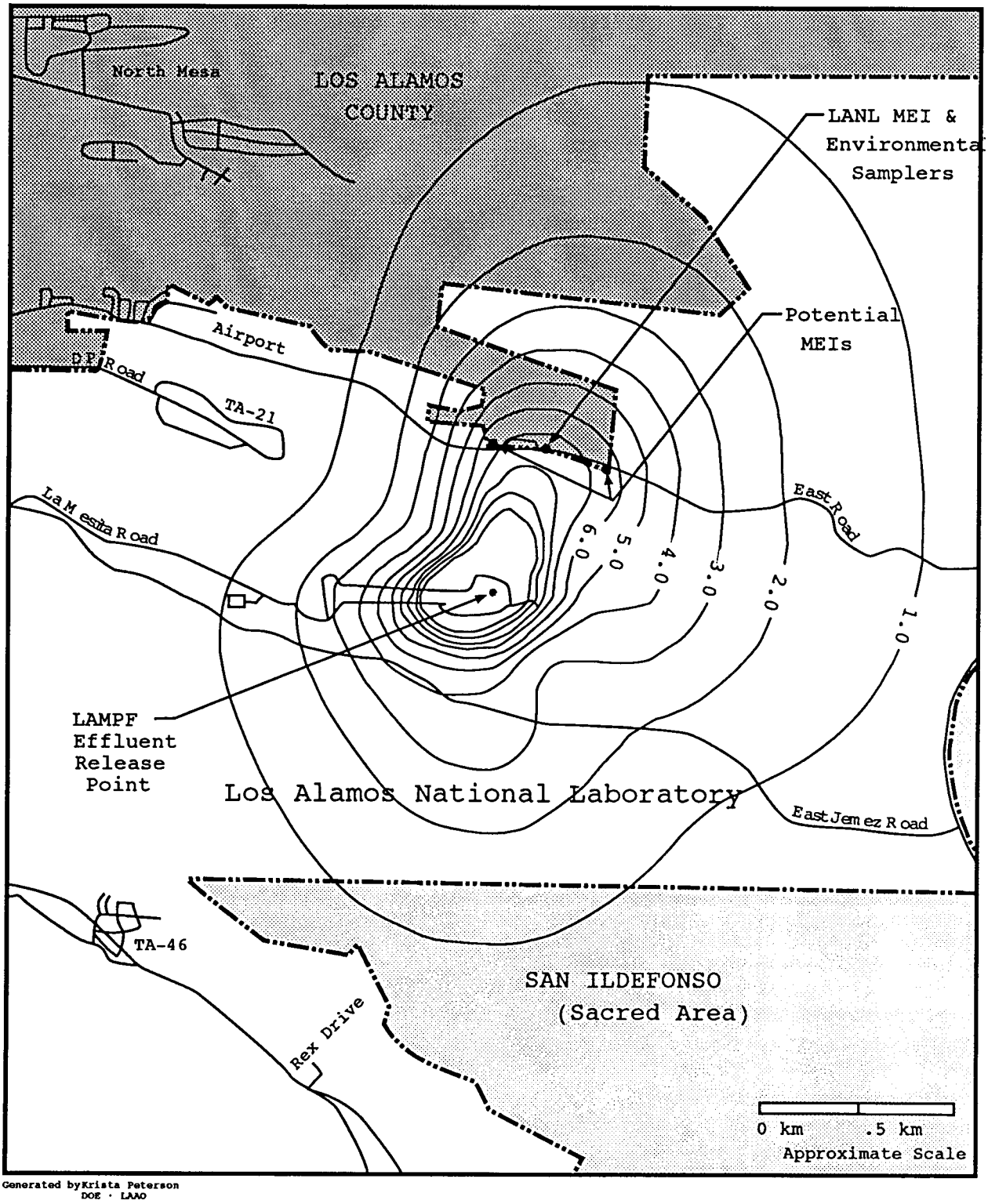

Figure V-23. CAP-88 calculated dose contours (mrem) for 1994 LAMPF airborne emissions.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables V-4 and V-5. Wind speed, wind direction, and stability class are continually measured at meteorology towers located at TA-54, TA-49, TA-6, and East Gate. Emissions were modeled with the wind information most representative of the release point.

The maximum individual EDE from airborne emissions, as determined by CAP-88, was 7.62 mrem (0.0762 mSv). As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The maximum dose, which would occur in the area just northeast of LAMPF, is 76.2% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) EDE. Presented in Figure V-23 is a contour plot of the estimated doses resulting from LAMPF air effluents in 1994. It should be noted that CAP-88 over estimates dose at the East Gate location because of the rough topography between the source and receptor, which is not accounted for in the computer code.

5. Collective Effective Dose Equivalents.

The collective EDE from 1994 Laboratory operations was evaluated for the area within 80 km (50 mi) of the Laboratory. Over 99% of this dose is expected to have resulted from airborne radioactive emissions from Laboratory programs. As a result, the collective dose was estimated by modeling 1994 radioactive air emissions, their transport off-site, and the resulting radiation exposures that could occur.

The 1994 collective EDE (in person-rem) was calculated with the CAP-88 collection of computer codes PREPAR2, AIRDOS2, and DARTAB2. These codes were also used to calculate the maximum EDE to a member of the public as required by the EPA regulations 40 CFR Part 61 (EPA 1989c).

The collective dose calculation used the EPA's CAP-88-generated agricultural profile of the area within an 80-km (50-mi) radius. The same exposure pathways that were evaluated for the maximum individual dose were also evaluated for the collective dose. These pathways include inhalation of radioactive materials, external radiation from materials present in the atmosphere and deposited on the ground, and ingestion of radionuclides in meat, produce, and dairy products.

The 1994 population collective EDE attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated to be 4.0 person-rem (0.04 person-Sv). This dose is <0.1% of the 72,000 person-rem (720 person-Sv) exposure from natural background radiation and <0.1% of the 12,000 person-rem (120 person-Sv) exposure from medical radiation (Table V-39).

The collective dose from Laboratory operations was calculated from measured radionuclide emission rates (Table V-5), atmospheric modeling using measured meteorological data for 1994, and population data based on the Bureau of Census count (Table II-3). The collective dose from natural background radiation was calculated using the background radiation levels given above. For the population living within the 80-km (50-mi) radius of the Laboratory, the dose from medical and dental radiation was calculated using a mean annual dose of 53 mrem (0.53 mSv) per capita (NCRP 1987a). The population distribution in Table II-3 was used in both these calculations to obtain the total collective dose.

Table V-39. Estimated Collective Effective Dose Equivalents during 1994 (person-rem)

Exposure Mechanism	Los Alamos County (18,400 persons)	80 km Region (234,000 persons)[a]
Total caused by Laboratory releases	3.7	4.0
Natural background		
Nonradon[b]	2,600	30,000
Radon	3,700	47,000
Totals caused by natural sources of radiation	6,300	77,000
Diagnostic medical exposures (~53 mrem/yr/person)[c]	1,000	12,000

[a]Includes doses reported for Los Alamos County.

[b]Calculations are based on TLD measurements. They include a 20% reduction in cosmic radiation from shielding by structures and a 30% reduction in terrestrial radiation from self-shielding by the body (NCRP 1987a).

[c]NCRP (1987a). 1 person mrem = 0.01 person mSv

Also shown in Table V-39 is the collective EDE in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 90% of the total collective dose from Laboratory operations is to Los Alamos County residents. This dose is less than 0.1% of the collective EDE from background and 0.4% of the collective dose from medical and dental radiation, respectively.

D. Risk to an Individual from Laboratory Releases

1. Estimating Risk.

Risk estimates of possible health effects from radiation doses to the public resulting from Laboratory operations have been made to provide a perspective in interpreting these radiation doses. These calculations, however, may overestimate actual risk for low-linear energy transfer (LET) radiation. The NCRP (1975a) has warned that "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose incidence curve at high doses and high dose rates . . . cannot be expected to provide realistic estimates of the actual risks from low-level, low-LET radiation, and have such a high probability of overestimating the actual risk as to be of only marginal vale, if any, for purposes of realistic risk-benefit evaluation."

Low-LET radiation, which includes beta particles and gamma rays, is the principal type of environmental radiation resulting from Laboratory operations. Estimated doses from high-LET radiation, such as neutron or alpha particle radiation, are less than 3% of estimated low-LET radiation doses. Consequently, risk estimates in this report overestimate the true risks.

Risk estimates used here are based on two recent reports by the National Research Council's Committee on the Biological Effects of Ionizing Radiation (BEIR IV 1988, BEIR V 1990). These reports incorporate the results of the most current research and update risk estimates in previous surveillance reports that were based on the work of the ICRP. The procedures used in this report for the risk estimates are described in more detail below.

2. Risk from Whole-Body Radiation.

Radiation exposures considered in this report are of two types: (1) whole-body exposures and (2) individual organ exposures. The primary doses from nonradon natural background radiation and from Laboratory operations are whole-body exposures. With the exception of natural background radon exposures, discussed below, radiation doses and associated risks from those radionuclides that affect only selected body organs are a small fraction of the dose and are negligible. Risks from whole-body radiation were estimated using the factors of the BEIR V report.

Risk factors are taken from the BEIR estimate (BEIR V 1990) of the risk from a single, instantaneous, high-dose rate exposure of 10 mrem. The BEIR V report states that this estimate should be reduced for an exposure distributed over time that would occur at a substantially lower dose rate. The committee discussed dose rate effectiveness factors (DREFs) ranging from 2 to 10 that should be applied to the nonleukemia part of the risk estimate.

For the risk estimates presented in this report, a DREF of 2 is used for the nonleukemia risk. Following the BEIR V report, no dose rate reduction is made for the leukemia risk. The risk is then averaged over male and female populations. The total risk estimate is 500 cancer (nonleukemia and leukemia) fatalities per 1×10^9 person-mrem (1×10^7 person mSv).

3. Risk from Exposure to Radon.

Exposures to radon and radon-decay products are important parts of natural background radiation. These exposures differ from the whole-body radiation discussed above in that they principally involve only the localized exposure of the lung and no other organs in any significant way. Consequently, the risks from radon exposure were calculated separately.

Exposure rates to radon (principally ^{222}Rn) and radon-decay products are usually measured with a special unit, the working level (WL); 1 WL corresponds to a liter of air containing short-lived radon decay products whose total potential alpha energy is 1.3×10^5 MeV. An atmosphere having a 100 pCi/L (3.7 Bq/L) concentration of ^{222}Rn at equilibrium with its decay products corresponds to 1 WL. Cumulative exposure is measured in working level months (WLMs). A WLM is equal to exposure to 1 WL for 170 hours.

The estimated national average radon EDE that was given by the NCRP is 200 mrem/yr (2 mSv/yr). The NCRP derived this dose from an estimated national average radon exposure of 0.2 WLM/yr. Because the risk factors are derived in terms of WLM, for the purposes of risk calculation it is more convenient to use the radon exposure of 0.2 WLM/yr than to use the radon dose of 200 mrem/yr (2 mSv/yr). However, the 0.2 WLM/yr and the 200 mrem/yr (2 mSv/yr) EDE correspond to the same radiation exposure.

Risks from radon were estimated using a risk factor of 350×10^{-6}/WLM. This risk factor was taken from the BEIR IV report (BEIR IV 1988).

4. Risk from Natural Background Radiation and Medical and Dental Radiation.

During 1994, persons living in Los Alamos and White Rock received an average EDE of 148 mrem (1.48 mSv) and 136 mrem (1.36 mSv), respectively, of nonradon radiation (principally to the whole body) from natural sources (including cosmic, terrestrial, and self-irradiation sources, with allowances for shielding and cosmic neutron exposure). Thus, the added risk of cancer mortality attributable to natural whole-body radiation in 1994 was approximately 1 chance in 15,000 in Los Alamos and approximately 1 chance in 17,000 in White Rock.

Natural background radiation also includes exposure to the lung from ^{222}Rn and its decay products (see above) in addition to exposure to whole-body radiation. This exposure to the lung also carries a chance of cancer mortality from natural radiation sources that was not included in the estimate for whole-body radiation. For the background EDE of 200 mrem/yr (2 mSv/yr), the added risk because of exposure to natural ^{222}Rn and its decay products is approximately 1 chance in 14,000.

The total risk of cancer mortality from natural background radiation is approximately 1 chance in 8,000 for Los Alamos and White Rock residents (Table V-40). The additional risk of cancer mortality from exposure to medical and dental radiation is 1 chance in 43,000.

5. Risk from Laboratory Operations.

The risks calculated above from natural background radiation and medical and dental radiation can be compared with the incremental risk caused by radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock from 1994 Laboratory activities were 0.27 and 0.06 mrem (0.0027 and 0.0006 mSv), respectively. These doses are estimated to add lifetime risks of cancer mortality of less than 1 in 1,000,000 (Table V-40). These risks are less than 0.1% of the risk attributed to exposure to natural background radiation or to medical and dental radiation.

For Americans, the average lifetime risk is approximately 1-in-4 chance of contracting cancer and approximately 1-in-5 chance of dying of cancer (EPA 1979). The incremental risk in Los Alamos attributable to Laboratory operations is equivalent to the additional exposure from cosmic rays a person would get from flying in a commercial jet aircraft for 50 minutes at an altitude of 9,100 m (30,000 ft) (NCRP 1987b). The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure of these people to natural cosmic and terrestrial sources and global fallout. For example, the amount of snow cover and variability of the solar sunspot cycle can explain a 10 mrem (0.1 mSv) difference from year to year (NCRP 1975b).

Table V-40. Added Individual Lifetime Cancer Mortality Risks Attributable to 1994 Radiation Exposure

Exposure Source	EDE used in Risk Estimate (mrem)[a]	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.27	less than 1 in 1,000,000
White Rock area	0.06	less than 1 in 1,000,000
80-km region	0.02[b]	less than 1 in 1,000,000
Natural Radiation		
Cosmic, terrestrial, self-irradiation, and radon exposure[c]		
Los Alamos	348	1 in 7,000[d]
White Rock	336	1 in 6,000[d]
80-km region	329	1 in 6,000[d]
Medical X-Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 38,000

[a]1 mrem = 0.01 mSv.

[b]Obtained by dividing the population dosse (Table V-39) by the number of people living within 80 km (50 mi) of the Laboratory.

[c]An EDE of 200 mrem (2.00 mSv) was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[d]The risks from natural radiation from nonradon sources were estimated to be 1 chance in 15,000 in Los Alamos and 1 chance in 17,000 for White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 14,000 for both locations. Risk estimates are derived from the NRC BEIR IV and BEIR V reports and the NCRP Report 93 (BEIR IV 1988, BEIR V 1990, NCRP 1987a).

VI. Environmental Nonradiological Program Information

Los Alamos National Laboratory (LANL or the Laboratory) quantifies and assesses nonradioactive pollutant releases to the environment by conducting sampling, calculating and monitoring nonradioactive emissions and effluents, and evaluating unplanned releases.

Air pollutants are measured in the ambient air; all nonradioactive air emissions remained within federal limits during 1994. Other air quality indices, such as visibility and acidity of rainfall, are also measured by the Laboratory. These have no standards but are used in federal programs to track the effects of pollutants on other air-quality-related values.

Surface water is monitored to determine the Laboratory's impact on the environment; no observable effects are caused by Laboratory operations. Municipal and industrial water quality met federal and state standards during 1994.

Soils are monitored for trace metals; values for 1994 reflect the natural background levels.

Sediments are also monitored to determine the Laboratory's impact on the environment and to account for geochemical processes. Concentrations of trace metals in sediments did not indicate significant contributions above natural concentrations; no organics were found above the limits of quantification.

A. Nonradioactive Emissions and Effluent Monitoring

1. Air Quality.

a. Introduction. In addition to the radiological monitoring network, the Laboratory operates a network of nonradiological ambient air monitors. The nonradiological monitoring network consists of a variety of monitoring stations: 1 on-site primary (or "criteria") pollutant monitor, 17 beryllium monitors, 1 perimeter acid rain monitor, and 1 perimeter visibility monitoring station. In addition, the emissions from nonresearch sources are calculated annually because these sources are responsible for nearly all of the nonradiological air pollutant emissions at the Laboratory. Research sources vary continuously and have very low emissions. Therefore, emissions from these sources are not calculated annually; instead, each new or modified research source is addressed in the new source review process. The monitoring network and emissions calculations are described below.

b. Primary Pollutants Monitoring. Since 1990, the New Mexico Environment Department (NMED) has operated the Laboratory-owned criteria pollutant monitoring station at TA-49, adjacent to Bandelier National Monument. The original purpose of this site was to collect baseline data for Bandelier National Monument over a three-year period. In 1994, the National Park Service, NMED, and the Laboratory all agreed that the original purpose of the study was fulfilled and that the low levels of pollutants measured did not warrant further study at the site. Therefore, the monitoring was discontinued on September 30, 1994.

This station continuously monitored air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Particulate matter (PM) was not monitored continuously; instead, particles with a diameter of less than 10 microns (PM_{10}) were collected from filters every six days and weighed. The NMED analyzed all results and provided the results to the Laboratory. The data collected through September of 1994 are shown in Table VI-1. No federal ambient air quality standard was exceeded. The only state standard exceeded was the NM ambient hourly standard for ozone, which was exceeded in many areas of the state. The causes of these statewide levels are unknown; the ozone levels may result from transport from urban areas or may be generated by local sources. Because the NM Air Quality Act does not specifically require compliance with state standards, there are no enforcement actions associated with these levels. Instead, the state uses these standards, based on modeling results, as guidelines for setting allowable emission limits for regulated sources. At present, LANL is not affected by these emissions limits.

c. Beryllium Monitoring. The Laboratory conducts beryllium monitoring at 12 of the ambient radionuclide monitoring stations (AIRNET). The stations include 1 regional station, 5 perimeter stations, and 6 on-site stations.

Table VI-1. Nonradiological Ambient Air Monitoring Results for 1994

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary	Maximum Measured Concentration
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.001
	24 hours	ppm	0.10	0.14		0.009
	+ 3 hours	ppm			0.05	NC[b]
	+ 1 hour +	ppm				0.011
Particulate Matter$_{10}$[a]	Annual arithmetic mean	$\mu g/m^3$		50	50	8.2
	24 hours	$\mu g/m^3$		150	150	29
Ozone[a]	+ 1 hour +	ppm		0.12	0.12	0.090
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.003
	24 hours	ppm	0.10			0.006
	+ 1 hour +	ppm				0.013
Beryllium[b]	Calendar quarter	ng/m^3				0.04
	30 day	ng/m^3	10			

[a]Measurements made at TA-49, near the boundary with Bandelier National Monument.
[b]NC = no concentration.

Biweekly samples are taken, composited quarterly, and analyzed; the data are shown for each site in Table VI-2. For 1994, all concentrations were well below the NM air standards.

d. Acid Precipitation Monitoring. LANL operates a wet deposition station that is part of the National Atmospheric Deposition Program (NADP) network. The station is located at the Bandelier National Monument perimeter station. In 1995, the National Park Service will begin operating the site, but the Laboratory will continue to pay for the analytical costs. The 1994 annual and quarterly deposition rates are presented in Table VI-3. The mean field pH is reported as a logarithmic mean. The NADP is in the process of analyzing the trend data for all stations; these data should be available by the end of 1995.

Deposition rates for the various ionic species vary widely and are somewhat dependent on precipitation. The highest deposition rates usually coincide with high precipitation. The lowest rates normally occur in the winter, probably reflecting the decrease in windblown dust. The ions in the rainwater are from both nearby and distant anthropogenic and natural sources. High nitrate and sulfate deposition may be caused by man-made sources, such as motor vehicles, copper smelters, and power plants.

The natural pH of rainfall, without man-made contributions, is unknown. Because of the contribution from entrained alkaline soil particles in the southwest, natural pH may be higher than 5.6, the pH of rainwater in equilibrium with atmospheric carbon dioxide. Some studies indicate that there may be an inverse relationship between elevation and pH.

e. Visibility Monitoring. Since October 1988, LANL, in conjunction with the National Park Service, has operated a visibility monitoring station, an optical transmissometer, on site (TA-49, TA-33) adjacent to Bandelier National Monument. Measurements are performed using protocols established for the National Park Service, the US Forest Service, the Environmental Protection Agency (EPA), and other government agencies under the auspices of the Interagency Monitoring of Protected Visual Environments Network. Visibility is determined by measuring the opacity of the air and is expressed as visual range; the visual range for each season in 1994 is shown in Table VI-4. The National Park Service did not have statistics available for the entire calendar year, but based on data collected January through May of 1994, the visibility at the site is generally very good, with the visual range exceeding 104 km (64 mi) half of the time. On the clearest days (highest 10 percent of the data), visibility exceeds 133 km (82 mi).

Table VI-2. Airborne Beryllium Concentrations for 1994

Station	Location[a]	No. of Samples	Concentrations (ng/m^3) Maximum	Minimum	Mean	2s
REGIONAL STATION						
2	Pojoaque	4	0.032	0.002	0.017	0.025
PERIMETER STATIONS						
4	Barranca School	4	0.015	0.002	0.010	0.011
6	48th Street	4	0.012	0.002	0.007	0.010
7	Los Alamos Shell	3	0.012	0.009	0.010	0.003
12	Royal Crest	4	0.012	0.002	0.007	0.011
17	Bandelier	4	0.012	0.003	0.008	0.009
Group Summary		19	0.015	0.002	0.008	0.009
ON-SITE STATIONS						
23	TA-52 Beta Site	4	0.012	0.002	0.008	0.010
25	TA-16 S-Site	4	0.040	0.002	0.023	0.037
33	TA-3	4	0.016	0.002	0.010	0.012
Group Summary		12	0.040	0.002	0.014	0.025
TA-15 FIRING SITES						
76	TA-15-NNW	3	0.019	0.002	0.008	0.018
77	TA-15-NNE	3	0.025	0.002	0.012	0.024
78	TA-15-N	2	0.032	0.002	0.017	0.041
Group Summary		8	0.032	0.002	0.012	0.024

Table VI-3. Annual and Quarterly Wet Deposition Statistics for 1994

	Quarter				
	First	Second	Third	Fourth	Annual
Field pH (Log)					
Mean	5.6	5.0	4.7	5.2	5.1
Minimum	4.9	4.6	4.5	4.5	4.5
Maximum	6.3	5.6	4.9	5.9	6.3
Precipitation (microns)	6.75	9.66	13.17	14.96	44.54
Deposition (microequivalents per square meter)					
Ca	1,247.50	1,596.81	1,347.31	998.00	4,890.22
Mg	82.24	238.49	156.25	123.36	583.88
K	53.71	66.50	56.27	71.61	66.50
Na	100.04	356.66	152.23	361.01	969.94
NH_4	776.05	1,330.38	1,274.94	776.05	942.35
NO_3	387.16	1,790.61	2,758.51	1,129.21	6,162.28
Cl	56.41	310.23	225.83	338.44	958.91
SO_4	624.57	1,873.71	2,019.44	1,623.88	6,099.97
H(lab)	88.50	1,060.00	2,420.00	1,160.00	4,920.00
H(fld)	126.00	1,420.00	2,520.00	1,230.00	5,580.00

Table VI-4. Average Visibility Measured at Bandelier National Monument in 1994

Sampling Period	Visibility (km)	(mi)
Winter	107	66
Spring	106	66
Summer	118	73
Fall	138	86

Factors that affect visibility at Bandelier National Monument and other locations include the amount of man-made pollution in the air, the amount of natural particles and light-scattering or light-absorbing gases in the air, and meteorological factors like relative humidity and precipitation.

f. Emissions Calculations. The 1994 estimated emissions are shown in Table VI-5. These are sources that are typical of industries; the nonradiological emissions from research operations are insignificant compared with the listed "industrial" emissions sources.

The NO_x emissions from the TA-3 power plant are estimated based on a source test conducted on August 29, 1995. Emission factors for PM for the asphalt plant are calculated using the results of a source test conducted on August 25, 1993. The remainder of the emission factors were standard EPA factors (EPA 1993).

The largest single source of emissions at the Laboratory are the three plants (TA-3, TA-16, and TA-21) used to supply steam for heating. The steam plant at TA-3 also produces electricity when sufficient power from outside sources is not available; approximately one third of the emissions from TA-3 result from electricity production. The plants are primarily operated on natural gas but can use fuel oil as a backup. The only other significant sources of emissions at the Laboratory are also combustion sources. They are the standby generators that are each run about 168 hours per year for maintenance purposes, the large boilers (natural gas boilers of less than 5 million Btu/h design value are considered insignificant by NMED and are not included in the calculations), and a small incinerator burning mainly paper and rags.

2. Water and Effluent Monitoring.

a. Surface Water Monitoring. The results of major chemical constituents in surface water samples for 1994 are listed in Table VI-6. The results are generally consistent with those observed in previous years, with some expected variability. The measurements in waters from areas receiving effluents show an effect of these effluents.

The results of trace metal analyses on surface water samples for 1994 are listed in Table VI-7. The levels are generally consistent with previous observations. NM General Stream Standards for Livestock and Wildlife Watering (see Appendix A) were exceeded at a limited number of stations for aluminum, arsenic, and cadmium. None of these exceedances are believed to be significant, as they probably reflect natural environmental conditions. The aluminum standard was exceeded at the regional Rio Grande at Frijoles station, at the perimeter Chaquehui at Rio Grande station, and at the on-site Cañada del Buey station. The results invariably reflect the presence of suspended solids in the water samples. Because these metals analyses are performed on unfiltered water samples, the results will be artificially high due to naturally occurring metals (e.g., aluminum, arsenic, iron, manganese, selenium) associated with the suspended solids.

Table VI-5. Emissions by Source in 1994

Source Category	Emissions (tons/year) NO_x	SO_x	PM_{10}	CO	VOC
TA-3 Steam Plant	60	<1	2	18	1
TA-16 Steam Plant	2	<1	<1	<1	<1
TA-21 Steam Plant	4	<1	<1	1	<1
Stationary Generators	21	1	2	7	2
Boilers/Heaters	3	<1	<1	<1	<1
Incinerators	2	2	5	7	2
Asphalt Plan[a]	<1	<1	<1	<1	<1
Nonmaintenance Painting	<1	<1	1	<1	1
Total Other Sources	194	<9	<14	<37	<10

[a]Measured in 1993.

Table VI-6. Chemical Quality of Surface Water for 1994

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity µS/cm
REGIONAL STATIONS																	
Regional																	
Rio Chama at Chamita	14	35	7.8	2	12	3	0.1	<5[c]	82	0.1	48	8.50	<0.01	168	119	8.1	255
Rio Grande at Embudo	22	41	8.9	3	23	7	0.8	<5	123	<0.02	54	9.20	<0.01	242	138	8.1	349
Rio Grande at Otowi	17	34	2.7	4	28	5	0.3	<5	90	0.2	47	<0.04	<0.01	254	95	7.0	251
Rio Grande at Frijoles	43	210	16.0	6	13	5	0.3	<5	74	<0.02	22	<0.04	<0.01	186	104	8.3	175
Rio Grande at Cochiti	16	39	7.8	3	16	4	0.3	<5	97	0.02	48	5.90	<0.01	210	128	8.2	281
Rio Grande at Bernalillo	17	46	8.8	4	21	7	0.4	<5	109	0.04	54	9.70	<0.01	204	150	8.2	309
Jemez River	44	49	6.2	11	60	75	1.0	16	166	0.1	11	4.30	<0.01	364	146	8.8	508
PERIMETER STATIONS (OFF SITE)																	
Acid-Pueblo Canyons																	
Acid Weir	20	10	1.5	4	51	44	0.6	<5	57	0.4	8	<0.04	<0.01	200	30	7.0	260
Pueblo 1	22	16	3.1	5	48	47	0.2	<5	67	0.6	9	<0.04	<0.01	306	52	7.4	278
Los Alamos Canyon																	
Los Alamos Canyon Reservoir	36	9	3.0	<2	7	6	<0.1	<5	26	<0.02	4	1.60	<0.01	138	34	8.2	84
Other Areas																	
Pajarito at Rio Grande	68	<0.4	<0.2	<1	0.15	5	0.5	<5	88	0.1	6	0.72	<0.01	182	60	8.5	161
Frijoles at Monument HQ	48	11	3.3	<2	11	4	0.2	<10	55	0.1	3	2.00	<0.0	200	42	8.1	129
Frijoles at Rio Grande	60	10	3.4	3	12	5	0.2	<5	55	0.04	3	<0.04	<0.01	152	38	8.3	105
Chaquehui at Rio Grande	80	27	12.0	10	7	3	0.5	<5	60	0.02	3	<0.04	<0.01	136	41	7.9	105
ON-SITE STATIONS																	
Mortandad Canyon																	
Mortandad at GS-1	50	25	4.4	4	21	6	0.4	<5	84	0.1	7	5.00	<0.01	228	80	7.9	198
DP-Los Alamos Canyons																	
DPS-1	15	22	2.1	5	10	4	0.3	<5	53	0.2	5	<0.04	<0.01	120	63	7.9	110
DPS-4	23	15	1.8	7	29	20	1.1	<5	71	0.1	6	3.90	<0.01	170	44	7.1	211
Other Areas																	
Cañada del Buey	36	13	4.7	5	20	7	0.5	<5	58	0.05	10	1.90	0.02	432	51	6.8	145
Ancho at Rio Grande	76	15	3.8	3	12	3	0.4	23	75	<0.02	4	<0.04	<0.01	160	53	9.3	123

Table VI-6. Chemical Quality of Surface Water for 1994 (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity µS/cm
Sandia Canyon																	
SCS-1	100	25	5.1	11	86	111	1.6	<5	118	2.8	58	14.00	0.02	590	83	8.2	630
SCS-2	90	33	7.3	14	110	50	1.9	<5	139	2.7	63	20.00	<0.01	516	112	8.5	510
SCS-3	86	40	5.6	3	88	52	2.0	<5	143	2.6	48	10.00	<0.01	566	140	8.6	475
EPA Primary Drinking Water Standard[d]							4					10	0.2				
EPA Secondary Drinking Water Standard[d]						250					250			500		6.8-8.5	
EPA Health Advisory[d]					20												

[a]Total dissolved solids.
[b]Standard Units.
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]Standards given here for comparison only, see Appendix A.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
REGIONAL STATIONS												
Regional												
Rio Chama at Chamita	<0.090[a]	3.60	0.004	<0.0100	0.070	<0.003	<0.003	<0.004	<0.0040	<0.004	2.10	0.0002
Rio Grande at Embudo	<0.090	0.20	0.003	0.0310	0.045	<0.003	<0.003	0.009	0.0060	0.008	0.14	<0.0001
Rio Grande at Otowi	<0.020	4.20	0.005	0.1400	0.370	0.050	0.051	0.050	0.2500	0.240	4.00	0.0001
Rio Grande at Frijoles	<0.010	14.00	0.003	0.0580	1.000	0.004	<0.003	0.029	0.0150	0.084	13.00	<0.0001
Rio Grande at Cochiti	<0.020	0.92	<0.002	0.0190	0.070	<0.003	<0.003	<0.003	0.0230	<0.004	0.75	0.0001
Rio Grande at Bernalillo	0.088	3.00	0.003	0.0350	0.190	<0.003	<0.003	<0.004	0.0460	<0.004	2.60	0.0001
Jemez River	<0.020	1.60	0.063	0.5700	0.100	<0.003	<0.003	<0.004	0.0460	<0.004	1.80	0.0001
PERIMETER STATIONS (OFF SITE)												
Acid-Pueblo Canyons												
Acid Weir	<0.010	2.90	0.003	0.0450	0.034	<0.003	<0.003	0.006	0.0060	0.014	1.90	0.0001
Pueblo 1	<0.010	1.80	0.003	0.0400	0.036	<0.003	<0.004	0.007	0.0060	0.014	1.40	0.0001
Los Alamos Canyon												
Los Alamos Canyon Reservoir	<0.030	2.00	<0.002	<0.0200	0.031	<0.003	<0.003	<0.004	<0.0040	<0.009	0.97	0.0001
Other Areas												
Pajarito at Rio Grande	0.096	0.23	0.002	0.2100	0.170	0.068	0.150	0.170	0.5100	0.520	0.26	<0.0001
Frijoles at Monument HQ[b]	<0.030	0.74	<0.005	<0.0297	0.019	<0.003	<0.003	<0.004	<0.0047	<0.009	0.48	<0.0002
Frijoles at Rio Grande	<0.010	0.17	<0.002	0.0110	0.022	<0.003	<0.003	<0.004	<0.0040	<0.004	0.24	<0.0001
Chaquehui at Rio Grande	<0.010	64.00	<0.002	<0.0100	0.620	0.005	<0.003	0.014	0.0360	0.033	60.00	<0.0001
ON-SITE STATIONS												
Mortandad Canyon												
Mortandad at GS-1	<0.020	4.70	0.002	0.0190	0.057	<0.001	<0.003	<0.004	<0.0040	0.012	2.50	<0.0001
DP-Los Alamos Canyons												
DPS-1	<0.010	4.60	0.003	0.0360	0.140	<0.003	<0.003	0.010	0.0170	0.021	3.70	0.0001
DPS-4	<0.010	2.90	0.003	0.0490	0.065	<0.003	<0.004	0.009	0.0080	0.013	1.80	0.0001
Other Areas												
Cañada Del Buey	0.013	19.00	0.005	0.0750	0.150	<0.003	<0.003	0.010	0.0180	0.070	13.00	0.0004
Pajarito Canyon	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	<0.010	0.93	<0.002	0.0110	0.043	<0.003	<0.003	<0.004	<0.0040	<0.004	0.89	<0.0001

*Data on additional trace metals from surface waters are presented on page 203.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
Sandia Canyon												
SCS-1	<0.200	2.00	<0.002	0.0420	0.047	<0.001	<0.003	<0.004	0.0220	0.023	1.50	0.0001
SCS-2	<0.200	3.30	0.005	0.4000	0.770	<0.001	0.150	0.160	0.7600	0.750	2.60	0.0001
SCS-3	<0.200	<0.10	0.006	0.0860	0.047	0.120	0.012	0.026	0.0170	0.024	0.09	<0.0001
EPA Primary Drinking Water Standard[d]			0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[d]		0.05-0.2									0.3	
EPA Action Level[d]										1.3		
Livestock Wildlife Watering Limit[d]		5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01

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

[b]Results are the mean of more than one sample analysis.

[c]N/A means analysis not performed, lost in analysis or not completed.

[d]Standards given here for comparison only, see Appendix A.

*Data on additional trace metals from surface waters are presented on page 203.

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS											
Regional											
Rio Chama at Chamita	0.067	<0.008[a]	<0.200	<0.002	0.009	0.008	<0.03	0.270	<0.002	0.01	0.0220
Rio Grande at Embudo	0.040	0.016	<0.200	<0.002	0.003	0.008	<0.03	0.300	<0.002	0.02	<0.0200
Rio Grande at Otowi	0.330	0.051	0.250	0.005	<0.001	<0.002	<0.03	1.000	<0.001	0.04	0.0650
Rio Grande at Frijoles	1.600	<0.008	0.037	0.004	<0.001	<0.002	<0.03	0.420	<0.001	0.13	0.2100
Rio Grande at Cochiti	0.051	0.290	0.017	<0.001	<0.001	<0.002	<0.03	0.300	<0.001	0.00	0.0250
Rio Grande at Bernalillo	0.089	0.980	0.038	0.002	<0.001	<0.002	<0.03	0.350	<0.001	0.01	0.0240
Jemez River	0.069	<0.020	0.034	0.001	<0.001	<0.002	<0.03	0.210	<0.001	0.01	<0.0200
PERIMETER STATIONS (OFF SITE)											
Acid-Pueblo Canyons											
Acid Weir	0.012	<0.008	<0.010	0.004	<0.001	<0.002	<0.03	0.054	<0.001	<0.02	0.0270
Pueblo 1	0.099	<0.008	<0.010	0.002	<0.001	<0.002	<0.03	0.094	<0.001	<0.02	<0.0200
Los Alamos Canyon											
Los Alamos Canyon Reservoir	0.029	<0.010	<0.010	<0.002	<0.002	<0.002	<0.03	0.063	<0.002	<0.00	<0.0200
Other Areas											
Pajarito at Rio Grande	0.250	0.150	0.240	0.002	<0.001	<0.002	<0.03	0.510	<0.001	0.10	0.2500
Frijoles at Monument HQ[b]	0.032	<0.027	0.054	<0.002	<0.003	<0.004	<0.03	0.060	<0.002	<0.01	0.0639
Frijoles at Rio Grande	0.036	<0.008	<0.010	0.001	<0.001	<0.002	<0.03	0.066	<0.001	<0.00	<0.0200
Chaquehui at Rio Grande	0.870	<0.008	0.024	0.003	<0.001	<0.002	<0.03	0.060	<0.001	0.06	0.2300
ON-SITE STATIONS											
Mortandad Canyon											
Mortandad at GS-1	0.033	0.088	<0.010	<0.002	<0.002	<0.002	<0.03	0.077	<0.002	0.01	0.0240
DP-Los Alamos Canyons											
DPS-1	0.340	<0.008	<0.020	0.034	<0.001	<0.002	<0.03	0.098	<0.001	<0.02	0.1000
DPS-4	0.020	<0.008	<0.020	0.004	<0.001	<0.002	<0.03	0.088	<0.001	<0.02	<0.0200
Other Areas											
Cañada Del Buey	0.250	0.160	<0.020	0.011	<0.001	<0.002	<0.03	0.090	<0.001	0.02	0.1200
Pajarito Canyon	N/A[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancho at Rio Grande	0.024	<0.008	<0.010	0.006	<0.001	<0.002	<0.03	0.076	<0.001	0.01	<0.0200

Table VI-7. Total Recoverable Trace Metals in Surface Water for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Sandia Canyon											
SCS-1	0.067	0.820	0.027	0.006	<0.002	<0.002	<0.03	0.110	<0.002	0.02	0.0430
SCS-2	0.800	1.200	0.790	0.002	<0.002	<0.002	0.13	0.910	<0.002	0.09	0.2100
SCS-3	0.660	0.980	0.640	0.019	<0.002	<0.002	0.24	0.740	<0.002	0.08	0.1100
EPA Primary Drinking Water Standard[d]			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[d]	0.05										5.0
EPA Action Level[d]				0.015							
EPA Health Advisory[d]								25-90		0.08-0.11	
Livestock Wildlife Watering Limit[d]				0.1						0.1	25.0

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

[b]Results are the mean of more than one sample analysis.

[c]N/A means analysis not performed, lost in analysis or not completed.

[d]Standards given here for comparison only, see Appendix A.

The arsenic stream standard was slightly exceeded at the Jemez River, consistent with the 1993 result. Arsenic is often found in elevated levels within volcanic settings like the Jemez Mountains. Cadmium values three times larger than the stream standard were detected at the perimeter Pajarito at Rio Grande station and at the on-site SCS-2 station. Sampling or analytical inaccuracies are suspected as the cause of the SCS-2 value, as none of the other stations upstream or downstream of SCS-2 within Sandia Canyon showed elevated levels on the same day. Results from the analysis of metals from the 1994 Pueblo 1 Perimeter Station meet stream standards, alleviating concerns raised by the 1993 sample result which showed values several times larger than the standards.

Analyses for organics in surface water were performed during 1994 at seven on-site stations (Cañada del Buey, Mortandad at GS-1, SCS-1, -2, and -3, and DPS-1 and -4), at two perimeter stations (Acid Weir, Pueblo 1), and at all regional stations. The parameters analyzed included the volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), except for the SCS stations which were tested only for VOCs (see Table D-22 for detailed listings of parameters). Of the 15 stations tested, 2 regional stations had traces of organic compounds detected. Possible traces of butyl-benzyl-phthalate were found in samples from the Jemez River and from the Rio Grande at Cochiti (both 11 ng/mL compared with the quantification limit of 10 ng/mL). At these trace levels, the source of the organics is likely to be from contamination of the water samples within the analytical laboratory, rather than being from the environment.

b. National Pollutant Discharge Elimination System. The Department of Energy (DOE) and the University of California have seven National Pollutant Discharge Elimination System (NPDES) permits. One permit covers the effluent discharges for 2 sanitary wastewater treatment facilities and 122 industrial outfalls at the Laboratory. A summary of these outfalls is presented in Table D-2. Another permit covers one industrial outfall at the hot dry rock geothermal facility located 50 km (30 mi) west at Fenton Hill. One permit covers storm water associated with industrial activity. Four additional permits are associated with construction activity. All permits are issued and enforced by the EPA Region 6 in Dallas, Texas. Under the Laboratory's permit for Los Alamos, samples are collected weekly for analysis, and results are reported at the end of each monitoring period for each respective outfall category to the EPA and the NMED. The NMED performs some compliance evaluation inspections and monitoring for the EPA through a Section 106 water quality grant. After having operated under an administrative continuance for several years, the EPA issued a final NPDES permit for the Laboratory in 1994. The new NPDES permit became effective on August 1, 1994.

During 1994, effluent limits were not exceeded in any of the 154 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 28 times in the 2,045 samples collected from the industrial outfalls. As shown in Figure III-1, overall compliance for the sanitary and industrial discharges during 1994 was 100% and 98.6%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1994.

Administrative Order (AO) Docket No. VI-94-1242, issued to the Laboratory on June 15, 1994, incorporated the revised High Explosive (HE) Wastewater Treatment Facility schedule and the schedule for completion of the remaining corrective actions on the Waste Stream Characterization project. This order replaced AO VI-94-1210, which was closed on June 15, 1994.

AO Docket No. VI-94-1051 was issued to the Laboratory on July 6, 1994. The scope of this AO required the Laboratory to present corrective actions and plans to eliminate the NPDES permit violations that occurred at the Laboratory from 1990 through 1993 in a "show cause" meeting. The show cause meeting took place in Dallas, Texas, at EPA Region 6 on August 25, 1994. No further action has been taken by EPA.

TA-50 Liquid Waste Treatment Plant. Treated effluents from the liquid waste treatment plant at TA-50 are subject to NPDES permit limits. Table VI-8 presents information on the quality of effluent from the plant during 1994. The total effluent volume decreased slightly in 1994, with the majority of NPDES regulated constituents showing a decrease (see Section V.B.3.c for information on radioactive constituents released from the plant). Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

TA-50 Treatment Studies. Although the TA-50 Radioactive Liquid Waste Treatment Facility meets NPDES outfall criteria, personnel employed at TA-50 have embarked on efforts to improve effluent quality through alternate or combined treatment technologies. Current efforts are centered around membrane processes primarily because these processes have been successfully demonstrated in a number of industrial treatment plants to treat industrial wastes to high-quality effluent streams at high-productivity rates. Currently, ultrafiltration and reverse

Table VI-8. Quality of Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1994

Mean Nonradioactive Constituents	Concentration (mg/L
Alkalinity-MO	422.
Alkalinity-P	7.
Al[a]	0.141
Sb	0.002
As[a]	0.00209
Ba	0.0128
Be	0.009
Cd[a]	0.00345
Ca	123.
Chloride	32.8
COD[a]	27.5
Conductivity	1,200.
CN	0.0525
Cu[a]	0.133
Fluoride	1.91
Fe[a]	0.174
Pb[a]	0.006
Mg	0.500
Hg[a]	0.00217
NH_3-N	5.50
Ni	0.0477
NO_2-N	1.18
NO_3-N	45.5
PO_4	0.334
K	11.2
Se[a]	0.00209
Ag[a]	0.00245
SO_4	46.6
N[a]	148.
TDS[b]	842.
Total cations	13.5
Total Cr[a]	0.0115
Total Hardness	124.
Va[a]	0.0615
Zn[a]	0.685
pH[a]	7.1 (su)
Total Effluent Volume (L)	2.08×10^7

[a]Regulated by NPDES permit.
[b]Total dissolved solids.

osmosis units are under evaluation to address their effectiveness in treating radioactive wastewater and providing better quality effluent.

c. Safe Drinking Water Act, Municipal and Industrial Water Supplies. This program includes sampling from various points in the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems, and from the Laboratory's water supply wellheads to ensure compliance with the federal Safe Drinking Water Act (SDWA) (40 CFR 141). DOE provides drinking water to Los Alamos County and Bandelier National Monument. The EPA has established maximum contaminant levels (MCLs) for microbiological organisms, organic and inorganic constituents, asbestos, and radioactivity in drinking water. These standards have been adopted by the State of NM and are included in the NM Water Supply Regulations (NMEIB 1991). The NMED has been authorized by the EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed at four state certified laboratories: NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque for VOCs, SOCs, inorganic constituents, and radioactivity; the Soil, Water, and Air Testing (SWAT) Laboratory at New Mexico State University in Las Cruces for synthetic organic compounds (SOCs), Triangle Laboratories of Durham, North Carolina, for dioxin; and QuanTEM Laboratories of Oklahoma City, Oklahoma, for asbestos. The SLD and SWAT laboratories report the analytical results directly to NMED. Triangle and QuanTEM laboratories report the analytical results to the Water Quality Group, who, in turn, transmits the results to NMED. The Johnson Controls, Inc. (JCI) Environmental (JENV) Laboratory also collects samples from the Laboratory, Los Alamos County, and Bandelier National Monument distribution systems and tests them for microbiological contamination, as required under the SDWA. The JENV Laboratory is certified by NMED for microbiological testing of drinking water.

Chemical Analyses of Drinking Water. In 1994, the analytical results for inorganic constituents (Table VI-9), total trihalomethanes (Table VI-10), lead and copper (Table VI-11), VOCs (Table VI-12), SOCs (Table VI-13), and asbestos fibers (Table VI-14) in drinking water were all below the SDWA MCLs.

In 1994, inorganic constituents in drinking water were collected at each of the nine operating water supply wellheads and analyzed by SLD. Taps are flushed for several minutes so that samples represent water that is freshly drawn from the water main. As shown in Table VI-9, all locations and all parameters were below the MCLs.

In 1994, total trihalomethanes (TTHM) samples were collected during each quarter from six sites in the Laboratory and Los Alamos County water distribution systems. As is shown in Table VI-10, the annual average for TTHM was well below the SDWA MCL.

Table VI-9. Inorganic Constituents in Drinking Water in 1994 (mg/L)

	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO_3	SO_4	Se	Sb	Tl
Sample Location														
Wellheads														
Pajarito														
Well PM-1	<0.005[a]	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.4	7.0	<0.005	<0.001	<0.001
Well PM-2	<0.005	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Well PM-3	<0.005	<0.1	<0.001	<0.001	0.004	0.3	<0.1	<0.0005	<0.01	0.4	7.0	<0.005	<0.001	<0.001
Well PM-4	<0.005	<0.1	<0.001	<0.001	0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Well PM-5	<0.005	<0.1	<0.001	<0.001	<0.005	0.3	<0.1	<0.0005	<0.01	0.3	<5.0	<0.005	<0.001	<0.001
Guaje														
Well G-1	0.008	<0.1	<0.001	<0.001	0.004	0.6	<0.1	<0.0005	<0.01	0.4	9.0	<0.005	<0.001	<0.001
Well G-1A	0.010	<0.1	<0.001	<0.001	0.007	0.6	<0.1	<0.0005	<0.01	0.4	6.0	<0.005	<0.001	<0.001
Well G-2	0.031	<0.1	<0.001	<0.001	0.007	0.9	<0.1	<0.0005	<0.01	0.4	6.0	<0.005	<0.001	<0.001
Well G-6	0.002	<0.1	<0.001	<0.001	0.002	0.3	<0.1	<0.0005	<0.01	0.4	<5.0	<0.005	<0.001	<0.001
EPA MCLs	0.05	2.0	0.004	0.005	0.10	4.0	0.20	0.002	0.1	10.0	250.0	0.05	0.006	0.002

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

Table VI-10. Total Trihalomethane Concentrations in Drinking Water in 1994 (μg/L)

	1994 Quarters			
Sampling Location	**First**	**Second**	**Third**	**Fourth**
Los Alamos Airport	4.10	5.80	9.20	13.40
White Rock Fire Station	N[a]	1.30	0.90	N
North Community Fire Station	3.60	1.60	2.50	N
S-Site Fire Station	0.70	2.90	4.80	1.20
Barranca School	1.30	1.80	1.80	2.90
TA-33, Bldg. 114	7.10	6.20	15.50	16.00
1994 Average	4.36 μg/L			
EPA MCL	100.00 μg/L			
Laboratory Practical Quantitation Level	2.00 μg/L			

[a]N = none detected above detection limit.

Table VI-11. Lead and Copper in Drinking Water in 1994

Values	**Lead**	**Copper**
Less than or equal to Detection Limit	65 samples	25 samples
Detectable but less than Action Level	3 samples	44 samples
Values greater than Action Level	1 sample	0 samples
Totals	69 samples	69 samples
Detection Limit	5 μg/L	50 μg/L
90th Percentile Value	<5 μg/L	160 μg/L
EPA Action Level	15 μg/L	1,300 μg/L

Table VI-12. Volatile Organic Compounds (VOCs) in Drinking Water in 1994

Sample Location	**VOC Group I 63 Compounds**
Pajarito Well Field	
Well PM-1	N[a]
Well PM-2	N[b]
Well PM-3	N
Well PM-4	N
Well PM-5	N[b]
Guaje Well Field	
Well G-1A	N
Well G-1	N
Well G-2	N
Well G-6	N

[a]N: None detected above detection limit.
[b]The presence of an unregulated compound was detected in the initial sample but not in the confirmation sample.

Table VI-13. Synthetic Organic Compounds (SOCs) in Drinking Water in 1994 (μg/L).

	EPA Method Number								
Sample Location	**525.1**	**515.1**	**505**	**549**	**548**	**547**	**531.1**	**1613A**	**504**
3rd Quarter 1994									
WELL HEADS									
Pajarito									
Well PM-1	N[a]	N	N	N	N	N	N	N	N
Well PM-2	N	N	N	N	N	N	N	N	N
Well PM-3	N	N	N	N	N	N	N	N	N
Well PM-4	N	N	N	N	N	N	N	N	N
Well PM-5	N	N	N	N	N	N	N	N	N
Guaje									
Well G1-A	N	N	N	N	N	N	N	N	N
Well G-1	2.10[b]	N	N	N	N	N	N	N	N
Well G-2	N	N	N	N	N	N	N	N	N
Well G-6	N	N	N	N	N	N	N	N	N
4th Quarter 1994									
WELL HEADS									
Pajarito									
Well PM-1	N	N	N	N	N	N	N	N	N
Well PM-2	N	N	N	N	N	N	N	N	N
Well PM-3	3.29[c]	N	N	N	N	N	N	N	N
Well PM-4	N	N	N	N	N	N	N	N	N
Well PM-5	N	N	N	N	N	N	N	N	N
Guaje									
Well G1-A	N	N	N	N	N	N	N	N	N
Well G-1	N	N	N	N	N	N	N	N	N
Well G-2	N	N	N	N	N	N	N	N	N
Well G-6	N	N	N	N	N	N	N	N	N

[a]N = No analyte was detected at sufficient concentrations to make an accurate quantitation.
[b]Bis(2-ethyhexyl)phthalate: MCL = 6.0 ppb
[c]Di(2-ethylhexyl)adipate: MCL = 400 ppb

Table VI-14. Asbestos Fibers in Drinking Water in 1994 (in MFL[a])

Sample Location	**Results** (MFL)
TA-53 Building 1	<0.2
TA-60 Building 1	<0.2
TA-15 Building 185	<0.2
TA-21 Building 229	<0.2
EPA MCL (Maximum Contaminant Level)	7

[a]MFL (Million Fibers per Liter, for fibers ≥10 microns in length)

In accordance with the requirements of the SDWA, the sampling program for lead and copper at residential taps that was initiated in 1992, continued in 1994. There is currently no set MCL for lead or copper in the tap water. Instead an action level is set for each metal. If more than 10% of the samples from selected sites exceed the action level, then water suppliers must take prescribed actions to monitor and control the corrosivity of the water supplied to the customers. If 90% of the values for lead and copper are less than the action levels, then the system is in compliance without the need to implement corrosion control. As is shown in Table VI-11, during 1994, only one sample was above the EPA action level for lead, and none exceeded the action level for copper. Since the 90th percentile values for lead and copper were below the EPA action levels, the system is in compliance with the SDWA regulations for lead and copper in drinking water for 1994.

In 1994, VOC samples were collected from each of the nine operating water supply well heads and analyzed by SLD. As shown in Table VI-12, all locations were below the laboratory's detection limit and the MCL. At the PM-5 well, the presence of an unregulated compound was detected in the initial sample but was not found in the confirmation sample.

Microbiological Analyses of the Water Distribution System. Each month during 1994, an average of 48 samples was collected from the Laboratory, Los Alamos County, and Bandelier National Monument water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the drinking water. During 1994, of the 581 samples analyzed, 5 indicated the presence of total coliforms, and 2 indicated the presence of fecal coliforms. Noncoliform bacteria were present in 27 of the microbiological samples. A summary of the monthly analytical data is found in Table VI-15. Noncoliform bacteria are not regulated, but their presence in repeated samples may serve as indicators of biofilm growth in water pipes.

In the third and fourth quarters of 1994, sampling for SOCs was initiated at the nine operating water supply well heads, as required by the SDWA. Table VI-16 presents the nine categories of SOC contaminants and the laboratory conducting the analysis for each method.

