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Los Alamos National Laboratory Environmental Report 2011



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Los Alamos National Laboratory Environmental Report 2011

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Los Alamos National Laboratory Environmental Reports are prepared annually by the Los Alamos National Laboratory (LANL or the Laboratory) environmental organizations, as required by US Department of Energy Order 450.1, *Environmental Protection Program*, and US Department of Energy Order 231.1A, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the LANL site and the Laboratory's major environmental programs as well as the Las Conchas Fire and 50-Year Environmental Stewardship Plan. Chapter 2 reports the Laboratory's compliance status for 2011. Chapter 3 provides a summary of the maximum radiological dose the public and biota populations could have potentially received from Laboratory operations and discusses chemical exposures. The environmental surveillance and monitoring data are organized by environmental media (air in Chapter 4, water and sediments in Chapters 5 and 6, soils in Chapter 7, foodstuffs and biota in Chapter 8, and subsurface soil vapor in Chapter 10) in a format to meet the needs of a general and scientific audience. Chapter 9 provides a summary of the status of environmental restoration work around LANL. Chapter 11 provides an overview of the performance of the analytical chemistry laboratories that provide sample analyses to the Laboratory. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurement used in this report, Appendix C describes the Laboratory's technical areas and their associated programs, and Appendix D provides web links to more information. Appendix E provides a glossary of terms, Appendix F provides acronyms and abbreviations, and Appendix G provides elemental and chemical nomenclature.

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PREFACE	xxiii
EXECUTIVE SUMMARY	ES-1
1.0 Introduction.....	1-1
A. Background and Report Purpose	1-1
1. Background	1-1
2. Report Purpose.....	1-1
B. Environmental Setting	1-2
1. Location	1-2
2. Geology and Hydrology	1-2
3. Biological Resources.....	1-5
4. Cultural Resources	1-6
5. Climate.....	1-6
C. Laboratory Activities and Facilities	1-7
D. Management of Environment, Safety, and Health	1-9
1. Environmental Management System.....	1-9
2. Waste Management Program	1-9
3. Pollution Prevention Program.....	1-10
4. Environmental Restoration Programs.....	1-10
5. Compliance and Surveillance Programs.....	1-10
6. Las Conchas Fire.....	1-11
7. 50-Year Environmental Stewardship Plan for Los Alamos National Laboratory	1-15
E. References	1-17
2.0 Compliance Summary	2-1
A. Introduction.....	2-1
B. DOE Orders and Executive Orders.....	2-1
1. DOE Order 231.1B, Environment, Safety, and Health Reporting.....	2-1
2. DOE Order 436.1, Departmental Sustainability	2-1
3. DOE Order 5400.5 and 458.1, Radiation Protection of the Public and the Environment.....	2-6
4. DOE Order 435.1, Radioactive Waste Management.....	2-6
C. Compliance Status.....	2-8
1. Resource Conservation and Recovery Act.....	2-11
2. Toxic Substances Control Act.....	2-15
3. Comprehensive Environmental Response, Compensation, and Liability Act.....	2-15
4. Emergency Planning and Community Right-to-Know Act.....	2-15
5. Federal Insecticide, Fungicide, and Rodenticide Act.....	2-16
6. Clean Air Act	2-16
7. Clean Water Act	2-19

8.	Safe Drinking Water Act	2-25
9.	Groundwater	2-26
10.	National Environmental Policy Act	2-29
11.	Endangered Species Act.....	2-29
12.	Migratory Bird Treaty Act	2-30
13.	Cultural Resources.....	2-31
D.	Unplanned Releases	2-31
1.	Air Releases	2-31
2.	Water Releases	2-32
E.	References.....	2-32
3.0	Radiological and Non-Radiological Dose Assessment.....	3-1
A.	Introduction	3-1
B.	Radiological Dose Assessment for Humans	3-1
1.	Overview of Radiological Dose Equivalents.....	3-1
2.	Public Dose Calculations.....	3-2
3.	Dose Calculations and Results	3-4
4.	Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation.....	3-8
5.	Conclusion.....	3-9
C.	Biota Dose Assessment.....	3-10
1.	Biota Dose Assessment Approach.....	3-10
2.	Biota Dose Results	3-11
3.	Conclusion.....	3-11
D.	Non-Radiological Risk Assessment	3-11
1.	Overview.....	3-11
2.	Results	3-11
3.	Conclusion.....	3-13
E.	Summary	3-13
F.	References.....	3-13
4.0	Air Surveillance	4-1
A.	Ambient Air Sampling.....	4-1
1.	Introduction.....	4-1
2.	Air Monitoring Network.....	4-1
3.	Sampling Procedures, Data Management, Chemical Analysis, and Quality Assurance	4-5
4.	Ambient Air Concentrations.....	4-5
5.	Special Monitoring.....	4-10
B.	Stack Sampling for Radionuclides	4-14
1.	Introduction.....	4-14
2.	Sampling Methodology	4-14