Table VI-13 presents the analytical results for SOC sampling in the 3rd and 4th quarters of 1994; SOC concentrations at each of the nine well heads sampled were below the SDWA MCLs. In 2 of the method 525.1 analyses, phthalates or adipates were detected at concentrations greater than the minimum quantitation level of 2.0 ppb but below the compound's MCL. Phthalates and adipates are common plasticizers, present in most plastic products. Regulators from the NMED, Drinking Water Bureau, and analysts from the SLD laboratory have reported to LANL's Water Quality and Hydrology Group (ESH-18) that phthalates and adipates are routinely detected at low

Table VI-15. Bacteria in Drinking Water at Distribution System Taps in 1994

Month	Number of Samples Collected	Number of Positive Results		
		Coliform	Fecal Coliform	Noncoliform
January	68	3	2	8
February	47	0	0	2
March	46	0	0	0
April	46	0	0	2
May	45	0	0	2
June	45	0	0	0
July	46	0	0	0
August	48	0	0	2
September	53	2	0	4
October	45	0	0	5
November	45	0	0	1
December	47	0	0	1
Total	581	5	2	27
MCL		[a]	[b]	[c]

[a]The MCL for Coliforms is positive samples not to exceed 5% of the monthly total.
[b]The MCL for Fecal Coliforms is no coliform positive repeat samples following a fecal coliform positive sample.
[c] There is no MCL for Noncoliforms.

Table VI-16. Synthetic Organic Compounds (SOCs) Analytical Methods and Laboratories

	Contaminant	Laboratory	EPA Method
1.	Semivolatiles/Pesticides	SLD	525.
2.	Acid Herbicides	SLD	515.1
3.	PCBs & Endrin	SLD	505
4.	Diquat	SWAT[a]	549
5.	Endothall	SWAT[a]	548
6.	Glyphosate	SWAT[a]	547
7.	Carbamate Pesticides	SLD	531.1
8.	Dioxin	Triangle[b]	1613A
9.	EDB & DBCP	SLD	504

[a]New Mexico State University
Soil and Water Testing Laboratory (SWAT)
Las Cruces, NM
Accreditation:
NMED Approved Laboratory

[b]Triangle Labs of RTP, Inc.
Durham, NC
Accreditation:
NMED Approved Laboratory

concentrations due to sample contamination during collection or laboratory analysis. The Drinking Water Bureau and SLD support ESH-18's conclusion that their presence at low concentrations in two samples is most likely an indicator of sample contamination and not contamination of the groundwater. Personnel from ESH-18 are working closely with SLD analysts to eliminate all identifiable sources of phthalate and adipate contamination. Sampling for SOCs will continue during the 1st and 2nd quarters of 1995.

In 1994, as required by the SDWA, sampling for asbestos fibers in drinking water was initiated at four locations within the Laboratory which are served by asbestos-cement lines. Samples were submitted to QuanTEM Laboratories of Oklahoma City, OK, for analysis by Transmission Electron Microscopy (TEM), the method approved by the EPA. As is shown in Table VI-14, all locations sampled were below the MCL of 7 MFL (million fibers per liter, for fibers >10 microns in length). Asbestos sampling of the well heads will not be conducted unless a statewide waiver is lifted or until the NMED determines that the Los Alamos Water System has a vulnerability to source water contamination from asbestos.

d. Sewage Sludge Monitoring. This program includes sampling of the sewage sludge generated at the TA-46 Sanitary Wastewater System Consolidation (SWSC) plant as part of routine wastewater treatment operations. Sampling of sewage sludge is conducted in accordance with 40 CFR Part 503 regulations, which require that the Laboratory collect representative samples of sewage sludge prior to land application in order to demonstrate that the sludge is not a hazardous waste and that it meets the minimum standards for pollutant concentrations. Sludge samples are analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals and organics, total metals, physical parameters, agronomic parameters, and polychlorinated biphenyls (PCBs) by an EPA approved contract laboratory. Additionally, all samples are analyzed for radiochemistry by the Inorganic Trace Analysis Group's radiation laboratory. During 1994, all analytical results from the monitoring of SWSC plant sewage sludge were in full compliance with federal standards. Table VI-17 presents the analytical results of sludge monitoring conducted in 1994.

3. Soils Monitoring.

Soils were also analyzed for trace and heavy metals. These data will ultimately be used to establish a database of results comparable to those reported by other agencies such as the US Geological Survey (USGS); these data are meaningful from a Laboratory operation/effects standpoint as well as for geochemical process. The results of the 1994 soil sampling program are found in Table VI-18.

The average concentrations of all heavy metals measured in soils collected from perimeter and on-site areas, with the exception of beryllium, were not significantly higher than metals in soils collected from regional (background) stations. Most, in fact, are within the range of metals normally encountered in the Los Alamos area (Ferenbaugh 1990) and continental United States (Shacklette 1984). Beryllium concentrations, on the other hand, were significantly higher in both perimeter and on-site stations than in background soils. This was the same case as in 1993. Although the average concentrations of beryllium in soils collected from perimeter and on-site stations were significantly higher than background, they were still within the regional statistical reference level (RSRL) (<0.96 μg/g) and within the range of concentrations for beryllium in the Los Alamos area (1.1 to 3.3 μg/g) (Ferenbaugh 1990) and continental US (<1 to15 μg/g) (Shacklette 1984). Also, beryllium levels were far below the Laboratory's screening action level.

Table VI-17. Minimum, Mean, and Maximum Values for Sewage Sludge Analyses Conducted in 1994

Contaminant (Total)	Minimum (mg/kg)	Mean (mg/kg)	Maximum (mg/kg)	Pollutant Limits[a] (mg/kg)
Arsenic	2	4	5	75
Cadmium	4	5	6	85
Chromium	88	119	160	3,000
Copper	400	472	530	4,300
Lead	180	293	560	840
Mercury	1	5	9	57
Molybdenum	18	37	52	75
Nickel	18	22	26	420
Selenium	2	4	5	100
Zinc	3,500	3,967	4,700	7,500

[a]40 CFR Part 503 Table 1 Pollutant Ceiling Concentrations.

4. Sediment Monitoring.

a. Trace Metals. Beginning in 1992, sediments from known radioactive effluent release areas were analyzed for trace metals. These analyses are being made to establish a database of results comparable to those reported by other agencies such as the USGS. Hopefully these data will be meaningful for accounting for variations in natural geochemical processes. The monitoring network, including individual sample locations, is described in detail in Section V.B.5.b (Monitoring Network). All of the sediment sampling locations are shown in Figure V-14 (Off-Site Regional Stations), Figure V-15 (Off-Site Perimeter and On-Site Stations), and Figure V-16 (Solid Waste Management Areas). All of these locations are also listed in Table D-14.

Trace metal results for the sediment samples collected in 1994 are presented in Table VI-19. None of the results show any indication of any significant accumulations of metals above what can be attributed to natural concentrations. Before September 1992, at least two different sediment sample preparation procedures were employed by the Laboratory. Before March 1992, all soil and sediment samples were analyzed using the EPA's TCLP to determine whether any sediments or soils exceeded the criteria for hazardous wastes. None of these pre-1991 sediment samples exceeded or even approached the Resource Conservation and Recovery Act hazardous waste criteria. However, a more environmentally sensitive and meaningful surveillance database was sought. Around March 1992, the TCLP was modified to include nitric acid with small additions of hydrofluoric acid in glass digestion vessels; hence, this procedure represented a total digestion process. Beginning in September of 1992, all soil and sediment samples were prepared in the laboratory following EPA procedures specified in SW-846 Method 3050. Differences in individual station concentration values between 1992 and the 1993 and 1994 data sets for specific metals may occur due to variability in nature or in laboratory sample preparation procedures. Since there were no laboratory analytical or procedural changes between 1993 and 1994, the data from these sample times should reflect only natural variability. Some of the effects that these procedural differences can potentially have on metals data are summarized below.

Reported detection limits for antimony, mercury, and molybdenum increased during 1992 to 1994 (i.e., from about 0.05 μg/g, 0.01 μg/g, and 0.30 μg/g, respectively, to about 0.20 μg/g, 0.10 μg/g, and 2.0 μg/g, respectively). These differences probably resulted from a decrease in the typical sediment sample size from 250 mg in 1992 to 125 mg in 1994; in addition, the sediment sample preparation procedures also changed. The reported 1992 iron values were two to three times higher than their respective counterparts in 1994. In addition, the 1992 aluminum values were about 10 times larger than their 1994 counterparts. Note that the reported 1992 values for aluminum and iron in Table IV-22 of the "Environmental Surveillance at Los Alamos during 1992" (EPG 1994) should each be multiplied by a factor of 10; this omission resulted from a units conversion error. The concentration differences between aluminum and iron values are probably due to changes in sample preparation procedures mentioned above. A more complete analysis of all trace metal concentration levels will be made once the 1995 sediment analyses have been completed.

Sediments from the perimeter locations in White Rock Canyon were first analyzed for specific trace metals in 1991. None of the results indicate significant accumulations of metals above what can be attributed to natural

Tables VI-18. Total Recoverable Trace and Heavy Metals (μg/g) in Soils Collected in 1994[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Rio Chama	4.7	N/A[b]	160.0	0.38	<0.40[c]	14.0	0.03	13.0	17.0	N/A	<0.30	N/A
Embudo	<1.0[c]	1.00	82.0	0.21	<0.40	9.3	0.03	7.7	8.5	N/A	<0.30	N/A
Otowi	<1.0	—	63.0	0.22	0.46	5.7	0.03	8.7	23.0	N/A	0.50	N/A
Santa Cruz	4.3	—	160.0	0.52	<0.40	14.0	0.03	11.0	14.0	N/A	<0.30	N/A
Cochiti	<1.0	—	130.0	0.46	<0.40	12.0	0.04	15.0	10.0	N/A	0.30	N/A
Bernalillo	<1.0	—	60.0	<0.08	<0.40	3.2	0.03	2.0	6.4	N/A	0.50	N/A
Jemez	<1.0	3.00	130.0	0.37	<0.40	8.1	0.02	9.4	4.7	N/A	0.60	N/A
Mean (± 2SD)	<2.0 (3.4)	2.00 (2.83)	112.1 (86.6)	<0.32 (0.31)	<0.41 (0.05)	9.5 (8.3)	0.03 (0.01)	9.5 (8.4)	11.9 (12.9)		<0.40 (0.26)	
RSRL[d]	<3.9	6.43	227.5	0.96	<0.54	17.9	<0.04	15.5	22.4	<0.30	<1.28	3.6
SAL[e]	400.0	6.43[f]	5,600.0	0.96[f]	80.00	400.0	24.00	1,600.0	500.0	32.00	400.00	6.4
OFF-SITE PERIMETER STATIONS												
Sportsman's Club	<1.0	4.00	160.0	0.82	<0.40	11.0	0.05	8.9	19.0	N/A	<0.30	N/A
North Mesa	<1.0	3.00	99.0	0.56	<0.40	8.3	0.03	6.8	6.9	N/A	<0.30	N/A
TA-8	<1.0	2.00	70.0	0.34	<0.40	6.7	0.05	4.9	9.2	N/A	<0.30	N/A
TA-49	<1.0	4.00	84.0	0.36	<0.40	9.0	0.04	4.6	17.0	N/A	<0.30	N/A
White-Rock	<1.0	2.00	130.0	0.76	<0.40	10.0	0.03	5.8	34.0[g]	N/A	<0.30	N/A
Tsankawi	<1.0	1.00	49.0	0.67	<0.40	4.2	0.02	3.7	16.0	N/A	<0.30	N/A
Mean (± 2SD)	<1.0 (0.0)	2.67 (2.42)	98.7 (81.2)	0.59 (0.40)[h]	<0.40 (0.00)	8.2 (4.9)	0.04 (0.02)	5.8 (3.7)	17.0 (19.1)		<0.30 (0.00)	
ON-SITE STATIONS												
TA-21	<1.0	6.0	130.0	0.83	<0.40	10.0	0.03	7.5	39.0[g]	N/A	<0.30	N/A
East of TA-53	<1.0	2.0	57.0	0.38	<0.40	6.6	0.02	4.0	14.0	N/A	<0.30	N/A
TA-50	<1.0	2.0	110.0	0.58	<0.40	8.1	0.02	5.6	11.0	N/A	<0.30	N/A
2-Mile Mesa	<1.0	2.0	76.0	0.17	0.50	4.0	0.03	3.0	14.0	N/A	<0.30	N/A
East of TA-54	<1.0	1.0	66.0	0.37	<0.40	5.7	0.02	4.6	11.0	N/A	<0.30	N/A
R-Site-RD-E	<1.0	3.0	140.0	0.74	0.46	11.0	0.03	9.1	17.0	N/A	<0.30	N/A
Potrillo-DR	<1.0	3.0	120.0	0.64	<0.40	8.8	0.03	7.9	11.0	N/A	<0.30	N/A
S-Site	<1.0	2.0	82.0	0.36	<0.40	6.8	0.04	4.1	10.0	N/A	<0.30	N/A
Near Well DT9	<1.0	3.0	150.0	0.63	<0.40	8.4	0.03	7.3	20.0	N/A	<0.30	N/A
Near TA-33	<1.0	2.0	80.0	0.62	<0.40	12.0	0.04	7.5	46.0 [g]	N/A	<0.30	N/A
Mean (± 2SD)	<1.0 (0.0)	2.6 (2.7)	101.1 (66.0)	0.53 (0.41)[h]	<0.42 (0.07)	8.1 (4.9)	0.03 (0.01)	6.1 (4.1)	19.3 (25.4)		<0.30 (0.00)	

[a]Analysis by EPA Method 3051 for total recoverable metals.

[b]Analysis not performed or lost in analysis.

[c]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

[d]RSRL (Regional Statistical Reference Level; this is the upper-limit background concentration [mean + 2 std dev] from Fresquez 1995).

[e]SAL (Los Alamos National Laboratory Screening Action Level).

[f]The SAL guidelines refer the use of the upper-limit background concentration for these elements.

[g]Equal or higher than the RSRL.

[h]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
REGIONAL STATIONS												
Regional												
Rio Chama at Chamita	3.0	2,200.0	2.00	1.0	73.0	<0.08[a]	1.00	5.40	8.90	2.50	9,400.0	<0.02
Rio Grande at Embudo	3.0	4,300.0	4.00	<1.0	120.0	<0.08	0.90	6.60	12.00	11.00	14,000.0	0.02
Rio Grande at Otowi	<1.0	1,300.0	3.00	<1.0	46.0	<0.08	<0.40	2.30	5.70	<0.50	7,900.0	0.02
Rio Grande at Frijoles	<1.0	970.0	<0.50	<1.0	14.0	0.14	<0.40	0.96	0.55	2.40	2,100.0	0.03
Rio Grande at Bernalillo	3.0	200.0	3.00	3.0	64.0	<0.08	0.80	4.20	5.70	4.80	9,300.0	0.02
Jemez River	3.0	3,900.0	4.00	5.0	100.0	<0.08	0.60	6.80	7.20	3.20	6,800.0	0.02
Rio Grande in White Rock Canyon												
Rio Grande at Sandia	<1.0	3,300.0	1.90	<1.0	110.0	0.29	<0.40	2.40	4.60	3.90	5,400.0	0.03
Rio Grande at Pajarito	<1.0	4,700.0	2.10	2.6	94.0	0.47	0.63	3.20	7.20	2.60	7,400.0	0.03
Rio Grande at Water	<1.0	13,000.0	4.50	2.2	450.0	0.77	<0.40	6.90	13.00	6.20	12,000.0	0.06
Rio Grande at Ancho	<1.0	6,100.0	3.00	2.0	110.0	0.45	0.60	4.30	7.80	6.10	8,700.0	0.04
Rio Grande at Chaquehui	<1.0	4,000.0	2.10	<1.0	120.0	0.49	0.70	3.10	5.40	2.60	6,000.0	0.04
PERIMETER STATIONS (OFF SITE)												
Acid-Pueblo Canyon												
Acid Weir	<1.0	1,800.0	1.00	<1.0	38.0	<0.08	0.62	3.70	4.20	3.20	5,000.0	0.04
Pueblo 1	<1.0	1,100.0	0.50	<1.0	21.0	<0.08	0.79	1.30	1.80	2.90	2,700.0	0.02
Pueblo 2	4.0	1,800.0	0.50	<1.0	20.0	<0.08	0.60	1.60	2.00	2.00	8,000.0	0.02
DP-Los Alamos Canyon												
Los Alamos at Totavi	<1.5	1,300.0	<0.30	<1.0	27.0	<0.08	<0.40	0.79	1.60	2.00	2,200.0	<0.02
Los Alamos at LA-2	3.7	1,900.0	65.00	<1.0	39.0	<0.08	0.46	2.70	15.00	4.60	22,000.0	0.02
Los Alamos at Otowi	15.0	2,600.0	<0.30	<1.0	28.0	<0.08	<0.40	1.60	3.30	1.80	3,600.0	<0.02
Other Areas												
Guaje at SR 4	2.9	2,500.0	0.60	<1.0	53.0	<0.08	<0.40	2.60	12.00	7.30	17,000.0	<0.02
Bayo at SR 4	<1.0	2,000.0	0.40	2.9	32.0	<0.08	<0.40	1.90	2.80	3.00	3,300.0	<0.02
Sandia at Rio Grande	<1.0	3,600.0	1.00	<1.0	52.0	0.39	<0.40	1.70	3.70	4.30	4,700.0	<0.01
Cañada Ancha at Rio Grande	<1.0	5,800.0	13.00	<1.0	130.0	0.48	0.51	3.80	5.00	4.90	6,300.0	0.03
Pajarito at Rio Grande	<1.0	1,200.0	0.50	1.6	15.0	0.11	<0.40	0.79	2.90	2.40	2,600.0	0.04
Water at Rio Grande	<1.0	8,000.0	2.40	2.5	240.0	0.62	0.57	6.40	7.10	12.00	12,000.0	0.04
Ancho at Rio Grande	<1.0	7,700.0	2.80	2.4	140.0	0.59	<0.40	3.80	7.30	7.60	8,300.0	0.04
Chaquehui at Rio Grande	<1.0	3,100.0	0.70	<1.0	55.0	0.31	<0.40	2.60	3.10	5.00	6,000.0	0.03
Frijoles at Monument HQ	<1.5	2,600.0	1.00	<1.0	32.0	<0.08	<0.40	1.40	2.90	7.80	3,900.0	<0.02
Frijoles at Rio Grande	<1.0	380.0	<0.50	<1.0	4.9	0.10	<0.40	0.73	0.58	2.10	820.0	0.03
Sandia Canyon Stations												
Station 1	<1.0	1,600.0	0.80	3.0	18.0	<0.08	<0.40	1.20	4.60	2.20	2,400.0	<0.02
Station 2	<1.0	1,900.0	1.00	<1.0	27.0	0.08	<0.40	2.10	6.20	2.60	2,900.0	<0.02
Station 3	<1.0	2,800.0	10.00	1.0	39.0	0.11	<0.40	1.90	3.00	2.70	3,300.0	<0.02

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
Mortandad Canyon on Pueblo of San Ildefonso Lands												
Mortandad A-6	<1.0	1,400.0	<0.50	1.0	15.0	0.17	<0.40	1.00	1.20	<0.50	4,200.0	<0.02
Mortandad A-7	<1.0	3,600.0	2.00	<1.0	61.0	0.47	<0.40	3.00	3.20	3.80	5,900.0	<0.02
Mortandad A-8	<1.0	4,000.0	2.00	<1.0	63.0	0.46	<0.40	2.80	3.30	3.50	5,600.0	<0.02
Mortandad at SR 4 (A-9)	<1.0	3,900.0	1.30	3.0	62.0	0.22	<0.40	5.00	9.20	6.20	4,800.0	<0.02
Mortandad A-10	<1.0	5,900.0	2.00	<1.0	100.0	0.60	<0.40	5.00	5.00	5.00	7,200.0	<0.02
Mortandad at Rio Grande (A-11)	<1.0	2,500.0	1.90	<1.0	80.0	0.29	0.58	2.50	4.40	4.20	4,800.0	0.04
Mortandad at Transect	<1.0	6,300.0	2.40	<1.0	110.0	0.89	0.70	5.90	5.50	7.70	9,200.0	<0.02
ON-SITE STATIONS												
Acid-Pueblo Canyons												
Hamilton Bend Spring	3.0	2,000.0	0.70	<1.0	30.0	<0.90	0.70	3.50	1.80	2.40	3,800.0	0.03
Pueblo 3	2.0	N/A[b]	0.60	N/A	N/A	<0.08	0.50	N/A	1.40	4.30	2,500.0	<0.02
Pueblo at State Route	<1.0	1,300.0	0.60	<1.0	14.0	0.02	<0.40	1.70	6.10	2.50	25,000.0	<0.02
DP-Los Alamos Canyons												
DPS-1	<1.5	1,700.0	1.00	<1.0	19.0	<0.08	<0.40	1.20	2.50	2.70	4,000.0	0.02
DPS-4	13.0	1,200.0	2.00	1.1	17.0	<0.08	<0.40	1.30	1.90	7.90	2,500.0	< 0.02
Los Alamos at Bridge	<1.0	1,700.0	1.00	<1.0	19.0	0.23	<0.40	4.20	2.60	1.90	4,200.0	<0.02
Los Alamos at LAO-1	<1.0	1,100.0	1.00	<1.0	14.0	0.14	<0.40	2.80	3.60	2.60	2,300.0	0.03
Los Alamos at GS-1	<1.0	1,500.0	0.70	2.5	19.0	0.20	<0.40	2.10	1.80	1.20	2,500.0	0.02
Los Alamos at LAO-3	<1.0	2,300.0	2.00	<1.0	27.0	0.34	0.54	4.20	3.60	2.10	5,300.0	0.02
Los Alamos at LAO-4.5	<1.0	1,600.0	1.00	<1.0	16.0	0.20	<0.40	2.10	2.40	11.00	3,900.0	0.03
Los Alamos at SR 4	<1.0	2,300.0	0.60	2.5	22.0	<0.08	<0.40	1.40	3.10	3.00	3,900.0	<0.02
Mortandad Canyon												
Mortandad Near CMR Building	<1.0	2,000.0	0.50	<1.0	18.0	<0.08	<0.40	2.20	3.40	2.50	4,200.0	<0.02
Mortandad West of GS-1	<1.0	860.0	0.30	1.3	10.0	<0.08	0.66	0.82	1.10	2.30	1,300.0	<0.02
Mortandad at GS-1	<1.0	2,600.0	0.70	<1.0	14.0	<0.08	<0.40	1.20	2.50	1.30	5,600.0	0.02
Mortandad at MCO-5	<1.0	1,600.0	0.40	<1.0	18.0	<0.08	0.49	0.83	1.40	3.50	2,500.0	<0.02
Mortandad at MCO-7	<1.0	2,800.0	0.50	<1.0	22.0	<0.08	<0.40	1.10	2.50	3.20	5,300.0	0.03
Mortandad at MCO-9	<1.0	6,200.0	2.00	1.5	63.0	0.48	0.70	2.90	4.50	5.10	6,800.0	<0.02
Mortandad at MCO-13 (A-5)[c]	<1.0	4,400.0	0.97	1.2	45.0	0.24	0.62	2.25	3.45	4.30	5,050.0	<0.02
Other Canyons												
Sandia at SR 4	<1.0	1,700.0	0.40	3.2	16.0	<0.08	<0.40	1.60	5.30	3.10	2,300.0	<0.02
Cañada Del Buey at SR 4	<1.0	2,700.0	0.70	2.1	41.0	<0.08	<0.40	2.30	1.90	3.00	2,600.0	<0.02
Pajarito at SR 4	<1.0	15,000.0	3.00	5.7	120.0	0.54	<0.40	11.00	14.00	12.00	14,000.0	<0.02
Potrillo at SR 4	<1.0	4,100.0	1.00	2.9	31.0	0.12	<0.40	2.80	3.40	3.40	5,300.0	<0.02
Fence at SR 4[c]	<1.0	7,250.0	1.70	2.8	72.5	0.76	<0.40	2.90	6.30	5.20	7,550.0	0.02
Water at SR 4	<1.0	2,900.0	1.10	4.8	41.0	<0.08	<0.40	2.00	2.50	3.20	4,200.0	<0.02
Indio at SR 4	<1.0	3,400.0	0.90	<1.0	27.0	0.15	<0.40	2.60	2.50	2.00	4,300.0	0.02
Ancho at SR 4	<1.0	3,400.0	0.80	2.4	20.0	<0.08	<0.40	<0.50	2.70	2.70	6,000.0	<0.02
Ancho at Ancho Spring	<1.0	770.0	<0.50	<1.0	9.9	0.18	<0.40	0.62	0.64	2.00	1,400.0	0.04

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
TA-54, Area G												
G-1	<1.0	6,900.0	2.00	<1.0	59.0	0.34	<0.40	2.90	5.70	3.40	7,900.0	<0.02
G-2	<1.0	4,000.0	1.00	<1.0	57.0	0.17	<0.40	3.00	4.50	0.95	16,000.0	<0.02
G-3	<1.0	7,400.0	<0.50	1.5	83.0	0.48	<0.40	4.10	8.10	5.70	8,400.0	0.02
G-4	<1.0	6,000.0	1.00	<1.0	46.0	0.31	<0.40	4.30	8.20	1.50	12,000.0	<0.02
G-5	<1.0	8,800.0	<0.50	1.4	59.0	0.43	<0.40	3.60	6.90	2.60	8,300.0	<0.02
G-6	<1.0	1,1000.0	1.00	2.2	78.0	0.69	<0.40	2.90	9.20	6.50	11,000.0	0.02
G-7	<1.0	2,100.0	1.00	<1.0	39.0	0.21	<0.40	3.30	2.20	3.60	2,500.0	0.02
G-8	<1.0	5,000.0	1.00	1.3	29.0	1.10	1.10	3.70	4.90	<0.40	4,800.0	<0.02
G-9	<1.0	5,500.0	1.00	<1.0	57.0	0.56	<0.40	4.40	6.20	<0.50	8,200.0	<0.02
TA-49, Area AB												
AB-1	<1.0	13,000.0	3.00	1.8	140.0	2.10	1.70	6.70	13.00	12.00	12,000.0	0.02
AB-2	<1.0	10,000.0	4.00	<1.0	140.0	<1.00	<1.00	8.90	11.00	9.20	12,000.0	0.02
AB-3	<1.0	,700.0	2.00	<1.0	81.0	<1.00	<1.00	2.80	6.10	5.60	5,800.0	0.02
AB-4	<1.0	11,000.0	0.90	1.6	190.0	<1.00	<1.00	5.20	7.90	9.40	9,300.0	0.03
AB-4A	<1.0	8,700.0	2.00	<1.0	110.0	<1.00	<1.00	3.40	6.50	6.10	8,100.0	<0.02
AB-5	<1.0	19,000.0	1.00	1.6	160.0	1.40	<1.00	5.50	12.00	7.70	13,000.0	0.03
AB-6	<1.0	6,000.0	2.00	<1.0	90.0	<1.00	<1.00	2.90	5.20	7.10	7,200.0	0.02
AB-7	<1.0	14,000.0	<0.50	3.1	150.0	2.90	2.30	8.30	13.00	9.10	13,000.0	<0.02
AB-8	<1.0	2,500.0	2.00	<1.0	31.0	<1.00	<1.00	1.30	2.60	2.50	4,800.0	<0.02
AB-9	<1.0	4,400.0	2.00	<1.0	87.0	<1.00	<1.00	2.90	3.70	5.20	7,200.0	0.02
AB-10	<1.0	8,800.0	2.00	1.6	72.0	<1.00	<1.00	3.60	7.60	4.40	9,300.0	<0.02
AB-11	<1.0	5,700.0	2.00	<1.0	67.0	<1.00	<1.00	4.50	5.20	3.40	7,600.0	<0.02

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Results averaged from more than one analysis.

*Data on additional trace metals from sediments are on page 217.

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS											
Regional											
Rio Chama at Chamita	130.00	<0.90[a]	<2.00	<4.00	<0.50	<0.30	<4.00	21.0	<0.50	28.00	18.00
Rio Grande at Embudo	390.00	3.90	10.00	6.00	<0.50	<0.30	<4.00	26.0	<0.50	24.00	53.00
Rio Grande at Otowi	110.00	<0.90	<10.00	<10.00	<0.25	0.50	<4.00	9.5	<0.25	21.00	15.00
Rio Grande at Frijoles	97.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	3.4	< 0.20	1.50	14.00
Rio Grande at Bernalillo	160.00	<0.90	2.00	<4.00	<0.50	<0.30	<4.00	28.0	<0.50	19.00	20.00
Jemez River	290.00	<0.90	<2.00	<4.00	<0.50	<0.30	<4.00	36.0	<0.50	13.00	21.00
Rio Grande in White Rock Canyon											
Rio Grande at Sandia	110.00	<0.90	<2.00	<4.00	<0.20	2.70	<4.00	51.0	<0.20	12.00	13.00
Rio Grande at Pajarito	150.00	3.50	5.80	10.00	<0.20	1.90	<4.00	44.0	<0.20	15.00	19.00
Rio Grande at Water	340.00	2.20	11.00	10.00	<0.20	0.40	<4.00	220.0	<0.20	23.00	32.00
Rio Grande at Ancho	190.00	< 0.90	5.00	5.40	<0.20	<0.30	<4.00	57.0	<0.20	16.00	23.00
Rio Grande at Chaquehui	160.00	2.00	<2.00	11.00	<0.20	<0.30	<4.00	61.0	<0.20	13.00	18.00
PERIMETER STATIONS (OFF SITE)											
Acid-Pueblo Canyon											
Acid Weir	250.00	1.40	<10.00	33.00	<0.25	0.40	<4.00	4.1	<0.25	5.60	47.00
Pueblo 1	250.00	<0.90	<10.00	14.00	<0.25	0.50	<4.00	2.80	<0.25	2.50	28.00
Pueblo 2	220.00	< 0.90	<2.00	6.00	<0.50	<0.30	<4.00	4.90	<0.50	5.00	48.00
DP-Los Alamos Canyon											
Los Alamos at Totavi	83.00	0.49	4.00	<4.00	<0.20	0.50	<4.00	4.80	0.60	3.10	11.00
Los Alamos at LA-2	400.00	1.40	9.10	6.80	<0.20	68.00	<4.00	7.60	<0.20	42.00	93.00
Los Alamos at Otowi	110.00	<0.90	<10.00	<10.00	<0.25	<0.30	<4.00	8.00	<0.25	5.90	18.0
Other Areas											
Guaje at SR 4	320.00	1.40	9.10	8.30	<0.20	0.50	<4.00	12.00	<0.20	33.00	75.00
Bayo at SR 4	110.00	1.40	2.00	<4.00	<0.20	<0.30	<4.00	7.50	<0.20	5.60	11.00
Sandia at Rio Grande	120.00	<0.90	2.60	7.10	<0.20	<0.30	<4.00	17.00	<0.20	7.80	18.00
Cañada Ancha at Rio Grande	180.00	<0.90	4.00	5.90	<0.20	<0.30	<4.00	97.00	<0.20	12.00	17.00
Pajarito at Rio Grande	65.00	1.90	<2.00	11.00	<0.20	0.50	<4.00	3.70	<0.20	3.50	12.00
Water at Rio Grande	340.00	<0.90	8.60	12.00	<0.20	0.40	<4.00	95.00	<0.20	15.00	45.00
Ancho at Rio Grande	220.00	<0.90	6.10	9.80	<0.20	0.50	<0.04	81.00	<0.20	12.00	26.00
Chaquehui at Rio Grande	130.00	1.80	3.80	7.80	<0.20	<0.30	<4.00	10.00	<0.20	6.50	19.00
Frijoles at Monument HQ	150.00	<0.90	2.70	6.60	<0.20	0.60	<4.00	7.70	<0.20	5.40	30.00
Frijoles at Rio Grande	37.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	1.40	<0.20	<1.00	5.50
Sandia Canyon Stations											
Station 1	97.00	<0.90	2.00	5.00	<0.30	*0.30	6.00	2.90	<0.30	2.70	18.00
Station 2	140.00	<0.90	2.00	9.00	<0.30	*0.50	6.00	3.50	<0.30	3.50	22.00
Station 3	160.00	<0.90	2.00	4.00	<0.30	*0.60	4.00	6.80	0.30	4.50	20.00

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Mortandad Canyon on Pueblo of San Ildefonso Lands											
Mortandad A-6	160.00	<2.00	<2.00	<4.00	NA	NA	NA	NA	NA	NA	NA
Mortandad A-7	300.00	<0.90	4.00	10.00	<0.30	*0.60	4.00	9.40	<0.30	7.60	33.00
Mortandad A-8	290.00	1.00	3.00	9.00	<0.30	*0.40	6.00	8.80	<0.30	7.10	31.00
Mortandad at SR 4 (A-9)	300.00	2.50	4.60	8.20	<0.20	<0.30	<4.00	7.80	<0.20	6.90	18.00
Mortandad A-10	310.00	<0.90	5.00	9.00	<0.30	*0.50	6.00	18.00	<0.30	12.00	34.00
Mortandad at Rio Grande (A-11)	110.00	2.30	3.00	6.20	<0.20	<0.30	<4.00	36.00	<0.20	10.00	16.00
Mortandad at Transect	420.00	1.10	4.00	15.00	<0.30	*0.50	5.00	20.00	<0.30	12.00	330.00
ON-SITE STATIONS											
Acid-Pueblo Canyon											
Hamilton Bend Spring	150.00	<0.90	< 2.00	9.00	<0.50	<0.30	<4.00	7.00	<0.50	3.50	20.00
Pueblo 3	47.00	< 0.90	N/A[b]	N/A	< 0.50	0.50	N/A	N/A	<0.50	N/A	21.00
Pueblo at State Route	520.00	14.00	<2.00	8.10	<0.20	<0.30	<4.00	2.60	<0.20	13.00	140.00
DP-Los Alamos Canyon											
DPS-1	140.00	<0.90	<2.00	12.00	<0.20	0.40	<4.00	3.80	<0.20	4.30	32.00
DPS-4	110.00	1.60	<2.00	8.30	<0.20	<0.30	<4.00	3.10	<0.20	4.20	23.00
Los Alamos at Bridge	120.00	<0.90	2.10	<4.00	<0.30	0.40	<4.00	4.40	<0.30	4.40	26.00
Los Alamos at LAO-1	86.00	<0.90	2.60	<4.00	<0.30	<0.30	<4.00	3.50	<0.30	3.20	18.00
Los Alamos at GS-1	87.00	<0.90	<2.00	8.20	<0.30	<0.30	<4.00	4.90	<0.30	3.10	19.00
Los Alamos at LAO-3	210.00	1.30	2.10	19.00	<0.30	0.40	<4.00	5.20	<0.30	6.20	40.00
Los Alamos at LAO-4.5	140.00	<0.90	2.60	<5.00	<0.30	<0.30	<4.00	3.80	<0.30	6.90	23.00
Los Alamos at SR 4	160.00	1.80	<2.00	9.50	<0.20	<0.30	<4.00	4.80	<0.20	3.70	31.00
Mortandad Canyon											
Mortandad near CMR Building	79.00	<0.90	13.00	<10.00	<0.25	0.40	<4.00	7.30	0.31	5.50	46.00
Mortandad West of GS-1	140.00	2.50	<2.00	17.00	<0.25	0.50	<2.00	1.60	<0.25	<0.40	9.30
Mortandad at GS-1	220.00	1.80	<10.00	11.00	<0.25	<0.30	<4.00	2.00	<0.25	3.90	38.00
Mortandad at MCO-5	160.00	1.30	<10.00	<10.00	<0.25	<0.30	<4.00	2.00	<0.25	1.50	19.00
Mortandad at MCO-7	160.00	1.90	< 0.00	11.00	<0.25	<0.30	<4.00	3.80	<0.25	4.00	39.00
Mortandad at MCO-9	330.00	1.70	<10.00	14.00	0.25	0.30	<4.00	9.70	<0.25	7.70	43.00
Mortandad at MCO-13(A-5)[c]	240.00	2.60	<10.00	11.10	<0.30	0.47	5.80	7.40	0.30	5.75	34.00
OtherCanyons											
Sandia at SR 4	100.00	<0.90	<2.00	5.40	<0.20	<0.30	<4.00	2.90	<0.20	2.90	18.00
Cañada Del Buey at SR 4	170.00	<0.90	1.10	6.30	<0.20	<0.30	<4.00	5.00	<0.20	3.60	11.00
Pajarito at SR 4	280.00	5.50	8.40	37.00	<0.20	0.40	<4.00	31.00	0.20	19.00	140.00
Potrillo at SR 4	220.00	2.40	<2.00	6.80	<0.20	<0.30	<4.00	4.60	<0.20	6.00	31.00
Fence at SR 4[c]	225.00	1.10	6.50	9.40	<0.30	0.70	2.40	12.30	0.30	10.10	34.50
Water at SR 4	150.00	1.80	1.90	3.10	<0.20	<0.30	<4.00	4.30	<0.20	3.50	22.00
Indio at SR 4	150.00	<0.90	<2.00	<4.00	<0.30	<0.30	< 4.00	5.10	< 0.30	4.00	31.00
Ancho at SR 4	150.00	2.80	<2.00	2.90	<0.20	<0.30	<4.00	3.50	<0.20	6.50	26.00
Ancho at Ancho Spring	45.00	<0.90	<2.00	<4.00	<0.20	<0.30	<4.00	2.10	<0.20	1.40	5.90

Table VI-19. Total Recoverable Trace Metals in Sediments for 1994 (μg/g) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
TA-54, Area G											
G-1	270.00	<0.90	<2.00	8.00	<0.25	0.30	<4.00	12.00	0.25	12.00	36.00
G-2	620.00	< 0.90	<2.00	10.00	<0.25	0.40	<4.00	8.60	<0.25	14.00	89.00
G-3	360.00	<0.90	<2.00	43.00	<0.25	<0.30	<4.00	14.00	<0.25	11.00	55.00
G-4	320.00	<0.90	<2.00	7.40	<0.25	<0.30	<4.00	7.70	<0.25	25.00	58.00
G-5	320.00	<0.90	<2.00	6.60	<0.25	<0.30	<4.00	9.90	<0.25	12.00	45.00
G-6	330.00	<0.90	<2.00	16.00	<0.25	<0.30	<4.00	19.00	< 0.25	14.00	55.00
G-7	160.00	< 0.90	<2.00	5.10	<0.25	0.30	<4.00	9.20	<0.25	1.80	33.00
G-8	140.00	< 0.90	3.10	7.40	<0.25	<0.30	<4.00	6.90	<0.25	8.00	27.00
G-9	280.00	<0.90	4.80	6.80	<0.25	<0.30	<4.00	8.00	<0.25	16.00	30.00
TA-49, Area AB											
AB-1	520.00	<5.00	9.60	22.00	<0.20	0.30	<4.00	30.00	0.30	20.00	650.00
AB-2	480.00	<5.00	11.00	18.00	<0.20	<0.30	<4.00	30.00	<0.20	24.00	58.00
AB-3	250.00	<5.00	5.90	12.00	<0.20	<0.30	<4.00	14.00	<0.20	6.60	140.00
AB-4	380.00	<5.00	7.60	15.00	<0.20	0.30	<4.00	35.00	<0.20	16.00	35.00
AB-4A	250.00	< 5.00	7.00	17.00	<0.20	<0.30	<4.00	18.00	<0.20	2.00	31.00
AB-5	340.00	<5.00	9.40	18.00	<0.20	<0.30	<4.00	28.00	<0.20	21.00	48.00
AB-6	280.00	< 5.00	5.40	15.00	<0.20	0.40	<4.00	17.00	<0.20	11.00	390.00
AB-7	450.00	<5.00	11.00	17.00	<0.20	0.30	<4.00	31.00	0.20	25.00	130.00
AB-8	160.00	<5.00	3.60	9.50	<0.20	<0.30	<4.00	4.80	< 0.20	7.10	25.00
AB-9	300.00	<5.00	4.50	12.00	<0.20	<0.30	<4.00	17.00	<0.20	10.00	28.00
AB-10	270.00	<5.00	6.40	11.00	<0.20	0.30	<4.00	15.00	<0.20	16.00	34.00
AB-11	270.00	< 5.00	9.70	15.00	<0.20	<0.30	<4.00	11.00	<0.20	13.00	21.00

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Results averaged from more than one analysis.

variability in trace metal concentrations or to variability due to differences in sample preparation methods. Differences in laboratory sample preparation procedures only apply to the 1992 and 1993 data. Except as mentioned above, the trace metal measurements reported for 1994 generally yielded results comparable to those obtained in both 1992 and 1993.

b. Organic Analyses. Beginning in 1993, sediments from known radioactive effluent release areas were also analyzed for VOCs, SVOCs, and PCBs. Lists of individual compounds that were analyzed in the laboratory are given in Tables D-21 (VOCs) and D-22 (SVOCs). These VOC, SVOC, and PCB analyses are scheduled to be repeated every three years for sediment samples. Details of the sediment monitoring network, including individual sample locations, are described in Section V.B.5.b (Monitoring Network). All of the sediment sampling locations are shown in Figure V-14 (Off-Site Regional Stations), Figure V-15 (Off-Site Perimeter and On-Site Stations), and Figure V-16 (Solid Waste Management Areas). All of these locations are also listed in Table D-14.

Beginning in 1994, sediment samples for VOC, SVOC, PCB, and pesticide analyses were collected at about one-third of the regional, perimeter, and on-site stations as reported in Table VI-20. Over the three year period from 1994-1996, these stations will be rotated so that all of the listed sediment stations will be sampled at least once. The analytical results confirmed that there were no PCB or pesticide compounds detected in any of the sediment samples collected during 1994. However, two samples from TA-49, Area AB, showed trace levels of the SVOC compounds benzo(ghi)perylene (Station AB-1 with 690 µg/kg), and benzo(a)pyrene (Station AB-3 with 500 µg/kg); the analytical laboratory Level-of-Quantitation (LOQ) for both of these compounds was 330 µg/kg. Both of these compounds are typically found in parking lot (asphalt) runoff waters. It was tentatively concluded that at these levels, the field samples became contaminated with SVOCs by surface runoff. Two Mortandad Canyon stations also showed positive results for the VOC acetone and methylene chloride. Sediments from station MCO-7 contained 39.2 µg/kg acetone (LOQ 20 µg/kg), and 11.4 µg/kg methylene chloride (LOQ 5 µg/kg), respectively; sediments from station MCO-13 contained 7.8 µg/kg of methylene chloride. The sample quality assurance/quality control trip blanks tested negative for both of these compounds; however, these compounds are common laboratory solvents. It was tentatively concluded that at these levels, the field samples became contaminated with acetone and methylene chloride during the laboratory analyses. None of the other sediment samples showed any VOC contamination levels above the respective LOQs.

Table VI-20. List of Sediment Stations Where Samples Were Collected in 1994 for Organic Analyses

Station Name
Chamita
Rio Grande at Bernalillo
Jemez River
Pueblo 2
Los Alamos at Otowi
Sandia at Rio Grande
Hamilton Bend Spring
DP-Los Alamos Canyons
DPS-1
DPS-4
Mortandad Near CMR Building
Mortandad West of GS-1
GS-1
Mortandad at MCO-5
Mortandad at MCO-7
Mortandad at MCO-9
Mortandad at MCO-13[c] (A-5)
Fence at SR-4
Indio at SR-4
TA-49, Area AB
AB-1
AB-2
AB-3
AB-4
AB-4A
AB-5
AB-6
AB-7
AB-8
AB-9
AB-10
AB-11

5. Foodstuffs Monitoring.

Various foodstuffs (produce and fish) were analyzed for trace and heavy metals during the 1994 season. In fact, this was the first time that trace and heavy metals have been analyzed and reported for produce collected within the Laboratory and the surrounding areas. This was the second time for fish—the first results were reported in the 1991 report (EPG 1993). These data will ultimately be used to establish a database and

are meaningful from a Laboratory operation/effects standpoint. The major contaminants of concern at firing sites, for example, are beryllium and lead, and the migration of these elements off site is a significant concern to the public. Section V.B.7.b presents information on the monitoring network used in this program. The results of the 1994 produce and fish sampling program are found in Tables VI-21 and VI-22, respectively.

a. Produce. Most trace and heavy metal elements, particularly arsenic, beryllium, antimony, and selenium, in produce from on-site, perimeter and regional locations were below the limit of detection. In those cases where some produce samples contained metals above the limit of detection (e.g., cadmium, chromium, and mercury), only cadmium showed statistical differences; levels of cadmium in produce collected from on-site and from the White Rock/Pajarito Acres area were significantly higher than cadmium levels in produce from the Española/Santa Fe/Jemez stations. These results should be viewed with caution. The mean values, for example, were estimated from less-than (<) values (censored data) and may be (biased) higher than otherwise expected (Gilbert 1987). Also, soil samples collected from these same areas did not contain higher cadmium (0.40 μg/dry g) than background soil samples (0.41 μg/dry g) (Table VI-18). In any case, the levels were still within the range of cadmium concentrations normally found in agricultural food crops around the country (Wolnik 1983, Wolnik 1985). No significant differences in any of the trace and heavy metal elements were found in produce collected from either Cochiti or San Ildefonso areas as compared to background concentrations.

b. Fish. Most trace and heavy metals in fish collected from Cochiti and Abiquiu reservoirs were below the limit of detection. For those elements that were above the limit of detection (e.g., barium, copper, mercury, and zinc), the levels were statistically ($p < 0.05$) similar in fish from Cochiti Reservoir as compared to fish collected from Abiquiu Reservoir. In addition, all of these metals, particularly beryllium, mercury, and lead, were similar to values reported in 1991 (EPG 1993). Mercury concentrations in fish from lakes and reservoirs in the State of NM have been of significant concern to the public for several years. However, the levels of mercury in 1991 in fish from Cochiti (0.350 μg/wet g) and Abiquiu Reservoirs (0.350 μg/wet g) were similar to mercury in fish from Cochiti (0.284 μg/wet g) and Abiquiu Reservoirs (0.371 μg/wet g) in 1994.

6. Emergency Planning and Community Right-to-Know Act.

Title III, Section 313, of the Emergency Planning and Community Right-to-Know Act (EPCRA) requires facilities meeting certain Standard Industrial Classification (SIC) code criteria to submit annual Toxic Chemical Release Inventory (TRI) reports. NM facilities meeting the SIC code criteria must submit TRI reports to the EPA and the NM Emergency Management Bureau every July for the preceding calendar year.

The Laboratory does not meet the SIC code criteria for reporting but has voluntarily submitted annual TRI reports since 1987. Because all research operations are exempt under provisions of the regulation, the Laboratory reports only pilot plant, production, or manufacturing operations. The Laboratory's release reporting has therefore been limited to regulated chemical use at the Plutonium Processing Facility (TA-55), the only Laboratory operation that uses a reportable chemical (nitric acid) in amounts greater than the Section 313 reporting threshold.

On August 3, 1993, the President of the US issued Executive Order 12856, requiring all federal facilities, regardless of SIC code, to report under Title III, Section 313 of EPCRA. Research operations remain exempt. This requirement does not go into effect until the July 1995 reporting deadline for the 1994 calendar year. The Laboratory, along with the DOE, elected to begin reporting under the new guidelines beginning with the 1994 report. The new guidelines require that LANL report on two chemicals in addition to nitric acid—chlorine for water treatment and sulfuric acid used to deionize water at the power plant (TA-3-22).

The 1994 report addresses the releases of nitric acid, chlorine, and sulfuric acid during 1993. About 6,090 kg (13,400) lb of nitric acid were used for plutonium processing, with releases to the air of approximately 78 kg (171 lb). The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in waste water treatment operations. In addition, 9,602 kg (21,149 lb) of chlorine were used in water purification operations involving noncontact cooling water, sewage treatment, and drinking water, resulting in air emissions of 381 kg (839 lb) of chloroform and 12 kg (26 lb) of chlorine. An estimated 2,479 kg (5,460) lb of chlorine were released with the discharged water. Finally, 24,430 kg (53,745 lb) of sulfuric acid were used to deionize water at the Laboratory's main power plant, resulting in less than 0.45 kg (1 lb) of air emissions. The remaining sulfuric acid was completely neutralized before being discharged to the environment.

Table VI-21. Total Recoverable Trace and Heavy Metals (μg/dry g) (ppm) in Produce Collected in 1994[a]

	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
OFF-SITE STATIONS												
Regional												
Española/Santa Fe/Jemez												
squash	N/A[b]	<0.50[c]	N/A	<0.08	<0.70	5.00	0.03	N/A	5.10	<0.20	<0.40	N/A
apricots	N/A	<0.50	N/A	<0.08	<0.40	1.30	0.02	N/A	<4.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	0.56	1.10	0.02	N/A	<7.00	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.40	<0.80	0.02	N/A	<6.00	<0.20	<0.40	N/A
pears	N/A	<0.50	N/A	<0.08	0.42	<1.00	0.01	N/A	<5.00	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.50	<0.90	0.02	N/A	<4.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	<0.50	<0.80	0.02	N/A	<5.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.40	<0.80	0.02	N/A	<7.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.48	<1.46	0.02	N/A	<5.39	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.21)	(2.88)	(0.01)	(N/A)	(2.37)	(0.00)	(0.00)	(N/A)
RSRL[d]	N/A	<0.50	N/A	<0.08	<0.69	<4.34	0.03	N/A	<7.76	<0.20	<0.40	N/A
Perimeter												
Los Alamos												
tomatoes	N/A	<0.50	N/A	<0.08	<0.50	<1.20	0.02	N/A	<9.00[e]	<0.20	<0.40	N/A
apricots	N/A	<0.50	N/A	<0.08	<0.70[e]	2.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
cherries	N/A	<0.50	N/A	<0.08	<0.40	1.40	0.02	N/A	<9.00[e]	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.53	<1.50	0.02	N/A	<7.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.31)	(0.80)	(0.00)	(N/A)	(5.80)	(0.00)	(0.00)	(N/A)
White Rock/Pajarito Acres												
apples	N/A	<0.60[e]	N/A	<0.08	<1.00[e]	<0.80	0.02	N/A	<5.00	<0.20	<0.40	N/A
squash	N/A	<0.60[e]	N/A	<0.08	<0.90[e]	<0.80	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
squash	N/A	<0.60[e]	N/A	<0.08	<0.70[e]	<0.90	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
tomatoes	N/A	<0.60[e]	N/A	<0.08	<0.50	<0.90	0.01	N/A	<8.00[e]	<0.20	<0.40	N/A
Mean	N/A	<0.60	N/A	<0.08	<0.78[f]	<0.85	0.02	N/A	<7.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.44)	(0.12)	(0.01)	(N/A)	(3.00)	(0.00)	(0.00)	(N/A)
Cochiti												
corn	N/A	<0.60[e]	N/A	<0.08	<0.40	0.89	0.02	N/A	5.00	<0.20	<0.40	N/A
apples	N/A	<0.60[e]	N/A	<0.08	<0.50	<1.20	0.02	N/A	<8.00[e]	<0.20	<0.40	N/A
apples	N/A	<0.60[e]	N/A	<0.08	<0.70[e]	<0.80	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.60	N/A	<0.08	<0.53	<0.96	0.02	N/A	<5.70	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.31)	(0.42)	(0.00)	(N/A)	(4.20)	(0.00)	(0.00)	(N/A)
San Ildefonso												
peaches	N/A	<0.50	N/A	<0.08	<0.40	1.30	0.02	N/A	<8.00	<0.20	<0.40	N/A
apples	N/A	<0.50	N/A	<0.08	<0.80[e]	<0.80	0.02	N/A	<4.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.70[e]	1.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.63	<1.03	0.02	N/A	<5.30	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.42)	(0.50)	(0.00)	(N/A)	(4.60)	(0.00)	(0.00)	(N/A)
ON-SITE												
LANL												
peaches	N/A	<0.50	N/A	<0.08	<0.80[e]	0.90	0.02	N/A	<4.00	<0.20	<0.40	N/A
peaches	N/A	<0.50	N/A	<0.08	<0.50	0.52	0.02	N/A	<4.00	<0.20	<0.40	N/A
tomatoes	N/A	<0.50	N/A	<0.08	<1.00[e]	1.00	0.02	N/A	<4.00	<0.20	<0.40	N/A
squash	N/A	<0.50	N/A	<0.08	<0.50	0.89	0.02	N/A	<10.00[e]	<0.20	<0.40	N/A
pumpkin	N/A	<0.50	N/A	<0.08	<0.90[e]	<1.10	0.02	N/A	<4.00	<0.20	<0.40	N/A
Mean	N/A	<0.50	N/A	<0.08	<0.74[f]	<0.88	0.02	N/A	<5.20	<0.20	<0.40	N/A
(±2SD)	(N/A)	(0.00)	(N/A)	(0.00)	(0.46)	(0.44)	(0.00)	(N/A)	(5.40)	(0.00)	(0.00)	(N/A)

[a]Analysis by EPA Method 3051 for total recoverable metals.

[b]N/A = analysis not performed or lost in analysis.

[c]The less than symbol (<) means the analysis was below the specified detection limit of the analytical method and/or sample.

[d]Regional Statistical Reference Level; this is the upper limit background concentration (mean + 2 std dev).

[e]Higher than the RSRL.

[f]Statistically significant (mean) from background (mean) using a Student's t-test at the 0.05 probability level.

Table VI-22. Total Recoverable Trace and Heavy Metals in Fish (μg/wet g) (ppm) Collected in 1994

Element	Abiquiu Reservoir Mean[a]	Abiquiu Reservoir +2 std dev	Cochiti Reservoir Mean	Cochiti Reservoir +2 std dev
Silver	<0.700	0.000	<0.700	0.000
Arsenic	<0.500	0.000	<0.500	0.000
Barium	0.100[b]	0.220	0.061	0.078
Beryllium	<0.020	0.000	<0.020	0.000
Cadmium	<0.300	0.000	<0.300	0.000
Chromium	<0.300	0.000	<0.300	0.000
Copper	0.340	0.240	0.440	0.284
Mercury	0.371	0.562	0.284	0.640
Nickel	<1.000	0.000	<1.000	0.000
Lead	3.110	0.600	<3.000	0.000
Selenium	<0.500	0.000	<0.500	0.000
Zinc	4.060	1.24	3.860	1.040

[a]The average of seven fish each from Cochiti and Abiquiu reservoirs.

[b]There were no significant differences in barium, copper, mercury, lead, and zinc levels in fish collected from Cochiti as compared to fish collected from Abiquiu (background) using a Student's t-test at the 0.05 probability level.

7. Federal Insecticide, Fungicide, and Rodenticide Act.

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the manufacturing of pesticides with requirements on registration, labeling, packaging, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include recommended procedures for storage and disposal and requirements for certification of workers who apply pesticides. The Laboratory is also regulated by the NM Pest Control Act, administered by NM Department of Agriculture (NMDA), which regulates pesticide use, storage, and certification. The NMDA conducts an annual inspection of JCI's compliance with the act. The application, storage, disposal, and certification of these chemicals are conducted in compliance with these regulations. JCI applies pesticides under the direction of the Laboratory's Pest Control Program Administrator. A Laboratory Pest Management Plan, which includes programs for managing vegetation, insects, and small animals, was established in 1984 and is being revised by the Pest Control Oversight Committee, a committee established to review and recommend policy changes in the overall pest management program at the Laboratory.

An annual inspection conducted by the NMDA found no deficiencies in the Laboratory's pesticide application program and certified applications equipment. The herbicide and insecticide usage for 1994 is summarized in Table VI-23.

B. Unplanned Releases of Nonradiological Materials

1. Airborne Releases.

There were no unplanned airborne nonradiological releases in 1994.

2. Liquid Releases.

During 1994, 24 releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and the NMED. The NMED Surface Water Bureau has requested that all liquid releases be reported regardless of any potential impact on the environment. Each of these discharges were minor in nature and were contained on Laboratory property. No discharges were found to be of any threat to health or the environment. Sampling and

Table VI-23. Herbicide and Insecticide Usage during 1994

Type	Brand Name	Annual Usage
Insecticides		
	Inspector (pyrethrin)	4.70 gallons
	Tempo (cyfluthrin)	21 grams
	BP100 (pyrethrin)	2.0 gallons
Herbicides		
	Velpar (hexazione)	350 gallons
	Confront (triclopyr)	4.0 gallons

Note: For purposes of reporting, the above volumes are stated as actual manufactured product, prior to mixing. The actual percent of active ingredient in each product is usually a small fraction of the respective application.

cleanup were completed, as appropriate, to confirm the presence or absence of pollutants and to prevent further migration.

The following is a summary of these 24 unplanned releases:

- fourteen releases of untreated sanitary sewage (all but two were less than 3,785 L (1,000 gal.) from the Laboratory's wastewater treatment plant collection systems;
- one release of ethylene glycol at TA-54, Area G of 5.7 L (1.5 gal.) on September 20, 1994;
- one hydraulic oil release at Guaje Pines of 5.7 L (1.5 gal.) on April 16, 1994;
- two releases of treated sanitary effluent: TA-46, Bldg. 333 of 18,927 L (5,000 gal.) on April 19, 1994; and TA-3, Bldg. 22 of 2,839 L (750 gal.) on October 18, 1994;
- one release of photo fixer at TA-35, Bldg. 87 of 151.4 L (40 gal.) on June 4, 1994;
- one release of treated cooling water at TA-53, Bldg. 3 of 378,541.2 L (100,000 gal.) on December 15, 1994;
- one release of diluted glycerin from fire sprinkler system at TA-3, Bldg. 38 of 567.8 L (150 gal.) on March 4, 1994;
- one release of sediment storm water in Los Alamos Canyon of runoff from gas line excavation;
- one release of mud and soil washings at TA-3, Sigma Mesa of 859,288.5 L (227,000 gal.) on August 2, 1994; and
- one release of ethylene glycol from a vehicle accident in Los Alamos Canyon, 11.3 L (3 gal.) on November 11, 1994.

All spills were investigated by ESH-18. Upon cleanup, personnel from NMED/Agreement in Principle inspected the spill sites to ensure adequate cleanup. NMED administratively closed 22 of the 24 spills which occurred in 1994.

ESH-18 prepared a generalized Notice of Intent (NOI) for the discharge of potable water from the Los Alamos water supply system, including production wells, transmission lines, storage tanks, booster pump stations, and other related facilities. The generalized NOI provides the Laboratory with regulatory coverage for releases of potable water from the water supply system that are not considered hazardous to public health and are not covered by the NPDES permit. ESH-18 also prepared a generalized NOI for the release of steam condensate and line disinfection from the Laboratory's steam distribution and condensate return systems.

VII. Groundwater Protection Management Program

Efforts to monitor and protect groundwater quality in the Los Alamos area began in 1949. The data indicate that Department of Energy (DOE) operations at Los Alamos National Laboratory (LANL or the Laboratory) have resulted in some contamination (i.e., concentrations of substances above background levels) of the main aquifer, particularly beneath Los Alamos and Pueblo Canyons. Here, signs of effluent from sewage treatment and past radioactive industrial releases have appeared in the top of the main aquifer. In the lower reaches of these canyons, streams have cut down through the Bandelier Tuff into the more permeable basalts and conglomerates directly overlying the main aquifer, facilitating seepage of contaminants into the aquifer formations. The radioactive contamination is restricted to trace amounts of tritium, an isotope of hydrogen, which moves through rocks much more readily than do other radionuclides. The presence of tritium does not pose a risk to public health, as the highest level was about 2% of the federal drinking water limit for tritium. In addition, there has been no significant depletion of the main aquifer groundwater resource.

A. Introduction

Groundwater resource management and protection at the Laboratory are focused on the main aquifer underlying the region (see Section II.C of this report). The aquifer has been of paramount importance to Los Alamos since the period following the World War II Manhattan Engineer District days, when the Atomic Energy Commission (AEC) needed to develop a reliable water supply to support Laboratory operations. The US Geological Survey (USGS) was extensively involved in overseeing and conducting various studies for development of groundwater supplies beginning in 1945 and 1946. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The monitoring data indicate that DOE operations at the Laboratory have resulted in some contamination of the main aquifer, particularly beneath Los Alamos and Pueblo Canyons. The term contamination refers to the presence of substances whose concentrations exceed background values because of human actions, whether or not these substances significantly affect water quality. The term pollution applies to levels of contamination which are undesirable, for example because of possible adverse health effects (Freeze 1979). In Los Alamos and Pueblo Canyons, signs of effluent from sewage treatment and past radioactive industrial releases have appeared in the upper part of the main aquifer. In the lower reaches of these canyons, the streams have cut down through the Bandelier Tuff into the more permeable basalts and conglomerates directly overlying the main aquifer, facilitating seepage of contaminants into the aquifer formations. The radioactive contamination is generally restricted to trace amounts of tritium, an isotope of hydrogen, which moves through rocks much more readily than do other radionuclides. Tritium contamination within the main aquifer has been found at four locations in Los Alamos and Pueblo Canyons, and also one location in Mortandad Canyon (see Section VII.E.1). Three test wells, TW-3, TW-4 and TW-8, also showed unexpected levels of ^{90}Sr during 1994. Unexpectedly high levels of nitrate were also found at several of these locations during 1994 (see Section VII.E.5). These discoveries are a matter of concern to the Laboratory and will be followed up with detailed studies.

As a result of the testing done between 1991 and 1993, tritium contamination was discovered in four test wells which penetrate only a short distance into the top of the main aquifer (EARE 1995b) and in a former water supply well in lower Los Alamos Canyon. Some of these wells (in Pueblo and Los Alamos Canyons) draw water from formations a relatively short distance below shallow alluvium, known to have past tritium contamination. The casing of other wells was probably not cemented during construction, and leakage down the well bore is possible. The wells are all located downstream of present or former sites of discharge of treated radioactive liquid industrial waste into Acid-Pueblo, DP-Los Alamos, or Mortandad Canyons. The presence of tritium does not pose a risk to public health, as the highest level detected was about 2% of the federal drinking water limit. Confirmed evidence of tritium contamination has not been discovered in samples taken from any of the current public water supply wells (see Section VII.E.1).

The development and production of the water supply have not resulted in any significant depletion of the resource as there is no major widespread decline of the main aquifer piezometric surface. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

The early groundwater management efforts evolved with the growth of the Laboratory's current Groundwater Protection Management Program that addresses environmental monitoring, resource management, aquifer protection, and geohydrologic investigations. Essentially all of the action elements required by DOE Order 5400.1 (DOE 1988a) as part of the Groundwater Protection Management Program have been functioning at the Laboratory for varying lengths of time before the DOE Order was issued. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990 and revised in 1995 (LANL 1995b). Several hundred reports and articles documenting studies and data germane to groundwater and the environmental setting of Los Alamos are listed in a bibliography (Bennett 1990).

Groundwater resource monitoring routinely documents conditions of the water supply wells and the hydrologic conditions of the main aquifer as part of the overall Groundwater Protection Management Program. This information is documented in a series of annual reports providing detailed records of pumping and water level measure-ments. The most recent reports in this series are entitled "Water Supply at Los Alamos during 1992" and "Water Supply at Los Alamos during 1993" (Purtymun 1995b and 1995c).

The groundwater quality monitoring described in this report reflects the current status of the program that was initiated by the USGS for the AEC in 1949. Groundwater quality monitoring addresses the main aquifer at Los Alamos; shallow alluvial groundwater in canyons; the intermediate depth perched systems in the basalt and the Puye conglomerate beneath parts of Pueblo, Los Alamos, and Sandia Canyons; and special studies relating to groundwater age and recharge mechanisms. See Section II.C for a general description of the hydrogeology of the Los Alamos area.

Concentrations of radionuclides in environmental water samples from the main aquifer, the alluvial perched water in the canyons, and the intermediate depth perched systems, whether collected within the Laboratory boundaries or off site, may be evaluated by comparison with derived concentration guides (DCGs) for ingested water calculated from DOE's public dose limits (see Appendix A). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to New Mexico Environment Department (NMED), New Mexico Environmental Improvement Board (NMEIB), and Environmental Protection Agency (EPA) drinking water standards or to the DOE DCGs applicable to radioactivity in DOE drinking water systems, which are more restrictive in a few cases.

The concentrations of nonradioactive chemical quality parameters may be evaluated by comparing them to NMEIB and EPA drinking water standards (maximum concentration levels [MCLs]), even though these standards are only directly applicable to the public water supply. The supply wells in the main aquifer are the source of the Los Alamos public water supply. The New Mexico Water Quality Control Commission (NMWQCC) has established standards for groundwater quality (NMWQCC 1993). Although it is not a source of municipal or industrial water, the shallow alluvial groundwater results in return flow to surface water and springs used by livestock and wildlife, and may be compared to the Standards for Groundwater or the Livestock and Wildlife Watering Standards, as well as the stream standards established by the NMWQCC (NMWQCC 1993, NMWQCC 1994).

B. Monitoring Network

There are three principal groups of groundwater sampling locations: main aquifer, alluvial perched groundwater in the canyons, and the localized intermediate depth perched groundwater systems. The sampling locations for the main aquifer, the intermediate depth perched groundwater systems, and for springs interpreted to be discharging from either the main aquifer (Purtymun 1980b) or from the perched intermediate systems are shown in Figure VII-1. The sampling locations for the canyon alluvial perched groundwater systems are shown in Figure VII-2. Water for drinking and industrial use is also obtained from a well at the Laboratory's experimental geothermal site (Fenton Hill, TA-57) about 45 km (28 mi) west of Los Alamos on Forest Service land. The well is about 133 m (436 ft) deep and is completed in volcanics. Information about groundwater and other environmental monitoring at this remote technical area is presented in Section IV.C.3.

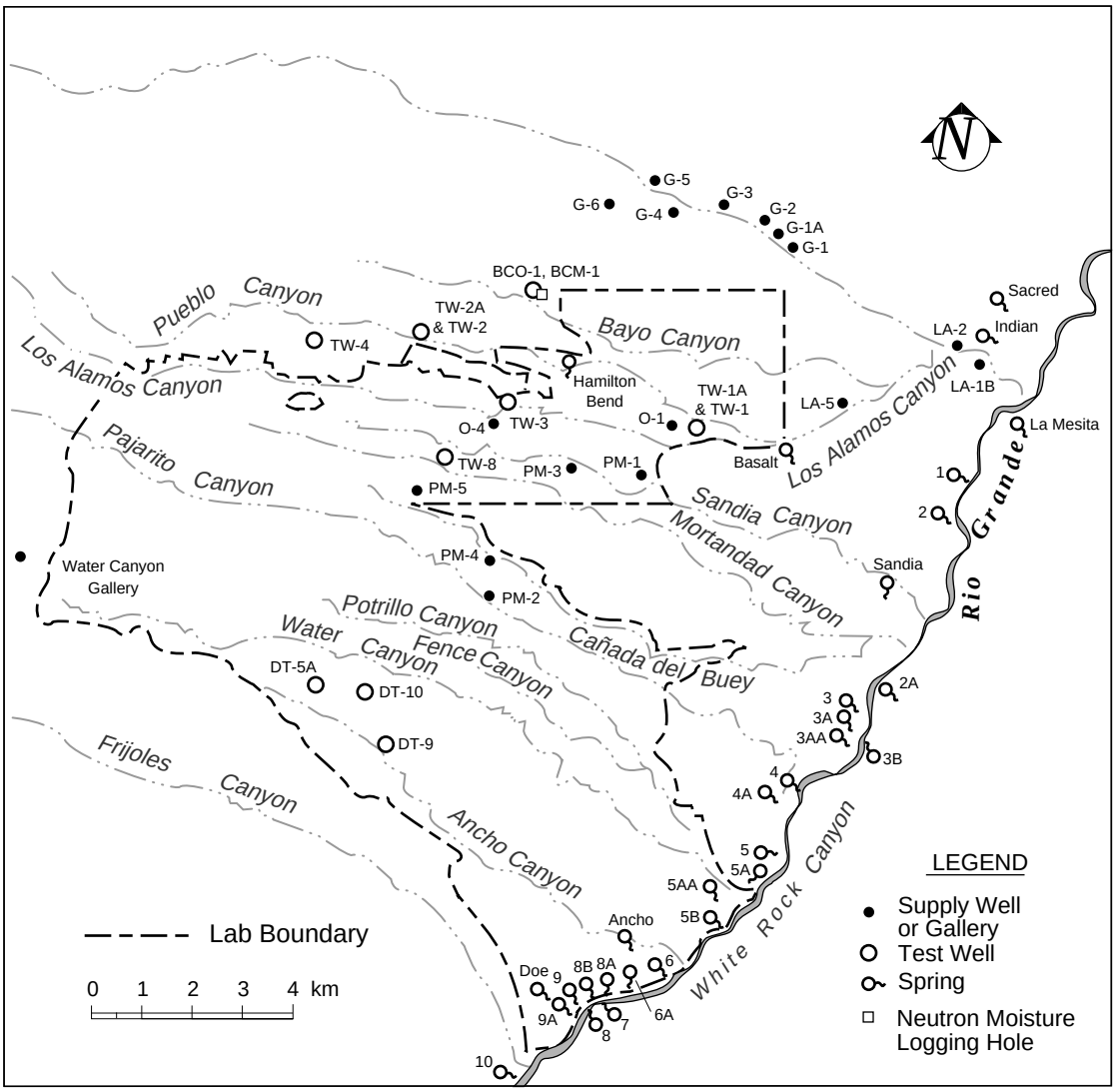

Figure VII-l. Springs and deep and intermediate wells used for groundwater sampling. (See Table D-16 for specific locations.)

1. Main Aquifer.

Sampling locations for the main aquifer include test wells, supply wells, and springs. Eight deep test wells, completed into the main aquifer, are routinely sampled. Two of the test wells are off site; the other six are within the Laboratory boundary. One off-site well, Test Well 2, drilled in 1949, is in the middle reach of Pueblo Canyon, downstream from the confluence with Acid Canyon, on Los Alamos County land. Depth to water in 1994 was 243 m (798 ft). Perched water at an intermediate depth was observed in nearby Test Well 2A (see Section VII.B.3 for a detailed discussion of the intermediate-depth perched groundwater systems). The other off-site well, Test Well 4, drilled in 1950 on the mesa above Acid Canyon, is near the former outfall of the decommissioned TA-45 radioactive liquid waste treatment plant. Depth to water in 1994 was 359 m (1,177 ft).

Of the on-site wells, Test Well 1, drilled in 1950, is in the lower reach of Pueblo Canyon, near the boundary with the Pueblo of San Ildefonso. Depth to water in 1994 was 167 m (549 ft). Perched water at an intermediate depth

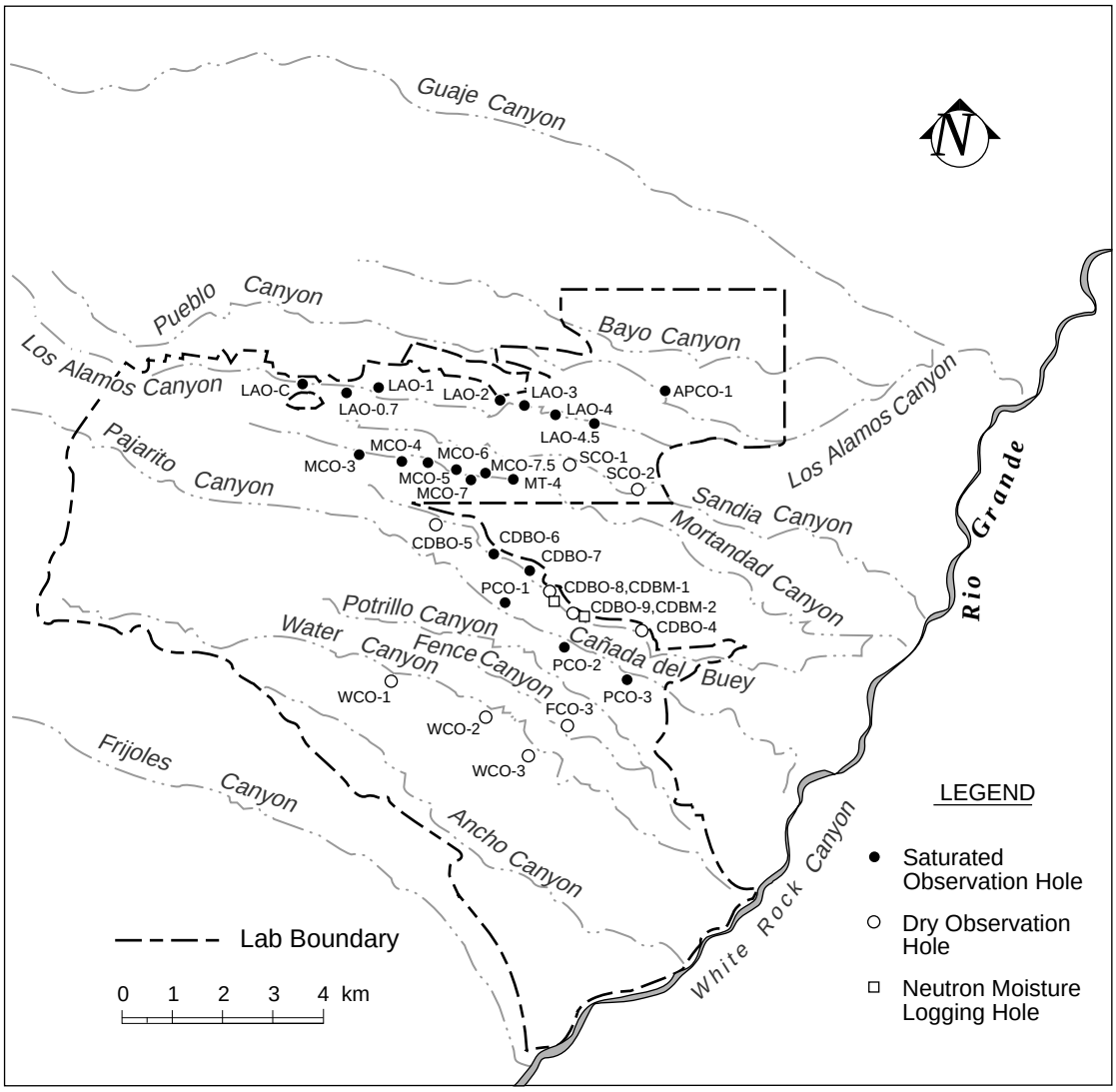

Figure VII-2. Alluvial observation wells and neutron moisture holes.

was observed in nearby Test Well 1A (see Section VII.B.3). Test Well 3, drilled in 1949, is in the middle reach of Los Alamos Canyon just upstream from the confluence with DP Canyon. Depth to water in 1994 was 238 m (781 ft). Test Well 8, drilled in 1960, is in the middle reach of Mortandad Canyon, downstream from the TA-50 radioactive liquid waste treatment plant outfall. Depth to water in 1994 was 303 m (993 ft). Test wells DT-5A, DT-9, and DT-10 (all of which were drilled in 1960) are at the southern edge of the Laboratory at TA-49. The depths to water in 1994 were 361 m (1,184 ft) at DT-5A, 340 m (1,116 ft) at DT-9, and 334 m (1,097 ft) at DT-10. No perched water between the surface of the mesa and the top of the main aquifer was observed when wells TW-3, TW-8, DT-5A, DT-9, and DT-10 were drilled.

Samples were also collected from eight deep water supply wells in three well fields that produce water for the Laboratory and community. The well fields include the Guaje Well Field, located off site in Guaje Canyon on US Forest Service lands northeast of the Laboratory and the on-site Pajarito and Otowi fields.

The Guaje Well Field contains seven wells, three of which had significant production during 1994. Wells in this field range in depth from 463 m to 610 m (1,519 ft to 2,001 ft). Movement of water in the upper 430 m (1,410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito Well Field is located in Sandia and Pajarito Canyons and on mesa tops between those canyons. The Pajarito Well Field comprises five wells ranging in depth from 701 m to 942 m (2,299 ft to 3,090 ft). Movement of water in the upper 535 m (1,755 ft) of the aquifer is eastward at 29 m/yr (95 ft/yr) (Purtymun 1984).

Two new water supply wells were completed in 1990. These are the first wells in a new field designated as the Otowi Well Field, and the wells were designated Otowi-1 and Otowi-4. Otowi-4 was connected to the distribution system and began production during 1993 but was shut down due to pump failure during 1994. Wells Otowi-1 and Otowi-4 are 795 m and 855 m in depth (2,609 ft to 2,805 ft).

Additional samples were taken from 13 other wells located in the Santa Fe Group of sedimentary deposits. These wells were sampled as part of the special sampling on the Pueblo of San Ildefonso. See Section IV.C.5 for information on the Memorandum of Understanding between DOE, the Bureau of Indian Affairs (BIA), and the Pueblo of San Ildefonso.

Numerous springs near the Rio Grande were sampled because they are interpreted to be representative of natural discharge from the main aquifer (Purtymun 1980b). See Section II.C. for information on discharge into the Rio Grande. Based on their chemistry, the springs in White Rock Canyon are divided into four groups. Three groups (I, II, and III) have similar, aquifer-related chemical quality. Chemical quality of springs in Group IV reflect local conditions in the aquifer, which are probably related to waters discharging through faults in volcanics. Indian and Sacred springs are west of the river in lower Los Alamos Canyon. These two springs discharge from faults in the siltstones and sandstones of the Tesuque Formation.

2. Perched Groundwater in Canyon Alluvium.

The alluvial perched groundwater in five canyons was sampled by means of shallow observation wells as part of the routine monitoring program. Pueblo and Los Alamos Canyons are former radioactive effluent release areas, and Mortandad Canyon presently receives treated radioactive effluents. The fourth is Pajarito Canyon, immediately south of the existing solid waste management areas at TA-54 on Mesita del Buey. The fifth is Cañada del Buey, immediately north of the existing solid waste management areas at TA-54 on Mesita del Buey, and downstream of the Laboratory's new Sanitary Wastewater Systems Consolidation (SWSC) project. All of these alluvial perched groundwater sampling locations are on site. The extent of saturation in the alluvial groundwater systems varies seasonally, in response to variations in runoff from snowmelt, summer thunderstorms, and discharges from the Laboratory's National Pollutant Discharge Elimination System (NPDES)-permitted outfalls. In any given year, some of these alluvial observations wells may be dry, and thus no water samples can be obtained.

Acid Canyon, a small tributary of Pueblo Canyon, received untreated and treated industrial effluent that contained residual radionuclides from 1944 to 1964 (ESG 1981). Pueblo Canyon currently receives treated sanitary effluent from the Los Alamos County Bayo sewage treatment plant in the middle reach of Pueblo Canyon. Water occurs seasonally in the alluvium, depending on the volume of surface flow from snowmelt, thunderstorm runoff, and sanitary effluents. One sampling point, Hamilton Bend Spring, which in the past discharged from alluvium in the lower reach of Pueblo Canyon, has been dry since 1990, probably because there was no discharge from the older, abandoned Los Alamos County Pueblo sewage treatment plant. Further east, at the location of Well APCO-1, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo sanitary sewage treatment plant. At APCO-1, the alluvium is about 3.4 m (11 ft) thick and depth to water is about 2.0 m (6.6 ft).

The on-site reach of Los Alamos Canyon presently carries flow from the Los Alamos Reservoir to the west of the Laboratory, as well as NPDES-permitted effluents from TA-2, TA-53, and TA-21. In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some radionuclides. An industrial liquid waste treatment plant at TA-21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of water in the alluvium of Los Alamos Canyon within the Laboratory boundary west of State Road 4. Water levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Sampling stations consist of seven observation wells completed into the alluvium in Los Alamos Canyon. The wells range in depth from about 6 m to about 9 m (20 to 30 ft). Depth to water is typically in the range of 1.2 m to 4.6 m (4 to 15 ft).

Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on the Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within the Laboratory and can be sampled utilizing wells installed by the BIA. During 1994 this groundwater was not sampled at locations on Pueblo of San Ildefonso lands. See Section IV.C.4 for information on results obtained at the Pueblo of San Ildefonso.

Mortandad Canyon has a small drainage area that heads at TA-3. Its drainage area presently receives inflow from natural precipitation and a number of NPDES-permitted effluents including those from the existing radioactive liquid waste treatment plant at TA-50. These effluents infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km (2.2 mi) downstream from the TA-50 outfall. The easternmost extent of saturation is on site, about 1.6 km (1 mi) west of the Laboratory boundary with the Pueblo of San Ildefonso. The alluvium is less than 1.5 m (5 ft) thick in the upper reach of Mortandad Canyon and thickens to about 23 m (75 ft) at the easternmost extent of saturation. The saturated portion of the alluvium is perched on weathered and unweathered tuff and is generally no more than 3 m (10 ft) thick. There is considerable seasonal variation in saturated thickness, depending on the amount of runoff experienced in any given year (Stoker 1991). Velocity of water movement in the perched alluvial groundwater ranges from 18 m/day (59 ft/day) in the upper reach to about 2 m/day (7 ft/day) in the lower reach of the canyon (Purtymun 1974c, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched alluvial groundwater. Monitoring wells that are sampled as part of the routine monitoring program consist of six observation wells in the shallow perched alluvial groundwater. These wells range in depth from about 3.7 m to about 21 m (12 to 69 ft) with depths to water ranging from about 0.9 m to about 14 m (3 to 46 ft). In any given year, some of these wells may be dry, and thus no water samples can be obtained. Additional wells that have been installed in the lower reach of the canyon are dry.

In Pajarito Canyon water in the alluvium is perched on the underlying tuff and is recharged mainly through snowmelt, thunderstorm runoff, and some NPDES-permitted effluents. Three shallow observation wells were constructed in 1985 as part of a compliance agreement with the State of New Mexico to determine if technical areas in the canyon or solid waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater. No effects were observed; the alluvial perched groundwater was found to be contained in the canyon bottom and does not extend under the mesa (Devaurs 1985).

Cañada del Buey contains a shallow alluvial perched groundwater system of limited extent. The thickness of the alluvium ranges from 1.2 to 5 m (4 to 17 ft), while the underlying weathered tuff ranges in thickness from 3.7 to 12 m (12 to 40 ft). In 1992, saturation was found within only a 0.8 km (0.5 mi) long segment, starting at about the location of well CDBO-6 and including well CDBO-7 (EPG 1994). The apparent source of the saturation is purge water from nearby municipal water supply well PM-4, as the alluvium is dry upstream of the purge water entry point. Because treated effluent from the Laboratory's new SWSC project may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture level holes was installed during the early summer of 1992 within the upper and middle reaches of the drainage (EPG 1994). Construction of the SWSC project was completed in late 1992. Possible changes in the quality and extent of groundwater in the alluvium will be monitored with five new shallow observation wells (CDBO-5 through CDBO-9) and an older well (CDBO-4) installed in 1985, all of which are located adjacent to the Cañada del Buey active stream channel. As a complement to the shallow groundwater monitoring network, two neutron moisture logging access tubes (CDBM-1 and -2) were installed to gauge the rate of downward movement of the effluent should the canyon bottom become saturated. Additionally, a continuously recording USGS stream gaging station was installed where Cañada del Buey crosses the eastern (downstream) Laboratory boundary at State Road 4.

The Cañada del Buey monitoring network was installed to demonstrate that effluent discharges from SWSC meet the requirements of the NMWQCC regulations. The monitoring also satisfies requirements of DOE Order 5400.1 for pre-operational studies.

3. Intermediate-Depth Perched Groundwater.

Perched groundwater of limited extent occurs in the conglomerates and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. Samples are obtained from two test wells and one spring. Test Well 2A is located in the off-site middle reach of Pueblo Canyon. Test Well 2A (drilled in 1949 to a depth of 40.5 m [133 ft]) penetrates the alluvium and Bandelier Tuff and is completed in the Puye Conglomerate. Pump tests indicated that the perched groundwater in the conglomerate is of limited extent. Depth to water was about 35 m (113 ft) in 1994.

Test Well 1A is located in the on-site lower reach of Pueblo Canyon. Test Well 1A (drilled in 1950 to a depth of 69 m [226 ft]) penetrates the alluvium, Puye Conglomerate, and basalt, and is completed in basalts. Depth to water was about 59 m (194 ft) in 1994. Perched water in the basaltic rocks is also sampled from Basalt Spring, which is off site in lower Los Alamos Canyon on the Pueblo of San Ildefonso. Measurements of water levels and chemical quality over a period of time indicate that the perched groundwater is hydrologically connected to the stream in Pueblo Canyon. Perched water was observed in the Puye Conglomerate during the drilling of water supply wells Otowi-4 in Los Alamos Canyon (depth about 61 to 76 m [200 to 250 ft]), Otowi-1 in Pueblo Canyon (depth about 69 to 76 m [225 to 250 ft]); in the basalts in water supply well PM-1 in Sandia Canyon (depth about 137 m [450 ft]); and in the Guaje Pumice at the base of the Bandelier Tuff during drilling of borehole LADP-3 (depth about 100 m [325 ft]) and borehole LAOI-1.1 (depth about 98 m [323 ft]) in Los Alamos Canyon.

Some recharge to the perched groundwater in the basalt occurs near Hamilton Bend Spring. The time for water from the recharge area near Hamilton Bend Spring to reach Test Well 1A is estimated to be 1 to 2 months, with another 2 to 3 months required for the water to reach Basalt Spring. Recharge may also occur in Los Alamos Canyon (Abrahams 1966).

Some perched water occurs in volcanics on the flanks of the Jemez Mountains off site to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from the gallery in Water Canyon. The gallery contributed to the Los Alamos water supply for 41 years, producing 23 to 96 million gal./yr. Since 1988 it has only been used for makeup water for the steam plant at TA-16, producing about 4.40×10^4 m^3 (11.63 million gal. or 35.7 ac ft) in 1993.

4. Vadose Zone.

The occurrence and movement of water in unsaturated conditions has been studied in numerous locations within the Laboratory starting with special USGS studies in the 1950s (Purtymun 1990b). Knowledge of vadose zone processes is relevant to understanding the potential for downward movement of water that could constitute recharge to the main aquifer and provide a mechanism for downward migration of contaminants.

In general, the vadose zone studies show that there is consistently low moisture content (less than 10% by volume) in the tuff beneath mesa tops at depths greater than a few meters, the zone affected by seasonal moisture and evapotranspiration. This carries the implication that very little, if any, recharge from the mesas is able to reach the main aquifer, which is about 305 m (1,000 ft) deep.

The canyons with alluvial groundwater are presumed to have a greater potential for downward water movement because there is a constant supply of water for potential recharge. Since the mid-1980s several alluvial groundwater investigations have been performed under various Resource Conservation and Recovery Act compliance require-ments. As part of these investigations, we have installed monitoring facilities in canyons, which further define the occurrence of alluvial water and help to understand the potential for movement of water or contaminants.

In 1985, observation wells were installed in canyons adjacent to the operating solid waste management and disposal areas at TA-54. These wells included the three in Pajarito Canyon (south of TA-54) that were already described in Section B.2 of this section, and four in the Cañada del Buey drainage (north of TA-54). Three of the wells in Cañada del Buey were located in a side drainage, west and north of Area L, and penetrated to 2.4 to 3.7 m (8 to 12 ft) of dry alluvium. The fourth well in the main channel north of the eastern end of Area G, penetrated 2.7 m (9 ft) of dry alluvium. These four wells have remained dry on subsequent observation, indicating the absence of any saturation in this reach of Cañada del Buey (Devaurs 1985).

In 1989, boreholes or monitoring wells were installed in four canyons to determine whether saturated conditions occurred in the alluvium. Two holes in Sandia Canyon, SCO-1 (near Supply Well PM-2), drilled to 24 m (79 ft), and SCO-2 (near Supply Well PM-1), drilled to 9 m (29 ft), penetrated the alluvium without encountering any saturated zone. These were completed as observation holes and have remained dry. One hole in Potrillo Canyon, PCTH-1 (about 0.3 km [1/2 mi] west of State Road 4) was drilled to 23 m (75 ft). It penetrated only dry weathered and unweathered tuff, and this hole was later plugged. One hole in Fence Canyon, FCO-1 (within 0.2 km [1/4 mi] of State Road 4) was drilled to 9 m (30 ft) and completed as an observation well. It penetrated only dry weathered and unweathered tuff, indicating no past saturation. Three holes in Water Canyon, WCO-1 (about 3.2 km [2 mi] west of State Road 4) drilled 11 m (36 ft), WCO-2 (about 0.6 km [1 mi] west of State Road 4) drilled to 12 m (39 ft), and WCO-3 (within about 0.2 km [1/4 m] of State Road 4) all penetrated the alluvium without revealing

saturated conditions. They were all completed as observation wells for future monitoring of potential saturation (Purtymun 1990b).

In 1987, nine observation wells were installed in Cañon del Valle adjacent to inactive Waste Disposal Area P in TA-16. These wells, drilled on the toe of the landfill above the channel alluvium, revealed no saturation and showed no evidence of leachate or seepage from the landfill.

In 1992, five new holes were drilled in Cañada del Buey to document the conditions in and beneath the alluvium. Two of them, completed as monitoring wells, were added to the routine monitoring locations in conformance with a Groundwater Discharge Plan submitted to the NMED for discharge from the new sanitary waste treatment plant at TA-46.

C. Analytical Results

1. Radiochemical Constituents.

The results of radiochemical analyses of groundwater samples for 1994 are listed in Table VII-1. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and finally the intermediate perched groundwater system.

a. Radiochemical Constituents in the Main Aquifer. For samples from wells or springs in the main aquifer, most of the results for tritium, ^{90}Sr, uranium, ^{238}Pu, ^{239,240}Pu, ^{241}Am, and gross beta were below the DOE DCGs or the EPA or New Mexico standards applicable to a drinking water system. The exceptions are discussed below. In addition, most of the results were near or below the detection limits of the analytical methods used.

Some samples from wells and springs contained levels of plutonium or americium slightly (generally less than a factor of two) above analytical method detection limits. Because of inconsistencies between the types of analyses, (i.e., apparent ^{238}Pu without any corresponding ^{239,240}Pu or vice versa), the large counting uncertainties in the measurements at the low levels near average detection limits (often 50% or more of the value), and, in the case of springs, the fact that such samples often must be collected in contact with surface rocks or channel sediments, none of the findings are interpreted to represent contamination of the main aquifer by plutonium or americium.

All of the uranium values were determined using the kinetic phosphonimetric analysis (KPA) method. In the past, uranium was evaluated with the induction coupled plasma emission spectroscopy (ICPES) method, which ordinarily gives high values for prepared standards; the alternative KPA method gives low values. La Mesita Spring and Spring 3B have high uranium concentrations; springs in this area have always contained a relatively high concentration of natural uranium (Purtymun 1980b). The uranium concentrations for these springs are both below the EPA primary drinking water standard MCL of 20 μg/L, however. These two springs also have high gross alpha values. Spring 3AA had a gross alpha value of 17 pCi/L, above the EPA primary drinking water standard of 15 pCi/L.

Three wells and one spring showed noticeable values of ^{90}Sr. For Test Well 4 (6.2 ± 3.4 pCi/L) and Test Well 8 (2.1 ± 0.7 pCi/L), the values are less than 2 to 3 times the radioactivity counting uncertainty and are therefore not a definite detection. Analysis of a split sample from Test Well 4 by the NMED/Agreement in Principle (AIP) showed a ^{90}Sr level of 6.6 ± 1.0 pCi/L, supporting a possible detection in that well.

The values of ^{90}Sr found in Spring 8 (19.7 ± 3.8 pCi/L) and Test Well 3 (35.1 ± 2.2 pCi/L) are well above the limits of analytical uncertainty and also above the EPA primary drinking water standard MCL of 8 pCi/L. However, these ^{90}Sr values are questionable because of the very low gross beta measurements for the samples, of 7 ± 1 pCi/L for Spring 8 and 2.2 ± 0.4 pCi/L for Test Well 3. The apparent detection of ^{90}Sr in Test Well 3 is plausible, as high levels of ^{90}Sr are present in the overlying Los Alamos Canyon alluvial groundwater.

In order to address these detections of ^{90}Sr, resampling of Test Wells 3, 4, and 8 will be conducted. Preliminary results of tests conducted during 1995 indicate no trace of strontium in any of these test wells. The samples were collected periodically during continual pumping of the wells, in order to ascertain the extent of possible contamination within the aquifer. All of the ^{90}Sr values were close to zero, less than 1 or 2 times the radioactivity counting uncertainty. These values are therefore viewed as nondetections.

All ^{137}Cs measurements of samples from the main aquifer wells and springs for 1994 are less than 5% of the DCG applicable to DOE Drinking Water Systems. Cesium measurements in past years have raised some questions about the potential presence of ^{137}Cs contamination in some areas because the previously used analytical method had a detection limit that was relatively high in comparison with the relevant guidelines or standards, and also

Table VII-1. Radiochemical Analysis of Groundwater for 1994

	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu (pCi/L)	$^{239,\ 240}$Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
MAIN AQUIFER ON SITE										
Test Wells										
Test Well 1	0.4 (0.3)[a]	N/A[b]	-2.7 (4.0)	2.5 (0.3)	-0.001 (0.030)	0.008 (0.020)	N/A	2 (1)	4 (1)	20 (60)
Test Well 3	0.1 (0.3)	35.1 (2.2)	<2.0[c]	0.6 (0.1)	-0.009 (0.030)	-0.001 (0.020)	0.043 (0.030)	-1 (1)	2 (0)	20 (50)
Test Well 8	-0.1 (0.3)	2.1 (0.7)	<0.6	0.3 (0.1)	-0.003 (0.005)	0.188 (0.032)	0.034 (0.017)	1 (0)	3 (0)	10 (50)
Test Well DT-5A	-0.1 (0.3)	0.1 (0.8)	<1.0	0.3 (0.1)	0.001 (0.005)	0.018 (0.09)	0.054 (0.017)	1 (1)	2 (1)	110 (50)
Test Well DT-9	0.1 (0.3)	0.7 (0.7)	<1.2	0.2 (0.0)	-0.004 (0.030)	0.026 (0.020)	0.062 (0.030)	1 (1)	4 (1)	90 (50)
Test Well DT-10	-0.1 (0.3)	0.0 (0.7)	<1.1	0.2 (0.1)	0.001 (0.030)	0.010 (0.020)	0.031 (0.030)	0 (0)	3 (0)	30 (50)
Water Supply Wells										
O-4	-0.03 (0.1)	N/A	<2.3	<1.0	0.019 (0.017)	0.003 (0.007)	N/A	0 (2)	4 (2)	N/A
PM-1	-0.3 (0.3)	0.3 (0.8)	<1.0	1.0 (0.0)	-0.007 (0.005)	0.055 (0.017)	0.020 (0.020)	1 (1)	3 (1)	110 (50)
PM-2	-0.2 (0.1)	N/A	<1.7	<1.0	0.005 (0.009)	-0.003 (0.010)	N/A	0 (2)	3 (2)	N/A
PM-4	-0.1 (0.1)	N/A	<2.2	<1.0	0.002 (0.011)	-0.006 (0.012)	N/A	2 (3)	2 (3)	N/A
PM-5	0.04 (0.1)	N/A	<1.4	<1.0	-0.003 (0.016)	0.006 (0.011)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER OFF SITE										
Test Wells										
Test Well 2	0.2 (0.3)	N/A	0.9 (11.0)	0.1 (0.0)	-0.011 (0.030)	-0.012 (0.020)	N/A	1 (0)	1 (0)	20 (60)
Test Well 4	0.4 (0.3)	6.2 (3.4)	<1.1	0.8 (0.1)	0.030 (0.030)	-0.010 (0.020)	0.021 (0.013)	3 (1)	8 (1)	10 (50)
Water Supply Wells										
G-1A	-0.02 (0.1)	N/A	<1.1	<1.0	0.021 (0.016)	-0.002 (0.006)	N/A	1 (2)	2 (2)	N/A
G-2	-0.1 (0.1)	N/A	<0.8	<1.0	0.015 (0.021)	0.014 (0.016)	N/A	1 (2)	4 (2)	N/A
G-4	-0.1 (0.1)	N/A	<0.8	N/A	0.012 (0.010)	-0.001 (0.006)	N/A	1 (2)	1 (2)	N/A
MAIN AQUIFER SPRINGS										
White Rock Canyon Springs Group I										
Sandia Spring	0.1 (0.3)	0.0 (0.7)	<0.5	1.1 (0.1)	0.011 (0.030)	0.037 (0.020)	0.025 (0.030)	1 (1)	8 (1)	120 (50)
Spring 3	0.2 (0.3)	0.1 (0.7)	<0.9	1.4 (0.2)	-0.003 (0.030)	0.021 (0.020)	-0.006 (0.030)	0 (1)	9 (1)	90 (50)
Spring 3A	0.4 (0.3)	-0.1 (0.7)	<0.5	1.1 (0.3)	-0.001 (0.030)	0.021 (0.020)	0.016 (0.030)	1 (1)	8 (1)	50 (50)
Spring 3AA	0.1 (0.3)	0.1 (0.8)	<1.2	5.8 (1.0)	-0.003 (0.030)	0.010 (0.020)	0.068 (0.030)	17 (5)	15 (2)	40 (50)
Spring 4	0.3 (0.3)	-0.5 (9.1)	<0.9	1.3 (0.3)	0.013 (0.030)	0.003 (0.020)	0.057 (0.030)	-1 (1)	3 (0)	50 (50)
Spring 4A	0.0 (0.3)	-0.2 (0.7)	1.4 (0.7)	0.9 (0.2)	0.004 (0.030)	0.018 (0.020)	0.079 (0.030)	-1 (1)	2 (0)	60 (50)
Spring 5	0.2 (0.3)	0.5 (0.7)	1.1 (0.5)	0.8 (0.1)	-0.001 (0.030)	0.001 (0.020)	0.035 (0.030)	1 (1)	2 (0)	150 (50)
Ancho Spring	0.5 (0.3)	0.0 (0.8)	<1.2	0.5 (0.1)	-0.007 (0.030)	0.032 (0.020)	0.008 (0.030)	1 (1)	3 (0)	-10 (50)
White Rock Canyon Springs Group II										
Spring 5A	0.4 (0.3)	0.2 (0.7)	1.6 (0.7)	6.6 (1.3)	0.006 (0.030)	0.022 (0.020)	0.070 (0.030)	11 (3)	14 (1)	-20 (50)
Spring 5B	0.5 (0.3)	-0.3 (0.7)	<1.3	3.6 (0.5)	-0.004 (0.030)	0.008 (0.020)	0.047 (0.030)	4 (1)	6 (1)	60 (50)
Spring 6	0.3 (0.3)	0.9 (0.9)	<1.1	0.4 (0.0)	0.025 (0.030)	0.052 (0.020)	0.071 (0.030)	-0 (1)	4 (1)	220 (50)
Spring 6A	0.3 (0.3)	0.9 (0.7)	<1.8	0.9 (0.1)	-0.002 (0.030)	0.010 (0.020)	0.033 (0.030)	1 (1)	4 (1)	10 (50)
Spring 7	0.5 (0.3)	0.2 (0.7)	<1.1	1.4 (0.1)	0.005 (0.030)	0.022 (0.020)	0.040 (0.030)	0 (0)	2 (0)	10 (50)
Spring 8	0.2 (0.3)	19.7 (3.8)	<1.2	2.0 (0.2)	0.001 (0.030)	0.013 (0.020)	0.046 (0.030)	6 (2)	7 (1)	80 (50)
Spring 8A	0.3 (0.3)	-0.3 (0.8)	1.2	0.4 (0.1)	-0.008 (0.030)	0.039 (0.020)	0.044 (0.030)	0 (1)	4 (1)	20 (50)
Spring 8B	0.5 (0.3)	0.0 (0.8)	<1.0	0.2 (0.0)	0.021 (0.030)	0.047 (0.020)	0.056 (0.030)	-1 (1)	3 (0)	50 (50)

Table VII-1. Radiochemical Analysis of Groundwater for 1994 (Cont.)

	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239, 240}$Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
White Rock Canyon Springs Group II (Cont.)										
Spring 9	0.7 (0.3)	-0.2 (0.8)	<1.1	4.1 (0.8)	0.006 (0.030)	0.026 (0.020)	0.050 (0.030)	4 (1)	4 (1)	20 (50)
Spring 9A	0.6 (0.3)	1.4 (0.7)	<1.3	6.9 (1.5)	-0.017 (0.030)	0.008 (0.020)	0.004 (0.030)	9 (2)	14 (2)	300 (60)
Doe Spring	0.4 (0.3)	-0.4 (0.8)	<1.2	0.3 (0.1)	0.023 (0.030)	0.023 (0.020)	0.067 (0.030)	-0 (0)	3 (1)	300 (60)
Spring 10	0.2 (0.3)	-0.2 (0.8)	<1.1	5.3 (0.5)	0.016 (0.030)	0.040 (0.020)	0.059 (0.030)	3 (2)	11 (1)	230 (60)
White Rock Canyon Springs Group III										
Spring 1	-0.1 (0.3)	0.0 (7.0)	<0.9	3.2 (0.3)	0.004 (0.030)	0.022 (0.020)	0.040 (0.030)	1 (1)	4 (1)	60 (50)
Spring 2	0.1 (0.3)	0.3 (0.8)	<0.6	4.6 (0.9)	0.001 (0.030)	0.023 (0.020)	0.024 (0.030)	4 (2)	9 (1)	90 (50)
White Rock Canyon Springs Group IV										
La Mesita Spring	0.1 (0.3)	1.6 (0.8)	1.0 (0.5)	14.7 (1.5)	0.053 (0.030)	0.028 (0.020)	0.016 (0.030)	12 (3)	10 (1)	40 (50)
Spring 3B	-0.2 (0.3)	0.2 (0.7)	0.7 (0.4)	17.3 (4.0)	0.001 (0.030)	-0.007 (0.020)	0.054 (0.030)	36 (8)	14 (1)	120 (50)
Other Springs										
Sacred Spring	-0.3 (0.3)	0.7 (0.8)	<1.1	0.8 (0.1)	0.006 (0.030)	0.040 (0.020)	0.026 (0.030)	1 (0)	3 (1)	30 (50)
Indian Spring	-0.1 (0.3)	0.6 (0.7)	<1.1	0.6 (0.1)	-0.009 (0.030)	-0.021 (0.020)	0.037 (0.017)	0 (2)	6 (1)	40 (50)
CANYON ALLUVIUM GROUNDWATER										
DP-Los Alamos Canyons										
LAO-C	-0.3 (0.3)	0.9 (0.8)	<0.4	0.2 (0.0)	0.026 (0.012)	0.026 (0.013)	0.038 (0.015)	1 (0)	2 (0)	60 (50)
LAO-0.7	0.5 (0.3)	6.1 (3.8)	<1.4	4.9 (1.3)	0.007 (0.030)	0.559 (0.056)	0.017 (0.016)	45 (10)	32 (3)	50 (50)
LAOR-1	2.0 (0.4)	20.8 (1.4)	<0.4	3.3 (0.3)	0.030 (0.030)	0.060 (0.020)	0.113 (0.023)	3 (3)	52 (5)	50 (50)
LAO-1	1.6 (0.4)	6.8 (0.7)	0.7 (0.4)	-0.3 (0.1)	0.009 (0.030)	0.003 (0.020)	0.034 (0.034)	0 (2)	18 (2)	20 (50)
LAO-2	-0.1 (0.3)	0.0 (0.8)	1.3 (0.5)	0.3 (0.1)	0.011 (0.013)	-0.018 (0.009)	0.151 (0.030)	0 (0)	3 (0)	40 (50)
LAO-3	0.9 (0.3)	49.2 (3.2)	1.2 (0.5)	-0.3 (0.1)	0.009 (0.030)	0.003 (0.020)	0.044 (0.016)	-10 (4)	93 (9)	10 (50)
LAO-4	0.4 (0.3)	4.4 (0.8)	<1.0	-0.4 (0.1)	-0.007 (0.030)	-0.009 (0.020)	0.001 (0.030)	0 (1)	13 (1)	80 (50)
LAO-4.5	0.8 (0.3)	0.9 (0.8)	1.5 (0.6)	-0.3 (0.1)	-0.014 (0.030)	0.038 (0.020)	0.094 (0.030)	1 (1)	6 (1)	60 (50)
Mortandad Canyon										
MCO-4	16.8 (1.2)	42.7 (2.7)	9.5 (2.0)	1.8 (0.5)	1.308 (0.102)	3.657 (0.223)	10.910 (0.555)	29 (7)	140 (10)	100 (50)
MCO-5	22.5 (1.5)	27.9 (1.8)	2.2 (0.7)	2.1 (0.5)	0.077 (0.030)	0.108 (0.025)	0.427 (0.050)	11 (6)	110 (10)	100 (50)
MCO-6	28.5 (1.6)	50.7 (3.3)	1.2 (0.5)	2.7 (0.5)	0.012 (0.030)	0.028 (0.020)	0.496 (0.060)	6 (8)	140 (10)	80 (50)
MCO-7	32.1 (1.8)	1.9 (0.8)	<1.03	4.6 (0.4)	0.012 (0.030)	0.024 (0.020)	0.556 (0.059)	31 (8)	54 (6)	60 (50)
MCO-7.5	32.8 (1.8)	0.3 (0.9)	2.0 (0.6)	1.0 (0.1)	0.037 (0.030)	0.003 (0.020)	0.164 (0.038)	5 (3)	24 (2)	60 (50)
MT-4	54.7 (2.3)	N/A	N/A	5.1 (0.7)	N/A	N/A	N/A	N/A	N/A)	N/A
Pajarito Canyon										
PCO-1	0.4 (0.3)	0.9 (0.8)	1.8 (0.7)	0.3 (0.1)	-0.006 (0.030)	0.006 (0.020)	N/A	4 (2)	8 (1)	60 (50)
PCO-2	0.1 (0.3)	1.6 (0.7)	<1.0	6.5 (1.6)	0.004 (0.030)	-0.002 (0.020)	N/A	50 (10)	54 (6)	50 (50)
PCO-3	0.1 (0.3)	0.9 (0.8)	<1.0	0.2 (0.0)	-0.002 (0.006)	0.011 (0.012)	0.047 (0.015)	1 (0)	2 (0)	40 (50)
Acid/Pueblo Canyons										
APCO-1	0.1 (0.3)	1.3 (0.6)	<1.0	1.2 (0.2)	-0.004 (0.030)	0.404 (0.048)	0.093 (0.025)	9 (3)	19 (2)	40 (50)
Cañada del Buey										
CDBO-6	0.4 (0.3)	0.2 (0.8)	<1.1	1.2 (0.3)	0.030 (0.015)	0.039 (0.015)	0.041 (0.016)	26 (5)	23 (2)	60 (50)
CDBO-7	0.4 (0.3)	0.9 (0.7)	<1.1	2.9 (0.3)	0.034 (0.017)	0.010 (0.012)	0.024 (0.012)	6 (1)	10 (1)	80 (50)

Table VII-1. Radiochemical Analysis of Groundwater for 1994 (Cont.)