3.	Sampling Procedures and Data Analysis.....	4-15
4.	Analytical Results	4-16
5.	Long-Term Trends	4-18
C.	Gamma and Neutron Radiation Monitoring Program.....	4-20
1.	Introduction	4-20
2.	Quality Assurance	4-22
3.	Results	4-22
4.	Conclusion	4-22
D.	Non-radiological Ambient Air Monitoring	4-22
1.	Introduction	4-22
2.	Air Monitoring Network and Equipment	4-23
3.	Ambient Air Concentrations	4-23
4.	Detonation and Burning of Explosives	4-23
5.	Beryllium Sampling.....	4-23
E.	Meteorological Monitoring	4-23
1.	Introduction	4-23
2.	Monitoring Network.....	4-23
3.	Sampling Procedures, Data Management, and Quality Assurance.....	4-24
4.	Climatology.....	4-25
5.	2011 in Perspective.....	4-26
F.	References	4-32
5.0	Groundwater Monitoring	5-1
A.	Introduction.....	5-1
B.	Hydrogeologic Setting	5-1
1.	Geologic Setting.....	5-1
2.	Groundwater Occurrence.....	5-2
C.	Groundwater Standards and Screening Levels	5-4
1.	Regulatory Overview	5-4
2.	Evaluation of Groundwater Results	5-6
D.	Overview of Groundwater Quality	5-6
E.	Monitoring Network	5-10
1.	Regional Aquifer and Intermediate Perched Groundwater Monitoring	5-16
2.	Alluvial Groundwater Monitoring	5-16
3.	Monitoring Network Modifications	5-16
F.	Summary of 2011 Sampling Results	5-16
G.	Groundwater Sampling Results by Constituents	5-19
1.	Organic Chemicals in Groundwater	5-20
2.	Radioactivity in Groundwater	5-21

3.	Metals in Groundwater	5-21
H.	Groundwater Sampling Results by Monitoring Group	5-22
1.	Water Supply Monitoring	5-22
2.	Guaje Canyon (including Rendija and Barrancas Canyons)	5-24
3.	TA-21 Monitoring Group (Los Alamos and DP Canyons) and Pueblo Canyon	5-25
4.	Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)	5-32
5.	MDA C and TA-54 Monitoring Groups (Mortandad, Pajarito, Twomile, and Threemile Canyons)	5-44
6.	TA-16 260 Monitoring Group (Pajarito Canyon, Water Canyon, and Cañon de Valle)	5-51
7.	MDA AB Monitoring Group (Ancho and Water Canyons)	5-59
8.	White Rock Canyon General Surveillance Monitoring	5-60
I.	References	5-61
6.0	Watershed Monitoring	6-1
A.	Introduction	6-1
B.	Hydrologic Setting	6-2
C.	Surface Water and Sediment Standards and Screening Levels	6-6
1.	Surface Water	6-6
2.	Radionuclides in Surface Water	6-9
3.	Sediment	6-10
D.	Sampling Locations and Methods	6-10
E.	Sampling Results by Constituents	6-15
1.	Background-Related Constituents	6-20
2.	LANL-Related Constituents	6-22
3.	Inorganic and Organic Chemicals	6-49
F.	Conclusions	6-52
G.	References	6-53
7.0	Soil Monitoring	7-1
A.	Introduction	7-1
B.	Soil Comparison Levels	7-1
C.	Institutional Monitoring	7-2
1.	Monitoring Network	7-2
2.	Methods and Analysis	7-5
3.	Radionuclides	7-5
4.	TAL Elements	7-6
D.	Facility Monitoring	7-7
1.	Monitoring Network for Area G at TA-54	7-7
2.	Radionuclide Analytical Results for Area G	7-8
3.	Monitoring Network for DARHT at TA-15	7-11
4.	Radionuclide and Chemical Analytical Results for DARHT	7-13

E.	Special Monitoring Studies.....	7-14
F.	Quality Assurance for the Soil, Foodstuffs, and Biota monitoring Program	7-14
1.	Quality Assurance Program Development.....	7-14
2.	Field Sampling Quality Assurance	7-14
3.	Analytical Laboratory Quality Assessment	7-15
G.	References	7-15
8.0	Foodstuffs and Biota Monitoring	8-1
A.	Foodstuffs Monitoring	8-1
1.	Introduction	8-1
2.	Foodstuffs Comparison Levels.....	8-1
3.	Fish Monitoring	8-2
4.	Crayfish Monitoring	8-14
5.	Deer and Elk Monitoring	8-19
B.	Biota Monitoring	8-22
1.	Introduction	8-22
2.	Biota Comparison Levels	8-22
3.	Institutional Vegetation Monitoring.....	8-23
4.	Benthic Macroinvertebrate Monitoring of the Rio Grande.....	8-23
5.	Facility Monitoring	8-26
C.	Special Monitoring Studies.....	8-31
1.	Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Basins: Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure	8-32
2.	Winter and Breeding Bird Surveys at Los Alamos National Laboratory.....	8-36
3.	Los Alamos National Laboratory Fall Avian Migration-Monitoring Report 2010	8-37
4.	Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2011	8-37
5.	Small Mammal Sampling at Open-Detonation Firing Sites	8-37
6.	Chemical Concentrations in Field Mice Collected from Open-Detonation Firing Sites	8-38
7.	Chemical Concentrations in Field Mice/Voles Collected from an Open-Burn Site at Technical Area 16	8-38
8.	Preliminary Results of Chytrid Fungus Testing of Amphibians at Los Alamos National Laboratory	8-38
9.	Life in the Fast Lane: Road-Crossing Behavior of Mule Deer in a Wildland-Urban Interface.....	8-39
10.	Bat and Small Mammal Use of Burned and Unburned Ponderosa Pine Forest following the Cerro Grande Fire in Los Alamos, New Mexico.....	8-39
D.	Quality Assurance for the Soil, Foodstuffs, and Biota Program	8-40
E.	References	8-40