	Tritium (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	Total Uranium (µg/L)	^{238}Pu (pCi/L)	$^{239, 240}$Pu (pCi/L)	^{241}Am (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS										
Test Well 1A	0.2 (0.3)	N/A	19.0 (10.9)	0.4 (0.1)	-0.002 (0.030)	0.007 (0.020)	N/A	0 (1)	7 (1)	40 (60)
Test Well 2A	2.6 (0.5)	N/A	1.1 (5.0)	0.8 (0.1)	-0.008 (0.030)	-0.004 (0.020)	N/A	1 (1)	3 (0)	20 (60)
Basalt Spring	0.3 (0.3)	0.4 (0.8)	<0.9	0.6 (0.1)	-0.011 (0.030)	0.014 (0.020)	0.038 (0.030)	1 (1)	8 (1)	20 (50)
PERCHED SYSTEM IN VOLCANICS										
Water Canyon Gallery	-0.01 (0.1)	N/A	<0.9	<1.0	0.003 (0.008)	-0.002 (0.007)	N/A	1 (2)	3 (2)	N/A
Limits of Detection[d]	0.4	1	2	0.1	0.02	0.02	0.02	3	3	
DOE DCG for Public Dose[d]	2000	1000	3000	800	40	60	30			
DOE Drinking Water System DCG[d]			120		1.6	1.2	1.2			
EPA Primary Drinking Water Standard[d]	20	8		20				15		
EPA Screening Level[d]									50	
NMWQCC Groundwater Limit[d]				5000						

[a]Radioactivity counting uncertainties are shown in parentheses.
[b]N/A means analysis not performed, lost in analysis or not completed.
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]Standards given here for comparison only, see Appendix A.

higher than typical environmental levels. A new method was implemented during 1992 by the Environmental Chemistry Group (EPG 1994), which has a much lower detection limit (about 2 pCi/L).

Tritium measurements of samples from main aquifer wells and springs were near or below the detection limit for the EPA-specified liquid scintillation analytical method. These results are consistent with additional tritium measurements made as part of a special study utilizing trace-level measurements of tritium to estimate the age of water in the main aquifer (see Section VII.E.1). In the case of the six water supply wells in the Guaje Well Field, the four wells in the Pajarito Well Field, and the Otowi-4 well in the Otowi Well Field, sampling conducted from 1991 through 1993 revealed no measurable tritium, even with the special method. An apparent detection of a trace amount of tritium in Well PM-3 was later discovered to have resulted from sample contamination in the laboratory (see Section VII.E.1), and subsequent detailed measurements confirm that water from Well PM-3 contains no measurable tritium. Trace-level measurements on the main aquifer springs also confirm that their tritium levels are far below the detection limit of the normal liquid scintillation analysis (see Section VII.E.1.e).

In 1993, White Rock Canyon Spring 3A showed a tritium value of 0.8 ± 0.3 nCi/L (800 ± 300 pCi/L), slightly above the detection limit of liquid scintillation analysis. However, low-level measurements of a sample collected for this spring in September 1994 give a much lower tritium value of 2.7 ± 0.3 pCi/L (see Section VII.E.1.e).

b. Radiochemical Constituents in Alluvial Groundwater. None of the alluvial groundwater concentrations are above the DOE DCGs for Public Dose for Ingestion of Environmental Water. Levels of tritium, ^{137}Cs, uranium, ^{238}Pu, ^{239,240}Pu, and ^{90}Sr, and gross alpha, beta, and gamma are all within the range of values observed in recent years.

The samples of the alluvial groundwater in Los Alamos Canyon show residual contamination, as has been seen since the original installation of the monitoring wells in the 1960s. In particular, for four of the wells, the concentration of ^{90}Sr is close to or exceeds the EPA primary drinking water standard MCL of 8 pCi/L. Residual tritium contamination resulting from the Omega West Reactor leak is also present, but mainly at levels below the detection limit of the EPA-specified liquid scintillation counting method and far below the present EPA tritium drinking water standard of 20,000 pCi/L (see Section VII.E.3).

In 1993, the sample from Los Alamos Canyon Well LAO-2 showed unusually high levels of ^{90}Sr, uranium, ^{238}Pu, ^{239,240}Pu, and ^{241}Am. This well is located at the mouth of DP Canyon, which received treated radioactive effluent discharges from TA-21 from 1952 to 1986. It appears (see discussion under Nonradioactive Analyses, below) that this sample had a high suspended sediment content; radionuclides tend to be associated with the sediment particles, rather than being dissolved in water. The 1994 sample results for Well LAO-2 show values typical of recent years.

The alluvial groundwater samples from Mortandad Canyon showed levels of radionuclides at levels within the ranges observed previously. The levels tend to be highest at Well MCO-4 and are lower further down the canyon. The levels of tritium, ^{90}Sr, ^{239,240}Pu, ^{241}Am, gross alpha, and gross beta exceed EPA drinking water criteria in many of the wells, but do not exceed the DOE DCGs for Public Dose for Ingestion of Environmental Water.

Pueblo Canyon Well APCO-1 again had a ^{239,240}Pu level (0.40 ± 0.05 pCi/L) above the detection limit. This well also had an ^{241}Am level (0.09 ± 0.025 pCi/L) above the detection limit. Pajarito Canyon Well PCO-2 and Pueblo Canyon Well APCO-1 had ^{90}Sr values above the detection limit. Well PCO-2 had high gross alpha and beta values of about 50 pCi/L, which were not supported by detection of specific radionuclides. Similarly, Cañada del Buey Well CDBO-6 had a high gross alpha value not supported by detection of specific radionuclides.

c. Radiochemical Constituents in Intermediate Perched Groundwater. The radioactivity measurements in samples from Test Wells 1A, 2A, and Basalt Spring in the intermediate-depth perched zones in Pueblo Canyon indicate a connection with surface and alluvial waters in Pueblo Canyon. Intermediate-depth perched zone waters have long been known to be influenced by contaminated surface water in the canyon based on measurements of major inorganic ions. Test Well 2A, the one furthest upstream and closest to the historical discharge area in Acid Canyon, showed the highest levels. The tritium measurement obtained by conventional methods was 2.6 nCi/L. In previous years this has been confirmed by the low detection limit measurements of about 2.3 nCi/L (see Section VII.E.1). Test Well 1A showed traces of ^{137}Cs (19 pCi/L). This test well had ^{137}Cs activities of 37 pCi/L in 1990 and 56 pCi/L in 1991.

The sample from the Water Canyon gallery was consistent with previous results, showing no evidence of contamination from Los Alamos operations.

2. Nonradioactive Constituents.

The results of general chemical parameter analyses of groundwater samples for 1994 are listed in Table VII-2, and results of total recoverable metal analyses are listed in Table VII-3. Discussion of the results will address the main aquifer, the canyon alluvial groundwater, and the intermediate perched groundwater system. Finally, results of organic analyses will be discussed.

High nitrate levels were discovered in samples taken during 1994 from several Los Alamos area test wells and from water supply wells at the Pueblo of San Ildefonso. These results are discussed in Section VII.E.5.

a. Total Recoverable Metals Analyses. As was noted in the Environmental Surveillance at Los Alamos during 1993 (EARE 1995b) several wells and springs show high values for some trace metals, greatly exceeding values previously reported (EPG 1994). We believe that the high trace metal values are due to several factors: (1) the samples drawn from some springs and wells are likely to contain a high amount of suspended sediment, (2) the samples were not filtered before analysis, (3) the technique by which samples were prepared for analysis is for total recoverable metals, which partially digests the suspended sediment, and (4) these elements are commonly either adsorbed onto suspended sediments, or (5) are constituents of the suspended sediment particles themselves. The elements affected were for the most part determined by the ICPES metals analyses: aluminum, arsenic, barium, beryllium, cadmium, chromium, iron, manganese, nickel, thallium, vanadium, and zinc, as well as calcium, magnesium, and potassium. Lead, antimony, and thallium analyses were by the induction coupled plasma mass spectroscopy (ICPMS) method. The reported total dissolved solids values confirm that suspended sediment is the probable source of the high metal concentrations. Total dissolved solids were determined by evaporation of filtered samples. For samples having high trace metals values, the total dissolved solids values are much lower than the sum of all of the analytes listed for the sample.

b. Nonradioactive Constituents in the Main Aquifer. A number of wells and springs have sodium concentrations greater than 20 mg/L, which is an EPA health advisory level.

Values for all parameters measured in the water supply wells were within drinking water limits, with the following exceptions. The arsenic level in Well G-2 was about 80% of the standard and was similar to previous measurements. The vanadium level in Well G-2 of 0.09 mg/L is at the lower end of the EPA health advisory range of 0.08 to 0.11 mg/L, but is lower than the 1993 value of 0.26 mg/L. Supply Well PM-1 had iron levels above the EPA secondary drinking water standard of 0.3 mg/L.

The test wells in the main aquifer showed levels of several constituents that exceed standards for drinking water distribution systems (see Section VII.E.1). However, the test wells are used for monitoring purposes only and are not part of the water supply system. These high levels are believed to be associated with the more than 40-year-old steel casings and pump columns in the test wells. Iron was high in all of the main aquifer test wells except Test Wells 3 and 8; manganese was high in Test Wells 2 and DT-9; and zinc was high in Test Wells 4 and DT-10. Lead levels exceeded the EPA action level in all of the main aquifer test wells except Test Well 3 and 8 (see Section VII.E.1). Several of the test wells have occasionally had elevated lead levels in previous years, and unusually high lead values were reported for 1993 (EARE 1995b). The lead levels in the test wells are much lower for 1994.

Samples from a few springs (La Mesita Spring, Doe Spring, and Springs 1, 2, 3AA, 5A, 6, and 8) in White Rock Canyon showed aluminum levels that are higher than expected and that exceed New Mexico Livestock and Wildlife Watering Standards. These levels are believed to be due to several factors, including sample turbidity, as discussed above. (Hem 1989) reports that for unfiltered samples, aluminum concentrations should only be a few mg/L. Samples from most of the springs in White Rock Canyon showed levels of iron and, in some cases, manganese that would exceed secondary standards for drinking water systems. However, these elements are also associated with suspended sediment particles. According to (Hem 1989) iron and manganese concentrations in aerated water, in the pH range 6.5 to 8.5, should be less than a few mg/L. Springs 2 and 4A had silver levels higher than the NMWQCC Groundwater Limit; Springs 2, 3AA, and 3B exceeded or approached the New Mexico Livestock and Wildlife Watering Standards for arsenic. Spring 3AA and 10 exceeded standards for barium, lead, and vanadium, as did Spring 10 for lead and Spring 1 for vanadium. Selenium levels were all again below the standard this year, discounting suspect levels from 1991 samples that were measured by a method with a much higher detection limit.

c. Nonradioactive Constituents in Alluvial Groundwater. Alluvial canyon groundwater in the areas receiving effluents showed the effects of those effluents, in that levels of some parameters were elevated. The effects were seen in the samples from Pueblo, Los Alamos, and Mortandad Canyons. Mortandad Canyon alluvial

Table VII-2. Chemical Quality of Groundwater for 1994 (mg/L)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
MAIN AQUIFER ON SITE																	
Test Wells																	
Test Well 1	20	48	9.9	<3[c]	16	32	0.4	<10	103	<0.0	22	23.00	<0.0	<272	161	7.9	400
Test Well 3	N/A[d]	20	6.2	2	13	N/A	N/A	N/A	N/A	<0.0	N/A	0.97	<0.01	N/A	75	N/A	N/A
Test Well 8	45	7	2.6	<1	5	2	0.1	<5	32	<0.0	2	5.10	<0.01	84	29	8.6	36
Test Well DT-5A[e]	70	8	2.4	1	10	3	0.2	<5	54	0.0	3	0.33	<0.01	112	16	8.1	96
Test Well DT-9	76	10	2.6	1	10	3	0.3	<5	54	<0.0	3	0.28	<0.01	139	0	8.3	103
Test Well DT-10	57	11	3.2	2	11	3	0.3	<5	74	<0.0	3	0.22	<0.01	139	40	8.1	123
Water Supply Wells																	
O-4	37	20	8.0	<2	20	8	0.3	<10	118	<0.0	6	2.52	<0.0	<236	83	7.5	246
PM-1	77	22	5.9	3	15	3	0.2	<5	125	0.1	4	0.50	<0.01	276	79	7.7	213
PM-2[e]	33	9	<3.0	<1	11	2	0.3	<10	53	<0.0	2	1.36	<0.01	<158	35	8.0	116
PM-4[e]	29	14	<3.9	<2	13	3	0.3	<10	68	<0.0	3	1.84	<0.01	<166	52	8.1	157
PM-5	36	12	<4.5	<1	13	3	0.3	<10	68	<0.0	3	1.50	<0.0	<170	47	7.8	148
MAIN AQUIFER OFF SITE																	
Test Wells																	
Test Well 2	18	13	<3.5	<1	13	2	0.5	<10	63	<0.0	3	1.02	<0.01	<138	46	8.0	144
Test Well 4	58	13	6.3	3	10	2	0.2	<5	81	0.0	3	0.19	<0.01	284	58	8.0	128
Water Supply Wells																	
G-1A	28	10	<0.5	<2	32	3	0.6	<10	83	<0.0	4	1.97	<0.01	<188	26	8.4	176
G-2	29	10	<0.5	<2	37	3	0.8	<10	98	<0.0	4	1.60	<0.01	<192	27	8.5	202
G-4	24	18	<3.7	<2	12	3	0.3	<10	73	<0.0	3	2.01	<0.01	<146	59	8.2	171
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs Group I																	
Sandia Spring	47	26	1.6	3	14	4	0.5	<5	115	0.0	7	0.37	<0.01	114	71	8.0	182
Spring 3	52	22	1.9	3	16	4	0.5	<5	95	0.0	6	1.00	<0.01	130	62	8.4	159
Spring 3A	53	21	1.9	3	14	4	0.4	<5	85	<0.0	6	0.73	<0.01	110	63	8.3	157
Spring 3AA	42	99	6.9	5	24	3	0.5	<5	127	2.1	5	28.00	0.04	134	273	8.0	218
Spring 4	55	23	4.5	3	14	6	0.5	<5	86	<0.0	9	1.25	<0.01	126	73	7.9	179
Spring 4A	72	20	4.5	2	11	5	0.5	<5	82	0.1	6	0.90	<0.01	134	68	8.2	156
Spring 5	69	17	4.8	2	13	5	0.4	<5	77	<0.0	6	0.74	<0.01	160	61	8.4	155
Ancho Spring	79	12	3.0	2	10	3	0.4	<5	61	0.1	4	0.48	<0.01	156	42	7.9	108
White Rock Canyon Springs Group II																	
Spring 5A	61	44	4.6	4	16	5	0.4	<5	107	0.3	8	0.55	<0.01	140	128	7.9	188
Spring 5B	59	22	5.3	3	15	4	0.5	<5	78	<0.0	7	2.30	<0.01	164	75	8.2	167
Spring 6	71	14	5.2	3	12	3	0.4	<5	81	<0.0	4	0.13	<0.01	154	63	7.6	145

Table VII-2. Chemical Quality of Groundwater for 1994 (mg/L) (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
White Rock Canyon Springs Group II (Cont.)																	
Spring 6A	75	13	2.9	3	12	3	0.5	<5	64	0.2	4	0.53	<0.01	152	44	7.8	115
Spring 7	77	12	3.0	3	15	3	0.3	<5	63	<0.0	5	0.47	<0.01	154	49	7.4	125
Spring 8	73	36	5.9	4	18	4	0.4	<5	111	0.3	8	0.54	<0.01	208	113	7.5	206
Spring 8A	80	13	3.4	2	11	3	0.5	<5	64	0.1	3	<0.04	<0.01	2100	46	8.2	115
Spring 8B	82	11	3.0	2	11	3	0.4	<5	66	0.0	3	0.15	<0.01	142	40	8.1	115
Spring 9	80	12	4.0	2	9	3	0.4	<5	60	0.1	3	0.28	<0.01	134	46	7.9	104
Spring 9A	76	17	3.7	2	12	3	0.5	<5	59	0.4	3	<0.04	<0.01	140	55	7.4	109
Doe Spring	78	19	7.2	6	5	3	0.5	<5	57	<0.0	3	0.13	<0.01	150	37	8.0	108
Spring 10	68	32	6.8	3	15	3	0.5	<5	85	0.1	5	0.45	<0.01	172	581	8.1	155
White Rock Canyon Springs Group III																	
Spring 1	34	36	4.7	5	31	4	0.6	<5	118	<0.0	7	0.24	<0.01	138	108	8.4	199
Spring 2	38	37	4.7	5	59	5	1.2	<5	170	0.2	8	<0.04	<0.01	208	111	8.5	289
White Rock Canyon Springs Group IV																	
La Mesita Spring	30	38	2.8	4	31	8	0.3	<5	127	0.0	14	5.80	0.01	188	105	7.6	269
Spring 3B	49	18	1.8	5	120	4	0.8	<5	298	0.0	16	1.40	<0.01	386	52	8.2	476
Other Springs																	
Sacred Spring	22	25	0.9	4	24	3	0.6	<5	106	2.5	6	1.80	<0.01	140	65	7.3	190
Indian Spring	55	37	5.7	3	26	21	0.5	<5	97	<0.0	7	0.83	<0.01	206	115	7.9	259
CANYON ALLUVIUM GROUNDWATER																	
DP-Los Alamos Canyon																	
LAO-C	29	8	2.3	2	4	6	<0.1	<5	28	0.1	5	<0.04	<0.01	122	28	7.0	77
LAO-0.7	34	48	6.4	9	45	76	0.3	<5	52	3.3	9	<0.04	<0.01	296	145	6.9	314
LAOR-1	39	26	5.6	7	39	61	0.3	<5	53	0.3	8	0.50	<0.01	244	86	6.9	348
LAO-1	38	21	4.0	4	41	68	0.2	<5	43	0.1	7	0.14	<0.01	202	68	6.9	343
LAO-2 [e]	41	16	3.7	5	21	32	0.8	<5	45	0.1	9	0.30	<0.01	171	55	6.9	220
LAO-3	44	25	5.1	8	42	54	0.9	<5	76	0.1	11	0.22	<0.01	184	83	7.4	377
LAO-4	40	17	4.6	5	32	48	0.6	<5	53	0.1	7	<0.04	<0.01	164	61	7.1	273
LAO-4.5	40	18	5.4	6	34	55	0.7	<5	46	0.2	8	<0.04	<0.01	184	67	6.8	290
Mortandad Canyon																	
MCO-4	33	23	2.1	12	71	12	1.8	<5	151	0.2	11	17.00	<0.01	396	66	7.8	415
MCO-5	34	28	3.7	21	100	16	1.9	<5	180	0.2	13	32.00	<0.01	506	84	7.6	584
MCO-6	36	42	4.4	28	120	20	1.8	<5	198	0.1	16	48.00	<0.01	296	123	7.5	723
MCO-7 [e]	37	46	11.7	16	125	19	1.3	<5	184	0.4	19	60.50	<0.01	509	162	7.2	826
MCO-7.5	37	54	15.0	26	130	22	1.1	<5	140	0.8	15	57.00	<0.01	480	197	7.1	727
MT-4	39	40	12.0	8	130	23	1.0	<5	130	0.9	19	46.70	0.02	480	150	7.4	740

Table VII-2. Chemical Quality of Groundwater for 1994 (mg/L) (Cont.)

Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Hardness as $CaCO_3$	pH[b]	Conductivity (µS/cm)
Pajarito Canyon																	
PCO-1	35	26	7.6	4	23	51	0.1	<5	59	0.1	9	2.80	<0.01	242	91	6.8	278
PCO-2	27	67	24.0	16	28	39	0.2	<5	80	3.1	12	5.00	<0.01	222	264	7.1	274
PCO-3	28	8	2.4	2	4	6	<0.1	<5	28	0.0	5	0.06	<0.01	11	29	7.0	79
Acid/Pueblo Canyon																	
APCO-1	76	27	5.0	15	62	38	0.7	<5	144	4.9	18	1.80	<0.01	396	87	7.1	399
Cañada del Buey																	
CDBO-6	53	13	5.1	7	21	13	0.2	<5	66	0.6	9	0.12	<0.01	196	53	7.0	180
CDBO-7	63	28	12.0	18	23	7	0.2	<5	85	0.3	6	0.08	<0.01	204	119	6.8	172
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS																	
Test Well 1A	21	28	8.5	7	60	41	0.6	<10	128	2.2	23	19.40	<0.0	<340	105	8.0	474
Test Well 2A	25	36	7.0	<3	24	40	0.2	<10	73	0.3	26	13.70	<0.01	<272	119	8.0	363
Basalt Spring	72	37	9.4	8	46	35	0.3	<5	92	0.2	21	15.00	<0.01	330	130	7.3	419
PERCHED SYSTEM IN VOLCANICS																	
Water Canyon Gallery	16	6	<2.7	<1	<5	1	<0.1	<10	28	<0.0	2	0.97	<0.0	<94	25	7.7	70
EPA Primary Drinking Water Standard[f]							4					10	0.2				
EPA Secondary Drinking Water Standard[f]						250					250			500		6.8-8.5	
EPA Health Advisory[f]					20												
NMWQCC Groundwater Limit[f]						250	1.6					10					

[a]Total dissolved solids
[b]Standard Units
[c]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[d]N/A means analysis not performed, lost in analysis, or not completed.
[e]Results averaged from more than one sample analysis
[f]Standards given here for comparison only, see Appendix A.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
MAIN AQUIFER ON SITE												
Test Wells												
Test Well 1	<0.004[a]	<0.039	<0.0050	<0.0658	<0.0719	<0.0010	<0.0020	<0.0061	<0.0040	<0.0028	0.58	<0.0002
Test Well 3	<0.010	0.120	0.0030	0.0190	0.0280	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.14	<0.0002
Test Well 8	<0.010	<0.100	<0.0030	<0.0200	<0.0040	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	<0.10	<0.0002
Test Well DT-5A[b]	<0.010	<0.100	<0.0030	0.0200	0.0218	<0.0030	<0.0030	0.0050	0.0330	0.0050	0.30	0.0001
Test Well DT-9	<0.010	<0.100	<0.0020	<0.0100	0.0160	<0.0030	<0.0030	<0.0040	<0.0040	0.0760	3.60	0.0001
Test Well DT-10	<0.010	<0.100	<0.0020	0.0500	0.0060	<0.0030	<0.0030	<0.0040	0.0050	0.1600	0.90	0.0001
Water Supply Wells												
O-4	<0.004	<0.009	<0.0050	<0.0490	<0.0366	<0.0010	<0.0021	<0.0040	<0.0045	<0.0020	<0.02	<0.0002
PM-1	<0.010	<0.100	<0.0030	0.0430	0.0690	<0.0030	<0.0030	<0.0040	<0.0070	0.0050	0.83	<0.0002
PM-2[b]	<0.004	<0.014	<0.0055	<0.0175	<0.0203	<0.0010	<0.0024	<0.0040	0.0163	<0.0020	<0.04	<0.0002
PM-4[b]	<0.004	<0.013	<0.0050	<0.0252	<0.0234	<0.0010	<0.0032	<0.0040	<0.0069	<0.0020	0.13	<0.0002
PM-5	<0.004	<0.019	<0.0050	<0.0192	<0.0272	<0.0010	<0.0020	<0.0040	<0.0040	<0.0020	<0.01	<0.0002
MAIN AQUIFER OFF SITE												
Test Wells												
Test Well 2	<0.004	<0.093	<0.0050	<0.0378	<0.0148	<0.0010	<0.0020	<0.0072	<0.0040	<0.0144	2.74	<0.0002
Test Well 4	<0.010	<0.100	<0.0020	0.0560	0.0520	<0.0010	0.0070	<0.0040	<0.0040	0.0120	0.56	<0.0001
Water Supply Wells												
G-1A	<0.004	<0.028	0.0119	<0.0422	<0.0326	<0.0010	<0.0020	<0.0040	<0.0082	<0.0020	<0.01	<0.0002
G-2	<0.004	<0.046	0.0427	<0.0438	<0.0585	<0.0010	<0.0038	<0.0040	<0.0091	<0.0136	<0.01	<0.0002
G-4	<0.004	<0.027	<0.0050	<0.0230	<0.0159	<0.0010	<0.0030	<0.0040	<0.0040	<0.0020	0.17	<0.0002
MAIN AQUIFER SPRINGS												
White Rock Canyon Springs Group I												
Sandia Spring	<0.010	0.300	0.0020	0.0200	0.1300	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.20	<0.0001
Spring 3	<0.010	0.100	0.0030	0.0200	0.0400	<0.0010	<0.0030	<0.0040	0.0040	<0.0040	0.10	<0.0001
Spring 3A	<0.010	0.100	0.0030	0.0400	0.0340	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.10	<0.0001
Spring 3AA	<0.010	7.700	0.0290	0.0500	0.8300	0.0030	<0.0030	0.0330	0.0330	0.0290	28.00	<0.0001
Spring 4	<0.010	<0.100	0.0020	0.0300	0.0530	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Spring 4A	0.050	<0.100	<0.0020	0.0200	0.0400	<0.0010	<0.0030	<0.0040	0.0050	<0.0040	<0.10	<0.0001
Spring 5	<0.010	<0.100	0.0020	0.0440	0.0300	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	0.12	<0.0001
Ancho Spring	<0.010	0.400	<0.0030	0.0200	0.0300	<0.0010	<0.0030	<0.0040	0.0050	<0.0040	0.30	<0.0001
White Rock Canyon Springs Group II												
Spring 5A	<0.010	4.400	0.0030	0.0400	0.1500	<0.0010	<0.0030	<0.0040	0.0080	0.0050	3.90	<0.0001
Spring 5B	<0.010	1.800	0.0020	0.0190	0.0810	<0.0030	<0.0030	<0.0040	0.0080	<0.0040	1.70	<0.0001
Spring 6	<0.010	8.800	<0.0020	<0.0100	0.0870	<0.0030	<0.0030	<0.0040	0.0340	0.0080	11.00	<0.0001
Spring 6A	<0.010	2.400	0.0030	0.0200	0.0730	<0.0010	<0.0030	<0.0040	0.0070	0.0040	2.10	<0.0001

*Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
White Rock Canyon Springs Group II (Cont.)												
Spring 7	<0.010	0.170	0.0020	0.0250	0.0260	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	0.14	<0.0001
Spring 8	<0.010	6.000	0.0040	0.0600	0.1400	<0.0010	<0.0030	<0.0040	0.0070	0.0070	5.10	<0.0001
Spring 8A	<0.010	0.600	<0.0030	0.0200	0.0350	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.60	<0.0001
Spring 8B	<0.010	<0.100	<0.0030	0.0200	0.0250	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Spring 9	<0.010	3.900	<0.0030	<0.0100	0.0580	<0.0010	<0.0030	<0.0040	0.0190	0.0070	5.20	<0.0001
Spring 9A	<0.010	<0.100	0.0020	0.0020	0.0340	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
Doe Spring	<0.010	36.000	<0.0020	0.0700	0.3800	<0.0030	<0.0030	0.0090	0.0210	0.0190	29.00	<0.0001
Spring 10	<0.010	3.200	0.0090	0.1000	0.0940	<0.0030	0.0040	<0.0040	<0.0040	<0.0040	2.50	<0.0001
White Rock Canyon Springs Group III												
Spring 1	<0.010	8.500	0.0110	0.0500	0.3200	0.0010	<0.0030	0.0080	0.0280	0.0120	9.40	<0.0001
Spring 2	0.130	9.200	0.0310	0.0800	0.2500	0.0010	<0.0030	<0.0040	0.0040	0.0100	6.10	<0.0001
White Rock Canyon Springs Group IV												
La Mesita Spring	<0.020	4.700	0.0020	0.0380	0.1600	<0.0030	<0.0030	0.0070	0.0190	<0.0040	4.40	0.0001
Spring 3B	<0.010	0.200	0.0170	0.1500	0.0570	<0.0010	<0.0030	<0.0040	0.0210	<0.0040	0.40	<0.0001
Other Springs												
Sacred Spring	<0.020	0.750	0.0020	0.0310	0.1800	<0.0030	<0.0030	<0.0040	0.0050	<0.0040	0.73	0.0001
Indian Spring	<0.200	<0.100	0.0040	0.0200	0.1000	<0.0030	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	0.0001
CANYON ALLUVIUM GROUNDWATER												
DP-Los Alamos Canyon												
LAO-C	<0.010	1.700	<0.0030	<0.0200	0.0240	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	0.74	<0.0002
LAO-0.7	<0.010	6.700	0.0040	0.0570	3.1000	0.0070	0.0080	0.0290	<0.0040	0.0350	3.30	0.0001
LAOR-1	<0.010	15.400	0.0060	0.0630	0.1740	0.0030	0.0050	<0.0200	<0.0300	0.0300	11.10	<0.0001
LAO-1	<0.010	0.490	<0.0020	0.0370	0.0480	0.0014	<0.0030	<0.0200	<0.0300	0.0150	0.30	<0.0001
LAO-2[b]	<0.010	1.800	<0.0030	0.0800	0.0405	<0.0030	<0.0030	<0.0200	0.0400	<0.0080	0.84	<0.0002
LAO-3	<0.100	<0.100	<0.0020	0.0590	0.0750	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	<0.10	<0.0001
LAO-4	<0.100	0.340	<0.0020	0.0500	0.0520	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.27	<0.0002
LAO-4.5	<0.100	0.540	<0.0020	0.0650	0.0530	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.42	<0.0002
Mortandad Canyon												
MCO-4	<0.020	2.200	0.0020	0.0530	0.0760	<0.0010	<0.0030	<0.0040	0.0280	0.0200	1.40	0.0002
MCO-5	<0.020	2.900	<0.0020	0.0500	0.1200	<0.0010	<0.0030	<0.0040	<0.0040	0.0130	1.80	0.0001
MCO-6	<0.010	0.025	<0.0020	0.0800	0.1400	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.05	<0.0001
MCO-7[b]	<0.010	9.140	0.0040	0.0850	0.4000	<0.0010	<0.0030	<0.0040	0.0200	0.1000	7.63	0.0001
MCO-7.5	<0.010	15.000	0.0020	0.0800	0.5400	<0.0010	<0.0030	0.0050	0.0170	0.0220	13.00	0.0001
MT-4	<0.010	16.000	0.0030	0.0900	0.9100	0.0120	<0.0030	0.0100	0.0110	0.0160	6.40	<0.0002

*Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg*
CANYON ALLUVIUM GROUNDWATER (Cont.)												
Pajarito Canyon												
PCO-1	<0.020	0.150	<0.0020	0.0200	0.1300	<0.0010	<0.0030	<0.0040	<0.0040	<0.0040	0.26	0.0001
PCO-2	<0.020	99.000	0.0340	0.0250	2.6000	0.0120	<0.0030	0.0590	0.1300	0.0670	120.00	0.0003
PCO-3	<0.010	2.100	<0.0030	<0.0200	0.0290	<0.0030	<0.0030	<0.0040	<0.0040	<0.0080	1.10	<0.0002
Acid/Pueblo Canyons												
APCO-1	<0.010	0.850	0.0100	0.3600	0.1100	<0.0010	<0.0060	<0.0040	<0.0040	0.0080	0.48	<0.0001
Cañada del Buey												
CDBO-6	<0.010	27.000	0.0110	0.0390	0.2400	<0.0030	<0.0030	<0.0040	0.0120	0.0050	16.00	0.0002
CDBO-7	<0.010	89.000	0.0300	0.0590	1.6000	0.0100	<0.0030	0.0150	0.0460	0.0290	40.00	0.0002
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYONS												
Test Well 1A	<0.004	<0.009	<0.0050	0.1960	<0.0682	<0.0010	<0.0020	<0.0075	<0.0040	<0.0033	1.09	<0.0002
Test Well 2A	<0.004	<0.009	<0.0050	<0.0878	<0.0351	<0.0010	<0.0020	<0.0072	<0.0040	<0.0020	1.17	<0.0002
Basalt Spring	<0.020	0.140	0.0050	0.2100	0.0840	<0.0030	<0.0030	<0.0040	0.0050	<0.0040	0.18	0.0001
PERCHED SYSTEM IN VOLCANICS												
Water Canyon Gallery	<0.004	0.799	<0.0050	<0.0145	<0.0103	<0.0010	<0.0020	<0.0040	<0.0040	<0.0020	0.32	<0.0002
EPA Primary Drinking Water Standard[c]			0.05		2.0	0.004	0.005		0.1			0.002
EPA Secondary Drinking Water Standard[c]		0.05-0.2									0.3	
EPA Action Level[c]										1.3		
Livestock Wildlife Watering Limit[c]		5.0	0.2	5.0			0.05	1.0	1.0	0.5		0.01
NMWQCC Groundwater Limit[c]	0.05		0.1	0.75	1.0		0.01	0.05	0.05	1.0		0.002

*****Data on additional trace metals in groundwater are presented on page 244.

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER ON SITE											
Test Wells											
Test Well 1	0.0199	<0.027[a]	<0.0060	0.1780	<0.0192	<0.0040	<0.001	0.2610	<0.0010	<0.01	0.8890
Test Well 3	0.0050	<0.008	<0.0100	<0.0025	<0.0025	<0.0020	0.035	0.0910	<0.0025	0.01	0.0490
Test Well 8	<0.0030	<0.008	<0.0100	0.0040	<0.0020	<0.0020	<0.030	0.0350	<0.0020	<0.00	0.4600
Test Well DT-5A[b]	0.0108	<0.008	<0.0100	0.0130	0.0085	<0.0030	<0.030	0.0463	<0.0020	0.01	0.6475
Test Well DT-9	0.0480	<0.008	<0.0100	0.0140	<0.0020	<0.0020	<0.030	0.0480	<0.0020	0.01	0.4500
Test Well DT-10	0.0140	<0.008	0.0900	0.0950	<0.0020	<0.0020	<0.000	0.0450	<0.0020	0.00	4.0000
Water Supply Wells											
O-4	<0.0010	<0.027	<0.0060	<0.0015	<0.0030	<0.0040	<0.001	0.1080	<0.0010	<0.01	0.0602
PM-1	<0.0030	<0.008	<0.0100	0.0030	<0.0040	<0.0020	<0.030	0.1400	<0.0020	0.01	<0.0200
PM-2[c]	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0431	<0.0010	<0.01	<0.0050
PM-4[c]	<0.0133	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	0.1040	<0.0011	<0.01	<0.0036
PM-5	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0554	<0.0014	<0.01	<0.0041
MAIN AQUIFER OFF SITE											
Test Wells											
Test Well 2	0.0946	<0.027	<0.0060	0.0476	<0.0030	<0.0040	<0.001	<0.0568	<0.0010	<0.01	0.4950
Test Well 4	0.0380	<0.008	<0.0100	0.0520	<0.0020	<0.0020	<0.030	0.0530	<0.0020	<0.00	7.0000
Water Supply Wells											
G-1A	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0725	<0.0010	<0.04	<0.0081
G-2	<0.0010	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0787	<0.0010	0.09	<0.0147
G-4	<0.0134	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	0.1030	<0.0010	<0.01	<0.0044
MAIN AQUIFER SPRINGS											
White Rock Canyon Springs Group I											
Sandia Spring	0.0400	<0.008	<0.0100	0.0020	<0.0010	<0.0010	<0.030	0.4300	<0.0010	0.01	0.0300
Spring 3	0.0040	<0.008	<0.1000	0.0020	<0.0010	0.0010	<0.030	0.2400	<0.0010	0.02	<0.0200
Spring 3A	0.0060	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.2300	<0.0010	0.02	<0.0200
Spring 3AA	7.0000	<0.008	0.0300	0.0360	<0.0010	0.0010	<0.030	0.3500	<0.0010	0.11	0.0700
Spring 4	<0.0020	<0.008	<0.0100	<0.0010	<0.0010	0.0020	<0.030	0.1700	<0.0010	0.01	<0.0200
Spring 4A	0.0020	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0960	<0.0010	0.01	0.0400
Spring 5	0.0030	<0.008	<0.0100	0.0010	<0.0010	<0.0002	<0.030	0.0910	<0.0010	0.01	<0.0200
Ancho Spring	0.0120	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0580	<0.0010	0.01	<0.0200
White Rock Canyon Springs Group II											
Spring 5A	0.2300	<0.008	<0.0100	0.0060	<0.0010	0.0010	<0.030	0.2300	<0.0010	0.03	0.0300
Spring 5B	0.0690	<0.008	<0.0200	0.0040	<0.0010	<0.0020	<0.030	0.1300	<0.0010	0.02	<0.0200
Spring 6	0.0730	<0.008	0.0180	0.0010	<0.0010	<0.0020	<0.030	0.0810	<0.0010	0.03	0.0310
Spring 6A	0.1400	<0.008	<0.0100	0.0030	<0.0010	<0.0010	<0.030	0.0720	<0.0010	0.02	0.0200

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
White Rock Canyon Springs Group I (Cont.)											
Spring 7	0.0030	<0.008	<0.0100	0.0010	<0.0010	<0.0020	<0.030	0.0670	<0.0010	0.01	<0.0200
Spring 8	0.3100	<0.008	<0.0100	0.0120	<0.0010	<0.0020	<0.030	0.1900	<0.0010	0.02	0.0300
Spring 8A	0.0270	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0590	<0.0010	0.01	<0.0200
Spring 8B	0.0040	<0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.0530	<0.0010	0.01	<0.0200
Spring 9	0.1600	<0.008	<0.0100	0.0030	<0.0010	0.0010	<0.030	0.0620	<0.0010	0.03	0.0200
Spring 9A	<0.0030	<0.008	<0.0100	0.0100	0.0010	<0.0020	<0.030	0.0770	<0.0010	0.01	<0.0200
Doe Spring	0.5400	<0.008	0.0190	0.0010	<0.0010	<0.0020	<0.030	0.0490	<0.0010	0.04	0.1300
Spring 10	0.1100	<0.008	<0.0100	0.1040	<0.0010	<0.0020	<0.030	0.2600	0.0010	0.01	<0.0200
White Rock Canyon Springs Group III											
Spring 1	0.2000	<0.008	0.0200	0.0120	<0.0010	<0.0010	<0.030	0.5100	<0.0010	0.16	0.0300
Spring 2	0.8500	<0.008	<0.0100	0.0110	<0.0010	<0.0010	<0.030	0.4500	<0.0010	0.05	0.0300
White Rock Canyon Springs Group IV											
La Mesita Spring	0.1100	<0.020	<0.0100	0.0040	<0.0010	0.0020	<0.030	0.8600	<0.0010	0.02	0.0190
Spring 3B	0.0100	0.008	<0.0100	<0.0010	<0.0010	<0.0010	<0.030	0.2700	<0.0010	0.04	<0.0200
Other Springs											
Sacred Spring	0.0420	<0.020	<0.0100	0.0010	<0.0010	<0.0020	<0.003	0.5300	<0.0010	<0.00	0.0250
Indian Spring	<0.0030	<0.008	<0.2000	<0.0050	0.0020	0.0020	<0.030	0.3800	<0.0010	0.01	0.4500
CANYON ALLUVIUM GROUNDWATER											
DP-Los Alamos Canyon											
LAO-C	0.0090	<0.008	<0.0100	<0.0020	<0.0020	<0.0020	<0.030	0.0480	<0.0020	<0.00	<0.0200
LAO-0.7	14.0000	<0.008	0.0630	0.0110	<0.0020	<0.0020	<0.030	0.4200	<0.0020	0.02	0.1500
LAOR-1	0.6800	0.062	<0.0100	0.0280	<0.0010	<0.0020	<0.030	0.1690	<0.0010	0.03	0.0820
LAO-1	0.0200	0.055	<0.0100	<0.0010	<0.0010	<0.0020	<0.030	0.1350	<0.0010	<0.02	<0.0200
LAO-2[b]	0.0090	0.440	<0.0200	<0.0020	<0.0020	<0.0020	<0.030	0.0750	<0.0020	<0.02	<0.0200
LAO-3	0.0060	0.250	<0.0100	<0.0020	<0.0010	<0.0020	<0.030	0.1500	<0.0010	<0.00	<0.0200
LAO-4	0.0130	0.038	<0.0100	<0.0020	<0.0010	<0.0020	<0.030	0.1200	<0.0010	<0.00	<0.0200
LAO-4.5	0.0300	<0.008	<0.0100	0.0040	<0.0010	<0.0020	<0.030	0.1200	<0.0010	<0.00	<0.0200
Mortandad Canyon											
MCO-4	0.1700	0.250	<0.0100	0.0060	<0.0020	<0.0020	<0.030	0.0750	<0.0020	0.01	0.0430
MCO-5	0.0450	0.260	<0.0100	0.0020	<0.0020	<0.0020	<0.030	0.1300	<0.0020	0.01	0.0340
MCO-6	<0.0020	0.250	<0.0100	<0.0020	<0.0020	<0.0020	<0.030	0.1900	<0.0020	<0.00	<0.0200
MCO-7	0.1870	0.050	<0.0100	0.0270	<0.0020	<0.0020	<0.0300	0.2850	<0.0020	0.03	0.0525
MCO-7.5	0.2900	0.060	<0.0100	0.0200	<0.0020	<0.0020	<0.0300	0.3500	<0.0020	0.02	0.0800
MT-4	0.7600	<0.020	0.1100	0.0580	<0.0010	<0.0020	<0.0300	0.2800	<0.0010	0.02	0.1000

Table VII-3. Total Recoverable Trace Metals in Groundwater for 1994 (mg/L) (Cont.)

Location	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
CANYON ALLUVIUM GROUNDWATER (Cont.)											
Pajarito Canyon											
PCO-1	0.0500	<0.008	<0.0100	<0.0020	<0.0020	<0.0020	0.044	0.1800	<0.0020	<0.00	<0.0200
PCO-2	6.5000	<0.008	0.0980	0.1470	<0.0020	<0.0020	<0.030	0.5200	<0.0020	0.14	0.3300
PCO-3	0.0220	<0.008	<0.0100	0.0020	<0.0020	<0.0020	<0.030	0.0500	<0.0020	<0.00	<0.0200
Acid/Pueblo Canyon											
APCO-1	2.4000	<0.008	<0.0100	0.0030	<0.0020	<0.0020	<0.030	0.1300	<0.0020	0.02	0.0300
Cañada del Buey											
CDBO-6	0.2500	<0.008	<0.0100	N/A[d]	N/A	0.0030	<0.030	0.1000	N/A	0.03	0.0870
CDBO-7	1.7000	<0.008	0.0300	N/A	N/A	<0.0020	0.044	0.2600	N/A	0.07	0.2400
PERCHED SYSTEM IN PUEBLO/LOS ALAMOS CANYON											
Test Well 1A	0.1490	<0.027	<0.0116	0.0079	<0.0030	<0.0040	<0.001	0.1560	<0.0010	<0.01	3.2700
Test Well 2A	0.0592	<0.027	<0.0069	0.0093	<0.0030	<0.0040	<0.001	0.2000	<0.0010	<0.01	0.4140
Basalt Spring	0.0360	<0.020	<0.0100	0.0010	0.0010	<0.0020	<0.030	0.2000	<0.0010	0.01	0.0220
PERCHED SYSTEM IN VOLCANICS											
Water Canyon Gallery	<0.0022	<0.027	<0.0060	<0.0010	<0.0030	<0.0040	<0.001	<0.0414	<0.0010	<0.01	<0.0030
EPA Primary Drinking Water Standard[c]			0.1		0.006	0.05			0.002		
EPA Secondary Drinking Water Standard[c]	0.05										5.0
EPA Action Level[c]				0.015							
EPA Health Advisory[c]								25-90		0.08-0.11	
Livestock Wildlife Watering Limit[c]				0.1						0.1	25.0
NMWQCC Groundwater Limit[c]		1.0		0.05		0.05					

[a]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b]Results are the mean of more than one sample analysis
[c]Standards given here for comparison only, see Appendix A.
[d]N/A means analysis not performed, lost in analysis, or not completed.

groundwater exceeds the NMWQCC Groundwater Limit for fluoride and nitrate. Nitrate is used in the treatment process at the TA-50 Radioactive Liquid Waste Treatment Plant. Mortandad Canyon alluvial groundwaters are also high in sodium. The trace metal data for the alluvial canyon groundwaters were particularly influenced by the effects of suspended sediment in unfiltered samples. The affected samples include the groundwater samples from Pajarito Canyon and Cañada del Buey. These effects include concentrations of aluminum, iron, and manganese that exceed the dissolved levels of these elements that are possible in unfiltered natural waters having pH between 6 and 8.

In particular, wells LAO-0.7, LAO-R1, PCO-2 and CDBO-7 had levels of some metals, including arsenic, barium, beryllium, cobalt, chromium, nickel, lead, and vanadium, which exceeded NMWQCC Groundwater Limits or EPA drinking water standards.

d. Nonradioactive Constituents in Intermediate Perched Groundwater. The nitrate values for Test Wells 1A, 2A, and Basalt Spring exceeded the NMWQCC Groundwater Limits or EPA drinking water standards. These results are discussed separately in Section VII.E.5.

Except for manganese and iron, none of the intermediate perched groundwater or the Water Canyon Gallery showed any concentrations of trace metals that are of concern.

e. Organic Constituents. Analyses for organic constituents were performed on most of the test wells, water supply wells, and alluvial observation wells in 1994. The analyses addressed the volatile organic compounds, semivolatile organic compounds, and polychlorinated biphenyls (see Tables D-20 and D-22 for detailed listings of parameters). The alluvial wells in Cañada del Buey were not sampled for organics. The samples where organics were detected are listed in Table VII-4. The two organic compounds detected (acetone and bis-2-ethylhexylphthalate) were a result of either laboratory contamination or were substances also detected in blank samples from the field, and therefore are suspected to result from other sample contamination. Acetone, bis-2-ethylhexylphthalate, di-n-octylphthalate, methylene chloride, and 2-butanone are common laboratory contaminants. Bis-2-ethylhexylphtha-late is a common contaminant found in samples that have come in contact with plastic laboratory and sampling equipment. The only organic detection not readily explained by trip or lab blank contamination was acetone in Test Well DT-5A.

D. Long-Term Trends

1. Main Aquifer.

The long-term trends of the water quality in the main aquifer have shown little impact resulting from Laboratory operations. Except for low levels of tritium contamination found at four locations in Los Alamos and Pueblo Canyons and one location in Mortandad Canyon, no concentrations of radionuclides above detection limits have been measured on water samples from the production wells or test wells that reach the main aquifer other than an

Table VII-4. 1994 Results for Samples with Detection of Organic Compounds

Well	Compound	Amount (μg/L)	Comments
Test Wells			
DT-5A	Acetone	22 ± 6.6	
TW-4	Bis-2-Ethylhexylphthalate	16 ± 4.8	lab contamination
Water Supply Wells			
PM-4	Bis-2-Ethylhexylphthalate	53 ± 15.9	common lab contaminant
Alluvial Observation Wells			
PCO-1	Bis-2-Ethylhexylphthalate	14 ± 4.2	lab contamination
PCO-2	Acetone	27 ± 8.1	trip blank contaminated
MCO-4	Acetone	23 ± 6.6	trip blank contaminated
MCO-5	Acetone	36 ± 6.6	trip blank contaminated
	Bis-2-Ethylhexylphthalate	<11	lab contamination
MT-4	Acetone	28 ± 8.4	lab blank contaminated

occasional analytical statistical outlier not confirmed by analysis of subsequent samples. The apparent detection of ^{90}Sr in Test Well 3 in 1994 presently appears to be due to analytical error, because the gross beta measurement does not support the strontium result. A follow-up sampling program to verify this result is underway.

Measurements of tritium by extremely low detection limit analytical methods (see Section VII.E.1) show the presence of some recent recharge (meaning within the last four decades) in water samples from six wells into the main aquifer at Los Alamos. The levels measured range from less than 2% to less than a 0.01% of current drinking water standards, and are all less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations. Recent detection of lead in the main aquifer test wells appears to have resulted from contamination by well casings, pumps, and monitoring devices (see Section VII.E.1).

The long-term trends of water levels in the water supply and test wells in the main aquifer indicate that there is no major depletion of the resource as a result of pumping for the Los Alamos water supply. The westernmost well, Test Well 4, shows less than 3 m (10 ft) of change. In the central part of the plateau, water levels in Test Wells 2, 3, and 8 have declined about 7.6 to 10.7 m (25 to 35 ft) in slightly more than 45 years, or less than about 0.25 m/yr. Test Well 3 is located about 1.6 km (1 mi) from the nearest supply wells (PM-5 and PM-3); Test Well 2 is about 3.0 km (2 mi); and Test Well 8 is less than 1 km (0.5 mi) from the nearest supply wells. Near the southern boundary of the Laboratory, water levels in Test Wells DT-5A, DT-9, and DT-0 have declined about 3 to 4 m (10 to 13 ft) in 33 years. The initial years of this decline occurred before any of the Pajarito field wells were drilled and must be attributed to a general regional trend unaffected by pumping. Thus, the decline observed in the test wells to the north and in the pumping wells is probably partly attributable to a general trend in the regional aquifer.

One test well, Test Well 1, shows an apparent increase in water level. The anomalous behavior of this well is not understood, and is under investigation. Two prior surveillance reports provide a detailed discussion of some preliminary tests to evaluate this well (EPG 1993, EPG 1994).

The wells in the Pajarito Field have always been the best producers. As expected, they show the least decline in water levels; about 6 to 12 m (20 to 40 ft) since they were drilled. Nonpumping levels in Supply Well PM-5 have declined about 5 m (16 ft) in 11 years and in PM-3 have declined about 9.4 m (31 ft) in 27 years. PM-3 is the largest producer of all the wells, producing more than 200 million gal./yr in the last several years.

In the Guaje Well Field northeast of the Laboratory, the water levels have ranged from almost no decline to about 37 m (120 ft) of decline since 1950. The westernmost wells show the least decline overall and have recovered significantly in recent years with somewhat lower production. Wells G-4 and G-5 recovered significantly in 1993 when they were not pumped. The overall nonpumping levels have declined an average of about 19 m (62 ft) for the entire field over the past 40 years.

The Los Alamos Well Field was retired from service after 1991. The average water level in the field declined about 18.6 m (61 ft) from 37 m (121 ft) in 1951 to 55 m (182 ft) in 1964. After 1965, the production from the field decreased, and the average water level recovered about 21 m (68 ft) from 55 m (182 ft) in 1964 to 35 m (114 ft) in 1991. With the end of production from the field, there was a sharp recovery in water levels to within about 12 to 20 m (20 to 50 ft) of original levels in the vicinity of Wells LA-1B, LA-2, and LA-3. In the vicinity of Wells LA-4, LA-5, and LA-6 the water levels were within about 20 to 31 m (50 to 80 ft) of original levels. All remaining facilities in the Los Alamos Well Field were turned over to the Pueblo of San Ildefonso in July 1992.

2. Alluvial Perched Groundwater in Mortandad Canyon.

Long-term trends of radionuclide concentrations in shallow alluvial perched groundwater in Mortandad Canyon (the current radioactive effluent release area for the waste treatment plant at TA-50) are depicted in Figure VII-3. The samples are from Observation Well MCO-6 in the middle reach of the canyon. The combined total of ^{238}Pu and $^{239,240}Pu$ concentrations are relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff that cause some dilution in the shallow alluvial water. Note that the current plutonium detection limit of 0.02 pCi/L applies to the separate analyses of ^{238}Pu and $^{239,240}Pu$, and might be doubled for the addition of these values, since results are often at or near the detection limit. The tritium concentration has fluctuated almost in direct response (with a time lag of about one year) to the average annual concentration of tritium in the TA-50 effluent.

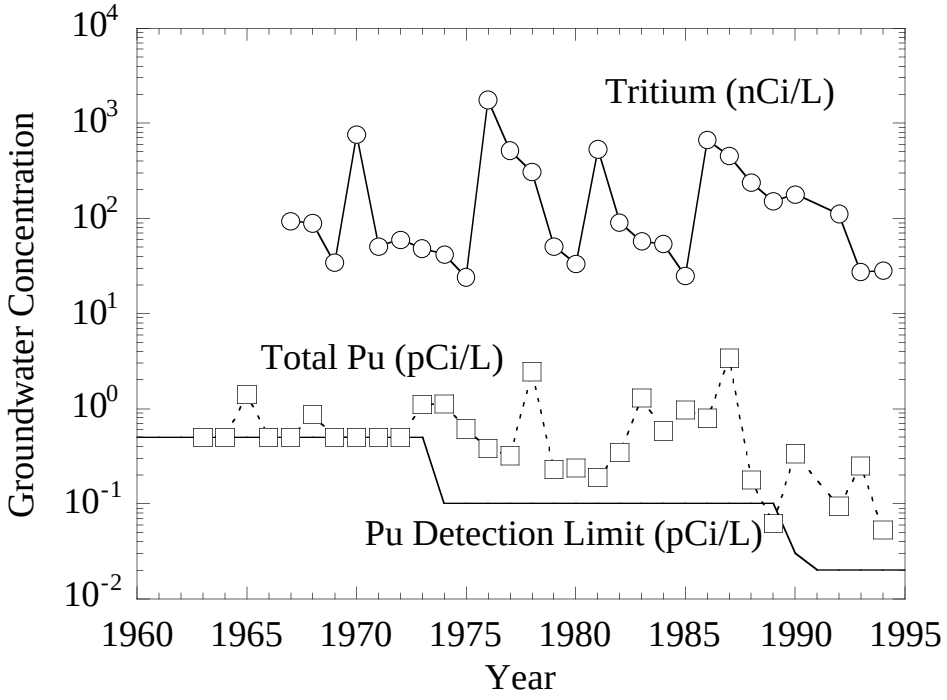

Figure VII-3. Tritium and plutonium concentrations in water samples from Mortandad Canyon Alluvial Observation Well MCO-6.

E. Special Studies

1. Main Aquifer Geochemistry.

a. Lead Evaluation in Test Well DT-5A (Max Maes and David Rogers, ESH-18)**.** In May of 1993, representatives of the NMED/AIP, the Geology and Geochemistry Group (EES-1), and the Environmental Protection Group (EM-8) collected water samples from several of the Laboratory's test wells (EARE 1995b). In July of 1993, the AIP staff informally advised EM-8 that their sample from Test Well DT-5A (located at TA-49) showed a lead level of 5 mg/L. (The EPA drinking water action level for lead is 0.015 mg/L; the NMWQCC lead limit for groundwater is 0.05 mg/L). The results were a significant departure from previous lead measurements in Test Well DT-5A (EARE 1995b) and suggested a possible upward trend in lead concentrations. Lead levels higher than previous values were also measured at four other test wells. The production wells that supply drinking water to the Los Alamos community generally have not shown excessive lead levels.

The dissolved concentrations of lead in surface water and groundwater of near-neutral pH (pH ~7) are commonly extremely low, due in part to precipitation with manganese or adsorption on particle surfaces (Hem 1989). Samples evaluated by the Laboratory and the NMED/AIP were unfiltered, however; thus the lead was possibly associated with suspended sediment particles. An analysis by EES-1 of a filtered sample showed a far lower lead concentration of 0.037 mg/L in Test Well DT-5A. For this well, the source of lead contamination was suspected to be the pump hardware (originally installed in Test Well 4 in the 1960s, then moved to DT-5A in the 1970s). For Test Well DT-5A and the other four test wells, modifications made to the wells in 1992 may have jarred the piping and caused lead particles to fall to the bottom of the well, to be later drawn into water samples.

The appearance of high lead levels in test wells at TA-49 is of concern because past underground tests at the site, involving high explosives and radioactive materials, raise the possibility of groundwater contamination (Purtymun 1987b). The tests were conducted in 1960 and 1961, at the direction of President Eisenhower, to evaluate safety aspects of certain nuclear weapons systems. Tests were carried out in large-diameter holes, up to 37 m (120 ft) deep. Materials dispersed by detonation of the high explosives remain at the bottom of the experimental holes. These materials include 40 kg (88 lb) of plutonium, 93 kg (205 lb) of enriched uranium, 82 kg

(180 lb) of depleted uranium, and 90,000 kg (198,000 lb) of lead which was used as shielding (Purtymun 1987b; LANL 1992b). The area is considered to be a hazardous and radioactive material disposal area for purposes of compliance with DOE and EPA requirements. Environmental monitoring carried out since the time of the testing has indicated no contamination of the groundwater, which lies at a depth of 366 m (1,200 ft) below TA-49. Age dating of groundwater from test wells at TA-49 supports the conclusion that there is no component of recent recharge in this area (see Section VII.E.1.b.).

A follow-up study was conducted at Test Well DT-5A as a result of elevated lead levels discovered in 1993. Modifications were made to the DT-5A pump in 1992, and elevated lead concentrations were suspected to have resulted from particles loosened from the hardware during this procedure. An x-ray diffraction test was done on pipe samples and showed that the piping indeed had lead coating.

The pump test of DT-5A ran from November 21 through December 1, 1994. The purpose of the study was to determine the amount of dissolved lead, and to what extent lead was associated with particles suspended in the water samples. In order to evaluate the lead concentrations associated with particles of different sizes, a three-step filtration system was designed using 1.0 micron, 0.45 micron, and 0.20 micron filters. Nearly 134,615 L (35,000 gal.) of water were pumped from the well, and on average, filtered and unfiltered samples were collected daily to monitor lead concentrations. The total volume of water purged was 130,846 L (34,020 gal.) over the two week period. The discharge was carried out under NPDES Permit Guidance and approved by the NMED.

Lead concentrations in unfiltered water showed concentrations ranging from the detection limit, which varied from 2 to 40 μg/L, up to a value of 50 μg/L (Table VII-5 and Figure VII-4). The filtered water showed no lead concentrations above the detection limit, which ranged from about 2 to 40 μg/L.

The sharp decline of lead levels in both filtered and unfiltered samples, in comparison to 1993 values, indicates that the lead was associated with a small amount of particles within the well bore, rather than reflecting a larger quantity of the lead within the aquifer. It is probable that most of these lead particles were removed from the well bore during repeated sampling in 1993 and 1994.

Well DT-5A is part of the environmental surveillance network and is tested annually for lead, as well as other trace metals and radiochemistry.

b. Recharge Age of Water in Main Aquifer (David Rogers and Alan Stoker, ESH-18; Fraser Goff, EES-1; and Andrew Adams, CST-7)**.** In order to evaluate the risk and possible pathways of contamination for the main aquifer system at Los Alamos, in 1991 the Water Quality and Hydrology Group's Hydrology Team initiated a study to help define the sources of recharge to the aquifer (EPG 1993, EPG 1994, EARE 1995b). The cooperative study involves participation by researchers in other divisions at Los Alamos (Earth and Environmental Sciences and Chemical Science and Technology Divisions) and another DOE contractor (RUST GeoTech at Grand Junction, Colorado).

Table VII-5. Time Series Lead Concentrations (μg/L) from Test Well DT-5A

	Unfiltered Samples		Filtered Samples		
Date	Lead Concentration	Analytical Uncertainty	Lead Concentration	Analytical Uncertainty	Water Volume (gal.)
11/21/1994	43	2	<2	2	0
11/21/1994	13	2.2	<2.2	2.2	194.4
11/22/1994	<30	30	<30	30	5,883.2
11/23/1994	<30	30			9,720.0
11/24/1994	50	30			13,608.0
11/25/1994	40	30			17,496.0
11/28/1994	<30	30	<30	30	22,356.0
11/29/1994	37	30	<30	30	26,244.0
11/30/1994	<40	40			30,132.0
12/01/1994	<40	40	<40	40	34,020.0

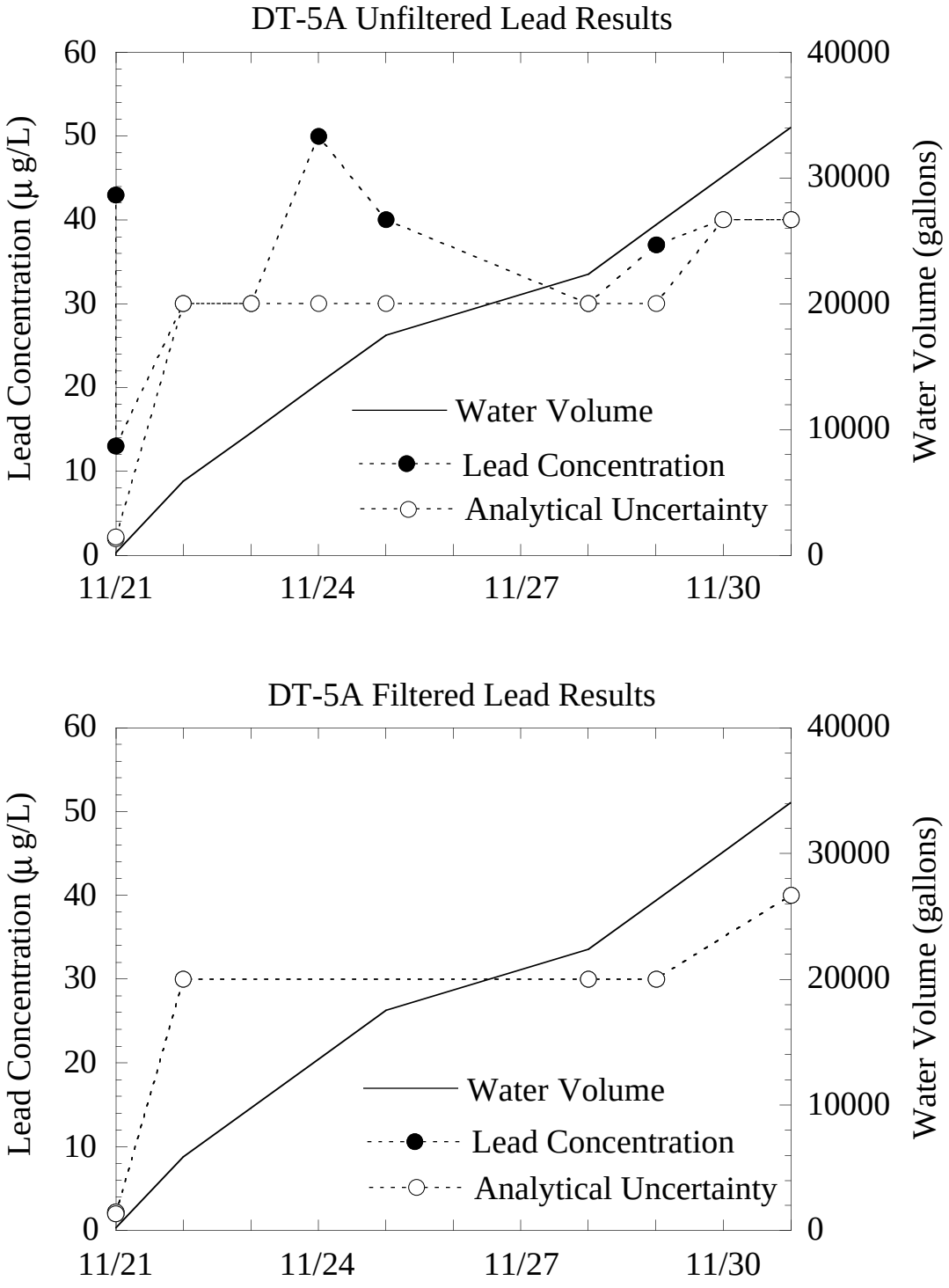

Figure VII-4. Unfiltered (top) and filtered (bottom) lead concentration time series from Test Well DT-5A at TA-49. The analytical uncertainty for each analysis is shown by open circles, and the lead concentration (where greater than the analytical uncertainty) is shown by solid circles. For the filtered analyses, measurements were at or below the detection limit so are not shown. The measurements were all below the analytical uncertainty; thus, the laboratory reported only the uncertainty values. The cumulative amount of water pumped from the well during the test is also indicated.

The study is attempting to apply a variety of radioactive and stable isotope geochronology techniques to help identify the sources and age of the main aquifer water. The measurements made starting in 1991 include several advanced techniques not commonly applied to groundwater samples. These techniques have much lower detection limits than can be achieved by conventional analytical methods and are used to quantify what are essentially trace levels of the isotopes in question. In some cases, the isotopic measurements permit estimates of the time it has taken water to move from the surface to the groundwater. Samples have been collected from the test wells and the water supply production wells that penetrate the main aquifer, and also from springs that issue along the Rio Grande. These springs have been interpreted to be discharging directly from the main aquifer (Purtymun 1980b).

This section is primarily concerned with the age dating results; the specific trace-level tritium measurements and some of the carbon-14 results are discussed in the following sections.

Use of Carbon-14 and Tritium as Age Indicators. An expanding database of measurements for trace-level tritium and carbon-14 is enhancing the knowledge of the groundwater processes in the vicinity of the Los Alamos National Laboratory. Some of the measurements confirm that there are pathways for transport of water from the land surface to the main groundwater aquifer beneath the Pajarito Plateau. In Los Alamos County the main aquifer lies hundreds of feet beneath the surface and is the source of municipal and industrial water supply for Los Alamos County, including both the Los Alamos National Laboratory and the adjacent community areas. The main aquifer also provides water for several residences in Los Alamos Canyon and discharges through springs into the Rio Grande in White Rock Canyon. Several household wells at the Pueblo of San Ildefonso also draw water from the main aquifer horizons, which are at a shallow level along the Rio Grande.

"Age of water" means the time elapsed since the water, as precipitation, entered the ground to form recharge and became isolated from the atmosphere. At the time of entry into the ground, the recharge water is assumed to have been in equilibrium with atmospheric concentrations of both tritium and carbon-14. Radioactive carbon-14 (or radiocarbon) comes from the interaction of cosmic rays with the atmosphere. Tritium is a naturally occurring isotope of hydrogen, produced in the atmosphere by cosmic rays, and by decay of naturally occurring radioactive elements in rocks. Tritium is also produced by nuclear reactors and as part of the development and testing of nuclear weapons. Once water enters the ground as recharge, radioactive decay and/or mixing with older water would result in reduction of the concentration of either isotope in present day groundwater samples. Carbon-14, with a half-life of about 5,730 years, is useful for estimating ages ranging from a few thousand to several tens of thousands of years. Tritium, with a half-life of about 12.3 years, is useful for estimating ages in the range of decades.

Perspective on Tritium Levels in Nature. Before discussing tritium measurements in the Los Alamos area deep wells, it is helpful to give some background on environmental tritium levels. Before atmospheric testing of nuclear weapons began, tritium levels in precipitation were about 20 pCi/L. This is 5 to 10 times the tritium levels detected in the Los Alamos public water supply wells. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi/L because of aboveground nuclear testing. At present, general atmospheric levels in northern New Mexico are about 30 pCi/L, and those in the Los Alamos vicinity range from 20 to 450 pCi/L (Adams 1995).

For comparison, the present EPA tritium drinking water standard is 20,000 pCi/L; in 1991 the EPA issued regulations proposing to raise this to 60,000 pCi/L. Monitoring of compliance with the drinking water regulations uses the EPA-specified liquid scintillation counting method with a detection limit of about 300 to 700 pCi/L. The trace-level tritium measurements in our study were performed at the University of Miami and have a detection limit of about 1 pCi/L.

Tritium Age-Dating of Groundwater. The tritium concentration in groundwater can be altered by mixing with water already in the aquifer. To account for this possibility, two different age-determination schemes are employed (Table VII-6). The "piston flow" calculation assumes that the tritium value measured in the groundwater results only from radioactive decay of the original tritium in recharge water, which has moved undiluted through the aquifer; this gives a minimum age. The "well-mixed" model assumes that the recharge has completely mixed with water from the entire groundwater reservoir; this gives a maximum age.

Age determinations from tritium are most reliable for times less than 100 years. For ages above 1,000 years, there is substantial uncertainty (Blake 1995). Confidence in greater ages is increased if carbon-14 ages are also available. Groundwater that contain between 16 and 65 pCi/L of tritium are most likely the result of recent recharge and are best modeled with the piston flow method (Blake 1995). Waters with tritium concentrations below about 1.6 pCi/L are likely to be old and can be modeled as well-mixed reservoirs. The ages of these waters

Table VII-6. Summary of Carbon-14 and Tritium-Based Age Estimates for Wells in the Los Alamos Area

Well or Spring	Carbon-14 (% modern)	Carbon-14 Age Estimates Minimum[a]	Carbon-14 Age Estimates Maximum[b]	Tritium (pCi/L)	Tritium (T.U.[c])	Tritium Age Estimates[d] Piston Flow[e]	Tritium Age Estimates[d] Well-mixed[f]
Los Alamos Main Aquifer Water Supply Wells							
O-4	25.0	3,890	11,500	1.04	0.32	>50	>5,000
PM-1	18.5	5,620	14,000	1.65	0.51	>45	>3,000
PM-2	62.7	50	3,860	1.59	0.49	>45	>3,000
PM-3	23.9	4,950	11,800	0.45	0.14	>70	>9,000
PM-3 @ 987'	28.2	6,770	10,500	0.42	0.13	>70	>9,000
PM-3 @ 1,226'	24.5	7,700	11,600	0.26	0.08	>70	>10,000
PM-3 @ 1,650'	22.9	7,910	12,200	0.03	0.01	>100	>10,000
PM-3 @ 2,000'	23.9	6,390	11,800	0.10	0.03	>100	>10,000
PM-5	53.7	1,040	5,140	0.29	0.09	>70	>10,000
G-5	26.8	6,110	10,900	0.26	0.08	>70	>10,000
Los Alamos Main Aquifer Test Wells							
TW-1	237.2		Cont.[h]	366	113		Cont.[h]
TW-2	57.3	<0[g]	4,610	2.75	0.85	~40	>1,500
TW-3	40.45	921	7,480	2.88	0.89	~40	>1,500
TW-4	57.1	<0[g]	4,630	10.8	3.34	~35	~500
TW-8	—	—	—	89	27.6		Cont.[h]
DT-5A	57.6	1810	4,560	0.23	0.07	>80	>10,000
DT-9	69.1	163	3,060	0.45	0.14	>70	>9,000
DT-10	82.0	<0[g]	1,640	1.33	0.41	~55	>4,500
Intermediate Depth Perched Groundwater							
TW-1A	182.2		Cont.[h]	148	45.8	20-30	<20
TW-2A	—	—	—	2,265	699		Cont.[h]
LADP-3	—	—	—	5,830	1800		Cont.[h]
Basalt Spring	—	—	—	162	50	20-30	<20
Perched Water in Volcanics- Water Canyon Gallery							
Gallery Spring			12.8	6.48	2-40	5-100	
San Ildefonso Wells							
LA-1B	<0.9	>27,000	>39,000	0.58	0.18	>60	>8000
LA-1A	13.9	6,250	16,300	63.8	19.7	20-30	10-50
LA-2	27.2	5,850	10,800	13.1	4.04	35-40	~400
East Artesian	3.8	18,200	27,000	1.0	0.31	>50	>5000
West Artesian	0.0	>35,000	>45,000	0.39	0.12	>70	>10000
Halladay House	10.7	13,400	18,500	0.94	0.29	>50	>5,000
Pajarito Pump #2	30.9	1,280	9,700	3.05	0.94	~ 40	>1,500

[a]Assumes dilution by dead carbon from dissolution of carbonates, estimated by $\delta^{13}C$.
[b]Assumes radioactive decay only, no dissolution of carbonates.
[c]Tritium Units, one tritium atom in 10^{18} hydrogen atoms; 1 TU = 3.24 pCi/L.
[d]From Blake (1995).
[e]Piston Flow model assumes no mixing or dilution with other water.
[f]Well-mixed model assumes complete mixing in reservoir, inflow = outflow, no other inputs.
[g]Applying dilution factor (footnote a) results in meaningless minimum age.
[h]"Contaminated" indicates sample contains recent contamination from the surface, because the concentration of tritium or carbon-14 is greater than could be attributed to any atmospheric or other natural source.

are ≥3,000 years, but there may be large errors associated with small tritium concentrations (Blake 1995). With a tritium concentration below 0.5 pCi/L, modeled ages are ≥10,000 years, but this is at the limit of tritium age determinations. Waters with tritium concentrations ≥1000 pCi/L and collected after 1990 cannot have their ages modeled, and can only be the result of contamination (Blake 1995).

Measurements of tritium by trace-level analytical methods show the presence of some recent recharge (meaning within the last four decades) in water samples from three locations in the main aquifer at Los Alamos. Because tritium has a short half-life of about 12.3 years and behaves chemically as do other isotopes of hydrogen, it is an extremely sensitive tracer for the movement of water. Recent recharge to intermediate depth perched groundwater beneath the Pajarito Plateau has also been indicated at four locations. Many other samples of well and spring water show no apparent recent recharge to the main aquifer. The levels measured range from about 1% to <0.01% of a percent of current drinking water standards, and most are far less than levels that could even be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

Carbon-14 Age-Dating of Groundwater. About 25 measurements of carbon-14 in samples of groundwater in the Los Alamos vicinity have been completed at present (Table VII-6). The measurement of carbon-14 in natural materials is an accepted and widely used method for estimating ages ranging from a few thousand to tens of thousands of years. These measurements indicate that the water in the main aquifer may have maximum ages ranging from a few thousand years in the central and western part of the Pajarito Plateau, up to as much as 40,000 years along the Rio Grande, near its confluence with Los Alamos Canyon.

The maximum possible ages (Table VII-6) result from a direct carbon-14 measurement, which gives an age based on the radioactive decay of carbon-14. This value is often greater than the actual age, because the amount of carbon-14 in relation to total carbon is frequently diluted in groundwater by the dissolution of "dead" carbon (carbon with no remaining radiocarbon) from carbonate minerals in the rocks. Estimating this dilution effect requires measurement of other carbon isotopes and assumptions about mixing. Calculating a minimum age based on the estimated dilution can lead to very young or meaningless ages if the carbonate geochemistry is not well characterized. It is also possible that carbon-14 from other sources such as Laboratory effluents could raise the amount of carbon-14 in a sample and lead to an inferred age that is very "young" or even negative. However, if the measured amount of carbon-14 present in the sample is greater than found in precipitation, then it is probably an indication of contamination.

Several of the Los Alamos vicinity groundwater samples indicated very young or meaningless ages, reflecting these possible complications (Table VII-6). The main aquifer sources with very young estimated ages include Supply Well PM-2 (50 years), Test Well 2 (negative age), Test Well 3 (921 years), Test Well 4 (negative age), Test Well DT-10 (negative age), and Test Well DT-9 (163 years). Most of these results are probably attributable to lack of complete understanding of the carbonate geochemistry because they are not confirmed by the presence of tritium. However, the result for Test Well 4 may be an indication of recent recharge because trace-level tritium was detected there. The results for Test Wells 2 and 3 also may be suspect as their tritium measurements were just at the detection limit. These wells will need to be studied further to resolve the questions.

The wells that clearly show carbon-14 contamination are Test Well 1, in the main aquifer, and Test Well 1A, an intermediate perched zone well. Both wells show significant recent recharge based on the tritium measurements.

Department of Health & Human Services Evaluation. The US Department of Health & Human Services Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the trace levels of tritium that we found in Los Alamos and the Pueblo of San Ildefonso water supply wells. Regarding the now discredited tritium measurement of 20 pCi/L for the Pajarito No. 3 Well (see Section VII.E.1.c), the ATSDR said, "It should be emphasized that 20 pCi/L is only 1/1000 of the present EPA drinking water limit and 3/10,000 of EPA's proposed limit for drinking water. ATSDR considers water at these drinking water levels to be safe for human consumption. The 20 pCi/L is orders of magnitude below a level that would present a health hazard to individuals drinking this water. In addition, this concentration is one to two orders of magnitude less than the minimum detectable limit of the recommended liquid scintillation counting method used by the EPA."

The discovery of trace levels of tritium in some test wells (EARE 1995b) is a matter of concern to the Laboratory. However, most of these test wells tap the top of the main aquifer; the water supply wells draw water from deeper levels. A higher tritium level was detected in a test well (Test Well 2A) that does not reach the main aquifer, but is used to monitor conditions at a much shallower level beneath Pueblo Canyon. Water from Test Well 2A had a tritium measurement of 2,237 pCi/L. Regarding this tritium measurement, the ATSDR said "Even though this well is only a test well and apparently does not provide drinking water . . . compared to the EPA drinking water limit . . . of total radioactivity, this level is not of concern to affect health."

c. Reevaluation of Tritium in Water Supply Well PM-3 (David Rogers, Max Maes, and Alan Stoker, ESH-18)**.** Water Supply Well PM-3 was sampled for trace-level tritium analysis in August of 1992, with the analysis showing 1.2 pCi/L (Table VII-7). This is considered to represent an essentially unmeasurable amount of tritium. A second sample was taken in May 1993; the analytical result was 22 pCi/L. The well, located in Sandia Canyon, had been in service without interruption since its completion in 1966, and is not near any known source of surface contamination. The well was completed with several grouted, telescoping casings. The casings reach a depth of 778 m (2,552 ft) below the surface and incorporate 485 m (1,591 ft) of inlet screens extending from 956 to 291 to 776 m (2,547 ft). The nonpumping water level in recent years has been at about 235 m (770 ft) below the surface. The pump operates at 5,000 to 5,385 L/min (1,300 to 1,400 gal./min) and has produced about 15% of the total Los Alamos water supply in recent years. Because of the considerable thickness of the aquifer tapped by the well, it would require a major influx of contaminated water to result in the apparent tritium level. Three other water supply wells within 1.6 to 3.2 km (1 to 2 miles) (PM-1, PM-5, and O-4) have shown no measurable tritium. Thus, the May 1993 sample result from Supply Well PM-3 had no obvious explanation.

In November, the University of Miami reported reanalysis of previously unused portions of the May 1993 samples from Test Well 4 and Supply Well PM-3. The result for Test Well 4 was unchanged, at about 11 pCi/L. The new result for the PM-3 sample was no detectable tritium, as compared to the earlier reported value of about 22 pCi/L. The University of Miami noted that their quality control records enabled them to establish that the initial result for the PM-3 sample was attributable to contamination from the Test Well 2A sample, which had a level of about 2,260 pCi/L. The reanalysis of the PM-3 sample is consistent with the August 1992 sample that was reported with no measurable tritium.

In order to increase confidence in the tritium results, zonal sampling was carried out in Supply Well PM-3 in April 1994. This sampling was made possible because the main pump had to be removed for repairs. The well service contractor completed removing the main pump from PM-3 in January 1994. A downhole video camera inspection determined that the production casing was in good condition. Welded joints appeared sound, no broken louvers were seen, and no corrosion problems appeared. Some expected scale deposits were observed at various depths. The bottom of the well was filled with sediments to a depth of about 683 m (2,240 ft). A smaller submersible pump was temporarily installed in Well PM-3 to conduct the zonal sampling. The well was left undisturbed until the sampling was conducted on April 25 through 28, 1994. The tritium analyses were made by two independent laboratories (University of Miami and Teledyne) and the sample sets include several special Quality Assurance samples, both blanks and known-concentration internal spikes.

Samples were collected on subsequent days at depths of 610, 503, 374, and 301 m (2,000, 1,650, 1,226, and 987 ft). The analyses from the University of Miami are listed in Table VII-7. The results at all four depths show no measurable tritium at the detection limit of the University of Miami method, which is about 0.3 pCi/L for this set of samples. Results from the Teledyne analyses were below that laboratory's detection limit (3 to 5 pCi/L) for the

Table VII-7. Trace-Level Tritium Measurements in Water Supply Well PM-3

	Sample	Tritium Units[a]		pCi/L	
	Date	Tritium	±[b]	Tritium	±
PM-3 First Analysis					
	8/18/92	0.37	0.09	1.20	0.29
PM-3 Suspect Result and Followup Reanalyses					
Original Analysis	5/19/93	6.67	0.22	21.61	0.71
Renalysis 1, 11/93	5/19/93	0.12	0.09	0.39	0.29
Renalysis 2, 11/93	5/19/93	-0.06	0.09	-0.19	0.29
PM-3 Zonal Sampling					
PM-3 @ 987'	4/28/94	0.13	0.09	0.42	0.29
PM-3 @ 1226'	4/27/94	0.08	0.10	0.26	0.32
PM-3 @ 1650'	4/26/94	0.01	0.09	0.03	0.29
PM-3 @ 2000'	4/25/94	0.03	0.09	0.10	0.29

[a]The University of Miami detection limit for this set of samples was 0.3 pCi/L (0.1 TU); 1 TU = 3.24 pCi/L.
[b]The ± values represent one standard deviation of the uncertainty of measurement.

503 and 301 m (1,650 and 987 ft) samples, showed 4.4 pCi/L in the 610 m (2,000 ft) sample, and 9.8 pCi/L in the 374 m (1,226 ft) sample. Both laboratories performed adequately on the QA samples, with the University of Miami performance in terms of detection limit being at least ten times lower than Teledyne. The Laboratory's interpretation is that the University of Miami results are better technically, and that there is no measurable tritium at any depth in the PM-3 supply well. However, the conflicting results from the second laboratory, even though judged to be less reliable, cast a small measure of doubt on the confidence in the tritium results.

The carbon-14 analyses on the four zonal depth samples from Supply Well PM-3 contribute to the interpretation of no recent recharge (Table VII-6). All four carbon-14 measurements were identical within the analytic uncertainty, and indicate an age range for the water of about 6,400 years to about 12,200 years. These results are almost the same as the carbon-14 measurement made on the May 1993 sample, which showed an age range of about 5,000 years to about 11,800 years.

d. Results for Wells Showing Recent Tritium. The information in this section supplements a previous report on the detection of trace levels of tritium in wells in the Los Alamos area (EARE 1995b). As previously reported, trace levels of tritium were detected at four household wells at the Pueblo of San Ildefonso (EARE 1995b). Recent recharge to intermediate-depth perched groundwater beneath the Pajarito Plateau has also been indicated at three wells and one spring. Many other samples of well and spring water show no apparent recent recharge to the main aquifer.

Measurements of tritium by trace-level analytical methods suggest the presence of some recent recharge (meaning within the last four decades) in water samples from six wells into the main aquifer at Los Alamos (EARE 1995b). In three of the locations involving the main aquifer, the results are unambiguous. The levels measured range from less than 2% to less than 0.01% of current drinking water standards, and all are less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

The locations where tritium measurements clearly indicate the presence of recent surface recharge to the main aquifer are (1) Test Well 1, situated in Pueblo Canyon near the confluence with Los Alamos Canyon; (2) in old observation and water supply wells LA-1A and LA-2, located in Los Alamos Canyon near its confluence with the Rio Grande; and (3) at Test Well 8, in Mortandad Canyon, located about a mile downstream from the outfall of TA-50, the radioactive liquid waste treatment plant for the Laboratory.

In two other main aquifer locations, the trace-level tritium results were questionable and required further investigation, starting with resampling incorporating meticulous quality assurance, to determine whether the results are real or an artifact of sampling or analysis error. The first of the ambiguous locations is at Supply Well PM-3, discussed in the previous section. The second of the questionable measurements is at Test Well 4, on the mesa east of Acid Canyon in the Los Alamos townsite.

The four intermediate-depth perched groundwater locations having trace-level tritium results demonstrating recent recharge include Test Well 2A in the middle reach of Pueblo Canyon, Test Well 1A in lower Pueblo Canyon, Well LADP-3 in mid-Los Alamos Canyon, and Basalt Spring in lower Los Alamos Canyon. The results at Test Wells 1A and 2A and Basalt Spring are consistent with other chemical quality observations extending back into the 1960s. This work was done by the USGS when they were performing groundwater monitoring for the Laboratory. Well LADP-3 was drilled in Los Alamos Canyon in 1993 as part of the Environmental Restoration Project investigations. Well LADP-3 is down gradient from the Omega West Reactor, which was discovered in 1993 to have been leaking tritiated cooling water for some time (EARE 1995b; see Section VII.E.3).

Test Well 1, Test Well 1A, and Basalt Spring. Test Well 1 is located in Pueblo Canyon near its confluence with Los Alamos Canyon. One sample was taken in August of 1992, with a result of about 350 pCi/L; the second sample was taken in May 1993, also with a result of about 350 pCi/L. Other information and observations since 1991 had indicated a suspected communication with the adjacent shallower test well, Test Well 1A, and Basalt Spring located further east in Los Alamos Canyon. Both wells were drilled in 1949 by cable tool, Test Well 1A to a depth of 69 m (225 ft) penetrating the intermediate-depth perched groundwater body in the basalts lying between the tuff and the main aquifer, and Test Well 1 to a depth of 196 m (642 ft) penetrating the top of the main aquifer in the Puye conglomerate.

The intermediate perched groundwater at Test Well 1A and Basalt Spring has long been known to be affected by effluents discharged into Pueblo Canyon, starting with measurements made by the USGS in the 1950s and 1960s. Starting in 1991 indications of unexpectedly high water levels in Test Well 1 and some chemical quality data suggested a downward communication of water from the intermediate perched groundwater sampled by Test Well

1A to the main aquifer penetrated by Test Well 1. Results of those initial investigations were reported in the "Environmental Surveillance at Los Alamos during 1991." The trace-level tritium samples were collected to help understand the potential problem. The two consistent results indicate the suspected problem does exist. One possible route of communication is along the ungrouted, cable-tool installed casings. The other possibility is a downward movement through the rock beneath the canyon.

Carbon-14 measurements on samples from both Test Well 1 and 1A (Table VII-6) show the definite presence of recent contamination from nonmeteoric sources because the carbon-14 levels are much higher than are found in atmospheric precipitation.

Test Well 2 and 2A. A similar paired-well situation occurs upstream (further west) in Pueblo Canyon. These are Test Wells 2A and 2, reaching to the intermediate perched groundwater and the main aquifer respectively. Samples from those wells in October 1992 and May 1992 showed the presence of tritium in Test Well 2A, as expected from previous routine environmental monitoring. (The level in Test Well 2A was about 2,200 pCi/L, which is consistent with previously reported levels and measurements made in 1992 and 1993.) Test Well 2 showed no measurable tritium in the 1992 sample, and a result just at the detection limit for the 1993 sample.

The carbon-14 sample for Test Well 2 resulted in a meaningless (negative) minimum estimated age, which could indicate either a lack of understanding of carbonate geochemistry or a possible recharge of recent water. This is taken as an indication that the seal around Test Well 2 is adequate to prevent significant downward movement in the well bore (even though it was installed by cable tool), but there may be a very small amount of recent recharge occurring.

Test Well 4. Test Well 4 is located on a mesa east of the former radioactive liquid effluent discharge points into Acid Canyon (untreated discharge from original TA-1 between 1944 and 1951, and treated effluents from the former liquid waste treatment plant at TA-45 from 1951 to 1964). It had been capped and out of service for about 20 years until the fall of 1992 when it was refurbished and equipped with a new pump. This operation included the introduction of some surface water for cleaning and priming the pump. The well is about 366 m (1,200 ft) deep and only penetrates into the main aquifer a short distance. Water fills less than the bottom 3 m (10 ft) of the well, so it can only be pumped at a very slow rate.

The sample taken in May 1993 showed a concentration of about 11 pCi/L. In November 1993, the University of Miami reported reanalysis of previously unused portions of the May 1993 sample from Test Well 4. The result for Test Well 4 was unchanged, at about 11 pCi/L. Other data (e.g., temperature) suggests there is some doubt that the well was pumped long enough to completely purge any introduced water, which constitutes a possible source of tritium.

The carbon-14 measurement of the sample from Test Well 4 indicates the possibility of recent recharge; the result is not conclusive because part of the interpretation requires an assumption to determine the amount of carbon isotope dilution that might occur as carbonates dissolve from rocks.

Pueblo of San Ildefonso Wells. Tritium was detected in two of three old water supply and observation wells, located in lower Los Alamos Canyon near its confluence with the Rio Grande. These wells have screened intervals starting at depths not far below the canyon alluvium. The tritium observed at these locations could be attributed to infiltration through the canyon alluvium of water containing both past Laboratory releases (from Acid-Pueblo Canyon and from DP-Site and other Los Alamos Canyon sources) and precipitation containing atmospheric weapons testing fallout.

Supply Well LA-1B (Figure IV-5) completed in 1960, is cased to 534 m (1,750 ft) with screens starting at 99 m (326 ft). Its construction included 20 m (64 ft) of surface casing set through the alluvium and cemented. This well showed no measurable tritium in samples collected in October of 1991 and May of 1993. The carbon-14 and tritium ages for LA-1B are in agreement, indicating water ages exceeding 30,000 to 40,000 years, and showing no component of recent recharge. This is consistent with the well construction method that would be expected to seal out infiltration along the wellbore, and the greater depth of the well screen within the main aquifer Santa Fe Group formations.

Two other Los Alamos canyon wells showed trace-level tritium detections. Observation Well LA-1A was constructed in 1946, as part of the USGS water supply investigations. This well is about 122 m (400 ft) deep, penetrating about 27 m (78 ft) of channel alluvium and then into the main aquifer formations; the well originally flowed under artesian pressure. Neither the completion method nor the depth of any perforations are documented, and the well casing is believed to not be grouted. The tritium content of the May 1993 sample was 64 pCi/L. This tritium value is similar to the range of recent rainfall levels in the Los Alamos area, of about 20 to 450 pCi/L

(Adams 1995) and indicates recent recharge from the surface. This analysis is suspect, as the sample may not be representative of the groundwater composition: the sample was collected using a bailer, and the well was not purged first. The chemical analyses of another sample collected a week later, after pumping the well, was significantly different from the first. However, the second sample was not analyzed for trace-level tritium.

The second result is from former supply well LA-2 (Figure IV-5), completed to a depth of 269 m (882 ft) in 1946; penetrating about 18 m (60 ft) of alluvium and then into the Santa Fe group. Screens or slotted casing start at 32 m (105 ft) depth. The tritium content of the May 1993 sample from LA-2 was 13 pCi/L. Because of the construction of these wells and their shallow depth of first screen it is not surprising to expect at least some downward movement of surface water.

The carbon-14 and tritium ages for Wells LA-1A and LA-2 are inconsistent. The radiocarbon ages range from about 6,000 to 16,000 years, while the tritium ages are about 20 to 400 years. The radiocarbon ages for Wells LA-1A and LA-2 are sharply lower than that for Well LA-1B, which is apparently unaffected by recent recharge. The presence of trace levels of tritium in Wells LA-1A and LA-2 indicates some component of recent recharge. One explanation for the different ages for carbon-14 and tritium might be that mixing of younger and older water has less of an effect on the radiocarbon age than the tritium age, as a result of the large difference in half-lives of these two isotopes. The addition of a small amount of surface water to much older main aquifer water would significantly raise the amount of the shorter-lived tritium, sharply decreasing the apparent tritium age. On the other hand, this dilution would only increase the component of the longer-lived carbon-14 a little, with a smaller effect on the carbon-14 age.

Radiocarbon and tritium ages were obtained for four other water supply wells at the Pueblo of San Ildefonso. The tritium ages for the wells are all greater than 1,500 years. The Pajarito Pump No. 2 has the smallest radiocarbon age, from 1,280 to 9,700 years. This well was found during 1994 to have a significant NO_3-N (nitrate as nitrogen) concentration, of 19 mg/L (See Section VII.E.5). Nitrate contamination is usually attributed to recharge from septic systems, feedlots, or fertilizers, and is common in wells in the Española Valley and in other agricultural areas. The presence of high NO_3-N and the lower radiocarbon age for the Pajarito Well Pump No. 2 suggest a significant component of recent surface recharge. This well is located along the Rio Grande, north of the confluence with Los Alamos Canyon (see Figure IV-5).

Three other wells had much greater radiocarbon ages: the East and West Artesian Wells and the Halladay House Well. The East and West Artesian Wells had some nitrate contamination in 1994, again suggesting that a small component of recent surface recharge has mixed with a larger quantity of much older water. These wells are also located along the Rio Grande, north of the confluence with Los Alamos Canyon.

The Halladay House Well had a very low NO_3-N concentration of 1.1 mg/L, which suggests little surface contamination. This well was sampled in February 1992 and May 1993, with both results showing no measurable tritium. This is consistent with the chemical quality of the well, which is similar to other main aquifer waters, and its location is far enough away from the stream channel within Los Alamos Canyon as to be unlikely to penetrate any saturated alluvium.

Future Work. Additional sampling of groundwater for trace-level tritium analyses is being planned. Continuing discussions with the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez and the Pueblo Office of Environmental Protection are expected to lead to a major sampling effort. This sampling will include groundwater sources on and adjacent to the pueblos that have not previously been analyzed for trace-level tritium. Most of the groundwater sources in the vicinity of Los Alamos will be resampled to add confidence to the validity of the measurements.

e. Trace-Level Tritium Results for the White Rock Canyon Springs (David Rogers and Alan Stoker, ESH-18; Fraser Goff, EES-1; and Andrew Adams, CST-7)**.** Most of the White Rock Canyon Springs and some surface waters were sampled for trace-level tritium in 1994 (Tables VII-8 and VII-9). For the most part, the 1994 results for the springs are similar to earlier measurements (EPG 1994). In general, the values are much lower than the tritium content of contemporary precipitation in the Los Alamos vicinity (from 20 to 450 pCi/L [Adams 1995]). The highest 1994 White Rock Canyon tritium value is 15.4 pCi/L for Spring 4 and could indicate mixing with rainwater; other values are generally below 5 pCi/L.

For Doe Spring in Chaquehui Canyon, the 1990 tritium value was about 18 pCi/L. This relatively high value was attributed to mixing with rainwater at the collection point. The 1994 value for Doe Spring was 2.2 pCi/L. Except for the 1990 Doe Spring sample, the 1990–91 White Rock Canyon Spring tritium values imply maximum tritium

Table VII-8. White Rock Canyon Springs Trace-Level Tritium Measurements

Location	September 90 pCi/L	± [a]	October 91 pCi/L	±	September 94 pCi/L	±
White Rock Canyon Springs Group I						
Sandia Spring					0.52	0.29
Spring 3	3.40	0.29	1.65	0.39	2.20	0.29
Spring 3A					2.75	0.32
Spring 3AA					0.29	0.32
Spring 4					15.4	0.55
Spring 4A			2.40	0.39	1.39	0.39
Spring 5					0.39	0.29
Ancho Spring	3.40	0.29	4.21	0.36	1.78	0.32
White Rock Canyon Springs Group II						
Spring 5A					4.05	0.32
Spring 5B					4.67	0.42
Spring 6			1.78	0.32	6.80	0.42
Spring 6A	0.06	0.29	0.03	0.29	0.39	0.29
Spring 7	1.46	0.29	2.10	0.29	1.30	0.29
Spring 8	5.83	0.29	7.09	0.55	4.54	0.32
Spring 8B	4.66	0.29			2.04	0.39
Spring 9					1.04	0.42
Spring 9A			1.78	0.29	2.69	0.32
Doe Spring	17.71	0.58			2.24	0.32
Chaquehui Spring					3.73	0.39
Spring 10					3.76	0.32
White Rock Canyon Springs Group III						
Spring 1					0.87	0.29
Spring 2			4.21	0.36	3.82	0.32
White Rock Canyon Springs Group IV						
Spring 3B	0.91	0.29	0.13	0.29	0.84	0.29

[a]The ± values represent one standard deviation of the uncertainty of measurement. The University of Miami detection limit is 1 pCi/L (0.3 TU); 1 TU = 3.24 pCi/L.

ages greater than 750 years (Spring 8 in 1991). The 1990 and 1991 Ancho Spring tritium values imply maximum ages of 1,750 and 1,500 years; ages for other springs are greater (Blake 1995).

The low tritium values and large apparent ages for water from the White Rock Canyon Springs are consistent with the view that many of these springs are discharging directly from the main aquifer (Purtymun 1980b). This hypothesis is further supported by indications from stable isotope (deuterium and oxygen-18) evaluations that the White Rock Canyon Springs are recharged at significantly higher elevations than the spring locations. The mean recharge elevation for the springs is about 2,234 ± 104 m (7,330 ± 460 ft), while the average discharge elevation is about 1,649 m (5,410 ft). These recharge elevations suggest that the White Rock Canyon Springs are recharged from the Pajarito Plateau or other upland areas within the Rio Grande Rift, but not from the Jemez or Sangre de Cristo Mountains (Blake 1995).

Two streams near White Rock Canyon were also evaluated for trace-level tritium. The tritium value for Pajarito Creek (Table VII-9) was about 2 pCi/L. This might reflect a strong component of discharge from springs feeding the creek (Spring 4A), with little contribution from rainwater. The tritium concentrations for Frijoles Creek (21 to 29 pCi/L) suggest a large contribution from contemporary precipitation.

2. Main Aquifer Hydrologic Properties. (Stephen McLin, ESH-18)

a. Measurement of Main Aquifer Water Levels. In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the main aquifer below Pajarito Plateau and in

Table VII-9. Trace-Level Tritium Measurements in Groundwater and Surface Water

Location	Sample Date	Tritium Units Tritium	± [a]	pCi/L Tritium	±
White Rock Canyon Surface Water					
Pajarito Creek	09/28/94	0.61	0.11	1.98	0.36
Frijoles Creek	09/29/94	6.54	0.22	21.2	0.71
Frijoles Creek	09/29/94	8.89	0.29	28.8	0.94
L***os Alamos Canyon Alluvial Groundwater***					
LAO-B	10/19/94	20.2	0.7	65.4	2.3
LAO-C	10/31/94	20.9	0.7	67.7	2.3
LAO-0.3	10/19/94	27.1	0.9	87.8	3.0
LAO-0.6	10/20/94	155	5	502	16
LAO-0.8	10/26/94	50.5	1.7	164	5.5
LAO-R1	10/25/94	444	15	1,440	49
LAO-0.91	10/25/94	144	5	467	16
LAO-1	10/24/94	158	5	512	16
L***os Alamos Canyon Surface Water***					
SW-1	10/19/94	24.2	0.8	78.4	2.6
SW-2	10/20/94	26.8	0.9	86.8	2.9
SW-3	10/20/94	29.3	1	94.9	3.2
SW-4	10/24/94	115.3	3.8	374	12
SW-5	10/26/94	132	4	428	13
L***os Alamos Canyon Intermediate-Depth Groundwater***					
LAOIA-1.1 Guaje	10/28/94	8.34	0.29	27.0	0.94
LAOIA-1.1 Puye	10/28/94	2.89	0.12	9.36	0.39
LAOIA-1.1 Guaje	11/17/94	0.24	0.11	0.78	0.36

[a]The ± values represent one standard deviation of the uncertainty of measurement. The University of Miami detection limit is 1 pCi/L (0.3 TU); 1 TU = 3.24 pCi/L.

various other monitoring wells throughout the facility. These data are automatically recorded at hourly intervals using calibrated pressure transducers. Table VII-10 summarizes the locations, start and end dates, and final water levels recorded during 1994. These same data are also presented in greater detail in the forthcoming Laboratory report entitled, "Water Supply at Los Alamos during 1994." Previous environmental surveillance and water supply reports contain additional historical water level data that are not reported here.

b. TA-49 Barometric and Earth Tide Monitoring Station. Two test holes were cored along the eastern edge of TA-49 near Test Well DT-10 during the week of May 18, 1993; locations are shown in Figure VII-5. These test wells were completed into the upper units of the Tshirege Member of the Bandelier Tuff. The first test hole, TBM-1, was cored to 42 m (138 ft) below the surface and penetrated Units 3 through 6; these geologic units were previously described by Weir and Purtymun (1962). Figure VII-6a depicts the geology, while Figure VII-6b shows the borehole completion. Test hole TBM-1 was constructed to measure barometric pressure fluctuations in the unsaturated Bandelier Tuff, including atmospheric pressure lags at varying depths as weather fronts pass over Pajarito Plateau. As seen in Figure VII-6b, three barometric pressure (BP) transducers were attached to each of the one-half inch diameter PVC pipes, and one BP transducer was open to the surface atmosphere. These BP transducers record fluctuations in barometric pressure at hourly intervals. A more detailed analysis of the BP data will be presented in a special report once a sufficiently long record has been collected.

Test hole TBM-2 was constructed within about 2.4 m (8 ft) of test hole TBM-1. However, TBM-2 was equipped with an Applied Geomechanics, Inc., Model 510 Geodetic Biaxial Tiltmeter. Borehole completion is shown in Figure VII-7. This borehole tiltmeter senses angular movement with respect to the vertical gravity vector using two extremely sensitive electrolytic tilt sensors, which are monitored hourly. These sensors measure rotations in two orthogonal vertical planes; the vector sum of these rotations in both planes yields the direction and magnitude of rotation of the tiltmeter. Tilt resolution is less than 10 nanoradians. Hence, the effects of earth tides associated

Table VII-10. Wells Equipped with Recording Transducers in 1994

Well	Start Date	End Date	Water Depth (ft)	Elevation (ft)
Main Aquifer Test Wells				
TW-1	01/01/94	12/31/94	548.70[a]	5,819.48[b]
TW-2	01/01/94	12/31/94	798.25	5,850.51
TW-3	01/14/94	12/31/94	780.80	5,816.81
TW-4	01/01/94	12/31/94	1,176.89	6,069.44
TW-8	01/11/94	12/31/94	993.11	5,884.92
DT-5A	01/01/94	09/11/94	1,183.65	5,960.98
DT-9	01/01/94	11/28/94	1,116.31	5,920.40
DT-10	01/01/94	09/20/94	1,097.21	5,922.71
Pueblo of San Ildefonso Main Aquifer Test Well				
LA-1B	01/01/94	12/31/94	artesian	5,634.72[c]
LA-1A	12/22/94	12/31/94	artesian	TOC[d]
Municipal Water Supply Well				
PM-1	04/30/94	12/31/94	755.48	5,766.02
PM-3	12/22/94	12/31/94	769.44	5,871.81
Otowi-1	12/22/94	12/31/94	677.23	5,721.52
Intermediate Perched Zone Wells				
TW-1A	01/01/94	12/31/94	194.39	6,176.83
TW-2A	01/12/94	12/31/94	113.50	6,539.86
LADP-3	05/06/94	10/28/94	323.21	6,434.79
Alluvial Canyon Wells				
LAO-C	07/10/94	10/28/94	3.82	7,047.66
LAO-3	07/10/94	10/28/94	8.92	6,571.43
LAO-4	07/10/94	10/28/94	12.86	6,508.75
LAO-6A	07/10/94	10/28/94	15.66	6,382.74
APCO-1	01/12/94	11/10/94	6.62	6,361.57
MCO-6B	01/01/94	11/28/94	33.34	6,817.62
MCO-5	01/01/93	12/01/93	20.67	6,856.75
PCO-1	07/13/93	10/26/93	12.19	6,675.58
PCO-2	07/13/93	10/26/93	10.14	6,608.95
PCO-3	07/13/93	09/04/93	7.17	6,539.99
Other Wells:				
SHB-3	12/22/94	12/31/94	664.46	6,943.79
CH-2	01/01/94	12/31/94	493.33	6,651.12

[a]Depth to water (ft) measured below top of casing on end date.
[b]Water elevation (ft) relative to mean sea level (MSL) on end date.
[c]Overflow drain-pipe elevation is about 5,616 ft above MSL; top-of-pipe elevation is about 5,622 ft above MSL. Water levels were recorded using a mechanical packer set below the overflow pipe.
[d]TOC = Top of Casing reference point.

with the lunar and solar bodies on rock deflections can be measured directly. These measurement will assist in the interpretation of small water level fluctuations recorded in main aquifer test wells across Pajarito Plateau. A detailed analysis of these data will be released once sufficient tiltmeter data has been assembled.

c. Water Production Records. Monthly water production records are provided to the State Engineer's Office under the water rights permit held by DOE for the Los Alamos water system. During 1994, total production from 10 water supply wells and the Water Canyon Gallery for potable and nonpotable use was 5.44 x 10^6 m^3 (1.438 billion gal. or 4,412 ac ft). This production amounts to 80% of the total diversion right of 6.8 x 10^6 m^3

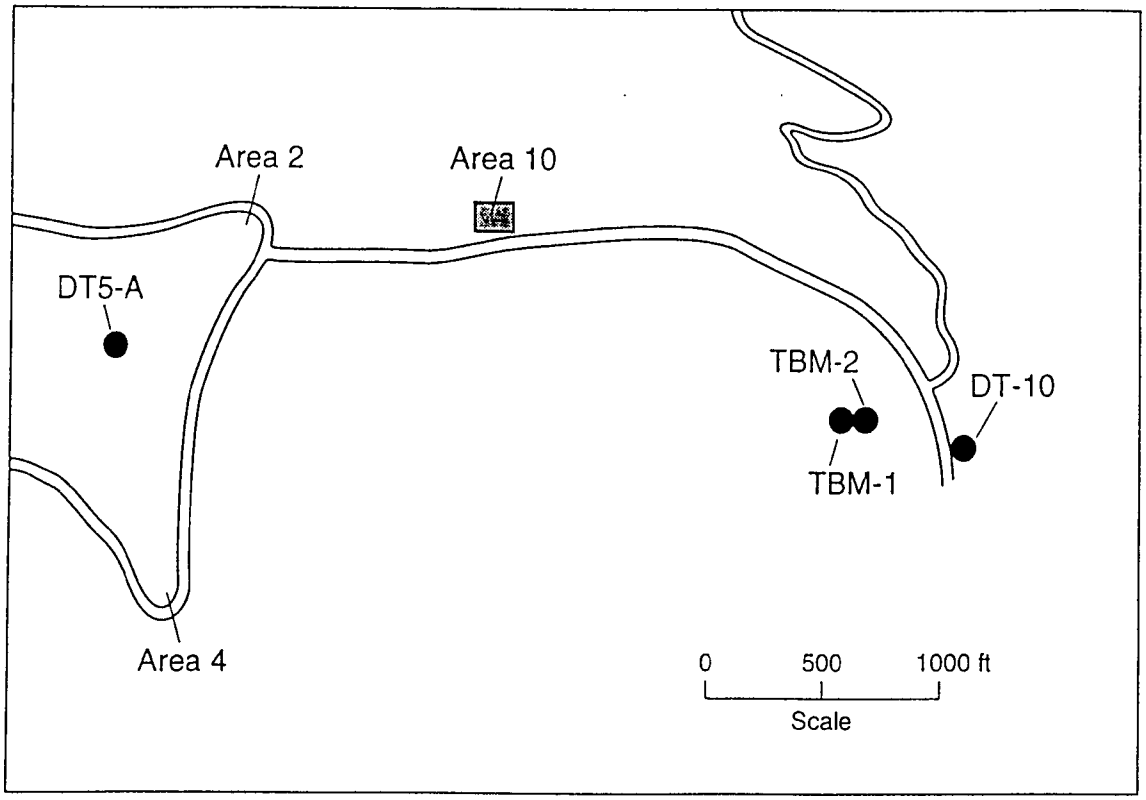

Figure VII-5. Locations of test holes TBM-1 and TBM-2 at TA-49.