9.0	Environmental Restoration.....	9-1
A.	Introduction	9-1
1.	Programs.....	9-2
2.	Work Plans and Reports	9-2
B.	Corrective Actions Program.....	9-11
1.	Consolidated Unit 16-021(c)-99 (260 Outfall) Corrective Measures Implementation	9-11
2.	MDA C.....	9-16
C.	TA-54 Closure Program.....	9-17
D.	TA-21 Closure Program.....	9-17
1.	DP Site Aggregate Area.....	9-17
2.	American Recovery and Reinvestment Act at TA-21.....	9-18
3.	MDA B	9-18
E.	Quality Assurance Program.....	9-21
1.	Quality Assurance Program Development	9-21
2.	Field Sampling Quality Assurance	9-21
F.	References.....	9-22
10.0	Subsurface Vapor Monitoring	10-1
A.	Introduction	10-1
B.	Field Screening and Sampling	10-2
C.	Facility Monitoring.....	10-2
D.	Analytic Data Comparison and Trends.....	10-3
1.	MDA C.....	10-4
2.	MDA G.....	10-7
3.	MDA H	10-8
4.	MDA L	10-9
5.	MDA T	10-10
6.	MDA V.....	10-11
E.	Summary	10-12
F.	References.....	10-12
11.0	Analytical Laboratory Quality Assurance	11-1
A.	Introduction	11-1
B.	Quality Control for Samples, Data Validation, and Analytical Results Review	11-1
C.	Qualification and Performance Assessment of Analytical Laboratories	11-3
D.	Department of Energy Contract Analytical Program Audits.....	11-4
E.	References.....	11-4

FIGURES

Figure ES-1	Regional location of Los Alamos National Laboratory.	2
Figure ES-2	Aggregate areas as defined for the Consent Order and their status.....	9
Figure ES-3	Three modes of groundwater occurrence	11
Figure ES-4	Locations of fish collected upstream and downstream of LANL on the Rio Chama and Rio Grande	16
Figure ES-5	Collection of crayfish samples from the Rio Grande.....	17
Figure ES-6	Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2010) operations at DARHT.....	18
Figure ES-7	Locations of MDAs where subsurface vapor monitoring was performed in 2011	19
Figure 1-1	Regional location of Los Alamos National Laboratory	1-3
Figure 1-2	Primary watersheds at Los Alamos National Laboratory	1-4
Figure 1-3	Technical areas and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings	1-8
Figure 1-4	Extent of the Las Conchas Fire	1-12
Figure 2-1	LANL LLW disposition	2-7
Figure 2-2	TRU waste shipping profile.....	2-8
Figure 2-3	Aggregate areas as defined for the NMED Consent Order and their status.....	2-14
Figure 2-4	LANL criteria pollutant emissions from 2007 through 2011 for annual emissions inventory reporting.....	2-18
Figure 2-5	Groundwater monitoring wells installed during 2011	2-28
Figure 3-1	Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 years.....	3-5
Figure 3-2	Annual airborne pathway (Rad-NESHAP) dose (mrem) to the MEI over the past 10 years.....	3-6
Figure 3-3	Average Los Alamos County radiation background dose compared with average US radiation background dose	3-9
Figure 4-1	AIRNET locations at and near Los Alamos National Laboratory.....	4-2
Figure 4-2	AIRNET station locations at TA-54, Area G, Los Alamos National Laboratory	4-3
Figure 4-3	AIRNET station locations near TA-21, MDA B.....	4-3
Figure 4-4	Regional and Pueblo AIRNET locations	4-4
Figure 4-5	Annual average concentrations of tritium by group	4-7
Figure 4-6	Annual average concentrations of americium-241 by group.....	4-7
Figure 4-7	Annual average concentrations of plutonium-238 by group	4-9
Figure 4-8	Annual average concentrations of plutonium-239/240 by group.....	4-9
Figure 4-9	NEWNET data during the releases from Fukushima Daiichi.....	4-12
Figure 4-10	NEWNET data before and during the Las Conchas Fire	4-13
Figure 4-11	Plutonium emissions from sampled LANL stacks	4-18
Figure 4-12	Uranium emissions from sampled LANL stacks	4-18
Figure 4-13	Tritium emissions from sampled LANL stacks.....	4-18
Figure 4-14	GMAP emissions from sampled LANL stacks	4-19
Figure 4-15	Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP	4-19
Figure 4-16	Average quarterly gamma doses (mrem) around the perimeter of Area G for calendar quarters 1, 2, 3, and 4 of 2011.....	4-20

Figure 4-17	Average quarterly neutron doses (mrem) around the perimeter of Area G for the last two quarters of 2010 and the four quarters of 2011	4-21
Figure 4-18	Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET)	4-21
Figure 4-19	Location of meteorological monitoring towers and rain gauges	4-24
Figure 4-20	Weather summary for Los Alamos for 2011 at the TA-6 meteorology station.....	4-27
Figure 4-21	Temperature history for Los Alamos.....	4-29
Figure 4-22	Total precipitation history for Los Alamos.....	4-29
Figure 4-23	Daytime and nighttime wind roses for 2011. Wind data for TA-49 are 2010 data	4-31
Figure 5-1	Generalized geologic cross-section of the Pajarito Plateau.....	5-2
Figure 5-2	Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence.....	5-3
Figure 5-3	Contour map of average water table elevations for the regional aquifer (based on a map in a LANL report [2012a]).....	5-4
Figure 5-4	Major liquid release outfalls (effluent discharge) potentially affecting groundwater; most outfalls shown are inactive.....	5-8
Figure 5-5a	Groundwater monitoring wells assigned to area-specific monitoring groups	5-11
Figure 5-5b	Groundwater monitoring wells assigned to area-specific monitoring groups	5-12
Figure 5-6a	Groundwater monitoring wells and springs assigned to general surveillance monitoring	5-13
Figure 5-6b	Groundwater monitoring wells and springs assigned to general surveillance monitoring	5-14
Figure 5-7	Water supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon	5-15
Figure 5-8	Perchlorate at general surveillance and water supply (well O-1) monitoring locations in Pueblo Canyon intermediate and regional aquifer groundwater.....	5-23
Figure 5-9	Wells with 2011 perchlorate concentrations above the 4-µg/L NM Consent Order screening level	5-27
Figure 5-10	Nitrate (as nitrogen) at general surveillance monitoring locations in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater	5-28
Figure 5-11	Tritium in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater ...	5-29
Figure 5-12	Perchlorate in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater	5-29
Figure 5-13	Perchlorate in the TA-21 monitoring group at R-9i and at general surveillance monitoring locations in Los Alamos Canyon intermediate groundwater	5-30
Figure 5-14	Strontium-90 at general surveillance monitoring locations in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results.....	5-31
Figure 5-15	Chloride at general surveillance monitoring locations in in Los Alamos and DP Canyon alluvial groundwater	5-32
Figure 5-16	Wells with 2011 dissolved or hexavalent chromium concentrations above the 50-µg/L NM groundwater standard.....	5-34
Figure 5-17	Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater.....	5-36
Figure 5-18	Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater.....	5-37
Figure 5-19	Nitrate (as nitrogen) in the Chromium Investigation monitoring group in Sandia Canyon intermediate and regional aquifer groundwater	5-37