(5,541 ac ft) that is available to the DOE under its permit. Details of the performance of the water supply wells (pumpage, water levels, drawdown, and specific yield) and their operation are published in a series of separate reports, the most recent of which is entitled "Water Supply at Los Alamos during 1993" (Purtymun 1995b).

3. Omega West Reactor Leak. (David Rogers, ESH-18; Patrick Longmire and Andrew Adams, CST-7)

In "Environmental Surveillance at Los Alamos during 1993" (EARE 1995b) we reported the discovery of a leak in the cooling system at the Omega West Reactor, TA-2 (location in Figure VII-8), during early January 1993. The reactor coolant water contained high tritium levels because it absorbs neutrons during its passage through the reactor core. At that time, the reactor operators determined that the cooling system was losing water at a rate of approximately 288 L/day (75 gal./day). Preliminary screening indicated that tritium was the primary contaminant of concern, and that other radionuclides were not released to the environment in significant levels. Data from water samples indicated that water containing higher levels of tritium remained within the Laboratory boundary. Following removal of the fuel elements from the reactor and draining of the cooling system, the leak ceased on March 18, 1993. The tritium leak was isolated in the cooling system delay line, located immediately west of the Omega West Reactor building.

During high stream flow, groundwater infiltrates into the basement of the reactor building. This groundwater is discharged through a sump outlet southeast of the reactor building, into the surface drainage of Los Alamos Canyon. On January 30 and 31, 1993, the groundwater tritium concentration in the reactor building basement was between 100,000 and 120,000 pCi/L (OWR 1993). Tritium concentrations in the wells and surface water stations just downstream from the reactor continued to fall after the leak was shut off on March 18, 1993: from 69,200 to 400 pCi/L for the wells, and from 21,700 to 200 pCi/L for the surface water stations (EARE 1995b).

An analysis of historical tritium levels in Los Alamos Canyon surface water and groundwater (EARE 1995b) showed that tritium concentrations since 1970 for alluvial Observation Well LAO-1 (Figure VII-8) had remained

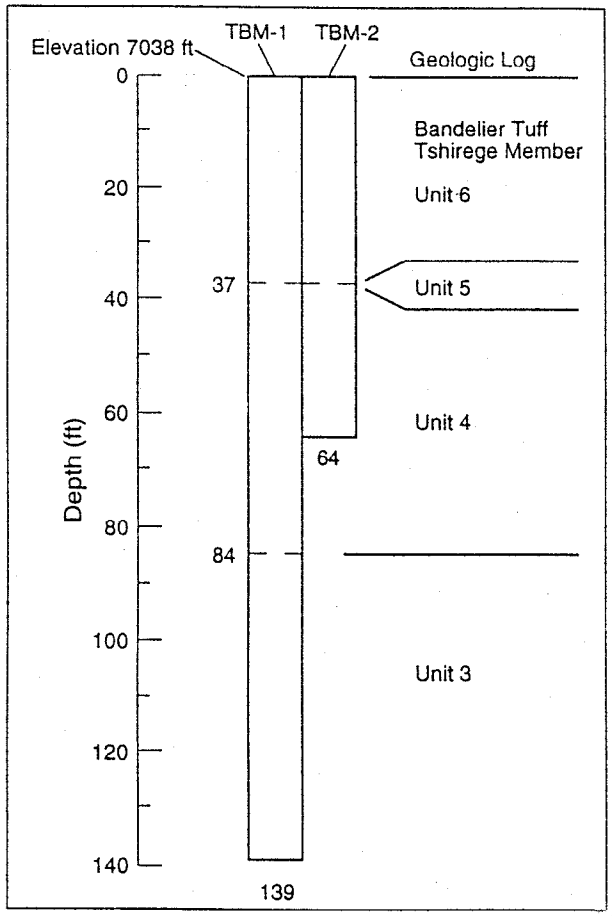

Figure VII-6a. Geologic logs of test holes TBM-1 and TBM-2 at TA-49.

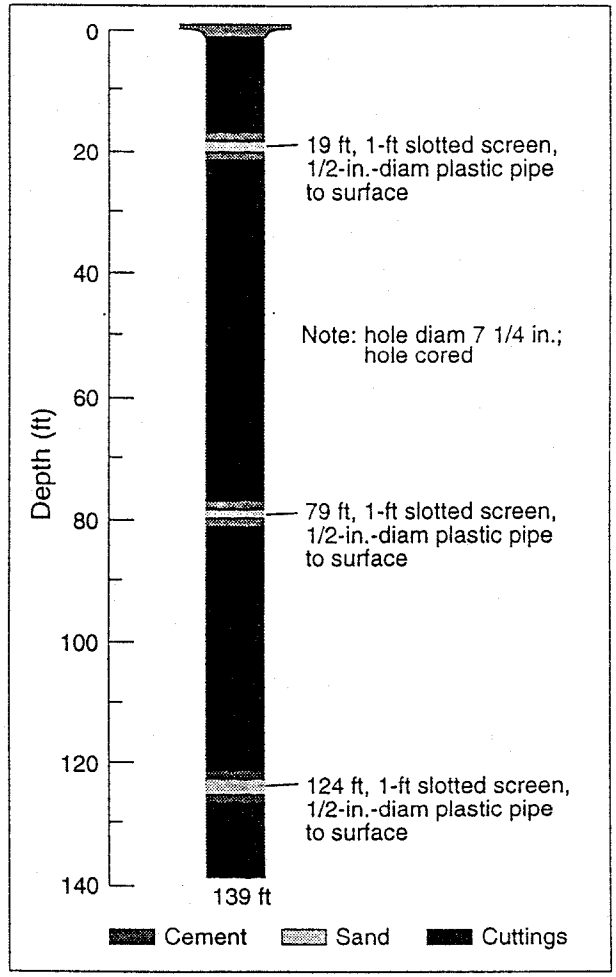

Figure VII-6b. Test hole TBM-1 constructed with three zones to measure barometric pressures in the tuff at depths of 19, 79, and 124 ft.

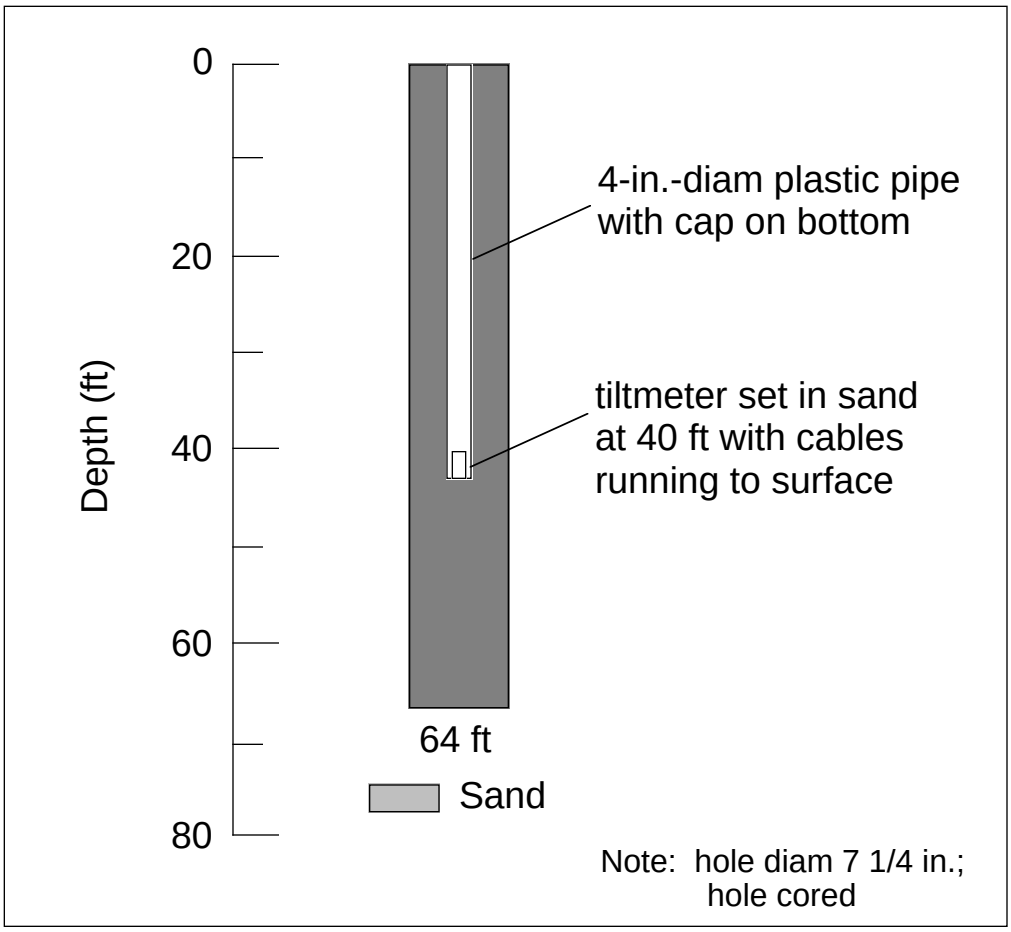

Figure VII-7. Test hole TBM-2 equipped with a biaxial tiltmeter to measure deformation of the tuff at 40 ft.

approximately constant, at about 10,000 pCi/L. Well LAO-1 is located just downstream from the reactor. This tritium concentration is a factor of 10 higher than both the tritium concentrations at the upstream Well LAO-C, and the tritium concentrations observed in downstream alluvial observation Wells LAO-2, -3, -4, and -4.5 in the early 1990s. In the early 1990s, the tritium concentrations in upstream Well LAO-C remained slightly above the detection limit, of about 300 to 700 pCi/L, for the EPA-specified liquid scintillation counting method. The steady tritium concentrations at Well LAO-1 suggest the pressure of a constant source of tritium immediately upstream, which is consistent with a steady leakage of cooling water from the Omega West Reactor since it began operation in 1956. The tritium concentration in Well LAO-1 had declined to 1,300 pCi/L on June 23, 1993, suggesting that the Omega West Reactor was no longer leaking tritiated water into Los Alamos Canyon.

Table VII-9 and Figure VII-8 show recent trace-level tritium measurements on Los Alamos Canyon groundwater and the Los Alamos Canyon stream, carried out as part of the Laboratory's Environmental Restoration Project. The trace-level tritium measurements employed by this study were performed at the University of Miami and have a detection limit of about 1 pCi/L (see Section VII.E.1 for a discussion of other trace-level tritium measurements).

The 1994 groundwater data show that upstream of TA-41, tritium concentrations found in Wells LAO-B, LAO-C, and LAO-0.3 are consistent with contemporary rainfall tritium levels (from 20 to 450 pCi/L [Adams 1995]) in the Los Alamos vicinity. The tritium concentration in Well LAO-C was 68 pCi/L. This is consistent with previously reported values, which were slightly above the standard scintillation technique detection limit, of about 300-700 pCi/L.

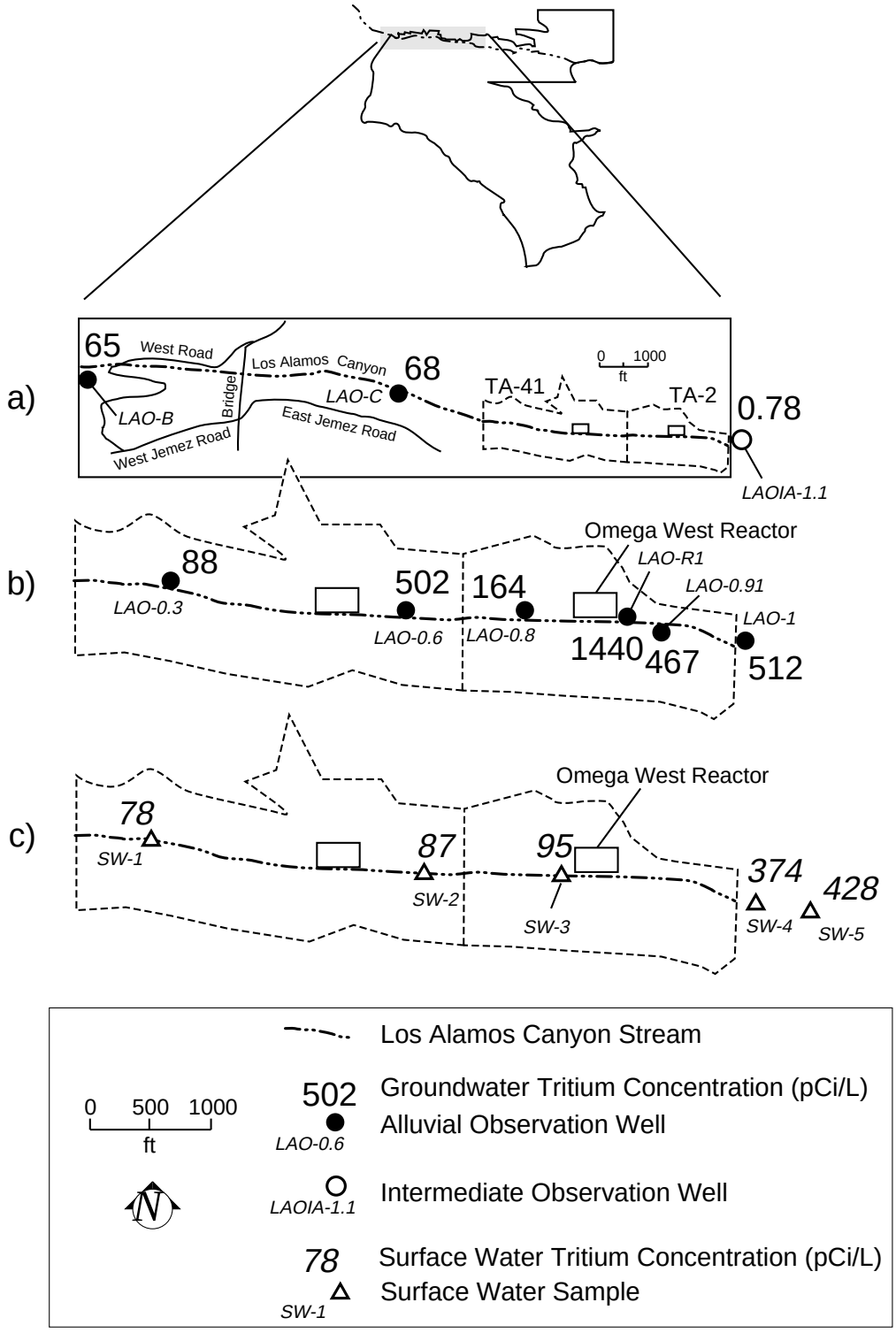

Figure VII-8. Map of Los Alamos Canyon showing locations of TA-2 and TA-41, the Omega West Reactor, alluvial and intermediate-depth observation wells, surface water stations, and trace-level tritium concentrations: (a) background groundwater tritium levels; (b) groundwater tritium levels near TA-2 and TA-41; (c) surface water tritium levels near TA-2 and TA-41.

A tritium concentration of 502 pCi/L at LAO-0.6 suggests that the main building at TA-41 could be a recent or present tritium source. This building is used for the development and testing of weapons systems. The facility has used major amounts of tritium in the past, and tritium releases have included major stack discharges and leaks of tritium into the septic system. Proceeding downstream from the main building at TA-41, Well LAO-0.8 shows a lower tritium concentration of 164 pCi/L.

Tritium concentrations in Well LAO-R1, just downstream from the Omega West Reactor, were about 70,000 pCi/L after discovery of the reactor leak in January 1993, and declined to about 1,400 pCi/L by July 1993. In October 1994, Wells LAO-R1 and LAO-0.91 had tritium values of 1,440 and 467 pCi/L. The tritium concentration for alluvial observation Well LAO-1, downstream of the Omega West Reactor has sharply decreased from about 10,000 pCi/L prior to 1993, to 1,300 pCi/L on June 23, 1993, and to a 1994 value of 512 pCi/L. The results for Wells LAO-R1, LAO-0.91, and LAO-1 suggest that, even though the reactor leak has ceased, tritium previously leaked in the area of the reactor building is continuing to disperse as a result of mixing and dilution by groundwater flowing down the canyon.

Surface water tritium values from five locations (Figure VII-8) confirm the picture of tritium derived from the alluvial well data. Tritium levels in the Los Alamos Canyon stream above the Omega West Reactor range from 78 to 95 pCi/L, and are in the range of contemporary rainfall tritium levels in the Los Alamos area. No increase of tritium occurs in the stream in the TA-41 area. For two surface water stations downstream from the Omega West Reactor, tritium values are 374 and 428 pCi/L. These tritium levels are similar to values in nearby alluvial Wells LAO-0.91, and LAO-1. This similarity in tritium levels between the groundwater and surface water suggests that there is rapid communication and mixing between the two water bodies, and that tritium is being rapidly diluted and carried away from the area of the Omega West Reactor.

The 1994 environmental surveillance data (discussed in Section VII.C.1.b) have a much higher detection limit (of about 300 to 700 pCi/L, for the EPA-specified liquid scintillation counting method) than the trace-level detection limit data. Nonetheless, with the larger analytical uncertainty taken into consideration, the surveillance data are in general agreement with the trace-level detection limit data described in this section.

The intermediate-depth Well LAO-IA-1.1 (depth about 98 m [323 ft]) was drilled within the Guaje Mountain fault zone about 305 m (1,000 ft) downstream from the Omega West Reactor during 1994. This borehole found 7 m (22 ft) of perched water in the Guaje Pumice Bed below 89.6 m (294 ft), but the tritium concentration was at background levels. The water initially pumped from the well had a tritium concentration of 27 pCi/L in the Guaje Pumice Bed, and 9 pCi/L in the underlying Puye Formation. This tritium could have been the result of downward leakage of stream water or rainwater during well construction. A second sample from the Guaje Pumice Bed, taken November 17, 1994, after well construction was finished, found no detectable tritium at that level. This lack of tritium suggests that tritium has not infiltrated much beneath the canyon bottom at this point, although tritium has been found within the Guaje Pumice Bed at Well LADP-3, about 1,067 m (3,500 ft) farther downstream. Borehole LADP-3 penetrated 20 m (65 ft) of alluvium and 74 m (243 ft) of the Otowi Member (Broxton 1995). Tritium (5,500 pCi/L) was found in perched groundwater at 99 m (325 ft) in the underlying Guaje Pumice Bed.

4. Trace-Level Mass Spectroscopic Analysis of Plutonium and Uranium. (David Rogers, Alan Stoker, and Bruce Gallaher, ESH-18)

Another extremely sensitive analytical chemistry technique is being evaluated for applicability to samples from groundwater and sediment sources. The method is trace-level mass spectroscopy for isotopes of uranium and plutonium. The isotopic uranium analyses of groundwater should provide much higher confidence levels in determining whether the observed uranium in groundwater is from entirely natural sources or contains some anthropogenic components. The trace-level mass spectrometry analyses for plutonium should provide both lower detection limits (better by several orders of magnitude) as well as isotopic ratio information that can distinguish between various sources such as worldwide fallout or specific effluent sources. A large number of groundwater and sediment samples have been collected and submitted to the ultra-clean mass spectroscopy facility at the Chemical Sciences and Technology Division for analysis. At the present time the analysis of these samples is incomplete.

5. Nitrate Levels at the Pueblo of San Ildefonso and Los Alamos-Pueblo Canyons. (David Rogers, ESH-18)

High nitrate values were found in analyses of water samples collected at several water supply wells at the Pueblo of San Ildefonso during 1994 (Table VII-11). (Nitrate values are reported here in terms of nitrate as nitrogen; the concentration of nitrate is 4.427 times the concentration of nitrogen.) Once the laboratory results

were verified, the Water Quality and Hydrology Group (ESH-18) notified the DOE of this discovery on March 27, 1995, and the DOE notified at the Pueblo of San Ildefonso immediately.

Nitrate levels exceeding the EPA primary drinking water MCL of 10 mg/L (nitrate as nitrogen) are a public health concern because of the potential for methemoglobinemia in small children. The hemoglobin of small children is not sufficiently developed, so nitrate can interfere with their oxygen supply resulting in suffocation, or blue-baby syndrome. High concentrations of nitrate are common in groundwater in rural areas, as a result of runoff and infiltration from feedlots, fertilizer use, and from septic systems (Hem 1989), and are a common problem in the Española Valley.

Several other high nitrate values were found in wells and a spring in Los Alamos and Pueblo Canyons (Table VII-11). The high nitrate values at several of these locations could arise from the Los Alamos County Bayo sew-

Table VII-11. Groundwater and Surface Water Nitrate Values (Nitrate as Nitrogen [mg/L])

Location	1988	1989	1990	1991	1992	1993	1994
San Ildefonso Wells							
Don Juan Playhouse				1.8		2.07	2.9
Eastside Artesian	2		1.8	<0.04		<0.04	8.6
Westside Artesian	<1	<0.1		<0.1		0.04	5.7
Halladay House	<1	0.5	1.4	0.5	0.54	0.61	1.1
Martinez House		0.2			8.36	9.54	15.8
Old Community			0.7				2.0
New Community	2				1.25	1.28	
Otowi House		0.6			0.26	0.33	10.8
Pajarito Pump No. 1	<1		0.4	0.1	0.17		7.7
Pajarito Pump No. 2		0.3	1.6		1.73	1.49	19.0
Sanchez House					0.85	1.07	9.5
San Ildefonso Springs							
La Mesita Spring	<0.2	2.2	4.4	1.4	2.65	2.91	5.8
Sacred Spring	<0.2	0.1	8.2	1.5	4.25	0.28	1.8
Indian Spring	0.7	0.7	0.8	0.5	0.42	0.88	0.83
Pueblo Canyon Surface Water							
Acid Weir	0.8	0.7	1.3	0.7	0.38	1.0	<0.04
Pueblo 1	<0.2	2.5	1.2	0.3	16.60	<0.04	<0.04
Pueblo 2	4.2	1.8	dry	dry	7.10	dry	dry
Pueblo 3	5.7	3.7	1.06	13.4	6.85	4.53	dry
Hamilton Bend Spring	dry	1.5	dry	dry	dry	dry	dry
Los Alamos/Pueblo Canyon Intermediate and Main Aquifer Groundwater							
TW-1	6			5.3	6.45	5.88	23.0
TW-1A	<0.2	2.7	0.0	2.9	1.82	5.78	19.4
TW-2A	<0.2	<0.1	1.4	<0.04	3.21	3.62	13.7
Basalt Spring	1.7	3.0	2.2	10.9	5.02	2.27	15
APCO-1					0.34	<0.04	1.8
Upper Los Alamos Canyon Groundwater							
LAO-3	1.5	0.4	0.6	0.4	0.30	0.15	0.22
LAO-4		<0.1	0.3	0.0	0.10	<0.04	<0.04
LAO-4.5		0.2	0.1	0.1		<0.04	<0.04
Lower Los Alamos Canyon Main Aquifer Groundwater							
LA1A						0.54	1.5
LA1B		0.5	0.5	0.5		0.69	6.3
Other							
TW-8	<0.2	0.3	0.2	<0.04		0.17	5.10

age treatment plant outfall. Infiltration to the intermediate perched and main aquifer groundwater has been shown to be relatively rapid beneath parts of Pueblo Canyon (see Section VII.E.1). This could explain nitrate levels at Test Wells 1, 1A, and 2A and Basalt Spring in Pueblo and Los Alamos Canyons. Further, Test Well 8 in Mortandad Canyon showed a large increase in nitrate. Nitrate is a common contaminant found in Mortandad Canyon alluvial groundwater, resulting from the treatment process at the TA-50 Radioactive Liquid Waste Treatment Plant.

Trace levels of tritium found in Test Well 8 in Mortandad Canyon and Test Wells 1, 1A, and 2A in Pueblo and Los Alamos Canyons also indicate the presence of recent recharge at these locations (see Section VII.E.1). Therefore, the presence of elevated nitrate levels is not surprising but tends to confirm the initial interpretation of the trace-level tritium discoveries in these wells.

The sudden increase in nitrate levels at several stations does suggest the possibility of laboratory or sampling error. The Inorganic Trace Analysis Group (CST-9) was asked to recheck all of their analytical procedures for these samples, and reported that the analyses all met quality control criteria. The possibility of field contamination of several samples cannot be ruled out.

The NMED/AIP collected duplicate samples at two stations, La Mesita and Basalt Spring on the same day as the ESH-18 samples (Table VII-12). The NMED/AIP value for La Mesita Spring (2.0 mg/L) is lower than the ESH–18 value (5.8 mg/L), but the disagreement is not great. For Basalt Spring, the NMED/AIP value (13.2 mg/L) compares well with the ESH-18 value (15 mg/L).

Table VII-12. 1994–95 Groundwater Nitrate Values (Nitrate as Nitrogen [mg/L])

	1994 Surveillance 7/27–7/28	1994 NMED/AIP 7/27–7/28	1995 Special Sampling 4/95	1995 Surveillance 5/24–5/25[a]
San Ildefonso Wells				
Don Juan Playhouse	2.9			
Eastside Artesian	8.6		2.00	
Westside Artesian	5.7			1.46
Halladay House	1.1			0.57
Martinez House	15.8		9.00	8.63
Old Community	2.0			
New Community				1.45
Otowi House	10.8			0.58
Pajarito Pump No. 1	7.7		0.20	0.21
Pajarito Pump No. 2	19.0			1.33
Sanchez House	9.5		0.90	0.95
San Ildefonso Springs				
La Mesita Spring	5.8	2.0		
Sacred Spring	1.8			1.29
Indian Spring	0.83			0.78
Los Alamos/Pueblo Canyon Intermediate and Main Aquifer Groundwater				
Basalt Spring	15	13.2	9.91[b]	2.27
			15.1[b]	
			9.7[b]	
Lower Los Alamos Canyon Main Aquifer Groundwater				
LA1A	1.5[c]			0.01
LA1B	6.3[c]			0.00

[a]Preliminary 1995 data subject to verification.
[b]Collected by EES-1 from three springs in the area of Basalt Spring.
[c]Samples collected August 2, 1994.

Preliminary 1995 ESH-18 special sampling data (Table VII-12) have shown lower nitrate values for four water supply wells at the Pueblo of San Ildefonso. Preliminary 1995 Surveillance data (Table VII-12) also give nitrate levels in line with those prior to 1994 (Table VII-11).

The possibility that nitrate and tritium are reaching the main aquifer at Test Well 8 beneath Mortandad Canyon is of great concern. Future testing of several of the test wells is planned, including time-series sampling of water drawn from the wells, to evaluate the possibility of well-bore leakage as a contamination source. This has also been suspected to be the cause of tritium contamination found in some wells (see Section VII.E.1.d).

VIII. Quality Assurance and Sampling Procedures

Quality assurance (QA) includes all of the planned and systematic actions and activities necessary to provide adequate confidence that a system or process will perform satisfactorily. Each monitoring and compliance activity sponsored by the Los Alamos National Laboratory's (LANL or the Laboratory) Environment, Safety, and Health (ESH) Division has its own quality assurance program (QAP) with documented sampling procedures. Each environmental chemistry and analysis activity of the Chemical Sciences and Technology (CST) Division also has documented QAPs for sample analysis and data verification.

A. Quality Assurance Program

Quality is the extent to which an item or activity meets or exceeds requirements. QA includes all the planned and systematic actions and activities necessary to provide adequate confidence that a facility, structure, system, component, or process will perform satisfactorily. In 1994, the Quality Assurance Support Group (ESH-14) provided support for QA functions at the Laboratory. ESH-14 performs QA and quality control (QC) audits and surveillance of Laboratory and subcontractor activities in accordance with the QAP for the Laboratory and for specific activities, as requested. The Laboratory's Internal Assessment Group (AA-2) manages an independent environmental appraisal and auditing program that verifies appropriate implementation of environmental requirements. The Quality and Planning Program Office provides management and coordination of the effort to become a customer-focused unified Laboratory. This office launched a number of initiatives in continuous improvement, including a Quality Council, quality awareness training, staff-level continuous quality improvement (CQI) teams, and management-initiated "re-engineering" teams aimed at the Laboratory's core processes.

Each monitoring activity sponsored by the ESH Division has its own QAP. QAPs are unique to activities but are guided by the need to establish policies, requirements, and guidelines for the effective implementation of regulatory requirements and to meet the requirements of US Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and 5700.6C (DOE 1991b). Each QAP must address the following criteria.

- Management
  program
  personnel training and qualification
  quality improvement
  documents and records
- Performance
  work processes
  design
  procurement
  inspection and acceptance training
- Assessment
  management assessment
  independent assessment

QAPs for each environmental monitoring program performed by groups in ESH Division have been included in the current Environmental Monitoring Plan (EMP) (EARE 1995a). The EMP is reviewed every year and revised every three years. The QAPs will be revised under DOE Order 5700.6C within two years. (ESH-14 distributed the QA Guidebook and Reference Manuals to Laboratory managers in 1993.)

B. Sampling Procedures

1. Thermoluminescent Dosimeters.

Thermoluminescent dosimeters (TLDs) used at the Laboratory are composed of lithium fluoride (LiF) crystals in the form of 6.4-mm-square by 0.9-mm-thick chips. After exposure to external penetrating radiation, TLDs emit

light when heated under laboratory conditions. The amount of light released is proportional to the amount of radiation absorbed by the TLD. The LiF TLDs used in the Laboratory's environmental monitoring program are insensitive to neutrons, so the contribution of cosmic neutrons to natural background radiation is not included in the exposure determined with LANL TLDs.

The chips are annealed at 400°C (752°F) for 1 hour and then cooled rapidly to room temperature. This is followed by annealing at 100°C (212°F) for 1 hour and again cooling rapidly to room temperature. For the annealing conditions to be repeatable, chips are put into rectangular borosilicate glass vials that each hold 48 LiF chips. These vials are placed in a borosilicate glass rack so that all vials in a batch can be simultaneously placed in the annealing ovens.

Each dosimeter contains four LiF chips, which are enclosed in a two-part threaded assembly made of an opaque yellow acetate plastic. A calibration set of TLDs is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The calibration set and exposure levels are established to coincide with the expected dose range. Each calibration set contains up to 150 dosimeters, which are irradiated at levels between 0 and 80 mR using a ^{137}Cs source calibrated by the National Institute of Standards and Technology (NIST).

Exposure in air is converted to dose using the conversion factor 1.05 mR = 1 mrem tissue dose. This factor is derived as the reciprocal of the product of the roentgen-to-rad conversion factor (0.958) for muscle tissue of the 661-KeV decay photon of ^{137}Cs, and 0.994, which is the attenuation factor at the electronic equilibrium thickness. A rad-to-rem conversion factor of l.0 for gamma rays is used, as recommended by the International Commission on Radiation Protection (Johns 1983, ICRP 1970). A weighted least-squares linear regression is used to determine the relationship between TLD reader response and dose, the weighting factor being the variance of the sample set (Bevington 1969).

The TLD chips are all from the same production batch and were selected by the manufacturer so that the measured standard deviation in thermoluminescent sensitivity is 2.0% to 4.0% of the mean at a 10 R exposure. At the end of each field cycle, the dose at each location in the network is estimated from the regression line, along with the upper and lower confidence limits at the estimated value (Natrella 1963). At the end of the calendar year, individual field cycle doses are summed for each location. The uncertainty is calculated as the summation in quadrature of the individual uncertainties (Bevington 1969).

2. Air Sampling.

a. Ambient Air Monitoring. For ambient air monitoring, the Air Quality Group (ESH-17) operated 52 air sampler stations at 50 locations (Table IV-1). All samples are collected twice each month.

Airborne particulates are collected from the atmosphere using vacuum pumps with constant flow rates of 2 L/s (approximately 4 cu ft per minute [cfm]). The particulates are collected on 60-mm-diameter polystyrene filters (Microsorban). A portion of the total airflow (200 mL/min) is passed through a cartridge containing silica gel (135 g) to collect atmospheric water vapor. The flow rates are multiplied by the total run time to determine the volume of air sampled.

The particulate filters are analyzed twice each month for gross alpha and gross beta activity. Particulate filters are also analyzed twice each month using gamma spectrometry. Particulate filters are combined and analyzed quarterly for plutonium, americium, and uranium. The silica gel collected twice each month is heated to drive off the moisture, which is then analyzed for tritium using liquid scintillation counting.

A rotameter, calibrated twice a year using a factory-calibrated flow meter, is used to determine air flow in both sampling trains. The total time of operation is multiplied by the average flow rate to determine the volume of air sampled.

A specific radioiodine (^{131}I) sampling program with six sampling stations has been operating since August 1991. The system uses vacuum pumps with constant airflow regulators that sample at 1 cfm. Cartridges that contain activated treated charcoal are used to collect ^{131}I as gas. A 47-mm borosilicate microglass particulate filter is placed in front of the charcoal cartridge to collect any iodine in particulate form. Air volumes are determined by multiplying the constant flow rate of 1 cfm by the total time sampled. Samples are collected weekly. Filters and cartridges are sent to the analytical laboratory for quantitative analysis.

b. Radioactive Air Emissions Monitoring. Samples are generally collected at weekly intervals from approximately 90 release points. Sample collection and analyses are performed by personnel from health physics groups (ESH-1 and ESH-4) and the Inorganic Trace Analysis Group (CST-9).

The typical system for monitoring particulate radioactivity in stack emissions consists of one or more sampling probes that continuously extract a sample from the stack exhaust stream. Samples are extracted by an air sampling pump, which passes the sample through a filter that traps the particles. The pumps typically sample at a rate of 2 cfm. The activity on the filter is then determined. The filters are counted for either gross alpha or gross beta activity or are counted by gamma spectroscopy, depending on the isotope(s) present at the facility. To determine the total activity released, the radioactivity on the sample filter is multiplied by the ratio of the stack flow to the sample flow during the sampling period. This total activity is expressed in Ci. The radioisotopes of plutonium are not listed separately because the gross alpha analysis does not distinguish between the individual isotopes. Likewise, the gross beta analysis does not distinguish between the individual radioisotopes in the group called mixed-fission products.

Tritium is monitored in one of three ways. The first method measures total tritium, which includes the gaseous form and the water vapor form. In this method, one or more sampling probes continuously extract a sample from the effluent or exhaust stream. This sample is passed through a remotely located instrument, which measures the concentration of tritium. This concentration, in conjunction with the effluent exhaust rate, is used to determine the tritium activity (in Ci) released to the environment. In the second method, which is used at facilities such as the Tritium Systems Test Assembly and the Weapons Engineering Tritium Facility, the effluent containing tritium is captured in a bubbler system. This system collects tritium gas and tritium water vapor separately so the quantity of each can be measured. A third method of measuring tritium is used at the Los Alamos Meson Physics Facility where tritium water vapor is captured on silica gel. Each month, the gel is replaced, and the activity of the vapor is determined.

The particulate/vapor activation products are captured on paper filters in the case of particulates or on charcoal filters in the case of vapor, and total radioactivity is counted. Gaseous mixed activation products are counted in a flow-through air ionization chamber to determine total radioactivity. Isotopic ratios are measured using high-purity germanium (HPGe) detectors.

Stack flow rates are measured by Johnson Controls World Services, Inc. (JCI) in accordance with the Environmental Protection Agency (EPA) reference methods that use calibrated Pitot tubes.

c. Nonradioactive Air Emissions Monitoring. The nonradiological monitoring network consists of 1 criteria pollutant station, 1 visibility monitoring station, 1 acid precipitation monitoring station, and 12 samplers where beryllium is monitored. Results of nonradiological monitoring are presented in Chapter VI.A.2.

Stack monitoring systems are not compliant with Subpart H; however, all stacks that require monitoring are monitored with adequate monitoring systems. Upgrades of the monitoring systems are in progress.

The criteria pollutant monitoring station owned by the Laboratory is located south of TA-49, adjacent to Bandelier National Monument. This station began operation in the second quarter of 1990 and operated until September 30, 1994. It continuously monitored air concentrations of nitrogen dioxide (NO2), ozone (O3), and sulfur dioxide (SO_2). A PM-10 high-volume air sampler was run every six days to collect small particulate matter (less than 10 microns in diameter). Once each month, the New Mexico Environment Department (NMED) audited the flow rate of the instrument.

Atmospheric visibility is monitored and analyzed with a transmissometer. A 10-min measurement is taken every hour, 24 h/day. The site path is 4.58 km (2.84 mi) long and runs between TA-49 and TA-33. Air Resource Specialists, Inc., of Fort Collins, Colorado, is responsible for data quality and analysis.

Acid deposition from precipitation is measured once per week. Water samples are examined in the field for visible contamination, pH, and electrical conductivity. Samples are sent to the University of Illinois for further analysis. Colorado State University coordinates the program. Blind samples are audited twice per year by the US Geological Survey.

Beryllium is monitored on the continuous ambient air monitors that are operated as part of the ambient radionuclide monitoring system. The samples are taken using a flow rate of 4 cfm. The equipment operates continuously, and samples are collected monthly. A composite of the monthly samples is generated quarterly for chemical analysis. A rotameter, calibrated twice a year with a factory-calibrated flow meter, is used to determine air flow.

3. Water Sampling.

a. Surface Water and Groundwater. The Laboratory maintains three separate programs for monitoring water quality: the surface and groundwater monitoring program, the National Pollutant Discharge Elimination

System (NPDES), and the Safe Drinking Water Act (SDWA) compliance sampling programs. The first program involves sampling of water supply wells and special monitoring wells under the long-term environmental surveillance program. The samples are collected by Water Quality & Hydrology (ESH-18) personnel and are analyzed by CST-9 or a contracted analytical laboratory. Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface water and shallow groundwater are not sources of municipal or industrial water supplies, results of these analyses are compared with NMED and EPA drinking water standards (maximum concentration levels). The chemical quality of surface water is compared to NM Livestock and Wildlife Watering Standards. The results of these programs are reported for nonradioactive constituents in Sections VI.A.2 and VII.C.2 of this report. Detailed descriptions of the procedures for sampling surface water and groundwater are presented in Section VIII.B.3.a.

Under the Laboratory's existing NPDES permit, samples are collected on a weekly basis and analyzed for the chemicals listed in the permit. Results are reported after each monitoring period for each outfall category to EPA and NMED. Samples collected from the Laboratory's industrial outfalls are collected by ESH-18 personnel and analyzed by CST-9 and contract laboratories. Samples collected from the sanitary outfalls are collected by JCI Environmental (JENV) staff and analysis is performed by JENV Laboratory. See Section VIII.B.3.b for more information on the NPDES compliance sampling program.

Samples collected by the Laboratory to ensure compliance with SDWA standards are analyzed for organic, inorganic, and radioactive constituents at the NM Health Department's Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMED. The JENV Laboratory also collects samples from the Laboratory and county water distribution systems and tests them for microbiological contamination, as required by SDWA. The JENV Laboratory is certified by SLD for microbiological testing of drinking water. See Section VIII.B.3.c for more information on the sampling program.

b. National Pollutant Discharge Elimination System. Personnel from ESH-18 complete sample collection, preservation, and field analysis of the Laboratory's industrial outfall discharges that are regulated through NPDES permits. Industrial effluent samples are collected for specific parameters at the monitoring frequencies and locations specified in the NPDES permit. Monitoring is conducted according to EPA-approved methods documented in 40 CFR Part 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants under the Clean Water Act; Final Rule and Technical Amendments" (EPA 1991) or otherwise specified NPDES Permit Nos. NM0028355 and NM0028576. Chain-of-custody (COC) procedures for sample collection and analysis are conducted during sampling for NPDES industrial compliance.

CST-9 analyzes industrial discharges for pollutants listed in the NPDES permits. A contract laboratory analyzes treated effluent from the TA-50 wastewater treatment plant for total toxic organics and ^{226}Ra plus ^{228}Ra. NPDES samples that are analyzed by contract laboratories are handled, shipped, and tracked by CST-3. Samples are tested according to EPA-approved methods documented in 40 CFR Part 136.

Treated effluent samples are collected from the sanitary treatment plants by JENV Laboratory in accordance with the monitoring conditions specified in NPDES Permit NM0028355. Representative samples are collected from the monitoring points designated for each outfall in the permit. Sample collection and preservation are conducted according to test procedures approved under 40 CFR 136. COC procedures are used by JENV Laboratory for sample collection and analysis. JENV Laboratory conducts the sanitary wastewater testing for pollutants listed in the NPDES permit. Testing procedures are conducted according to the 18th edition of "Standard Methods for the Examination of Water and Wastewater" (APHA 1989) and other conditions specified by the NPDES permit.

All instruments used for sanitary and industrial field and laboratory analyses are routinely serviced and calibrated; records are properly maintained. Measurements are made in accordance with the NPDES permit QA requirements, 40 CFR Section 122.41. QA procedures include the use of duplicate, replicate, and spike analyses; sample splits; outside reference samples; blanks; reagent blanks to check for sources of error; and method verification. Both JENV and the CST-9 laboratories participate in the National Discharge Monitoring Report Quality Assurance Program. CST-3 and CST-9 also participate in the EPA Water Pollution Study for blind spike analyses. The Laboratory's NPDES program is subject to annual compliance evaluation inspections by EPA and NMED.

c. Safe Drinking Water Act. The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the federal SDWA and the NM Environmental Improvement Act. Sampling

locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations.

Microbiological sampling and analysis are performed by the JENV Laboratory. Laboratory staff are certified by the NMED to perform drinking water compliance sampling, and the Laboratory is certified by the NMED for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved QA/QC program, and periodic audits by the NMED. Chemical and radiological sampling is performed by LANL staff certified by NMED to perform drinking water compliance sampling. These samples are sent to laboratories certified by the EPA and the NMED.

4. Sediment Sampling.

Sediment samples are collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently flowing streams are collected by scooping a line of uniform depth across the main channel. Reservoir sediments are collected from a boat, using an Eckman dredge. Bottom reservoir sediments are collected from an area 10 cm by 15 cm (4 in. by 6 in.) to a depth of 5 cm (2 in.).

Depending on the reason for taking a particular sediment sample, it may be analyzed for any of the following: gross alpha and gross beta activities, ^{90}Sr, uranium, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{241}Am, and possibly selected accelerator-induced activation products. Moisture distilled from soil and sediment samples may be analyzed for tritium.

5. Soil Sampling.

All samples are collected and handled in accordance with the guidelines recommended by the American Society for Testing and Materials (ASTM 1990). The procedure for taking soil samples involves taking five subsamples (plugs), 100 mm (4 in.) in diameter and 50 mm (2 in.) deep, with a stainless steel ring at the centers and corners of a 10-m (33-ft) square area. The five plugs are combined and mixed thoroughly in a gallon resealable plastic bag to form a single composite sample and then placed in pre-labeled 500-mL poly bottles for radionuclide analysis and 125 mL poly bottles for heavy metal analysis. They are fitted with COC tape, placed into individual resealable plastic bags, and then into a locked ice chest for transportation to the Laboratory. Most samples are submitted to CST-9 for the analysis of radiological constituents (gross alpha, gross beta and gamma activity, ^{90}Sr, uranium, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, and ^{241}Am) and trace and heavy metal elements (silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, and thallium). These are the only EPA regulated heavy and trace metals. In addition, moisture distilled from soil samples is analyzed for tritium.

6. Foodstuffs Sampling.

Produce samples are collected from local gardens in the summer and fall of each year (Salazar 1984). Each produce sample is collected with plastic gloves and sealed in a labeled plastic bag. Samples are transported in a locked ice chest and refrigerated until prepared for chemical analyses. Produce samples are washed, as if prepared for consumption, and quantitative wet, dry, and ash weights determined. All results are reported on an oven-dry-weight basis (dry g). A complete sample bank is kept frozen until all radiochemical analyses have been completed. Water is distilled from samples and submitted for tritium analysis. Heavy and trace metals in produce are sampled every three years. Samples are dried at 75°C for 48 h, ground in a Wiley Mill using a 20-mm stainless steel screen, and collected in 20-mL poly bottles. All samples are submitted under full COC for the analysis of silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, and thallium.

Bees and honey are collected by a professional (contract) bee keeper (Fresquez 1994c). Approximately 500 g of bees are collected. The frames of honey are enclosed in large plastic bags, marked for identification, and transported in an ice chest to the laboratory. At the laboratory, the honey is separated from the combs into labeled 500-mL poly bottles by a heat lamp. The bees and honey samples are submitted under COC for radiochemical analyses. Heavy and trace metals in honey are sampled every three years.

At each reservoir, hook and line, trot line, or gill nets are used to capture fish (Salazar 1984). Fish samples are transported under ice to the laboratory for preparation. Fish are individually washed, as if for consumption, and dissected. Wet, dry, and ash weights are determined, and ash is submitted for analysis. Concentrations of uranium, ^{90}Sr, ^{238}Pu, ^{239,240}Pu, and ^{137}Cs are determined. Also, the ratio of ^{235}U to ^{238}U in bottom-feeding fish is determined by thermal ionization mass spectrometry (Efurd 1993). All results are reported on an oven-dry-weight basis (dry g). Variations in the mean radionuclide content in fish collected upstream and downstream of the

Laboratory are tested using a Student's t-test at the 0.05 probability level (Gilbert 1987). Heavy and trace metals in fish are sampled every three years.

Elk (*Cervus elaphus*) meat and bone tissue are collected from fresh road kills around the Laboratory. Background samples are collected from the NM Department of Game and Fish during this same period of time. Tissue samples from each elk are collected: >1000 g each of leg bone and muscle. Samples are submitted to CST-9 for the determination of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, and ^{137}Cs. All results are reported on an oven-dry-weight basis (dry g). Variations in the mean radionuclide content for each tissue component from elk collected from on-site and off-site areas are tested using a Student's t-test at the 0.05 probability level (Gilbert 1987).

Milk is collected directly from the dairies in the Pojoaque Valley and Albuquerque, NM and submitted to CST-9 in the original containers for the analysis of tritium, uranium, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{131}I, and ^{137}Cs.

7. Meteorological Monitoring.

Because the Laboratory site is topographically complex, it is difficult to design a meteorological monitoring network capable of capturing the full spatial variability of all measured variables. Quantifying the representativeness of wind measurements is especially difficult. For most applications, however, data from the current network has been adequate for characterizing important features of the meteorological environment.

For the most part, it has been possible to locate meteorological monitoring stations in areas that provide good exposure to the processes being monitored. Wind and temperature measurements are made from towers of open lattice construction with instruments mounted on booms that project out from the towers toward the west a distance at least two tower cross sections; thus flow distortion effects for the prevailing wind directions are minimized. All temperature sensors are aspirated to minimize radiative effects. Towers are located in open areas where anemometers and rain gages are outside the wake effects of trees and buildings, and upward-looking radiometers have an unrestricted view of the sky.

Each tower is equipped with its own programmable datalogger that handles signal conditioning, sampling, simple statistical operations, and interim data storage. Most signals are sampled every 3 s and averaged over 15 min. After acquisition by the main computers, the data are processed to generate tables and plots for characterizing conditions and for quality control.

The calibration of all instrumentation is checked twice annually, once during an internal audit and once during an independent, external audit. Calibration and maintenance procedures are documented in LANL-ESH-17-402,RO (1995). In 1994, TRC Environmental Corporation performed the external audit. In the summary of their report, they state that "The overall operation, knowledge and attentiveness to this monitoring program is excellent and meets the requirements and goals stated in the Quality Assurance Project Plan" (TRC 1994).

By the time meteorological data have been permanently archived, they have been checked in a number of ways. Daily, statistical summaries of the data are evaluated and problems noted in a logbook. Weekly, when the data are transferred to the archive, all signals are checked against the expected range of values for each signal type. Detailed time series of all variables are checked by a meteorologist for reasonableness and internal consistency. Remaining problems are entered into the logbook. The logbook is then used by a data analyst to accomplish the final editing of the data. Recovery of good data from the network exceeded 95% in 1994.

Further details related to quality assurance and sampling procedures used in the meteorological monitoring program are given in Section 13 of the current Los Alamos Environmental Monitoring Plan (EARE 1995a).

8. Sewage Sludge Sampling.

Representative samples of sewage sludge are collected three times per year from the sludge beds at the TA-46 SWSC plant. Samples are collected in accordance with the procedures set forth in LANL-ESH-18-602 Administrative Procedures: Handling, Disposal and Reuse of Sanitary Treatment Solids (September 8, 1994). Samples are submitted for analysis to an EPA-approved contract laboratory for chemical constituents and CST-9 for radiochemistry.

C. Analytical Chemistry.

1. Methodology.

a. Introduction. Most analytical chemistry services are provided by the Laboratory's CST-3, -9, and -12 Groups which provide analytical services to the Laboratory's environmental, waste management, radiation

protection, and industrial hygiene operations. CST-3 is responsible for QA for the health and environmental analytical work. CST-9 and -12 participate in the following interlaboratory performance evaluation studies:

- National Institute for Occupational Safety and Health, Proficiency Analytical Testing Program;
- Environmental Monitoring and Support Laboratory, Cincinnati (EMSL-CI) Drinking Water Program;
- EMSL-CI Water Pollution Study;
- EPA Environmental Monitoring Systems Laboratory, Las Vegas, Radiochemistry Performance Evaluation Studies;
- DOE Environmental Measurements Laboratory, Quality Assessment program for Radiochemistry;
- NPDES; and
- DOE Beryllium Intercomparison Study.

CST-3 Sample Management functions as an interface between the groups CST-9 and -12 and its customers. This section provides the sample collector with presampling information about sample containers, sample volumes, and sample preservation techniques. Collection of samples for chemical and radiochemical analyses follows a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results.

Before sample collection, Sample Management discusses the schedule and procedures to be followed with the sample collector. The discussion includes

- number and type of samples;
- type of analyses and required limits of detection;
- proper sample containers;
- DOE Mixed Analyte Performance Evaluation Program;
- DOE In Vitro Performance Evaluation Study;
- preparation of sample containers with preservative, if needed; and
- sample schedule to ensure minimum holding time so that analyses comply with EPA criteria.

After a sample is collected, it is delivered to CST-3 Sample Management, where the pertinent information is entered into the CST Laboratory Information Management System, and the request is given an analytical service agreement. Sample numbers, each representing a single sample, are assigned to a particular station and are entered into the collector's log book. The processing of samples includes (1) validating all samples for sampling correctness and integrity, (2) scheduling and labeling all samples for analysis, (3) initiating internal COC procedures for all samples, and (4) arranging for the proper disposal of any unused portions of samples.

The analytical service agreement number is entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to CST-3. CST-3 provides COC forms for the samples once they are received if COC did not begin in the field. The date, time, temperature (if the sample is water), and other pertinent information and remarks are entered opposite the sample number and station previously listed in the collector's log book. The sample container is labeled with station name, sample number, date, and preservative if added.

The analytical request form contains the following information related to ownership and the program submitted: (1) requester, i.e., sample collector; (2) program code; (3) sample owner, i.e., program manager; (4) date; (5) total number of samples; (6) priority of sample or samples; and (7) remarks. The second part of the request form contains (1) sample number or numbers; (2) matrix, e.g., water; (3) types of analyses, i.e., specific radionuclide and/or chemical constituents; (4) technique, i.e., analytical method to be used for individual constituents; and (5) analyst, i.e., chemist to perform analyses. One copy of the form goes to the collector for filing, one is kept by Sample Management, and the other copies accompany the sample.

The analytical results are returned to the sample collector, who posts the data according to sample and station taken from the log book. These data sheets are included in the final report.

b. Radioactive Constituents. Environmental samples are routinely analyzed by CST-9 for the following radioactive constituents: gross alpha, gross beta, and ^{90}Sr by proportional counting; isotopic americium, plutonium, thorium, and uranium by radiometric alpha spectroscopy; elemental uranium by kinetic phosphorescence analysis; tritium by liquid scintillation; gross gamma, gamma scans, and isotope specific analysis for ^{137}Cs, ^{144}Ce; ^{57}Co; ^{60}Co; ^{152}Eu; ^{129}I; ^{40}K; ^{22}Na; ^{237}Np; ^{106}Ru; ^{241}Am; ^{106}Ru; ^{226}Ra; and ^{228}Ra by gamma-ray spectrometry.

During 1994, an improved procedure for separation of americium for radiometric alpha spectroscopy of air and water samples was implemented. This method increased analytical throughput by at least a factor of 2, decreased environmental/safety hazards from acid and alcohol/acid waste generation, and improved analytical accuracy, reproducibility, and reliability over the complex and laborious method previously used.

In addition, development of a new microwave-based method for dissolving 10-g soil samples for radiometric alpha spectroscopy was initiated. In the past, only 1-g samples were used for microwave dissolution. This method should increase throughput, improve data quality, and reduce workspace and environmental hazards for soil digestion.

CST-9 also enhanced throughput capabilities for gamma spectroscopy by having six working HPGe detectors available for counting and increasing utilization of the robotics system for automated sample counting. The alpha spectroscopy count room was updated by replacing 32 of the 144 detectors with state-of-the-art commercial instrumentation.

New gamma spectroscopy procedures were developed for ^{241}Am and ^{226}Ra in soil samples. The ^{241}Am procedure by gamma spectroscopy provided more rapid throughput for customers requiring less measurement sensitivity than obtained by radiometric alpha spectroscopy.

For biological environmental samples, productivity was increased due to reorganization of work responsibilities within this task area and adaptation of procedures used for human tissues samples. Finally, a new sample preparation, tracking, and disposal system was implemented for environmental samples which has improved CST-9's ability to provide results to customers in a timely manner.

c. Stable Constituents. A number of analytical methods are used by CST-9 for various stable isotopes. The choice of method is based on many criteria, including the operational state of the instruments, time limitations, expected concentrations in samples, quantity of sample available, sample media, and EPA regulations. Instrumental techniques available include atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, ICPMS, and inductively coupled plasma atomic emission spectrometry. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, and cold vapor. The methods used and references for determination of various chemical constituents are presented elsewhere (Gautier 1986).

d. Organic Constituents. Environmental soil and water samples are analyzed by CST-9 using EPA procedures outlined in EPA SW-846 (EPA 1989d) or modified procedures (Gautier 1986) that meet QA criteria outlined in Chapter 1 of SW-846, as shown in Table VIII-1. Methods used are supported by documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind QC samples. Volatile organic compounds (VOCs) are analyzed using Method 8260, SW-846. Tables D-20 and D-21 list VOCs on the target list for water and soil samples, respectively. Semivolatile organic compounds (SVOCs) are analyzed using Method 8270, SW-846. Table D-22 is the target list for SVOCs in water. Soil-gas (poregas) monitoring is performed by collecting organic vapors on charcoal adsorbent traps or thermal desorption traps. Charcoal traps are chemically desorbed while thermal desorption traps are thermally desorbed. Both desorption methods are followed by gas chromatography/mass spectrometry (GC/MS) analysis. Chemical and thermal desorption result in different analyte lists as shown in Tables D-23 and D-24. Polychlorinated biphenyls (PCBs) in soil, water, and oil samples are analyzed using GC with electron capture detection using a modified version of Method 8080.

Instruments available for organic analysis include GC/flame ionization detector, GC/electron capture detector, GC/MS, high performance liquid with UV and refractive index detectors, Fourier transform infrared spectrometer, and UV/visible spectrophotometer. Sample preparation methods include Soxhlet extraction, ultrasonic extraction, continuous liquid/liquid extraction, separatory funnel extraction, Kuderna Danish concentration, evaporative blowdown, and gel permeation chromatography cleanup of sample extracts.

Table VIII-1. Method Summary (Organic Compounds)

Analyte	Matrix	Method	Technique[a]
VOCs	Air	E0700	GC/MS
	Soil	E0720 (8260)	PAT/GC/MS
	Water	E0730 (8260)	PAT/GC/MS
PCBs[b]	Water	E0430 (modified 8080)	GC/ECD
	Oil	E0400 (modified 8080)	GC/ECD
	Soil	E0410 (modified 8080)	GC/ECD
	Swipes	E0420(modified 8080)	GC/ECD
SVOCs	Soil, waste	E0500 (8270)	GC/MS
	and water	E0530;	GC/MS

[a]Gas chromatography (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometry (MS).
[b]Polychlorinated biphenyl (PCBs)

Organic mixed waste analyses are performed for samples containing up to the following limits of radioactivity:

Alpha 300 nCi/g or 300 nCi/L
Beta 1 mCi/g or 1 mCu.K
Gamma 500 nCi/g or 500 nCi/L
Tritium 50 mCi/g or 50 mCi/L

Higher level samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than the levels listed above.

2. Quality Evaluation Program.

a. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, spikes, and reference materials. Analysis of control samples fills two needs in analytical work: (1) it provides QC over analytical procedures so that problems that might occur can be identified and corrected, and (2) data obtained from analysis of control samples permits evaluation of the capabilities of a particular analytical technique to determine a given element or constituent under a certain set of circumstances.

Blind QC samples are numbered to resemble unknown samples in a set. The concentrations of the analytes of interest are not revealed until after the data have been formally reported. These samples are submitted to the laboratory at regular intervals and are analyzed in association with other samples; that is, they are not handled as a unique set of samples. Up to 10% of stable constituent, organic, and selected radioactive constituent analyses are run as QC samples using the materials described above. A detailed description of CST's QA Plan and a complete listing of results have been published annually since 1976 (Gautier 1993).

b. Radioactive Constituents. In addition to samples prepared internally, QC and QA samples for radioactive constituents are provided by outside agencies. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA, Las Vegas) provides water, milk, and air filter samples for analysis of gross alpha, gross beta, tritium, ^{40}K, ^{60}Co, uranium, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory performance evaluation program. NIST provides several soil and sediment standard reference materials (SRMs) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, ^{239}Pu, ^{241}Am, and several other nuclides. The DOE's Environmental Measurements Laboratory also provides QA samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey (CGS) and from NIST are used for QA of uranium and thorium determinations in silicate matrices. CST-9's own in-house standards are prepared by adding known quantities of liquid SRMs for radioactivity, prepared by NIST to blank matrix materials.

c. Stable Constituents. QA for the stable constituent analysis program is maintained through analyses of certified or well-characterized environmental materials. NIST has a large set of silicate, water, and biological SRMs. EPA distributes standards for minerals and other trace constituents in water . Rock and soil reference materials have been obtained from the CGS and the United States Geological Survey. Details of this program have been published elsewhere (Gautier 1993). Stock solutions of inorganic analytes are prepared and spiked on blank matrices by CST-9's Quality Assurance Team.

The analytical QC program for a specific batch of samples is a combination of many factors. These include the calibration of the instrument and/or reagents, recovery for SRMs, method blanks, duplicate precision, spike sample recovery, and run time instrumental QC (i.e., continuing calibration standards and blanks).

d. Organic Constituents. Soil samples are analyzed for VOCs, SVOCs, pesticides, and herbicides for compliance work done under Resource Conservation and Recovery Act. Certified matrix-based reference materials are not available for these analyses, so stock solutions of the analytes are prepared and spiked directly on blank soil by the Quality Assurance Team. Because homogeneity of the sample cannot be ensured, the entire sample is analyzed. VOCs are analyzed by GC/MS and are spiked in the microgram-per-kilogram range.

The majority of water samples submitted during 1994 were environmental compliance samples analyzed for pesticides, VOCs, SVOCs, and PCBs. Methods were developed and refined for in-house preparation of QC samples for VOCs and SVOCs in water.

Oil samples are received for the analysis of PCBs and organic solvents. For routine PCB analysis, daily calibration is only performed for Aroclors 1242, 1254, and 1260. These aroclors represent the bulk of the target analytes found at the Laboratory. Other aroclors are included in the calibration mixture run on the GC system each time a full calibration curve is run. QC samples for PCBs are prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. Aroclors 1242, 1254, and 1260 are used to spike the QC samples which are prepared using a vacuum pump oil base as the blank matrix.

3. Data Handling of Radiochemical Samples.

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

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

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

$$s = \sqrt{\frac{\sum_{i=1}^{N} \left(\bar{c} - c_i\right)^2}{(N-1)}},$$

where

ci = sample i

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

N = number of samples comprising a station or group.

This value is reported as the uncertainty for the station and group means.

4. Indicators of Analytical Accuracy and Precision.

Accuracy is the degree of difference between average test results and true results when the latter are known or assumed. Precision is the degree of mutual agreement among replicate measurements (frequently assessed by

calculating the standard deviation of a set of data points). Accuracy and precision are evaluated from results of analyses of reference materials. These results (r) are normalized to the known quality in the reference material to permit comparison among references of a similar matrix containing different concentrations of the analyte:

$$r = \frac{\text{Reported quantity}}{\text{Known quantity}}.$$

A mean value R for all normalized analyses of a given type is calculated as follows for a given matrix type (N is total number of analytical determinations):

$$R = \frac{\sum_i^{r_i}}{N},$$

Standard deviations of R are calculated assuming a normal distribution of the population of analytical determinations (N):

$$s = \sqrt{\frac{\sum_i \left(R - r_i\right)^2}{\left(N - 1\right)}}.$$

These calculated values are presented as the CST-3 "Ratio ± Std Dev" in Table D-28. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias in the analysis; values less than unity indicate a negative bias. The standard deviation is a measure of precision. Precision is a function of the concentration of analyte; that is, as the absolute concentration approaches the limit of detection, precision deteriorates. For instance, the precision for some determinations is quite good because many standards approach the limits of detection of a measurement. We address this issue by calculating a new QA parameter:

$$\left|\overline{X}_{\mathrm{E}} - \overline{X}_{\mathrm{C}}\right|,$$

where X_{E} is the experimentally determined mean concentration based on N measurements, and X_{C} is the certified or consensus mean concentration. The total standard deviation, S_{T}, of $X_{\mathrm{E}} - X_{\mathrm{C}}$ is given by

$$Sr = \sqrt{\left(U_{\mathrm{E}}^2 / N\right) + S_{\mathrm{C}}^2},$$

where U_{E} is the standard deviation of a single experimentally determined measurement, and S_{c} is the standard deviation of the certified or consensus mean elemental concentration.

5. Analytical Control Conditions.

Analyses are considered under control if the absolute value of the difference between our result (X_{E}) and the certified or consensus mean (X_{c}) is within the propagated standard deviation of the experimental uncertainty (U_{E}) and of the certified mean (S_{c}). N is equal to the number of measurements on a sample, and in this case, is equal to 1. This concept, an adaptation of Dixon and Massey (Dixon 1969), is expressed in the following equation to include the experimental uncertainty:

$$z = \frac{\left|\overline{X}_{\mathrm{E}} - \overline{X}_{\mathrm{C}}\right|}{\sqrt{\left(U_{\mathrm{E}}^2 / N\right) + S_{\mathrm{C}}^2}}$$

The test statistics used in this document are based on 5% and 0.2% levels of significance. The respective critical regions are defined for values of z between 2 and 3. Data having a calculated z value ≤2 are accepted as in control at the 5% level of significance. Data that have a calculated z value >2 and ≤3 are considered at the warning level, or the 0.2% level of significance. Data with a z value >3 are considered out of control. These test statistics are also incorporated in the QACHECK computer program.

The percentage of the tests for each parameter where X_E - X_C fell within ≤2 ST (under control), between $2S_T$ and $3S_T$ (warning level), or outside >$3S_T$ (out of control).

With the exception of bulk materials, more than 90% of the organic analyses are within <2 propagated standard deviations of the certified/consensus mean values (under control). Inorganic data has a lower percentage of analyses within control limits, but the data is comparable to that obtained during 1993. Trace levels of radiochemical constituents in biological materials and soils still provide more analytical difficulty as illustrated by the lower level of overall analytical control. Other radiochemical measurements are unchanged since 1992. Areas with <90% of the analyses being under control were the focus of increased quality assurance/quality control efforts during 1993. Data on analytical detection limits are given in Table D-8.

IX. Publications

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IX. Publications

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R.J. Wechsler, T.M. Sandoval, D.E. Bryant, L. Hupke, and L. Esquibel, “1993 Annual PCB Document,” Los Alamos National Laboratory report LA-UR-94-2839, (July 1994).

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STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, and foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" 5480.1, "Environmental Protection, Safety, and Health Protection Standards;" 5480.11, "Requirements for Radiation Protection for Occupational Workers;" and 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements."

Radiation Standards. DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the dose factors from Refs. A1 and A2. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A3]

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard (RPS) for the public.[A4] Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem/yr. The PDLs and the information in Refs. A1 and A2 are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements.[A3,A4]

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

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared with DOE's derived air concentrations (DACs) and derived concentration guides (DCGs), respectively (Table A-2).[A5] These guides represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual EDEs equal to the PDL of 100 mrem in the 50th year of exposure.

In addition to the 100 mrem/yr effective dose PDL, exposures from the air pathway are also limited by the Environmental Protection Agency's (EPA's) 1989 standard of 10 mrem/yr EDE.[A6] To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits. This dose limit of 10 mrem/yr replaced the previous EPA limits of 25 mrem/yr (whole body) and 75 mrem/yr (any organ).[A7]

Nonradioactive Air Quality Standards. Federal and state ambient air quality standards for nonradioactive pollutants are shown in Table A-3. New Mexico nonradiological standards are generally more stringent than national standards.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by EPA and adopted by the New Mexico Environment Department (NMED) as part of the NM Water Supply Regulations (Table A-4).[A8] EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in drinking water that is delivered to the ultimate user of a public water system.[A9] EPA has set "action levels" in lieu of MCLs for lead and copper. If more than 10% of the samples from specified sites exceed the action level, the agency that manages the public water supply must initiate a corrosion control program. EPA's secondary drinking water standards, which are not included in the NM Water Supply Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water.[A9] There may be health effects associated with considerably higher concentrations of these contaminants.

Appendix A

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

Exposure of Any Member of the Public[a]	**EDE[b] at Point of Maximum Probable Exposure**
All Pathways	100 mrem/yr[c]
	EDE at Point of Maximum Probable Exposure
Air Pathway Only[d]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[a]	
Stochastic Effects	5 rem (annual EDE[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual EDE[e])
Extremity	50 rem (annual EDE[e])
Skin of the whole body	50 rem (annual EDE[e])
Organ or tissue	50 rem (annual EDE[e])
Unborn Child	
Entire gestation period	0.5 rem (annual EDE[e])

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. DOE's PDL applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from Ref. A4. Limits for occupational exposure are taken from DOE Order 5480.11.

[b]As used by DOE, EDE includes both the EDE from external radiation and the committed EDE to individual tissues from ingestion and inhalation during the calendar year.

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

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

[e]Annual EDE is the EDE received in a year.

Table A-2. DOE's Derived Concentration Guides for Water and Derived Air Concentrations[a]

Nuclide	DCGs for Water in Uncontrolled Areas (μCi/mL)	DCGs for Drinking Water Systems (μCi/mL)	DACs (μCi/mL) Uncontrolled Areas	DACs (μCi/mL) Controlled Areas
^{3}H	2×10^{-3}	8×10^{-5}	1×10^{-7}	2×10^{-5}
^{7}Be	1×10^{-3}	4×10^{-5}	4×10^{-8}	8×10^{-6}
^{89}Sr	2×10^{-5}	8×10^{-7}	3×10^{-10}	6×10^{-8}
^{90}Sr[b]	1×10^{-6}	4×10^{-8}	9×10^{-12}	2×10^{-9}
^{137}Cs	3×10^{-6}	1.2×10^{-7}	4×10^{-10}	7×10^{-8}
^{234}U	5×10^{-7}	2×10^{-8}	9×10^{-14}	2×10^{-11}
^{235}U	6×10^{-7}	2.4×10^{-8}	1×10^{-13}	2×10^{-11}
^{238}U	6×10^{-7}	2.4×10^{-8}	1×10^{-13}	2×10^{-11}
^{238}Pu	4×10^{-8}	1.6×10^{-9}	3×10^{-14}	3×10^{-12}
^{239}Pu[b]	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
^{240}Pu	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
^{241}Am	3×10^{-8}	1.2×10^{-9}	2×10^{-14}	2×10^{-12}
	(μg/L)	**(μg/L)**	**(pg/m^3)**	**(pg/m^3)**
Natural Uranium	800	30	1×10^{5}	3×10^{7}

[a]Guides for uncontrolled areas are based on DOE's PDL for the general public[A4]; those for controlled areas are based on occupational RPSs for DOE Order 5480.11. Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

[b]Guides for ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta, respectively.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141[A9] and New Mexico Water Supply Regulations, Sections 206 and 207.[A8] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed 5×10^{-9} μCi/mL (5 pCi/L). Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mL (15 pCi/L).

A screening level of 5×10^{-9} μCi/mL (5 pCi/L) for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (Table A-4) and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2). For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem/yr. DCGs for drinking water systems based on this requirement are in Table A-2.

Toxicity Characteristic Leaching Procedure Standards. In its Resource Conservation and Recovery Act (RCRA) regulations, EPA has established minimum concentrations of certain contaminants in water extracted from wastes that will cause the waste to be designated as hazardous because of its toxicity.[A10] The toxicity characteristic leaching procedure (TCLP) must follow steps outlined by the EPA in 40 CFR 261, Appendix II. In this report, the TCLP minimum concentrations (Table A-5) are used for comparison with concentrations of selected constituents extracted from the Laboratory's active waste areas.

Wildlife Water Standards. The purpose of these standards is to designate the uses for which the surface waters of the State of New Mexico shall be protected and to describe the water quality standards necessary to sustain the designated uses. In this report, the Wildlife Watering Standards (Table A-6)[A11] are used to compare with the quality of surface water at the Laboratory.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03	
	24 hours[a]	ppm	0.10	0.14	
	3 hours[a]	ppm			0.5
Total suspended particulate matter	Annual geometric mean	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours[a]	$\mu g/m^3$	150		
PM_{10} [b]	Annual arithmetic mean	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	0.12	0.12
Nitrogen dioxide	Annual arithmetic mean	ppm	0.05	0.053	0.053
	24 hours[a]	ppm	0.10		
Lead	Calendar quarter	$\mu g/m^3$		1.5	1.5
Beryllium	30 days	$\mu g/m^3$	0.01		
Asbestos	30 days	$\mu g/m^3$	0.01		
Heavy metals (total combined)	30 days	$\mu g/m^3$	10		
Nonmethane hydrocarbons	3 hours	ppm	0.19		

[a]Maximum concentration, not to be exceeded more than once per year.

[b]Particles <10 μm in diameter.

[c]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the limit is ≤1.

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a]

Inorganic Chemical Contaminants		Radiochemical Contaminants	
Primary Standards	**MCL (mg/L)**		**MCL**
Asbestos	7 million fibers/L (longer than 10 μm)		
As	0.05	Gross alpha[b]	15 pCi/L
Ba	2.0	Gross beta & photon	4 mrem/yr
Be	0.004	^{3}H	20,000 pCi/L
Cd	0.005	^{90}Sr	8 pCi/L
CN	0.2	^{226}Ra & ^{228}Ra	5 pCi/L
Cr	0.1		
F	4.0		
Hg	0.002		
Ni	0.1		**Screening Limits**
NO_3 (as N)	10.0	Gross alpha[b]	5×10^{-9} μCi/mL
NO_2 (as N)	1.0		(5 pCi/L)
Se	0.05		
Sb	0.006	Gross beta	50×10^{-9} μCi/mL
Tl	0.002		(50 pCi/L)
	Action Levels (mg/L)		
Pb	0.015		
Cu	1.3		

Secondary Standards	**(mg/L)**
Cl	250
Cu	1.0
Fe	0.3
Mn	0.05
SO_4	250
Zn	5.0
TDS[c]	500
pH	6.5–8.5 standard unit

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a] (Cont.)

Organic Chemical Contaminants	MCL (μg/L)
Alachlor	2
Atrazine	3
Carbofuran	40
Chlordane	2
Dibromochloropropane	0.2
2,4-D	70
Ethylene dibromide	0.05
Heptachlor	0.4
Heptachlor epoxide	0.2
Lindane	0.2
Methoxychlor	40
Polychlorinated biphenyls	0.5
Pentachlorophenol	1
Toxaphene	3
2,4,5-TP	50
Benzo[a]pyrene	0.2
Dalaphon	200
Di(2-ethylhexyl)adipate	400
Di(2-ethylhexyl)phthalate	6
Dinoseb	7
Diquat	20
Endothall	100
Endrin	2
Glyphosate	700
Hexachlorobenzene	1
Hexachlorocyclopentadiene	50
Oxamyl (Vydate)	200
Picloram	500
Simazine	4
2,3,7,8-TCDD (Dioxin)	0.00003
Total trihalomethanes	100
Vinyl chloride	2
Benzene	5
Carbon tetrachloride	5
1,2-dichloroethane	5
Trichloroethylene	5
para-Dichlorobenzene	75
1,1-Dichloroethylene	7
1,1,1-Trichloroethane	200
cis-1,2-Dichloroethylene	70
1,2-Dichloropropane	5
Ethylbenzene	700
Monochlorobenzene	100

Table A-4. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a] (Cont.)

Organic Chemical Contaminants (Cont.)	MCL (μg/L)
o-Dichlorobenzene	600
Stryene	100
Tetrachloroethylene	5
Toluene	1000
trans-1,2-Dichloroethylene	100
Xylenes (total)	10000
Dichloromethane	5
1,2,4-Trichlorobenzene	70
1,1,2-Trichloroethane	5

Microbiological Contaminants	MCL
Presence of total coliforms	5% of samples/month
Presence of fecal coliforms or *Escherichia coli*	No coliform positive repeat samples following a fecal coliform positive sample

[a]Refs. A8 and A9.

[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mL.

[c]Total dissolved solids.

Table A-5. Levels of Contaminants Determined by the Toxicity Characteristic Leaching Procedure[a]

Contaminant	(mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[a]Ref. A10.

Table A-6. Wildlife Watering Standards

Livestock Contaminant	Concentration (mg/L)
Dissolved Al	5.0
Dissolved As	0.02
Dissolved B	5.0
Dissolved Cd	0.05
Dissolved $Cr^{(+3, +6)}$	1.0
Dissolved Co	1.0
Dissolved Cu	0.5
Dissolved Pb	0.1
Dissolved Hg	0.01
Dissolved Se	0.05
Dissolved V	0.1
Dissolved Zn	25.0
$^{226}Ra + {}^{228}Ra$	30 pCi/L

Appendix A

REFERENCES

A1. US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0071 (July 1988).

A2. US Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0070 (July 1988).

A3. International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, *Annals of the ICRP* **2**(3/4) –**8**(4) (1979–1982), and Publication 30, Part 4, **19**(4) (1988).

A4. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

A5. US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

A6. US Environmental Protection Agency, "40 CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," *Federal Register* **54,** 51 653–51 715 (December 15, 1989).

A7. US Environmental Protection Agency, "National Emission Standard for Radionuclide Emissions Other than Radon from Department of Energy Facilities," *Code of Federal Regulations,* Title 40, Part 61, Subpart H (December 15, 1989).

A8. New Mexico Environmental Improvement Board, "NM Water Supply Regulations," (as amended through April 12, 1991).

A9. US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," *Code of Federal Regulations,* Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

A10. US Environmental Protection Agency, "Identification and Listing of Hazardous Waste, Table I. Maximum Concentration of Contaminants for the Toxicity Concentrations," *Code of Federal Regulations*, Title 40, Section 261.24 (1992).

A11. New Mexico Water Quality Control Commission, "Water Quality Standards for Interstate and Intrastate Streams in New Mexico," Section 3-101.K (as amended through November 12, 1991).

UNITS OF MEASUREMENT

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

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

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

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

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

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

Multiply SI (Metric) Unit	By	To Obtain US Customary Unit
Celsius (°C)	9/5 + 32	Fahrenheit (°F)
Centimeters (cm)	0.39	Inches (in.)
Cubic meters (m^3)	35.3	Cubic feet (ft^3)
Hectares (ha)	2.47	Acres
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Kilometers (km)	0.62	Miles (mi)
Liters (L)	0.26	Gallons (gal.)
Meters (m)	3.28	Feet (ft)
Micrograms per gram (µg/g)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Square kilometers (km^2)	0.386	Square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
ac ft	acre feet
Bq	becquerel
Btu/yr	British thermal unit per year
cc/sec	cubic centimeters per second
cfm	cubic feet per minute
cfs	cubic feet per second
Ci	curie
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
gal.	gallon
in.	inch
kg	kilogram
kg/h	kilogram per hour
L	liter
lb	pound
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
µR	microroentgen
mCi	millicurie
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 µm diameter)
R	roentgen
S_T or σ	standard deviation
Sv	sievert
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than
<	less than
±	plus or minus

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure II-3. The main programs conducted at each of the areas are listed in this Appendix.

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

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It served as a research tool by providing a source of neutrons for fundamental studies in nuclear physics and associated fields before it was shut down in 1993.

TA-3, Core Area: The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, and earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space. A Van de Graaff accelerator was put on shutdown status in 1994.

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

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

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

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

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

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

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

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

TA-18, Pajarito Laboratory Site: The fundamental behavior of nuclear chain reactions with simple, low-power reactors called critical assemblies is studied here. Experiments are operated by remote control and observed by closed-circuit television. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a critical amount of fissionable material so that the effects of various shapes, sizes, and configurations can be studied. These machines are also used as a large-quantity source of fission neutrons for experimental purposes.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West is gradually being decontaminated and decommissioned. DP East is a tritium research site.

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

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

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

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

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

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

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

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

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

TA-43, Health Research Laboratory and Center for Human Genome Studies: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics.

TA-46, WA Site: Applied photochemistry, which includes development of technology for laser isotope separation and laser enhancement of chemical processes, is investigated here. The Sanitary Wastewater System Consolidation project has been installed at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made, and hot cells are used for remote handling of radioactive materials.

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

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid and radioactive liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment.

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

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

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, materials studies, and isotope production. The Los Alamos Neutron Scattering Center, the Ground Test Accelerator, and the Proton Storage Ring are also located at this TA.

TA-54, Waste Disposal Site: The primary function of this site is radioactive solid and hazardous chemical waste management and disposal.

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

TA-57, Fenton Hill Site: About 45 km (28 mi) west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains, this site is the location of the Laboratory's Hot Dry Rock geothermal project.

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

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

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

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

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

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

TA-64: This is the site of the Central Guard Facility.

TA-65: This undeveloped TA was incorporated into TA-51 and no longer exists.

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

TA-67: This is a dynamic testing area that contains significant archaeological sites. It is designated for future mixed and low-level hazardous waste storage.

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

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

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

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

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

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

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

Appendix D

Supplementary Environmental Information

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory

Technical Area/Building	Facility Type	Included in RCRA Permit or Interim Status[a]
3-29[b]	Container (3 Units)	Interim S[c]
3-102-118A	Container	Closed
14-35	OB/OD[d] (2 Units)	Interim T[c]
15-184[b]	OD	Interim T[c]
16, Area P	Landfill	Closure in Progress
16	OB (6 Units)	Interim T[c]
16	Surface Impoundment	Closure in Progress
16-88[b]	Container	Interim S[c]
16-1150	Incinerator	Permitted T[e]
21-61[b]	Container	Interim S[c]
22-24	Container	Closed
35-85	Surface Impoundment	Closure in Progress
35-125	Surface Impoundment	Closed
36-8[b]	OD	Interim T[c]
39-6	OD	Interim T[c]
39-57	OD	Interim T[c]
40, SDS	OB/OD	Closure in Progress
40-2	Container	Closed
50-1-60A[b]	Container	Interim TS[c]
50-1-60D[b]	Container	Interim S[c]
50-1-BWTP	Aboveground Tank	Closed
50-37-115[b]	Aboveground Tank (2 Units)	Interim S[c]
50-37-115[b]	Container	Interim S[c]
50-37-117	Container	Permitted S[e]
50-37-117[b]	Container	Interim S[c]
50-37-118[b]	Container	Interim S[c]
50-37-CAI[b]	Incinerator	Interim T[c]
50-37-CAI	Incinerator	Permitted T[e]
50-69[b]	Container	Interim S[c]
50-69[b]	Container	Interim S[c]
50-114	Container	Permitted S[e]
50-114[b]	Container	Interim S[c]
50-137[f]	Container	Permitted S[e]
50-138[f]	Container	Permitted S[e]
50-139[f]	Container	Permitted S[e]
50-140[f]	Container	Permitted S[e]
53-166[b]	Surface Impoundment	Interim S[g]
53-166[b]	Surface Impoundment	Interim S[g]
53-166[b]	Surface Impoundment	Interim S[g]
54, Area G Over Pit 33[b]	Container	Interim S[c]
54, Area G	Landfill	Closure in Progress

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory (Cont.)

Technical Area/Building	Facility Type	Included in RCRA Permit or Interim Status[a]
54, Area G Pad 1[b]	Container	Interim S[c]
54, Area G Pad 2[b]	Container	Interim S[c]
54, Area G Pad 4[b]	Container	Interim S[c]
54, Area G Over Pit 30[b]	Container	Interim S[c]
54, Area G Shaft 145[b]	Container	Interim S[c]
54, Area G Shaft 146[b]	Container	Interim S[c]
54, Area G Shaft 148[b]	Container	Interim S[c]
54, Area G Shaft 147[b]	Container	Interim S[c]
54, Area G Shaft 149[b]	Container	Interim S[c]
54, Area H	Landfill	Closure in Progress
54, Area L	Aboveground Tank (2 Tanks)	Closure in Progress
54, Area L Shaft 36[b]	Container	Interim S[c]
54, Area L Shaft 37[b]	Container	Interim S[c]
54, Area L Gas Cyl[b]	Container	Interim S[c]
54, Area L Gas Cyl	Container	Permitted S[e]
54-8[b]	Container	Interim S[c]
54-31	Container	Permitted S[e]
54-32	Container	Permitted S[e]
54-33[b]	Container	Interim S[c]
54-48[b]	Container	Interim S[c]
54-49[b]	Container	Interim S[c]
54-68	Container	Permitted S[e]
54-69	Container	Permitted S[e]
55, Near Bldg 4[b]	Container	Interim S[c]
55-4[b]	Container (3 Units)	Interim S[c]
55-4[b]	Tank (13 Tanks)	Interim TS[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Container	Interim TS[c]
55-4[b]	Container	Interim S[c]
55-4[b]	Misc. Unit	Closure in Progress

[a]S = Storage; T = Treatment.
[b]Designates mixed waste units.
[c]Part A, January 1991.
[d]OB/OD = open burning/open detonation.
[e]November 1989.
[f]These units have not yet been constructed.
[g]Revised Part A, October 1993.

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under National Pollutant Discharge Elimination System Permit NM0028355 (Effective August 1, 1994)

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A	Power plant	1	Total suspended solids, free available chlorine, pH, flow	Once per month
02A	Boiler blowdown	2	pH, total suspended solids, flow, total copper, total iron, total phosphorus, sulfite (as SO3), total chromium	Once per three months
03A	Treated cooling water	40	Total suspended solids, free available chlorine, flow, total phosphorus, total arsenic, pH	Once per three months
04A	Noncontact cooling water	44	pH, flow, total residual chlorine	Once per three months
051	Radioactive waste treatment plant (TA-21 and TA-50)	1	Ammonia (as N), chemical oxygen demand, total suspended solids, total cadmium, total chromium, total copper, total iron, total lead, total mercury, total nitrogen, total nickel, nitrate-nitrite (as N), total zinc, total toxic organics, radium-226, radium-228, pH, flow	Once per week
05A	High explosives wastewater	18	Chemical oxygen demand, pH, flow, total suspended solids	Once per three months
06A	Photo waste water	14	Total silver, pH, flow	Once per three months
07A	Asphalt plant	1	pH, total suspended solids, chemical oxygen demand, oil & grease, flow	Once per three months
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, total iron, total copper, total silver, flow	Once per week
S	Sanitary wastewater (05S & 13S)	2	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once per three months

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under National Pollutant Discharge Elimination System Permit NM0028355 (effective August 1, 1994) (Cont.)

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A, 02A 03A, 04A 051, 05A 06A, 07A 128, 05S 13S	All discharge categories	124	Total aluminum, total arsenic, total boron total cadium, total chromium, total cobalt, total copper, total lead, total mercury, total, selenium, total vanadium, total zinc, radium-226 + radium-228, tritium[a]	Once per year

[a]When accelerator produced.

Note: See "Environmental Surveillance in Los Alamos during 1993" for NPDES permit limits for January 30, 1990 through July 31, 1994.

Table D-3. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
13S TA-46 SWSC	BOD[a]	30.0	45.0	mg/L
		100.0	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		100.0	N/A	lb/day
	Fecal coliform bacteria	500.0	500.0	org/100 mL
	pH	6-9	6-9	standard unit
05S TA-21 Package Plant	BOD[a]	30.0	45.0	mg/L
		0.5	N/A	lb/day
	TSS[b]	30.0	45.0	mg/L
		0.5	N/A	lb/day
	COD[c]	125.0	125.0	mg/L
		2.1	N/A	lb/day
	pH	6-9	6-9	standard unit

[a]Biochemical oxygen demand.
[b]Total suspended solids.
[c]Chemical oxygen demand
NOTE: Sanitary Outfalls 02S, 03S, 04S, 07S, 09S, 10S, and 12S were eliminated from the Laboratory's NPDES permit on July 9, 1993.

Table D-4. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls

Discharge Location (Outfall)	Permit Parameters	Number of Deviations
*TA-21 (05S)	Fecal coliform bacteria	0
	COD[a]	0
	BOD[b]	0
	TSS[c]	0
	pH	0
TA-46 (13S)	Fecal coliform bacteria	0
	BOD[b]	0
	TSS[c]	0
	pH	0

[a]Chemical oxygen demand.
[b]Biochemical oxygen demand.
[c]Total suspended solids.
*No discharge from outfall 05S during 1994.

Table D-5. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Industrial Outfall Discharges August 1, 1994

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01A Power plant	TSS[a]	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6-9	6-9	standard unit
02A Boiler blowdown	TSS	30.0	100.0	mg/L
	Total Fe	10.0	40.0	mg/L
	Total Cu	1.0	1.0	mg/L
	Total P	20.0	40.0	mg/L
	Sulfite	35.0	70.0	mg/L
	Total Cr	1.0	1.0	mg/L
	pH	6-9	6-9	standard unit
03A Treated cooling water	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	Total P	20.0	40.0	mg/L
	Total As	0.04	0.04	mg/L
	pH	6-9	6-9	standard unit
04A Noncontact cooling	pH	6-9	6-9	standard unit
	Total Cl	Report[b]	Report[b]	mg/L
051 Radioactive waste treatment plant (TA-50)	COD	94.0	156.0	lb/day
	TSS	18.8	62.6	lb/day
	Total Cd	0.06	0.3	lb/day
	Total Cr	0.19	0.38	lb/day
	Total Cu	0.63	0.63	lb/day
	Total Fe	1.0	2.0	lb/day
	Total Pb	0.06	0.15	lb/day
	Total Hg	0.003	0.09	lb/day
	Total Zn	0.62	1.83	lb/day
	TTO[c]	1	1	mg/L
	Ni	Report[b]	Report[b]	mg/L
	N	Report[b]	Report[b]	mg/L
	NO_3-NO_2	Report[b]	Report[b]	mg/L
	Ammonia (as N)	Report[b]	Report[b]	mg/L
	pH	6-9	6-9	standard unit
05A High explosive	Oil & Grease	15.0	15.0	mg/L
	COD[d]	125.0	125.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6-9	6-9	standard unit

Table D-5. Limits Established by National Pollutant Discharge Elimination System Permit NM0028355 for Industrial Outfall Discharges August 1, 1994 (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
06A Photo waste	Ag	0.5	1.0	mg/L
	pH	6-9	6-9	standard unit
07A Asphalt Plant	COD	125.0	125.0	mg/L
	TSS	100.0	100.0	mg/L
	Oil & Grease	15.0	15.0	mg/L
	pH	6-9	6-9	standard unit
128 Printed circuit board	COD	125.0	125.0	mg/L
	TSS	1.25	2.5	lb/day
	Total Fe	0.05	0.1	lb/day
	Total Cu	0.05	0.1	lb/day
		1.0	1.0	mg/L
	Total Ag	0.02	0.02	mg/L
	pH	6-9	6-9	standard unit
All Outfall Categories:	Total Aluminum	5.0	5.0	mg/L
Annual Water Quality	Total Arsenic	0.04	0.04	mg/L
Parameters	Total Boron	5.0	5.0	mg/L
	Total Cadmium	0.2	0.2	mg/L
	Total Chromium	5.1	5.1	mg/L
	Total Cobalt	1.0	1.0	mg/L
	Total Copper	1.6	1.6	mg/L
	Total Lead	0.4	0.4	mg/L
	Total Mercury	0.01	0.01	mg/L
	Total Selenium	0.05	0.05	mg/L
	Total Vanadium	0.1	0.1	mg/L
	Total Zinc	95.4	95.4	mg/L
	Radium 226+228	30.0	—	pCi/L
	Tritium	3,000,000	—	pCi/L

[a]Total suspended solids.
[b]Effluents are reported to EPA but are not subject to limits.
[c]Total Toxic Organics.
[d]Chemical Oxygen Demand.

Table D-6. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality at Industrial Outfalls: Deviation 1994

EPA ID	Technical Area	Date	Parameter		Results/Limits	Units
January						
03A037	TA-21-314	01/06/94	pH	(daily max)	9.3/9.0	su
03A037	TA-21-314	01/06/94	TSS	(daily max)	362/100	mg/L
February						
128128	TA-22-91	02/07/94	Cu	(daily max)	0.116/0.10	lbs/day
128128	TA-22-91	02/07/94	Fe	(daily max)	0.143/0.10	lbs/day
March						
06A123	TA-15-183	03/15/94	CN	(daily max)	0.37/0.20	mg/L
April						
03A049	TA-53-64	04/20/94	TSS	(daily max)	133,130/100	mg/L
03A049	TA-53-64	04/20/94	P	(daily max)	40/5	mg/L
03A049	TA-53-64	04/20/94	TSS	(daily avg)	29,584/30	mg/L
03A049	TA-53-64	04/20/94	P	(daily avg)	9.02/5	mg/L
May - - No exceedances during monitoring period.						
June						
05A066	TA-9A	06/07/94	TSS	(daily max)	80/45	mg/L
July - - No exceedances during monitoring period.						
August						
128	TA-22-91	08/24/94	pH	(daily max)	9.2/9.0	su
128	TA-22-91	08/04 94	Fe	(daily max)	1.64/0.10	lbs/day
128	TA-22-91	08/04/94	Fe	(daily avg)	0.33/0.05	lbs/day
September						
05A066	TA-09-A	09/07/94	TSS	(daily max)	92.0/45.0	mg/L
05A066	TA-09-A	09/07/94	TSS	(daily avg)	47.5/30.0	mg/L
05A053	TA-16-410	09/21/94	O & G	(daily max)	204.2/15.0	mg/L
05A053	TA-16-410	09/21/94	O & G	(daily avg)	103.0/15.0	mg/L
October						
03A045	TA-48-1	10/18/94	pH	(daily max)	9.3/9.0	su
November						
03A028	TA-15-202	11/29/94	As(T)	(daily max)	0.28/0.04	mg/L
03A045	TA-48-1	11/08/94	pH	(daily max)	9.5/9.0	su
03A045	TA-48-1	11/15/94	pH	(daily max)	9.1/9.0	su
03A047	TA-53-60	11/09/94	Cl_2	(daily max	0.60/0.50	mg/L
03A047	TA-53-60	11/29/94	Cl_2	(daily avg)	0.30/0.20	mg/L
December						
03A028	TA-15-202	12/15/94	As(T)	(daily max)	0.068/0.04	mg/L
03A028	TA-15-202	12/15/94	As(T)	(daily avg)	0.12/0.04	mg/L
05A056	TA-16-260	12/13/94	O & G	(daily max)	47/15	mg/L
05A056	TA-16-260	12/13/94	O & G	(daily avg)	26.2/15	mg/L
128	TA-22-91	12/05/94	pH	(daily max)	9.8/9.0	su

Table D-7. Federal Facilities Compliance Agreement and Administrative Order: Compliance Schedule for Waste Stream Characterization Program and High Explosives Wastewater Treatment Plant

Outfalls	Date	Status or Target Date
Outfall 05A (HE Wastewater Treatment)		
Complete conceptual design report	July 1992	Completed
Complete design criteria	June 1993	Completed
Begin line item project	January 1994	Completed
Complete Title I design	July 1994	Completed
Complete Title II design	July 1996	July 31, 1996
Advertisement of construction	August 1996	August 31, 1996
Award of construction contract	October 1996	October 31, 1996
Construction completion	September 1997	September 30, 1997
Achieve compliance with final permit limits	October 1997	October 31, 1997
Waste Stream Identification and Characterization		
Completion of waste stream final report	March 1994	Completed
Complete 25% corrective actions	September 1994	Completed
Complete 50% corrective actions	September 1995	September 30, 1995
Complete 100% corrective actions	September 1996	September 30, 1996
Achieve compliance with permit limitations	October 1996	October 31, 1996

Table D-8. Radiochemical Detection Limits for Analyses of Typical Environmental Samples

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration	
Air Sample				
Tritium	3 m^3	30 min	1×10^{-12}	µCi/mL
^{131}I	3.0×10^2 m^3	1×10^3 s	1×10^{-11}	µCi/mL
^{238}Pu	2.0×10^4 m^3	8×10^4 s	4×10^{-18}	µCi/mL
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{241}Am	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16}	µCi/mL
^{234}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
^{235}U	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	µCi/mL
^{238}U	2.0×10^4 m^3	8×10^4 s	3×10^{-18}	µCi/mL
Water Sample				
Tritium	0.005 L	30 min	4×10^{-7}	µCi/mL
^{90}Sr	0.5 L	200 min	3×10^{-9}	µCi/mL
^{137}Cs	0.5 L	5×10^4 s	4×10^{-8}	µCi/mL
^{238}Pu	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
^{241}Am	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
Gross alpha	0.9 L	100 min	3×10^{-9}	µCi/mL
Gross beta	0.9 L	100 min	3×10^{-9}	µCi/mL
Soil Sample				
Tritium	1 kg	30 min	0.003	pCi/g
^{90}Sr	2 g	200 min	2	pCi/g
^{137}Cs	100 g	5×10^4 s	0.1	pCi/g
^{238}Pu	10 g	8×10^4 s	0.002	pCi/g
$^{239,240}Pu$	10 g	8×10^4 s	0.002	pCi/g
^{241}Am	10 g	8×10^4 s	0.002	pCi/g
Gross alpha	2 g	100 min	3	pCi/g
Gross beta	2 g	100 min	3	pCi/g
U (delayed neutron)	2 g	20 s	0.2	µg/g

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
Plecoptera				
(Stoneflies)	Capniidae	*Capnia*		F
	Capniidae			F
	Chloroperlidae	*Chloroperla*		F
	Chloroperlidae	*Paraperla*	*frontalis*	G,L
	Chloroperlidae	*Paraperla*		F
	Chloroperlidae	*Sweltsa*	*coloradensis*	F
	Chloroperlidae	*Sweltsa a*	*lamba*	F
	Chloroperlidae	*Sweltsa*		F,G
	Chloroperlidae	*Suwallia*		G,L
	Chloroperlidae			F,G,L,SG
	Leuctridae	*Paraleuctra*	*vershina*	F
	Nemouridae	*Amphinemura*		F,G
	Nemouridae	*Amphinemura*	*banksi*	F,G,L,P,SG
	Nemouridae	*Malenka*	*coloradensis*	F
	Nemouridae	*Malenka*		G,L
	Nemouridae	*Nemoura*		F
	Nemouridae	*Podmosta*	*delicatula*	G
	Nemouridae	*Zapada*	*cinctipes*	F,L
	Nemouridae	*Zapada*	*frigida*	L
	Perlidae	*Acroneuria*	*abnormis*	F
	Perlidae	*Hesperoperla*	*pacifica*	F,L,SG
	Perlodidae	*Cultus*	*aestivalis*	GL
	Perlodidae	*Cultus*		G
	Perlodidae	*Isoperla*	*fulva*	F
	Perlodidae	*Isoperla*	*quinquepunctata*	F
	Perlodidae	*Isoperla*		F,G,L,S
	Perlodidae	*Kogotus*	*modestus*	G,L
	Perlodidae	*Skwala*	*parallela*	G
	Pteronarcyidae	*Pteronarcella*	*badia*	F,G
	Pteronarcyidae	*Pteronarcella*		F
	Pteronarcyidae	*Pteronarcys*	*californica*	G
	Pteronarcyidae	*Pteronarcys*		G
	Taeniopterygidae	*Taenionema*		F
Ephemeroptera				
(Mayflies)	Baetidae	*Baetis*	*bicaudata*	F
	Baetidae	*Baetis*	*insignificans*	F
	Baetidae	*Baetis*	*tricaudatus*	A,D,F,G,L,PS,S
	Baetidae	*Baetis*		A,C,F,G,H,L,P, PS,S,SG,128
	Baetidae	*Callibaetis*		G,L,P,PS,S,48
	Ephemerellidae	*Drunella*	*coloradensis*	G,L
	Ephemerellidae	*Drunella*	*doddsi*	F,G
	Ephemerellidae	*Drunella*	*grandis grandis*	F,G
	Ephemerellidae	*Ephemerella*	*inermis*	F,G,L
	Ephemerellidae	*Ephemerella*	*infrequens*	F,G
	Ephemerellidae	*Ephemerella*		F
	Heptageniidae	*Cinygmula*		F,G,L

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Heptageniidae	*Epeorus*	*longimanus*	F,G,L
	Heptageniidae	*Epeorus*		F,G,L
	Heptageniidae	*Heptagenia*		G
	Heptageniidae	*Nixe*	*simplicoides*	L
	Heptageniidae	*Rhithrogena*		F
	Leptophlebiidae	*Paraleptophlebia*		F,G,L
	Siphlonuridae	*Ameletus*		F,G,L,S,SG
	Siphlonuridae	*Siphlonurus*	*occidentalis*	F,L
	Siphlonuridae	*Siphlonurus*		F
	Siphlonuridae			A,L
	Tricorythidae	*Tricorythodes*	*minutus*	G,S
	Tricorythidae	*Tricorythodes*		A,F
Odonata				
suborder Anisoptera				
(Dragonflies)	Aeshnidae	*Aeshna*		A,C,F,I,S
	Aeshnidae	*Anax*		H,P,S,48
	Aeshnidae	*Boyeria*		L,S
	Cordulegastridae	*Cordulegaster*		F,S
	Corduliidae	*Belonia*?		A,C,P
	Gomphidae			L,P
	Libellulidae	*Leuchorrhina*		I
	Libellulidae	*Libellula*		PS
	Libellulidae	*Pantala*		A,C
	Libellulidae	*Platyhemis*?		P
	Libellulidae	*Sympetrum*?		PS
	Libellulidae			A,F,PS
suborder Zygoptera				
(Damselflies)	Agriidae	*Argion*		A
	Agriidae	*Hetaerina*		A,PS
	Coenagrionidae	*Argia*		A,C,F,P,S,PS
	Coenagrionidae	*Enallagma*		I,S
	Coenagrionidae	*Hyponeura*		F
	Coenagrionidae	*Ishnura*	*perparua*	F
	Coenagrionidae	*Ishnura*		H,S
	Coenagrionidae	*Zoniagrion*		S
	Lestidae	*Archilestes*		PS,S
Hemiptera				
(True bugs)	Corixidae	*Corisella*		F
	Corixidae	*Sigara*		F
	Corixidae	*Trichocorixa*		A,P,S
	Gerridae	*Gerris*	*marginatus*	F
	Gerridae	*Gerris*	*notabilis*	F
	Gerridae	*Gerris*		A,D,F,G,H,I,L, S,PS
	Gerridae	*Metrobates*		PS
	Gerridae	*Trepobates*		H,S
	Naucoridae	*Ambrysus*	*mormon*	A,C,PS
	Notonectidae	*Notonecta*	*undulata*	F
	Notonectidae	*Notonecta*		C,S

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Veliidae	*Microvelia*		F,G,L
	Veliidae	*Rhagovelia*		S
	Veliidae			A,PS
Trichoptera				
(Caddisflies)	Brachycentridae	*Amiocentrus*		F
	Brachycentridae	*Brachycentrus*	*americanus*	F
	Brachycentridae	*Brachycentrus*		F
	Brachycentridae	*Micrasema*		F,G,L
	Brachycentridae pupae	*Micrasema*		G
	Calamoceratidae	*Phylloicus*		F
	Glossomatidae	*Agapetus*		G
	Glossosomatidae	*Anagapetus*		G
	Glosssosomatidae	*Glossosoma*		F,G,L
	Helicosychidae	*Helicopsyche*	*borealis*	G,L,PS
	Helicopsychidae	*Helicopsyche*		F
	Hydropsychidae	*Arctopsyche*	*grandis*	A,F,G,L,S,PS
	Hydropsychidae	*Cheumatopsyche*		G,PS
	Hydropsychidae	*Hydropsyche*	*occentalis*	PS
	Hydropsychidae	*Hydropsyche*	*oslari*	A,F
	Hydropsychidae	*Hydropsyche*		F,G,L,S
	Hydrospsychidae	*Hydropsyche*		F,G,PS,S,SG
	Hydroptilidae	*Alisotrichia*		PS
	Hydroptilidae	*Hydroptila*		A,P,PS,S
	Hydroptilidae	*Leucotrichia*		PS
	Hydroptilidae	*Ochrotrichia*		F,G,L
	Hydroptilidae	*Stactobiella*		A,PS
	Lepidostomatidae	*Lepidostoma*		F,G,L,S,SG
	Lepidostomatidae			G
	Leptoceridae	*Oecetis*?		G,L,P,S
	Limnephilidae	*Dicosmoecus*		F
	Limnephilidae	*Hesperophylax*		G,L,P,S,SG
	Limnephilidae pupae	*Hesperophylax*		G
	Limnephilidae	*Limnephilus*		F,G,L,PW,S
	Limnephilidae	*Oligophlebodes*		F,G,L,P,S
	Limnephilidae pupae	*Oligophlebodes*		G
	Limnephilidae	*Psychoronia*		F,G
	Limnephilidae			G,L,PW
	Odontoceridae	*Namamyia*		G
	Philopotamidae	*Chimarra*		A,PS
	Philopotamidae	*Dolophilodes*	*aequalis*	F
	Philopotamidae	*Dolophilodes*	*sortosa*	F,G
	Philopotamidae	*Dolophilodes*		G,L
	Philopotamidae	*Wormaldia*		F,PS
	Polycentropidae	*Polycentropus*		F
	Rhyacophilidae	*Rhyacophila*	*acropedes*	F,G
	Rhyacophilidae	*Rhyacophila*	*brunnea* complex	F,G,L
	Rhyacophilidae pupae	*Rhyacophila*	*brunnea* complex	G,L
	Rhyacophilidae	*Rhyacophila*	*hyalinata*	F,G
	Rhyacophilidae	*Rhyacophila*	*valuma*	F,G

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Rhyacophilidae	*Rhyacophila*		F
	Rhyacophilidae	*Rhyacophila*	Type A	A
Megaloptera (Nerve-wings)	Corydalidae	*Neohermes*?		G,L
Lepidoptera (Butterflies and moths)	Noctuidae			G,L,PS
	Pyralidae			G,S
	Pyralidae	*Paraponyx*		PS
	Pyralidae	*Parargyractis*	*kearfottalis*	F,PS
	Pyralidae	*Petrophyla*		PS
Coleoptera (Beetles)	Amphizoidae	*Amphizoa*		G
	Curculionidae	*Phytonomus*		G,L,S
	Curculionidae			D,F
	Curculionidae adult			G
	Dryopidae	*Helichus*	*suturalis**	F
	Dryopidae	*Helichus*	*striatus**	F
	Dryopidae (adults)	*Helichus*		F,G,L,P,PS,S
	Dryopidae (adults)			S
	Dytiscidae	*Agabus*	*cordatus**	F
	Dytiscidae	*Agabus*	*tristus**	F
	Dytiscidae	*Agabus*		A,C,D,L,P,S
	Dytiscidae	*Deronectes*	*striatellus**	F
	Dytiscidae	*Deronectes**		L
	Dytiscidae	*Dytiscus**		F
	Dytiscidae	*Hydroporus*	*vilis**	F
	Dytiscidae	*Hydroporus*		S
	Dytiscidae	*Hygrotus*		S
	Dytiscidae			L,S
	Dytiscidae (adults)			G,L,PS,S
	Dytiscidae (adults)		Type A	M,S
	Dytiscidae (adults)		Type B	M,S
	Dytiscidae (adults)		Type C	S
	Dytiscidae (adults)	*Hydaticus*		G,L,PS,S
	Elmidae	*Cleptelmis*	*addenda**	F
	Elmidae	*Cylloepus*		F
	Elmidae	*Dubiraphia**		G
	Elmidae	*Heterlimnius*	*corpulentis*	F,G,L,PS,SG
	Elmidae (adults)	*Heterlimnius*	*corpulentis*	G,L,PS,SG
	Elmidae	*Microcylloepus**		PS
	Elmidae	*Narpus **	*concolor*	F
	Elmidae	*Narpus*		F,G,L
	Elmidae (adults)	*Narpus*		G,L
	Elmidae	*Optioservus*	*castanipennis**	F
	Elmidae	*Optioservus*	*divergens**	F
	Elmidae	*Optioservus**		D,F,L,PS,S
	Elmidae	*Rhizelmis*		F
	Elmidae	*Zaitzevia*	*parvula*	D,F,L
	Elmidae	*Zaitzevia*		G,L