Figure 5-20	Nitrate (as nitrogen) in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer groundwater	5-38
Figure 5-21	Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer wells R-15 and R-61 (1,125-ft screen)	5-38
Figure 5-22	Nitrate (as nitrogen) in the Chromium Investigation monitoring group and in the TA-54 monitoring group (R-55i) in Mortandad Canyon intermediate groundwater.....	5-39
Figure 5-23	Concentrations of 1,4-dioxane in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater	5-39
Figure 5-24	Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater	5-40
Figure 5-25	Tritium in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater	5-40
Figure 5-26	Total (unfiltered) strontium-90 at general surveillance monitoring locations in Mortandad Canyon alluvial groundwater	5-42
Figure 5-27	Chloride histories for general surveillance monitoring locations in Mortandad Canyon alluvial groundwater	5-43
Figure 5-28	Perchlorate at general surveillance monitoring locations in Mortandad Canyon alluvial groundwater	5-44
Figure 5-29	Trichloroethene in the TA-54 monitoring group at Pajarito Canyon regional aquifer well R-20 at 1,147 ft and intermediate well R-40 at 752 ft.....	5-47
Figure 5-30	Concentrations of 1,4-dioxane in the TA-54 monitoring group in Mortandad Canyon intermediate groundwater at 929 ft in R-37	5-48
Figure 5-31	RDX at general surveillance monitoring locations in Pajarito Canyon intermediate groundwater at Bulldog and Kieling Springs.....	5-49
Figure 5-32	Chloride history in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13	5-49
Figure 5-33	History of 1,1-dichloroethene in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13.....	5-50
Figure 5-34	History of 1,1,1-trichloroethane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13.....	5-50
Figure 5-35	History of 1,4-dioxane history in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13.....	5-51
Figure 5-36	Wells with 2011 RDX concentrations above the 6.1- $\mu\text{g/L}$ EPA tap water screening level	5-53
Figure 5-37	RDX in the TA-16 260 monitoring group and at general surveillance monitoring location Burning Ground Spring in Cañon de Valle intermediate groundwater	5-54
Figure 5-38	RDX in the TA-16 260 monitoring group and at general surveillance monitoring location Martin Spring in Cañon de Valle intermediate groundwater	5-54
Figure 5-39	RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater	5-55
Figure 5-40	Boron at general surveillance monitoring locations in Martin Spring Canyon (a Cañon de Valle tributary) intermediate groundwater at Martin Spring and in alluvial groundwater.....	5-56
Figure 5-41	Wells with 2011 barium concentrations above the 1,000- $\mu\text{g/L}$ NM groundwater standard.....	5-57
Figure 5-42	Barium in the TA-16 260 monitoring group (CDV-16-611923) and at general surveillance monitoring locations in Cañon de Valle alluvial groundwater.....	5-58
Figure 5-43	Barium at general surveillance monitoring locations in Fishladder Canyon intermediate groundwater at Fish Ladder Spring and in alluvial groundwater.....	5-58
Figure 5-44	RDX in the TA-16 260 monitoring group (CDV-16-611923) and at general surveillance monitoring locations in Cañon de Valle alluvial groundwater.....	5-59
Figure 6-1	Primary watersheds at LANL.....	6-2

Figure 6-2	Estimated storm water runoff volume in LANL canyons (Pueblo Canyon to Ancho Canyon) from 2010 to 2011 and precipitation at Technical Area 6 (TA-6) during the months of June through October from 1995 to 2011	6-3
Figure 6-3	Mean of the monthly total precipitation from LANL's meteorological tower network (TA-6, TA-49, TA-53, TA-54, and northern community) over the period of record 2002 to 2010 and the mean of the monthly total precipitation over 2011	6-4
Figure 6-4	Monthly mean of the daily maximum and minimum temperatures averaged from LANL's meteorological tower network (TA-6, TA-49, TA-53, TA-54, and northern community) over the period of record 2002 to 2010 and the monthly mean of the daily maximum and minimum temperatures during 2011.....	6-4
Figure 6-5	Sediment-control structures installed by LANL	6-5
Figure 6-6	Major drainages within Laboratory land, showing designated stream segments	6-8
Figure 6-7	Surface water locations sampled in 2011 as part of the Environmental Surveillance Program and the Los Alamos and Pueblo Canyons monitoring plan	6-11
Figure 6-8	Surface water locations sampled in 2011 at IP SMAs	6-12
Figure 6-9	Surface water locations sampled in 2011 under the MSGP.....	6-13
Figure 6-10	Sediment locations sampled in 2011 as part of the Environmental Surveillance Program.....	6-14
Figure 6-11a	Water Canyon watershed unfiltered barium concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-23
Figure 6-11b	Water Canyon watershed barium concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011).....	6-23
Figure 6-12a	Los Alamos Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011).....	6-24
Figure 6-12b	Los Alamos Canyon watershed lead concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-24
Figure 6-12c	Pajarito Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011).....	6-25
Figure 6-12d	Pajarito Canyon watershed lead concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-25
Figure 6-12e	Water Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)	6-26
Figure 6-12f	Water Canyon watershed lead concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011).....	6-26
Figure 6-13a	Los Alamos Canyon watershed unfiltered mercury concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011).....	6-27
Figure 6-13b	Los Alamos Canyon watershed sediment mercury concentrations from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-27
Figure 6-13c	Water Canyon watershed unfiltered mercury concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011).....	6-28
Figure 6-13d	Water Canyon watershed mercury concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011).....	6-28
Figure 6-14a	Pajarito Canyon watershed filtered silver concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)	6-29
Figure 6-14b	Pajarito Canyon watershed silver concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-29
Figure 6-14c	Water Canyon watershed filtered silver concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)	6-30