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Elmidae (adults)	*Zaitzevia*		C,G,L,S
	Elmidae			G,L,S
	Elmidae (adults)			C,S,PS
	Gyrinidae (adults)	*Gyrinus*		A,F,S,PS
	Haliplidae	*Haliplus*		IC
	Haliplidae	*Peltodytes*		G
	Haliplidae (adults)			S
	Helodidae			P
	Helodidae	*Prionocyphon*		G
	Hydrophilidae	*Ametor*	*scabrosus**	F
	Hydrophilidae	*Ametor*		A,C,G,L,S
	Hydrophilidae (adults)	*Ametor*		G
	Hydrophilidae	*Berosus*	*styliferous*	F
	Hydrophilidae	*Crenitis**		F
	Hydrophilidae	*Cymbiodyta*	*dorsalis**	F
	Hydrophilidae (adults)	*Enochrus?*		G
	Hydrophilidae (adults)	*Helphorus*		L
	Hydrophilidae (adults)	*Hydrobius*		L
	Hydrophilidae	*Hydrochus*		G
	Hydrophilidae (adults)	*Hydrochus*		G
	Hydrophilidae			G,L,P
	Hydrophilidae (adults)			G
	Psephenidae	*Psphenus*?		C,P,48
	Psephenidae			G
Diptera (Flies)	Blephariceridae			F
	Ceratopogonidae (Heleidae)	*Bezzia*		G,L,S
	Ceratopogonidae (Heleidae)			F,G,P,S,PS
	Chironomidae	*Ablabesmyia*		F
	Chironomidae	*Brillia*		F,L,S
	Chironomidae	*Cardiocladius*		F,G
	Chironomidae	*Crichotopus*		F
	Chironomidae	*Chironomus*		F
	Chironomidae	*Corynoneura*		PS
	Chironomidae	*Cricotopus*		A,F,G,PS
	Chironomidae	*Cryptochironomus*		F
	Chironomidae	*Eukiefferiella*		A,F,G,L
	Chironomidae	*Micropsectra*		A,F
	Chironomidae	*Microtendipes*		D,F
	Chironomidae	*Nanocladius*		F
	Chironomidae	*Pagastia*		L
	Chironomidae	*Parametriocnemus*		L
	Chironomidae	*Polypedilum*		A,F
	Chironomidae	*Procladius*		F
	Chironomidae	*Pseudochironomus*		A
	Chironomidae	*Pseudosmittia*		G
	Chironomidae	*Rheotanytarsus*		A,F,PS
	Chironomidae	*Thienemannimyia*		A,S
	Chironomidae	*Thienimanniella*		A
	Chironomidae	*Tvetnia*		L,PS,S

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Chironomidae	*Zavrelia*		F
	Chironomidae	Type A		C,G,H,L,P, PS,S, SG,128
	Chironomidae	Type B		G,L,P,S,PS
	Chironomidae	Type C		G,H,L,P,S,128
	Chironomidae	Type D		G,L,P,PS,S
	Chironomidae	Type E		G,L,PS
	Chironomidae	Type F		G,L,S
	Chironomidae	Type G		A,C,G,H,L,P, PS,S
	Chironomidae pupae	Type G		G
	Chironomidae	Type H		L,S
	Chironomidae	Type I		SG
	Chironomidae (pupae)			C,G,I,L,S
	Chironomidae pupae	Type PA		G,L
	Chironomidae (pupae)	Type PB		S
	Chironomidae (pupae)	Type PC		S
	Culicidae	*Aedes*		F
	Culicidae	*Chaoborus*		I,48
	Culicidae	*Culex*		F,H,128
	Culicidae	*Culiseta*		D,H,M,48,128
	Culicidae (pupae)			H,M,G,L,128
	Culicidae			S
	Dixidae	*Dixa*	*californica*	F
	Dixidae	*Dixa*		F,G,L,PS
	Dixidae	*Dixa*	Type A	G,L,P,PS
	Empididae	*Chelifera*		F,G,L
	Empididae	*Oreogeton*		C,F,G,L,P,S
	Empididae			H
	Empididae (pupae)	*Hemerodromia*		G,S
	Ephydridae	*Brachydeutera*		S
	Ephydridae (pupae)			S
	Muscidae	*Limnophora*	*aequifrons*	F
	Muscidae	*Limnophora*		A,D,L,S,SG
	Psychodidae	*Maruina*		G,L,S
	Psychodidae	*Pericoma*		F,G,L
	Psychodidae (pupae)			S
	Ptychopteridae	*Bittacomorpha*		A,G,L,S
	Ptychopteridae	*Ptychoptera*		G
	Ptychopteridae			F
	Simuliidae	*Prosimilium*		A,F,G,L,S
	Simuliidae	*Simulium*		A,F,L,PS,S
	Simuliidae			D,F,G,L,S,SG
	Simuliidae (pupae)			G,L,S
	Simuliidae pupae	Type PA		G
	Stratiomyidae	*Eulalia*		F
	Stratiomyidae	*Odontomyia*		G,PS,S
	Stratiomyidae			A,F,G
	Syrphidae	*Tubifera*	*bastardii*	F

Table D-9. Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (Cont.)
(* = life stage not known, all specimens are larval unless otherwise noted)

ORDER	FAMILY	GENUS	SPECIES	LOCATION**
	Tabanidae	*Chrysops*		H,M
	Tabanidae	*Tabanus*		128,PW,S
	Tabanidae			F,G,L,S
	Tanyderidae	*Protanyderus*		F
	Tipulidae	*Antocha*	*monticola*	F,G
	Tipulidae	*Antocha*		G,L
	Tipulidae	*Dicranota*		F,G,L,PS,S,SG
	Tipulidae	*Hexatoma*		F
	Tipulidae	*Holorusia*	*grandis*	F
	Tipulidae	*Limonia*		F
	Tipulidae	*Pedicia*		F
	Tipulidae	*Tipula*		D,F,G,L,PS,S
	Tipulidae	*Tipula*	Type B	G,L,S

****Locations:**

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi firestation pond
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
M = Mortandad
SG = Starmer's Gulch
48 = TA-48 pond
128 = outfall 128

Appendix D

Table D-10. Noninsect Aquatic Invertebrates Collected in Los Alamos County and Adjacent Watersheds

Phylum or Subphylum	Class, etc.	Common Name	Location[a]
Annelida (Segmented worms)	Naididae	Coil worms	F,G,L,S
	Oligochaeta, Lumbriculidae		
	Eiseniella tetraedra	Aquatic earthworms	F
	Oligochaeta, Lumbriculidae	Aquatic earthworms	A,F,G,L,PS,S,SG
	Oligochaeta B, Lumbriculidae	Aquatic earthworms	G
	Hirudinea	Leeches	A,F
Arthropoda, Arachnoidea (Spiders, ticks, and mites)	family Hydracarina	Water mites	C,F,G,L,PS,SG
Aschelminthes (Round worms and hairworms)	Nematomorpha	Horsehair worm	C,F,G,L,P,S,SG
	Nematomorpha, Gordioidea,Gordiidae, *Gordius*	Horsehair worm	F,G
Crustacea (Crustaceans)	Amphipoda, *Hyatella azteca*	Scuds	A,C,PS
	Cladocera	Water fleas	O
	Copepoda	Copepods	S
	Ostracoda, Candoniidae	Seed shrimp	S
	Ostracoda, Cyprididae	Seed shrimp	C,S,SG
	Amphipoda, Palaemonidae	Scuds	A,C
	Amphipoda, *Hyalella azteca*	Scuds	PS
Mollusca (Mollusks)	Planorbidae, *Gyralus parvus*	Snails	G,IC,S
	Lymnaeidae, *Lymnaea*	Snails	A,G,L,P,S
	Physidae, *Physella*	Snails	A
	Physidae, *Physa*	Snails	F,S
	Gastropoda	Snails	SG
	Gastropoda Type A	Snails	G,L
	Sphaeriidae, *Pisidium casertanum*	Clams	F,G,L
	Pelecypoda, *Pisidium compressa*	Clams	H
	Sphaeriidae	Clams	F
Nematoda (Round worms)		Free-living roundworm	F,G,S
Platyhelminthes (Flatworms)	Turbellaria	Planaria	A,C,F,G,PS,S,SG

[a]**Locations:**

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi Fire Station pond
M = Mortandad
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = Outfall 128

Table D-11. Summary of Selected Radionuclides Half-Life Information

Nuclide	Half-Life
^{3}H	12.3 yr
^{7}Be	53.4 d
^{11}C	20.5 min
^{13}N	10.0 min
^{15}O	122.2 s
^{22}Na	2.6 yr
^{32}P	14.3 d
^{40}K	1,277,000,000 yr
^{41}Ar	1.83 h
^{54}Mn	312.7 d
^{56}Co	78.8 d
^{57}Co	270.9 d
^{58}Co	70.8 d
^{60}Co	5.3 yr
^{75}Se	119.8 d
^{85}Sr	64.8 d
^{89}Sr	50.6 d
^{90}Sr	28.6 yr
^{131}I	8 d
^{134}Cs	2.06 yr
^{137}Cs	30.2 yr
^{234}U	244,500 yr
^{235}U	703,800,000 yr
^{238}U	4,468,000,000 yr
^{238}Pu	87.7 yr
^{239}Pu	24,131 yr
^{240}Pu	6,569 yr
^{241}Pu	14.4 yr
^{241}Am	432 yr

NOTE: For the half-life of the principal airborne activation products, see discussion in Section V.B.1.

Table D-12. Locations of Air Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
Regional (28-44 km)		
1. Española	1819247.9	544369.5
2. Pojoaque	1770753.2	564196.6
3. Santa Fe	1698592.5	297029.1
Perimeter (0-4 km)		
4. Barranca School	1783276.3	490540.6
5. Arkansas Avenue	1783435.0	472030.6
6. 48th Street	1776555.5	476714.3
7. Shell Station	1775843.3	483461.3
8. McDonald's	1774932.1	485435.7
9. Los Alamos Airport	1776244.0	492348.4
10. East Gate	1773917.6	498437.5
11. Well PM-1	1768256.6	507326.5
12. Royal Crest Trailer Park	1772809.5	485105.5
13. White Rock- Piñon School	1754709.8	511035.6
14. Pajarito Acres	1743891.3	512275.3
15. White Rock Fire Station	1756934.4	513175.6
16. White Rock Church of the Nazarene	1754506.1	508400.5
17. Bandelier National Monument	1739541.6	495304.8
18. North Rim	(non-active)	
On Site Stations, Controlled Areas		
19. TA-21 DP Site	1773715.6	494734.2
20. TA-21 Area B	1774828.5	491772.0
21. TA-6	1771795.4	471440.1
22. TA-53 (LAMPF)	1771895.6	495063.1
23. TA-52 Beta Site	1767650.1	492181.5
24. TA-16 S Site	1764329.7	468060.8
25. TA-16-450	1760923.5	469442.7
26. TA-49	1756028.7	479579.8
27. TA-54 Area G	1757907.9	503080.9
28. TA-33 HP Site	1740552.3	497858.9
29. TA-2 Omega Site	1770682.3	495062.9
30. Booster P-2	1762897.1	495802.5
31. TA-3	1773116.5	478357.4
32. TA-48	1774935.5	480119.8
00. TA-59 OHL	1770897.2	480387.6
Waste Site Stations, Controlled Areas		
33. Area AB	1755216.2	485590.5
34. Area G-1 NE Corner	1757855.5	504906.8
35. Area G-2 South Fence	1757153.7	501450.2
36. Area G-3 Gate	1758458.7	500850.0
37. Area G-4 H_2O Tank	1756065.1	505642.7

Table D-12. Locations of Air Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
Area G TRU Waste Inspectable Storage Program		
43. Area G/S of Dome	1757484.2	504240.4
44. Area G/S Perimeter	1757408.6	504638.2
45. Area G/SE Perimeter	1757359.2	504855.1
46. Area G/E Perimeter	1757627.8	504893.9
47. Area G/N Perimeter	1757947.9	505612.4
TA-21 Decontamination and Decommissioning Project		
71. TA-21.01	1774879.3	491782.3
72. TA-21.02	1774815.7	492045.3
73. TA-21.03	1774682.8	492390.2
74. TA-21.04	1774133.2	491841.1
75. TA-21.05	1773984.0	492259.9
Pueblo Stations		
41. San Ildefonso	1780214.9	538094.3
42. Taos Pueblo	1971428.7	703170.0
48. Jemez Pueblo	1503337.0	356323.6

[a]See Figure V-8 for station locations.
[b]New Mexico State Plane Coordinates.

Table D-13. Locations of Surface Water Sampling Stations[a]

Location[a]	Northing Coordinate[b]	Easting Coordinate[b]
OFF-SITE STATIONS		
REGIONAL STATIONS		
Rio Chama at Chamita	30°05″	106°07″
Rio Grande at Embudo	36°12″	105°58″
Rio Grande at Otowi	1 773 000	532 300
Rio Grande at Cochiti	35°37″	106°19″
Rio Grande at Bernalillo	35°17″	106°36″
Jemez River	35°40″	106°44″
PERIMETER STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyons		
Acid Weir	1 778 741	484 214[b1]
Pueblo 1	1 778 817	484 165 [b1]
Pueblo 2	1 776 803	495 013[b1]
Los Alamos Canyon		
Los Alamos at Rio Grande	1 773 000	532 300[b2]
Other Areas		
Guaje Canyon	1 794 000	471 600[b2]
Los Alamos Reservoir	1 777 200	468 600[b2]
Mortandad at Rio Grande	1 756 595	523 638[b3]
Pajarito at Rio Grande	1 747 532	516 715[b3]
Frijoles at Park Headquarters	1 737 929	494 140[b3]
Frijoles at Rio Grande	1 729 494	499 198[b3]
ON-SITE STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyons		
Pueblo 3	1 774 826	506 429[b1]
Pueblo at SR 502	1 771 862	512 695[b1]
DP–Los Alamos Canyons		
DPS-1	1 774 796	493 081[b1]
DPS-4	1 773 228	497 258[b1]
Mortandad Canyon		
GS-1	1 770 230	486 502[b1]
Other Areas		
Cañada del Buey	1 766 666	491 631[b1]
Pajarito Canyon	1 759 676	497 730
Water Canyon at Beta	1 757 513	485 058
Sandia Canyon		
SCS-1	1 773 872	480 978[b1]
SCS-2	1 771 081	492 581[b1]
SCS-3	1 770 207	495 655[b1]
Ancho at Rio Grande	1 735 497	509 307[b3]

[a]Off-site regional surface water sampling locations are shown in Figure V-11; off-site perimeter and on-site sampling locations are given in Figure V-I2.

[b]New Mexico State Plane Coordinates, NAD27.

[b1]Coordinate measured by professional land surveyor.

[b2]Coordinate measured by Global Positioning System (GPS) instrument, estimated accuracy ± 2 to 5 m.

[b3]Coordinate scaled from map, estimated accuracy ± 100 m.

Table D-14. Locations of Sediment Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
OFF-SITE STATIONS		
REGIONAL STATIONS		
Chamita[c]	36°05″	106°07″
Embudo[c]	36°12″	106°58″
Rio Grande at Otowi[c]	35°52≤	106°08″
Rio Grande at Sandia[d]	1758925	525014
Rio Grande at Pajarito[d]	1747532	516715
Rio Grande at Water[d]	1741139	514154
Rio Grande at Ancho[d]	1735497	509307
Rio Grande at Frijoles[d]	1729494	499198
Rio Grande at Cochiti[c]	35°37″	106°19″
Rio Grande at Bernalillo[c]	35°17″	106°36″
Jemez River[b]	35°40″	106°44″
PERIMETER STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyon		
Acid Weir[e]	1778741.5	484213.6
Pueblo 1[e]	1778817.4	484165.4
Pueblo 2[e]	1776802.8	495013.5
DP-Los Alamos Canyon		
Los Alamos at Totavi	1772357.9	519683.8
Los Alamos at LA-2[e]	1777157.0	526680.137
Los Alamos at Otowi	1774114.9	531709.9
Other Canyons		
Guaje at SR 502	1777366.5	525674.0
Bayo at SR 502	1774361.7	522361.8
Sandia at Rio Grande[d]	1758925	525014
Cañada Ancha at Rio Grande	N/A[f]	N/A
Pajarito at Rio Grande[d]	1747532	516715
Frijoles at National Monument Headquarters	1737929.3	494139.8
Frijoles at Rio Grande[d]	1729494	499198
Mortandad Canyon on San Ildefonso Pueblo Land		
Mortandad A-6	N/A	N/A
Mortandad A-7	N/A	N/A
Mortandad A-8	N/A	N/A
Mortandad at SR 4 (A-9)[e]	1763782.7	509436.7
Mortandad A-10	N/A	N/A
Mortandad at Rio Grande (A-11)[c]	1756595	523638

Table D-14. Locations of Sediment Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
ON-SITE STATIONS		
Radioactive Effluent Release Areas		
Acid-Pueblo Canyon		
Hamilton Bend Spring[e]	1775857.4	502232.8
Pueblo 3[e]	1774826.4	506425.0
Pueblo at SR 502[e]	1771862.0	512694.7
DP-Los Alamos Canyon		
DPS-1[e]	1774796.3	493080.9
DPS-4[e]	1773227.8	497258.4
Los Alamos at Bridge[e]	1775550.8	478015.5
Los Alamos at LAO-1[e]	1773884.4	489162.8
Los Alamos at GS-1[e]	1770827.3	507906.9
Los Alamos at LAO-3[e]	1773012.4	497803.4
Los Alamos at LAO-4.5[e]	1772073.7	503410.1
Los Alamos at SR 4[d]	1771473.8	511651.0
Mortandad Canyon		
Mortandad near CMR Building[e]	1772092.7	479491.8
Mortandad west of GS-1	N/A	N/A
Mortandad at GS-1[e]	1770229.5	486502.2
Mortandad at MCO-5[e]	1769482.7	492212.1
Mortandad at MCO-7[e]	1768419.6	494306.2
Mortandad at MCO-9[e]	1768309.1	497813.6
Mortandad at MCO-13 (A-5)[e]	1767168.7	501051.6
Other Canyons		
Sandia at SR 4[e]	1767568.8	507558.5
Cañada del Buey at SR 4[e]	1756281.4	511459.2
Pajarito at SR 4[e]	1754333.2	508284.8
Potrillo at SR 4[e]	1751097.4	505375.0
Fence at SR 4	1751220.5	505153.7
Water at SR 4[e]	1749965.7	500428.6
Indio at SR 4	1747798.3	501075.1
Ancho at SR 4	1741156.4	500015.5
Water at Rio Grande[d]	1741139	514154
Ancho at Rio Grande[d]	1735497	509307
Chaquehiu at Rio Grande[d]	1733012	502768
Solid Radioactive Waste Management Areas		
Area G, TA-54[e]		
G-1	1757654.9	501645.5
G-2	1757160.7	502094.9
G-3	1756706.5	503162.6
G-4	1756643.1	503955.1
G-5	1756592.8	504153.1
G-6	1756494.6	504786.9

Table D-14. Locations of Sediment Sampling Stations[a] (Cont.)

Location	Northing Coordinate[b]	Easting Coordinate[b]
Area G, TA-54[e] (Cont.)		
G-7	1757361.2	505155.7
G-8	1757539.2	506507.4
G-9	1758521.8	505236.2
Area AB, TA-49[e]		
AB-1	1775633.2	484290.4
AB-2	1755169.0	485200.5
AB-3	1755569.9	485238.6
AB-4	1755640.2	486640.9
AB-4A	1755773.2	486638.4
AB-5	1754799.9	485631.3
AB-6	1754684.8	485643.4
AB-7	1754417.4	485583.5
AB-8	1754383.4	484698.5
AB-9	1756396.7	488195.0
AB-10	1754547.5	488279.6
AB-11	1752019.9	488479.1

[a]Sediment sampling locations in Figures V-14 and V-15.

[b]New Mexico State Plane Coordinates.

[c]Latitude/Longitude data from US Geological Survey (USGS).

[d]Coordinate data from GPS, estimated accuracy ± 2 to 5 m.

[e]Coordinate data from standard land survey.

[f]Not available.

Table D-15. Locations of Soil Sampling Stations[a]

Location	Northing Coordinate[b]	Easting Coordinate[b]
Regional Soil		
Rio Chama	1844693.096	1677875.228
Embudo	1816440.315	1744693.086
Otowi 1777182.637	1668721.670	
Near Santa Cruz	1816438.561	1744700.759
Cochiti 1644216.892	1647114.194	
Bernalillo	1572864.707	1549601.021
Jemez 1719495.437	1502276.101	
Perimeter Soils		
L.A. Sportsman Club	1788136.211	1636493.387
North Mesa	1780072.446	1630330.015
Near TA-8 (GT Site)	1768805.627	1609433.446
Near TA-49	1755456.289	1620318.345
White Rock (east)	1758301.447	1655116.466
Tsankawi	1768110.302	1647985.099
On-Site Soil		
TA-21 (DP Site)	1774989.218	1631266.389
East of TA-53	1772914.010	1629196.631
TA-50 1769548.575	1626390.047	
Two-Mile Mesa	1769494.453	1615386.422
East of TA-54	1757882.733	1645162.755
R-Site Road East	1761923.229	1625863.108
Potrillo Drive	1759475.770	1635153.829
S-Site (TA-16)	1759328.803	1618868.688
Near Test Well DT-9	1752337.978	1629594.961
Near TA-33	1740806.015	1638487.987

[a]Soil sampling locations are given in Figures V-14 and V-18.
[b]New Mexico State Planar Coordinates, NAD 1983

Table D-16. Locations of Groundwater Sampling Stations

Location[a]	Northing Coordinate	Easting Coordinate
MAIN AQUIFER ON SITE		
Test Wells		
Test Well 1	1772014.8	509797.3
Test Well 3	1773076.0	497483.2
Test Well 8	1769444.5	492329.6
Test Well DT-5A	1754923.5	485098.3
Test Well DT-9	1752318.4	489300.0
Test Well DT-10	1755228.5	488780.9
Water Supply Wells		
Well PM-1	1768050.0	507490.1
Well PM-2	1760264.0	496542.0
Well PM-3	1769364.0	502386.8
Well PM-4	1764612.0	495472.4
Well PM-5	1767747.0	492839.0
Well O-4	1772933	497093
MAIN AQUIFER OFF SITE		
Test Wells		
Test Well 2	1777205.8	493986.9
Test Well 4	1777618	483783.9
Water Supply Wells		
Well G-1	1783547.0	515946.4
Well G-1A	1784291.0	514996.6
Well G-2	1785061.0	513966.2
Well G-3	1786156.0	511432.1
Well G-4	1786390.0	508704.8
Well G-5	1787845.0	506705.3
Well G-6	1786789.0	504580.1
MAIN AQUIFER SPRINGS		
White Rock Canyon Springs		
Group I		
Sandia Spring[b]	1761428	522938
Spring 3[b]	1753500	521243
Spring 3A[b]	1753236	521276
Spring 3AA[b]	1750988	521047
Spring 4[b]	1747825	515784
Spring 4A[c]	1747800	515900
Spring 5[b]	1742479	515812
Spring 5AA[c]	1742500	510900
Ancho Spring[c]	1739900	505400
Group II		
Spring 5A[b]	1741943	515121
Spring 5B[c]	1738100	510800
Spring 6[b]	1735455	508638
Spring 6A[b]	1734210	506318
Spring 7[c]	1733500	504800
Spring 8[c]	1733400	504200
Spring 8A[b]	1733446	503574
Spring 8B[c]	1733500	503000
Spring 9[b]	1733255	503191

Table D-16. Locations of Groundwater Sampling Stations (Cont.)

Location[a]	Northing Coordinate	Easting Coordinate
MAIN AQUIFER SPRINGS		
White Rock Canyon Springs		
Group II (Cont.)		
Spring 9A[b]	1733085	502498
Doe Spring[b]	1733536	502081
Spring 10[b]	1728100	497779
Group III		
Spring 1[b]	1767795	527684
Spring 2[b]	1766286	527068
Group IV		
La Mesita Spring[c]	1770700	516300
Spring 2A[c]	1754800	522400
Spring 3B[b]	1749752	521110
Other Springs		
Sacred Spring[c]	1780300	529800
Indian Spring[c]	1777200	525700
ALLUVIAL CANYON GROUNDWATER		
DP-Los Alamos Canyons		
LAO-C	1775187.8	481913.6
LAO-1	1773894.3	489150.7
LAO-2	1773033.8	497363.4
LAO-3	1773036.3	497766.3
LAO-4	1772667.4	500507.7
LAO-4.5	1772025.6	503414.8
Mortandad Canyon		
MCO-3	1770174.7	487118.3
MCO-4	1769725.8	490970.1
MCO-5	1769475.9	492221.9
MCO-6	1768950.7	493391.1
MCO-7	1768447.8	494273.6
MCO-7.5	1768378.4	495210.6
Pajarito Canyon		
PCO-1	1759928.6	497675.1
PCO-2	1757380.8	501456.2
PCO-3	1755427.3	505844.4
Acid-Pueblo Canyons		
APCO-1	1772957.9	508965.3
Cañada del Buey		
CDBO-6	1764698	495965
CDBO-7	1763239	497156
PERCHED SYSTEM IN CONGLOMERATES AND BASALT		
Test Well 1A	1772003.7	509812.7
Test Well 2A	1777226.0	493940.6
Basalt Spring[c]	1770700	516300
PERCHED AQUIFER IN VOLCANICS		
Water Canyon Gallery[c]	1762500	463900

Table D-16. Locations of Groundwater Sampling Stations (Cont.)

Location[a]	Northing Coordinate	Easting Coordinate
SAN ILDEFONSO WELLS		
Well LA-1B	1776890.0	528003.5
Well LA-2	1777157.0	526680.1
Well LA-5	1772471.0	519582.1
Westside Artesian Well	N/A[d]	N/A
Halladay Welll	N/A	N/A
Pajarito Well (Pump 1)	N/A	N/A
Eastside Artesian Well	N/A	N/A
Don Juan Playhouse Well	N/A	N/A

[a]See Figure VII-1 for locations of springs and deep wells, Figure VII-2 for alluvial observation wells, Figure IV-5 for the location of Pueblo of San Ildefonso wells. Coordinates are surveyed unless noted.
[b]Coordinate data from GPS, estimated accuracy ± 2 to 5 m.
[c]Coordinates estimated from USGS quadrangle map.
[d]Not available.

Table D-17. Locations of Beehives

Location	Northing Coordinate[b]	Easting Coordinate[b]
OFF-SITE STATIONS, UNCONTROLLED AREAS		
Regional (28–44 km)		
San Pedro	1809664.111	554217.954
Pojoaque	1783159.441	568681.063
San Juan	1839089.577	548510.294
Perimeter (0–4 km)		
P1. Northern Los Alamos County		
P2. White Rock/ Pajarito Acres (TA-36)	1755631.839	506042.806
ON-SITE STATIONS, CONTROLLED AREAS		
2. TA-5	1768416.067	494776.600
3. TA-8	1768539.659	469339.373
4. TA-9	1765971.113	472725.585
5. TA-15	1763387.514	487418.827
6. TA-16	1758766.096	468362.902
7. TA-21	1774400.589	493945.945
8. TA-33	1740570.164	498738.650
10. TA-49	1751354.820	485772.089
11. TA-50	1770129.362	485363.401
12. TA-53	1770340.109	499720.283
13. TA-54	1757000.077	503475.736

[a]Approximate locations of off-site regional beehives are presented in Figure V-19; on-site beehives are presented in Figure V-20.
[b]New Mexico State Plane Coordinates.

Table D-18. Dose Conversion Factors for Calculating Internal Doses[a]

Inhalation

Radionuclide	EDE (rem/μCi Intake)
^{3}H	6.3×10^{-5}
^{234}U	1.3×10^{2}
^{235}U	1.2×10^{2}
^{238}U	1.2×10^{2}
^{238}Pu	4.6×10^{2}
$^{239,240}Pu$	5.1×10^{2}
^{241}Am	5.2×10^{2}

Ingestion

Radionuclide	EDE (rem/μCi Intake)
^{3}H	6.3×10^{-5}
^{7}Be	1.1×10^{-4}
^{90}Sr	1.3×10^{-1}
^{137}Cs	5.0×10^{-2}
^{234}U	2.6×10^{-1}
^{235}U	2.5×10^{-1}
^{238}U	2.3×10^{-1}
^{238}Pu	3.8
$^{239,240}Pu$	4.3
^{241}Am	4.5

[a]Dose conversion factors taken from DOE 1988b.

Table D-19. Dose Conversion Factors for Calculating External Doses

Radionuclide[a]	EDE ([mrem/yr]/[μCi/m^3])
^{10}C[b]	8,830
^{11}C	5,110
^{13}N	5,110
^{16}N	29,300
^{14}O[b]	18,900
^{15}O	5,120
^{41}A	6,630

[a]Dose conversion factors taken from DOE 1988c.

[b]Dose conversion factors for ^{10}C and ^{14}O were not given in DOE 1988c and were calculated with the computer program DOSFACTER II (Kocher 1981).

Table D-20. Volatile Organic Compounds in Water Determined by PAT[a] Analyses

Compound	CAS[b] #	Limit of Quantification (μg/L)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,2-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-2	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
2-Butanone	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
Ethylbenzene	100-41-4	5
o,m,p-Xylene (mixed)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5

Table D-20. Volatile Organic Compounds in Water Determined by PAT[a] Analyses (Cont.)

Compound	CAS[b] #	Limit of Quantification (μg/L)
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	95-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
Dichlorodifluoromethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5

[a]Purge-and-trap gas chromatography/mass spectrometry.
[b]Chemical abstract service.

Table D-21. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260

Compound	CAS[a] #	Limit of Quantification (μg/kg)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,5-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-4	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5

Table D-21. Volatile Organic Compounds in Solids Determined by SW-846 Method 8260 (Cont.)

Compound	CAS[a] #	Limit of Quantification (μg/kg)
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
Ethylbenzene	100-41-4	5
o,*m*,*p*-Xylene (mixed)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	98-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
Dichlorodifluonomethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5

[a]Chemical abstract service.

Table D-22. Semivolatile Organic Compounds in Water

Compound	CAS[a] #	Limit of Quantification (μg/L)
N-Nitrosodimethylamine	62-75-9	10
Aniline	62-55-3	10
Phenol	108-95-2	10
bis(-2-Chloroethyl)ether	111-44-4	10
2-Chlorophenol	95-57-8	10
1,3-Dichlorobenzene	541-73-1	10
1,4-Dichlorobenzene	106-46-7	10
Benzyl alcohol	100-51-6	10
1,2-Dichlorobenzene	95-50-1	10
2-Methylphenol	95-48-7	10
bis(2-Chloroisopropyl)ether	39638-32-9	10
4-Methylphenol	106-44-5	10
N-Nitroso-di-*n*-propylamine	621-64-7	10
Hexachloroethane	67-72-1	10
Nitrobenzene	98-95-3	10
Isophorone	78-59-1	10
2-Nitrophenol	88-75-5	10
2,4-Dimethylphenol	105-67-9	10
Benzoid acid	65-85-0	50
bis(-2-Chloroethoxy)methane	111-91-1	10
2,4-Dichlorophenol	120-83-2	10
1,2,4-Trichlorobenzene	120-82-1	10
Naphthalene	91-20-3	10
4-Chloroaniline	106-47-8	10
Hexachlorobutadiene	87-68-3	10
4-Chloro-3-methylphenol	59-50-7	10
2-Methylnaphthalene	91-57-6	10
Hexachlorocyclopentadiene	77-47-4	50
2,4,6-Trichlorophenol	88-06-2	10
2,4,5-Trichlorophenol	95-95-4	10
2-Chloronaphthalene	91-58-7	10
2-Nitroaniline	88-74-4	20
Dimethyl phthalate	131-11-3	10
Acenaphthylene	208-96-8	10
3-Nitroaniline	99-09-2	10
Acenaphthene	83-32-9	10
2,4-Dinitrophenol	51-28-5	10
4-Nitrophenol	100-02-7	50
Dibenzofuran	132-64-9	50
2,4-Dinitrotoluene	121-14-2	10
2,6-Dinitrotoluene	606-20-2	10
Diethylphthalate	84-66-2	10
4-Chlorophenyl-phenylether	7005-72-3	10
Fluorene	86-73-7	10
4-Nitroaniline	100-01-6	20
4,6-Dinitro-2-methylphenol	534-52-1	50
N-Nitrosodiphenylamine	86-30-6	10

Table D-22. Semivolatile Organic Compounds in Water (Cont.)

Compound	CAS[a] #	Limit of Quantification (μg/L)
Azobenzene	103-33-3	10
4-Bromophenyl-phenylether	101-55-3	10
Hexachlorobenzene	118-74-1	10
Pentachlorophenol	87-86-5	50
Phenanthrene	85-01-8	10
Anthracene	120-12-7	10
Di-*n*-butylphthalate	84-74-2	10
Fluoranthene	206-44-0	10
Benzidine	92-87-5	10
Pyrene	129-00-0	50
Butylbenzylphthalate	85-68-7	10
3,3'-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	20
bis(2-Ethylhexyl)phthalate	117-81-7	10
Chrysene	218-01-9	10
Di-*n*-octyl phthalate	117-84-0	10
Benzo(*b*)fluoranthene	205-99-2	10
Benzo(*k*)fluoranthene	207-08-9	10
Benzo(*a*)pyrene	50-32-8	10
Indeno(1,2,3-*cd*)pyrene	193-39-5	10
Dibenzo(*a*,*h*)anthracene	53-70-3	10
Benzo(*g*,*h*,*i*)perylene	191-24-2	10

[a]Chemical abstract service.

Table D-23. Volatiles Determined in Air (Pore Gas) - Thermal Desorption

Compound	CAS[a] #	Limit of Quantification (μg/L)
Dichlorodifluoromethane	75-71-8	1.0
Chloromethane	74-87-3	1.0
Vinyl chloride	75-01-4	1.0
Bromomethane	74-83-9	1.0
Chloroethane	75-00-3	1.0
Trichlorofluoromethane	75-69-4	1.0
1,1-Dichloroethene	75-35-4	1.0
Acetone	67-64-1	1.0
Trichlorotrifluoroethane	76-13-1	1.0
Carbon disulfide	75-15-0	1.0
Methylene chloride	75-09-2	1.0
t-1,2-Dichloroethene	156-60-5	1.0
1,1-Dichloroethane	75-34-3	1.0
2-Butanone	78-93-3	1.0
c-1,2-Dichloroethene	156-59-2	1.0
Bromochloromethane	74-97-5	1.0
Chloroform	67-66-3	1.0
1,1,1-Trichloroethane	71-55-6	1.0
1,1-Dichloropropene	563-58-6	1.0
Carbon tetrachloride	56-23-5	1.0
1,2-Dichloroethane	107-06-2	1.0
Benzene	71-43-2	1.0
1,2-Dichloropropane	78-87-5	1.0
c-1,3-Dichloropropene	1006-10-15	1.0
Trichloroethene	79-01-6	1.0
Dibromomethane	74-95-3	1.0
Bromodichloromethane	75-27-4	1.0
4-Methyl-2-pentanone	10-81-1	1.0
Toluene	108-88-3	1.0
t-1,3-Dichloropropene	1006-10-26	1.0
1,1,2-Trichloroethane	79-00-5	1.0
2-Hexanone	59-17-86	1.0
Tetrachloroethene	127-18-4	1.0
Chlorodibromomethane	124-48-1	1.0
Chlorobenzene	108-90-7	1.0
1,1,1,2-Tetrachloroethane	630-20-6	1.0
Ethylbenzene	100-41-4	1.0
o,m,p-Xylene (total)	133-02-7	1.0
Styrene	100-42-5	1.0
Bromoform	75-25-2	1.0
1,1,2,2-Tetrachloroethane	79-34-5	1.0
Bromobenzene	108-86-1	1.0
n-Propylbenzene	103-65-1	1.0
1,3,5-Trimethylbenzene	108-67-8	2.0
1,2,4-Trimethylbenzene	95-63-6	2.0
1,3-Dichlorobenzene	541-73-1	1.0
1,4-Dichlorobenzene	106-46-7	1.0
1,2-Dichlorobenzene	95-50-1	1.0

[a]Chemical abstract service.
[b]Assuming a 0.5 L sample volume.

Table D-24. Volatiles Determined in Air (Pore Gas) - Charcoal Desorption

Compound	CAS[a] #	Limit of Quantification (μg/L)
Benzene	71432	10.0
Bromobenzene	108861	10.0
Carbon tetachloride	56235	10.0
Chlorobenzene	108907	10.0
Chloroform	67663	10.0
Ethylbenzene	100414	10.0
m-Xylene	108383	10.0
o-Xylene	95476	10.0
Tetachloroethylene	127184	10.0
Toluene	108883	10.0
Trichloroethylene	79016	10.0
1,1,1-Trichloroethane	71556	10.0
1,2,4-Trimethylbenzene	95636	10.0

[a]Chemical abstract service.

activation products	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
ALARA	As low as reasonably achievable. The term that describes an approach to radiation exposure control or management whereby the exposures and resulting doses are maintained as far below the limits specified for the appropriate circumstances as economic, technical, and practical considerations permit.
alpha particle	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
AEC	Atomic Energy Commission**.** A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. It was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administrat-ion (now part of the US Department of Energy and the US Nuclear Regulatory Commission).
artesian well	A well in which the water rises above the top of the water-bearing bed.
atom	Smallest particle of an element capable of entering into a chemical reaction.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; global fallout and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.
BOD	Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.
CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.

CFR Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the *Federal Register*.

confined aquifer An aquifer bounded above and below by low-permeability rock or soil layers.

COC Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

contamination (1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

controlled area Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

Ci Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.

cosmic radiation High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

DOE US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.

dose A term denoting the quantity of radiation energy absorbed.

- ***absorbed dose*** The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)
- ***EDE*** Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to $100 \times 0.12 = 12$ mrem.
- ***equivalent dose*** A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)
- ***maximum boundary dose*** The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding (for example, by buildings).
- ***maximum individual dose*** The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)
whole body dose	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
dosimeter	A portable detection device for measuring the total accumulated exposure to ionizing radiation.
EA	Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
effluent	A liquid waste discharged to the environment.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation, through environmental surveillance, that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection.
environmental monitoring	The collection and analysis of samples, or measurements, of liquid and gaseous liquid effluents and gaseous emissions for the purpose of characterizing and quantifying contaminants.
environmental surveillance	The collection and analysis of samples or direct measurements of air, water, sediments, soils, foodstuffs, and plants and animals for the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public and assessing the impacts on the environment.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x ray or gamma radiation. (The unit of exposure is the roentgen).
external radiation	Radiation originating from a source outside the body.
fission products	Atoms created by the splitting of larger atoms into smaller ones accompanied by release of energy.
friable asbestos	Asbestos that is brittle or readily crumbled.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible

	light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete water saturation containing no air.
^{3}H	Tritium. A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactive decay makes it one of the least hazardous radionuclides.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) and the NM Hazardous Waste Act (NMHWA) regulations set strict controls on the management of hazardous wastes.
hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms.
ion	An atom or compound that carries an electrical charge.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.

- long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

LDR Land Disposal Restrictions (land ban). A regulatory program that identifies hazardous wastes that are restricted from land disposal. The regulations incorporate a phasing-in of restrictions in three stages.

MCL Maximum Contaminant Level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-4). The MCLs are specified by the EPA.

mixed waste Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).

mrem Millirem (10^{-3} rem). See definition of rem. The dose equivalent that is one-thousandth of a rem.

NEPA National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment prior to decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.

NESHAP National Emission Standards for Hazardous Air Pollutants. These standards are found in the Clean Air Act; they set limits for such pollutants as beryllium and radionuclides.

NMHWA The NM Hazardous Waste Act authorizes and governs the hazardous waste program in New Mexico.

nonpoint source Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, and parking lot drainage).

NPDES National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.

nuclide A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content; or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.

PA Performance Assessment. A systematic analysis of the potential risks posed by waste management systems to the public and environment, and a comparison of those risks to established performance objectives.

part B permit Part of the RCRA permitting process that is submitted by organizations that treat, store, or dispose of hazardous wastes. It covers in detail the procedures followed at a facility to protect human health and the environment.

PCBs Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and

caulking compounds. They are also produced in certain combustion processes. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976. In general, PCBs are not as toxic in acute short-term doses as some other chemicals, although acute and chronic exposure can cause liver damage. PCBs have also caused cancer in laboratory animals. When tested, most people show traces of PCBs in their blood and fatty tissues.

PDL Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

perched groundwater A groundwater body above a slow-permeablity rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.

person-rem The unit of population dose that expresses the sum of radiation exposures received by a population. For example, two persons, each with a 0.5 rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.

pH A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

point source Any confined and discrete conveyance from which pollutants are discharged into a body of water (e.g., pipe, ditch, well, or stack).

pollution Levels of contamination that may be objectionable (perhaps due to a threat to health [see contamination]).

ppb Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or mg/kg.

ppm Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as mg/g or mg/kg.

QA Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

R Roentgen. The roentgen is a unit for measuring exposure. It is defined only for the effect on air and applies only to gamma and x-rays in air. It does not relate biological effects of radiation to the human body.

1 roentgen = 1,000 milliroentgen (mR)

rad Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the

radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body.

1 rad = 1,000 millirad (mrad)

radiation The emission of particles or energy as a result of an atomic or nuclear process.

radionuclide An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RCRA Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

reagent Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another.

release Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains to only people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) due to the different types of radiation.

rem = rad x quality factor
1 rem = 1000 millirem (mrem)

RPS Radiation Protection Standards. See PDL.

SAL Screening Action Limit. A defined contaminant level that if exceeded in a sample, requires further action.

SARA Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.

saturated zone Rock or soil where the pores are completely filled with water and no air is present.

SWMU Solid Waste Management Unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released. Potential release sites include, for example, waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).

TCLP Toxicity Characteristic Leaching Procedure. An analytical method designed to determine the mobility of both organic and inorganic compounds present in liquid, solid, and multi-phase wastes. It is used to determine applicability of the LDR to a waste.

TDS Total Dissolved Solids. The portion of solid material in a waste stream that is dissolved and passed through a filter.

terrestrial radiation Radiation emitted by naturally occurring radionuclides such as ^{40}K; the natural decay chains of ^{235}U, ^{238}U, or ^{232}Th; or cosmic-ray-induced radionuclides in the soil.

TLD Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that, after being exposed to radiation, luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed.

TRU Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and NRC. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium.

TSCA Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the Act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this Act for controlling substances found to be detrimental to human health or to the environment.

TSP Total suspended particulates. Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

tuff Rock formed from compacted volcanic ash fragments.

uncontrolled area An area beyond the boundaries of a controlled area (see controlled area in this glossary).

unsaturated zone See vadose zone in this glossary.

uranium

	Isotopic Abundance (atom %)		
	^{234}U	^{235}U	^{238}U
depleted	≤0.0055	<0.72	>99.2745
natural	0.0055	0.72	99.2745
enriched	≥0.0055	>0.72	<99.2745

Total uranium is the chemical abundance of uranium in the sample, regardless of its isotopic composition.

UST Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.

vadose zone The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces, and much of the pore spaces filled with air.

water table The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.

water year October through September.

watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
WLM	Working level month. A unit of exposure to ^{222}Rn and its decay products. Working level (WL) is any combination of the short-lived ^{222}Rn decay products in 1 L of air that will result in the emission of 1.3×10^5 MeV potential alpha energy. At equilibrium, 100 pCi/L of ^{222}Rn corresponds to 1 WL. Cumulative exposure is measured in working level months, one of which is equal to 170 working level hours.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

ACIS	Automated Chemical Inventory System
ADS	Activity Data Sheet
AEC	Atomic Energy Commission
AIP	Agreement in Principle
AL	Albuquerque Operations Office (DOE)
ALARA	as low as reasonably achievable
ANOI	Advanced Notice of Intent
ANSI	American National Standards Institute
AO	Administrative Order
AQCR	Air Quality Control Regulation (New Mexico)
BEIR	biological effects of ionizing radiation
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOD	biochemical/biological oxygen demand
BP	barometric pressure
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAI	controlled-air incinerator
CAS	Condition Assessment Survey
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGS	Canadian Geologic Survey
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COC	chain-of-custody
COD	chemical oxygen demand
COPC	contaminants of potential concern
CSU	Colorado State University
CWA	Clean Water Act
CY	calendar year
CYRSL	current years regional statistical reference level
DAC	derived air concentration (DOE)
DAHRT	Dual Axis Radiographic Hydrotest
DCG	Derived Concentration Guide (DOE)
D&D	decontamination and decommissioning
DEC	DOE Environmental Checklist
DoD	Department of Defense
DOE	Department of Energy
DOE-EM	DOE, Environmental Management
DOT	Department of Transportation
DREF	dose rate effectiveness factors
EA	Environmental Assessment

EARE	Environmentall Assessments & Resource Evaluations
ECD	electron capture detection
EDE	effective dose equivalent
EES	Earth and Environmental Sciences (LANL Division)
EES-1	Geology and Geochemistry Group
EIS	Environmental Impact Statement
EMSL-CI	Environmental Monitoring and Support Laboratory - Cincinnati
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration Program
ERAM	Ecological Risk Assessment Model
ERDA	Energy, Research, and Development Administration
ESAL	Ecotoxicological Screening Action Level
ESH	Environment, Safety, & Health (LANL Division)
ESH-13	ESH Training Group
ESH-14	Quality Assurance Group
ESH-17	Air Quality Group
ESH-18	Water Quality & Hydrology Group
ESH-19	Hazardous & Solid Waste Group
ESH-20	Environmental Assessments & Resource Evaluations Group
EST	Ecological Studies Team (ESH-20)
FDA	Food and Drug Administration
FFCA	Federal Facilities Compliance Agreement
FFCAct	Federal Facilities Compliance Act
FONSI	Finding of No Significant Impact
FY	fiscal year
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GMP	Groundwater Monitoring Plan
GMPMPP	Groundwater Protection Management Program Plan
HAP	Hazardous Air Pollutant
HAZWOPER	hazardous waste operations
HE	high-explosive
HEPA	high-efficiency particulate air (filter)
HPGe	high purity germanium detector
HPIC	high pressure ion chamber
HPTL	High Pressure Tritium Laboratory
HSWA	Hazardous and Solid Waste Amendments
HWMR	Hazardous Waste Management Regulations (New Mexico)
HWTU	Hazardous Waste Treatment Unit
ICPMS	inductively coupled plasma mass spectrometry
ICPES	inductively coupled plasma emission spectroscopy
ICRP	International Commission on Radiological Protection
JCI	Johnson Controls Inc.

JENV	JCI Environmental
KPA	kinetic phosphorimetric analysis
LAAO	Los Alamos Area Office
LAMPF	Los Alamos Meson Physics Facility (a.k.a. Clinton P. Anderson Meson Physics Facility - LANL building)
LAMPFNET	Los Alamos Meson Physics Facility network
LANL	Los Alamos National Laboratory (or the Laboratory)
LDR	land disposal restrictions
LET	linear energy transfer
LLW	low-level radioactive waste
LLMW	low-level mixed waste
LTRSL	long-term regional statistical reference level
MCL	maximum contaminant level
MDA	minimum detectable amount (activity)
MDA	material disposal area
MDL	minimum detection limit
MEI	maximum exposed individual
MIDAS	Meteorological Information Dispersion Assessment System
MOU	Memorandum of Understanding
MS	mass spectrometry
MWDF	Mixed Waste Disposal Facility
MWRSF	Mixed Waste Receiving and Storage Facility
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFA	no further action
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology (formerly National Bureau of Standards)
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMHWA	New Mexico Hazardous Waste Act
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NOD	Notice of Deficiency
NOI	Notice of Intent
NON	Notice of Noncompliance
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OB/OD	open burning/open detonated
ODS	ozone depleting substance
O&G	oil and gas
OHL	Occupational Health Laboratory (LANL building)

ORSRL	overstory regional statistical reference level
OSHA	Occupational Safety and Health Act/Administration
OU	operable unit
PA	performance assessment
PAT	purge-and-trap gas chromatography/mass spectrometry
PCB	polychlorinated biphenyl
PDL	public dose limit
PHERMEX	Pulsed High-Energy Machine
ppb	parts per billion
ppm	parts per million
P^3O	Pollution Prevention Program Office
PP	pollution prevention
PPOA	Pollution Prevention Opportunity Assessment
PRP	peer review panel
PRS	potential release site
PWA	Process Waste Assessment
QA	quality assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	quality control
RAS	Radiochemistry and Alpha Spectometry
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RD&D	desearch, development, and demonstration
RFA	RCRA facility assessment
RFI	RCRA facility investigation
ROD	Record of Decision
RPS	Radiation Protection Standard (now PDL)
RSRL	regional statistical reference level
SAL	screening action level
SARA	Superfund Amendments and Reauthorization Act
SCYLLA	LA/NTS Explosive Pulsed Power Experiment
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer (New Mexico)
SIC	Standard Industrial Classification
SIO	Stakeholder Involvement Office
SLD	Scientific Laboratory Division (New Mexico)
SOC	synthetic organic compound
SODAR	sound, distance, and ranging
SOP	standard operating procedure
SOP	stratospheric ozone protection
SPCC	Spill Prevention Control and Countermeasures
SR	state road
SRM	standard reference material
SVOC	semivolatile organic compound

SW	solid waste
SWAT	soil, water, and air testing
SWEIS	Site-Wide Environmental Impact Statement
SWPP	Storm Water Prevention Plan
SWDA	Solid Waste Disposal Act
SWMR	solid waste management regulations
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation
TA	Technical Area
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
THM	trihalomethane
TLD	thermoluminescent dosimeter
TLDNET	thermoluminescent dosimeter network
TRI	toxic chemical release inventory
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSS	total suspended solids
TU	tritium unit
TWISP	Transuranic Waste Inspectable Storge Project
UC	University of California
ULB	upper limit background
URSRL	understory regional statistical reference level
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VAC	Voluntary Corrective Action
VOC	volatile organic compound
WCTF	Weapons Component Testing Facility
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Project
WL	working level
WLM	working level month
WM	Waste Minimization
WM	Waste Management
WSC	Waste Stream Characterization
WQCC	Water Quality Control Commission

Elemental and Chemical Nomenclature

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

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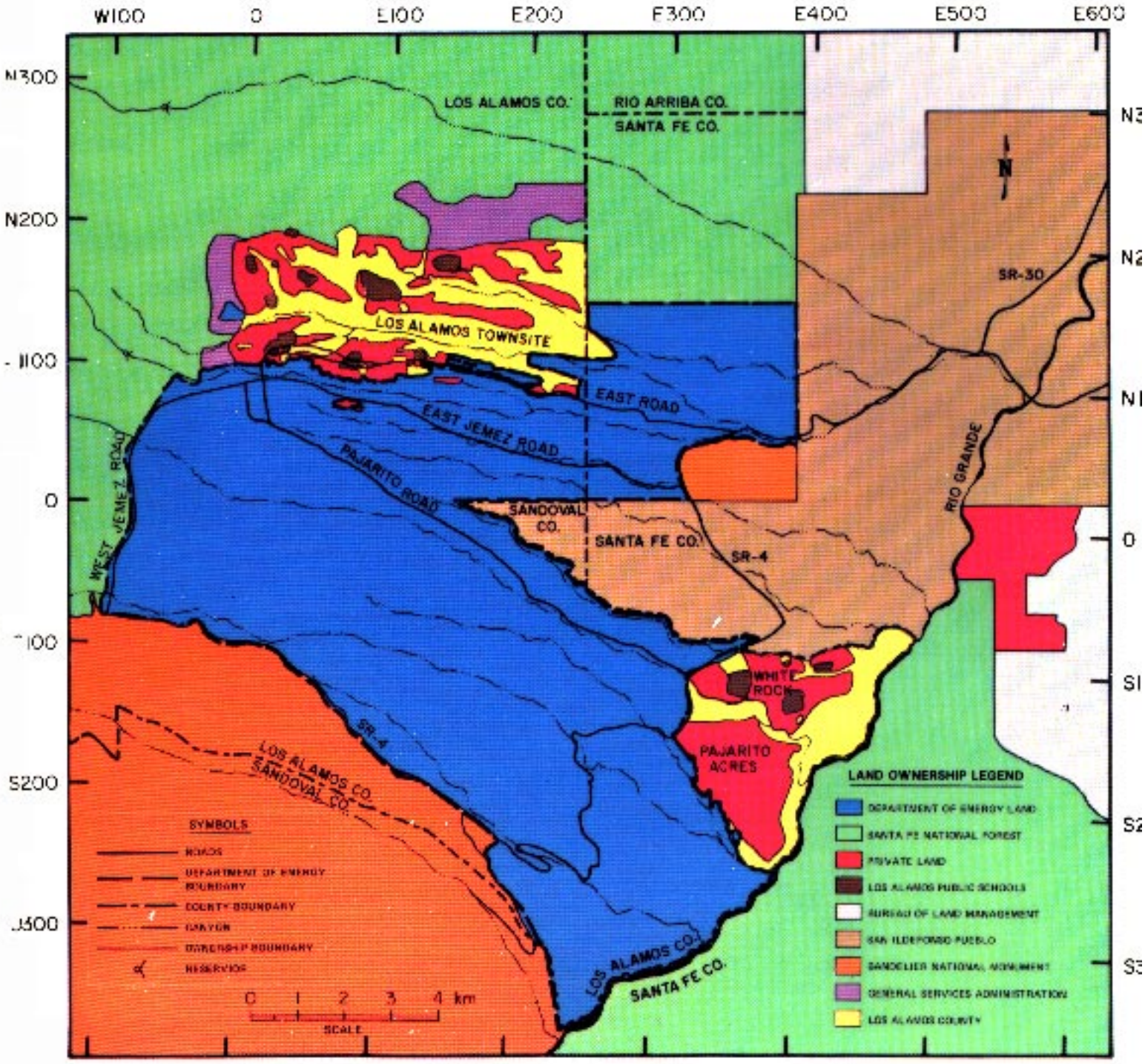

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