Figure 6-14d	Water Canyon watershed silver concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011)	6-30
Figure 6-15a	Los Alamos Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2009–2011).....	6-31
Figure 6-15b	Los Alamos Canyon watershed total PCB concentrations in sediment from ESRs (data from 2009–2011)	6-31
Figure 6-15c	Pajarito Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2010–2011).....	6-32
Figure 6-15d	Pajarito Canyon watershed total PCB concentrations in sediment from ESR (data from 2011), congeners not analyzed in Pajarito Canyon before 2011	6-32
Figure 6-15e	Water Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2010–2011).....	6-33
Figure 6-15f	Water Canyon watershed total PCB concentrations in sediment from ESR (data from 2011), congeners not analyzed in Water Canyon before 2011.....	6-33
Figure 6-16a	Los Alamos Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-34
Figure 6-16b	Los Alamos Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)	6-34
Figure 6-16c	Pajarito Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-35
Figure 6-16d	Pajarito Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-35
Figure 6-16e	Water Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-36
Figure 6-16f	Water Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-36
Figure 6-17a	Los Alamos Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-37
Figure 6-17b	Los Alamos Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)	6-37
Figure 6-17c	Pajarito Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-38
Figure 6-17d	Pajarito Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-38
Figure 6-17e	Water Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-39
Figure 6-17f	Water Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-39
Figure 6-18a	Los Alamos Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-40
Figure 6-18b	Los Alamos Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)	6-40
Figure 6-18c	Pajarito Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-41
Figure 6-18d	Pajarito Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)	6-41
Figure 6-18e	Water Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-42

Figure 6-18f	Water Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 2000, 2008–2011) and ESRs (data from 2003–2011).....	6-42
Figure 6-19a	Los Alamos Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-43
Figure 6-19b	Los Alamos Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-43
Figure 6-19c	Pajarito Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-44
Figure 6-19d	Pajarito Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011).....	6-44
Figure 6-19e	Water Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-45
Figure 6-19f	Water Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 2000, 2008–2011) and ESRs (data from 2003–2011).....	6-45
Figure 6-20a	Los Alamos Canyon watershed americium-241 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-46
Figure 6-20b	Los Alamos Canyon watershed americium-241 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-46
Figure 6-21a	Los Alamos Canyon watershed strontium-90 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-47
Figure 6-21b	Los Alamos Canyon watershed strontium-90 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-47
Figure 6-22a	Los Alamos Canyon watershed cesium-137 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed	6-48
Figure 6-22b	Los Alamos Canyon watershed cesium-137 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011).....	6-48
Figure 7-1	On-site, perimeter, and regional soil-sampling locations	7-3
Figure 7-2	Plutonium-238 (detectable and nondetectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL.....	7-5
Figure 7-3	Tritium (detectable and nondetectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL.....	7-6
Figure 7-4	Plutonium-239/240 (detectable and nondetectable) concentrations in soil samples collected from PSI lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL.....	7-6
Figure 7-5	Locations of soil samples collected around Area G in 2011	7-7
Figure 7-6	Tritium concentrations in surface-soil samples collected from the southern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL	7-8
Figure 7-7	Americium-241 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL	7-9
Figure 7-8	Plutonium-238 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL.....	7-9
Figure 7-9	Plutonium-239/240 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL	7-10

Figure 7-10	Americium-241 (detectable and nondetectable) concentrations in surface soil collected from the LANL/Pueblo de San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2011 compared with the RSRL and the RSL.....	7-10
Figure 7-11	Plutonium-238 (detectable and nondetectable) concentrations in surface soil collected from the LANL/PSI boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2010 compared with the RSRL and the RSL.....	7-11
Figure 7-12	Plutonium-239/240 (detectable and nondetectable) concentrations in surface soil collected from the LANL/PSI boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2011 compared with the RSRL and the RSL.....	7-11
Figure 7-13	Soil, sediment, and biota sample locations at DARHT in 2011	7-12
Figure 7-14	Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2011 (operations) compared with the BSRL and the ISL	7-13
Figure 7-15	Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2011 (operations) compared with the BSRL and the ISL	7-14
Figure 8-1	Locations of fish collected upstream and downstream of LANL on the Rio Chama and Rio Grande	8-3
Figure 8-2	Mean cesium-137 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir [AR]) and downstream (Cochiti Reservoir [CR]) of LANL from 1981 through 2011 compared with the RSRL.....	8-5
Figure 8-3	Mean strontium-90 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1982 through 2011 compared with the RSRL.....	8-6
Figure 8-4	Mean plutonium-238 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL.....	8-6
Figure 8-5	Mean plutonium-239/240 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL	8-7
Figure 8-6	Mean americium-241 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1996 through 2011 compared with the RSRL.....	8-7
Figure 8-7	Mean total uranium concentrations (all isotopes combined) in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL.....	8-8
Figure 8-8	Mean (± 1 standard deviation) total mercury concentrations in predator (PF) and bottom-feeding (BF) fish upstream (Abiquiu Reservoir [AR] and Rio Grande at San Ildefonso [RG @ SI]) and downstream (Rio Grande at Los Alamos Canyon [RG @ LAC], Rio Grande at 4–20 miles from LAC [RG @ 4–20], and Cochiti Reservoir [CR]), compared with the SL.....	8-9
Figure 8-9	Mean mercury concentrations in predator fish collected upstream (AR) and downstream (CR) of LANL from 1991 through 2011 compared with the SL.....	8-9
Figure 8-10	Mean mercury concentrations in bottom-feeding fish collected upstream (AR) and downstream (CR) of LANL from 1991 through 2011 compared with the SL.....	8-10
Figure 8-11	Mean (± 1 standard deviation) total PCBs in muscle fillets of predator fish collected from AR (upstream of LANL) and Cochiti Reservoir (CR, downstream of LANL) in 2005, 2008, and 2011 compared with the RSRL	8-11
Figure 8-12	The mean homolog distribution in muscle fillets of predator fish collected upstream (AR) and downstream (CR) of LANL in 2011	8-12
Figure 8-13	Mean (± 1 standard deviation) total PCB concentrations in muscle fillets of bottom-feeding fish collected upstream (AR and Rio Grande at San Ildefonso [RG@SI]) and downstream (RG @ LAC, RG @ 4-8, 10-14, and 16-20 river miles from LAC, and CR) of LANL in 2011 compared with the RSRL	8-13

Figure 8-14	The mean homolog distribution in the muscle tissues of bottom-feeding fish collected upstream (AR and RG @ SI) and downstream (RG @ LAC, RG @ 4-20 miles from LAC, and CR) of LANL in 2011	8-13
Figure 8-15	Mean total PCB concentrations in bottom-feeding fish collected upstream (AR and RG @ SI) and downstream (RG @ LAC, Rio Grande @ 4-8 miles from LAC, and CR) of LANL from 2000 to 2011	8-14
Figure 8-16	Location of crayfish and benthic macroinvertebrate sampling reaches within the Rio Grande in relation to the location of LANL.....	8-15
Figure 8-17	Collection of crayfish samples from the Rio Grande	8-16
Figure 8-18	Strontium-90 concentrations (± 1 standard deviation) in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2009 and 2011 compared with the RSRL	8-17
Figure 8-19	Mean (± 1 standard deviation) total PCBs in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2009 and 2011 compared with the RSRL	8-18
Figure 8-20	The mean PCB homolog distribution in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2011	8-18
Figure 8-21	Location of deer and elk collected as road kills from within and around the perimeter of LANL in 2011	8-20
Figure 8-22	The PCB homolog distribution in muscle tissue of a road-killed deer collected alongside State Road 502 (SR 502) in 2011 compared with regional background (RBG) and with Aroclor-1242 and -1260 formulations	8-21
Figure 8-23	Collecting benthic macroinvertebrates (BMIs) in the Rio Grande using a kick net.....	8-24
Figure 8-24	Rinsing the net free of BMIs with water in a 5-gallon poly bucket.....	8-25
Figure 8-25	Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G at TA-54 (site #29-03 or 30-01) from 1994 through 2011 compared with the RSRL and the SL.....	8-27
Figure 8-26	Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996–1999 (preoperations) through 2000–2011 (during operations) compared with the BSRL and the SL	8-28
Figure 8-27	Uranium-238 concentrations in (whole-body) mice ($n > 5$) collected from the north (N) and northeast (NE) sides of the DARHT facility at TA-15 from 1997–1999 (preoperations) through 2002–2011 (during operations) compared with BSRL and the SL	8-29
Figure 8-28	Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (preoperations) through 2003–2011 (during operations) compared with the BSRL and the SL.....	8-30
Figure 8-29	Populations, number of species, diversity, and evenness of birds occurring before (1997–99) and during (2011) operations at DARHT	8-31
Figure 8-30	Populations, number of species, diversity, and evenness of birds occurring before (1997–99) and during (2003–2011) operations at DARHT	8-31
Figure 8-31	Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side (retention basin) of the LACW from 2005 through 2010.....	8-33
Figure 8-32	Americium-241, plutonium-238, and plutonium-239/240 in composite whole-body field mouse samples ($n > 5$) collected on the upgradient side (retention basin) of the LACW from 2005 through 2011, compared with the SL	8-33
Figure 8-33	Mean total PCB concentrations in whole-body field mice collected on the upgradient side (retention basin) of the LACW from 2007 through 2011 compared with the RSRL (885 pg/g wet)	8-34

Figure 8-34	The mean total PCB homolog distribution for whole-body field mice samples collected on the upgradient side of the LACW in 2011 compared with Aroclor-1260	8-35
Figure 8-35	Mean total PCB concentrations (± 1 standard deviation) in whole-body field mouse samples collected on the upgradient side (retention basin) of the PCFRS from 2007 through 2011 compared with the RSRL	8-36
Figure 8-36	Mean PCB homolog distribution of whole-body field mouse samples collected on the upgradient side of the PCFRS in 2011 compared with Aroclor-1260	8-36
Figure 9-1	Location of MDAs, SWMUs/AOCs, canyons, and aggregate areas where remediation and/or characterization work was performed in 2011	9-11
Figure 10-1	Location of MDAs where subsurface vapor monitoring was performed in 2011	10-1
Figure 10-2	MDA C vapor monitoring wells.....	10-5
Figure 10-3	Plan and map views of the average TCE vapor concentrations measured at MDA C, based on second quarter FY10 through third quarter FY11 data	10-6
Figure 10-4	MDA G vapor monitoring wells	10-7
Figure 10-5	MDA H vapor monitoring wells	10-8
Figure 10-6	MDA L vapor monitoring wells	10-9
Figure 10-7	MDA T vapor monitoring wells.....	10-10
Figure 10-8	Vertical profiles of methylene chloride in vapor monitoring wells 21-607955 and 21-25262 at MDA T	10-11
Figure 10-9	MDA V vapor monitoring wells.....	10-12

TABLES

Table ES-1	Approximate Number of Environmental Samples, Locations, and Analytes Collected in 2011	3
Table ES-2	FY11 Environmental Objectives and Accomplishments	4
Table ES-3	Sustainability Performance Status.....	5
Table ES-4	Environmental Permits or Approvals under which the Laboratory Operated during 2011	7
Table ES-5	LANL Radiological Doses for Calendar Year 2011	10
Table ES-6	Groundwater Analytes with Results above Screening Levels in 2011	12
Table ES-7	VOCs that Exceeded Tier I and Tier II Screening Values during 2011	20
Table 1-1	Key Facilities	1-7
Table 1-2	Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2011	1-11
Table 2-1	FY11 Environmental Objectives and Accomplishments	2-2
Table 2-2	Comparison of FY10 and FY11 Routine Waste Generation and Recycling Percentage	2-3
Table 2-3	Sustainability Performance Status.....	2-4
Table 2-4	DOE Approval to Dispose of LLW at TA-54, Area G	2-7
Table 2-5	Environmental Permits or Approvals under which the Laboratory Operated during 2011	2-9
Table 2-6	Environmental Inspections and Audits Conducted at the Laboratory during 2011	2-11
Table 2-7	Summary of 2011 Reported Releases under EPCRA Section 313.....	2-16
Table 2-8	Herbicides and Pesticides Used at LANL in 2011.....	2-17
Table 2-9	Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2011.....	2-17
Table 2-10	Volume of Effluent Discharge from NPDES Permitted Outfalls in 2011.....	2-20
Table 2-11	Monitoring Wells Installed in 2011	2-27

Table 2-12	Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL	2-30
Table 2-13	2011 Unplanned Non-Radioactive Releases	2-32
Table 3-1	LANL Radiological Doses for Calendar Year 2011	3-10
Table 4-1	Average Background Radionuclide Concentrations in the Regional Atmosphere	4-1
Table 4-2	Airborne Tritium as Tritiated Water Concentrations for 2011—Group Summaries	4-7
Table 4-3	Airborne Americium-241 Concentrations for 2011—Group Summaries	4-7
Table 4-4	Airborne Plutonium-238 Concentrations for 2011—Group Summaries	4-8
Table 4-5	Airborne Plutonium-239/240 Concentrations for 2011—Group Summaries	4-8
Table 4-6	Airborne Uranium-234 Concentrations for 2011—Group Summaries	4-9
Table 4-7	Airborne Uranium-235 Concentrations for 2011—Group Summaries	4-10
Table 4-8	Airborne Uranium-238 Concentrations for 2011—Group Summaries	4-10
Table 4-9	Airborne Radioactive Emissions (Ci) from LANL Buildings with Sampled Stacks in 2011	4-16
Table 4-10	Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2011	4-17
Table 4-11	Radionuclide Half-Lives	4-17
Table 4-12	PM-2.5 and PM-10 Concentration Summary for 2011	4-23
Table 4-13	Monthly and Annual Climatological Data for 2011 at Los Alamos	4-28
Table 5-1	Application of Standards or Screening Levels to LANL Groundwater Monitoring Data	5-5
Table 5-2	Alluvial Groundwater Contaminants above Screening Levels in 2011	5-7
Table 5-3	Intermediate Groundwater Contaminants above Screening Levels in 2011	5-9
Table 5-4	Regional Aquifer Groundwater Contaminants above Screening Levels in 2011	5-9
Table 5-5	Total Number of Groundwater Sample Results Collected by LANL in 2011	5-17
Table 5-6	Total Number of Groundwater Sample Results above Screening Levels in 2011	5-18
Table 5-7	Groundwater Analytes with Results above Screening Levels in 2011	5-18
Table 5-8	Radioactivity Results above Screening Levels in Alluvial Groundwater for 2011	5-21
Table 5-9	Groundwater Quality in Los Alamos Water Supply Wells	5-23
Table 5-10	Groundwater Quality in San Ildefonso Water Supply Wells	5-24
Table 5-11	Groundwater Quality in Buckman Well Field Supply Wells	5-24
Table 5-12	Summary of Groundwater Contamination in Guaje Canyon (includes Rendija and Barrancas Canyons)	5-25
Table 5-13	Summary of Groundwater Contamination in Los Alamos Canyon and the TA-21 Monitoring Group (includes Bayo, Acid, Pueblo, and DP Canyons)	5-25
Table 5-14	Groundwater Quality in Pueblo Canyon (includes Acid Canyon)	5-26
Table 5-15	Groundwater Quality in TA-21 Monitoring Group	5-28
Table 5-16	Groundwater Quality in Los Alamos Canyon (includes DP Canyon)	5-31
Table 5-17	Groundwater Quality in Lower Los Alamos Canyon	5-32
Table 5-18	Summary of Groundwater Contamination in Sandia and Mortandad Canyons and the Chromium Investigation Monitoring Group	5-33
Table 5-19	Groundwater Quality in the Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)	5-35
Table 5-20	Groundwater Quality in Mortandad Canyon Alluvial Groundwater	5-41
Table 5-21	Summary of Groundwater Contamination in Pajarito Canyon and the MDA C and TA-54 Monitoring Groups	5-44
Table 5-22	Groundwater Quality in MDA C and TA-54 Monitoring Groups	5-45
Table 5-23	Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)	5-45

Table 5-24	Summary of Groundwater Contamination in Water and Pajarito Canyons and the TA-16 260 Monitoring Group.....	5-51
Table 5-25	Groundwater Quality in the TA-16 260 Monitoring Group.....	5-55
Table 5-26	Groundwater Quality in Water Canyon (includes Cañon de Valle and Potrillo, Fence, and Indio Canyons)	5-59
Table 5-27	Summary of Groundwater Contamination in Ancho Canyon and the MDA AB Monitoring Group	5-60
Table 5-28	Summary of Groundwater Contamination in White Rock Canyon Springs	5-60
Table 5-29	Groundwater Quality in White Rock Canyon Springs	5-61
Table 6-1	Application of Surface Water and Sediment Standards and Screening Levels to Monitoring Data.....	6-7
Table 6-2	NMWQCC Designated Uses for LANL Surface Waters	6-9
Table 6-3	Summary of Results for Radionuclides and Inorganic Chemicals in Pajarito Plateau Sediment Samples from 2011	6-16
Table 6-4	Summary of Results for Radionuclides in Pajarito Plateau Storm Water Samples Collected at Gauge Stations from 2011	6-17
Table 6-5	Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Storm Water Samples Collected at Gauge Stations from 2011.....	6-19
Table 7-1	Application of Soil Standards and Other Reference Levels to LANL Monitoring Data	7-2
Table 8-1	Standards and Other Reference Levels Applied to Foodstuffs.....	8-3
Table 8-2	Locations and Types of Fish Collected.....	8-4
Table 8-3	Standards and Other Reference Levels Applied to Biota	8-23
Table 9-1	Summary of Work Plans Submitted and/or Approved in 2011	9-3
Table 9-2	Reports Submitted and/or Approved in 2011.....	9-7
Table 9-3	SWMUs and AOCs Granted Certificates of Completion in 2011	9-8
Table 9-4	Summary of Site, Aggregate Area, and Canyon Investigations Conducted and/or Initially Reported on in 2011 under the Corrective Actions Program	9-12
Table 10-1	Vapor Monitoring Locations	10-3
Table 10-2	VOCs that Exceeded Tier I and Tier II Screening Values during 2011	10-4
Table 11-1	Overall Quality of 2011 Samples	11-2
Table 11-2	Routine Validation Summary for 2011 Data	11-2

APPENDICES

Appendix A	Standards for Environmental Contaminants.....	A-1
Appendix B	Units of Measurement	B-1
Appendix C	Description of Technical Areas and their Associated Programs.....	C-1
Appendix D	Related Websites.....	D-1
Appendix E	Glossary.....	E-1
Appendix F	Acronyms and Abbreviations.....	F-1
Appendix G	Elemental and Chemical Nomenclature.....	G-1

LOS ALAMOS NATIONAL LABORATORY ENVIRONMENTAL REPORT 2011

This year's report incorporates some changes to the format and content, including a change in the report's organization, discussion of the 2011 Las Conchas Fire, a summary of the 50-Year Environmental Stewardship Plan, and posting of this report on the Intellus New Mexico website:

<http://www.intellusnmdata.com/>.

REPORT ORGANIZATION

Last year, Chapter 12, Environmental Stewardship, was presented. This year, environmental stewardship will fall under LANL's 50-Year Environmental Stewardship Plan. A brief summary is discussed in Chapter 1.

2011 EVENTS SUMMARIZED

The Las Conchas Fire and its mitigations are discussed in detail in Chapter 1. Supporting data evaluations and their findings are discussed in appropriate chapters.

DISTRIBUTION OF LOS ALAMOS NATIONAL LABORATORY ENVIRONMENTAL REPORT 2011

This year, a minimal number of hardcopies will be distributed. This report will be available on the Intellus New Mexico website: <http://www.intellusnmdata.com/>.

Abstract/Preface/Executive Summary

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1.0 Introduction

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Introduction

Los Alamos National Laboratory (LANL or the Laboratory) is located in Los Alamos County in north-central New Mexico (NM), approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure ES-1). The 36-square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet above the Rio Grande at White Rock Canyon. Most Laboratory and Los Alamos County developments are confined to the mesa tops. With the exception of the towns of Los Alamos and White Rock, the surrounding land is largely undeveloped, and large tracts of land



north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. In addition, Pueblo de San Ildefonso borders the Laboratory to the east.

The mission of LANL is to develop and apply science and technology to (1) ensure the safety and reliability of the US nuclear deterrent, (2) reduce global threats, and (3) solve other emerging national security challenges. Meeting this diverse mission requires excellence in science and technology to solve multiple national and international challenges. Inseparable from the Laboratory's focus on excellence in science and technology is its commitment to environmental stewardship and full compliance with environmental protection laws. Part of LANL's commitment is to report on its environmental performance, and as such, this report does the following:

- Characterizes LANL's environmental management, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment;
- Summarizes environmental occurrences and responses;
- Confirms compliance with environmental standards and requirements; and
- Highlights significant programs and efforts.

Environmental Monitoring

The Laboratory monitors emissions, effluents, and environmental media to meet environmental compliance requirements, determine actions to protect the environment, and monitor the long-term health of the local environment. LANL monitoring includes the radiological ambient air sampling network (AIRNET); groundwater, soil, foodstuffs, and biota (plants and animals) sampling as far away as Dixon, NM (40 direct miles away); and sediment monitoring in watersheds crossing LANL and along the Rio Grande as far upriver as Abiquiu Reservoir and as far downriver as Cochiti Reservoir. LANL's environmental compliance and surveillance programs monitor for environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. During 2011, the Laboratory collected samples from air, water, soil, sediment, foodstuffs, and associated biota at approximately 1,800 locations (Table ES-1). Results for each of these monitoring programs are presented in Chapters 2 to 10 of this report. The Laboratory also works with and assists neighboring communities and pueblos in performing environmental monitoring.

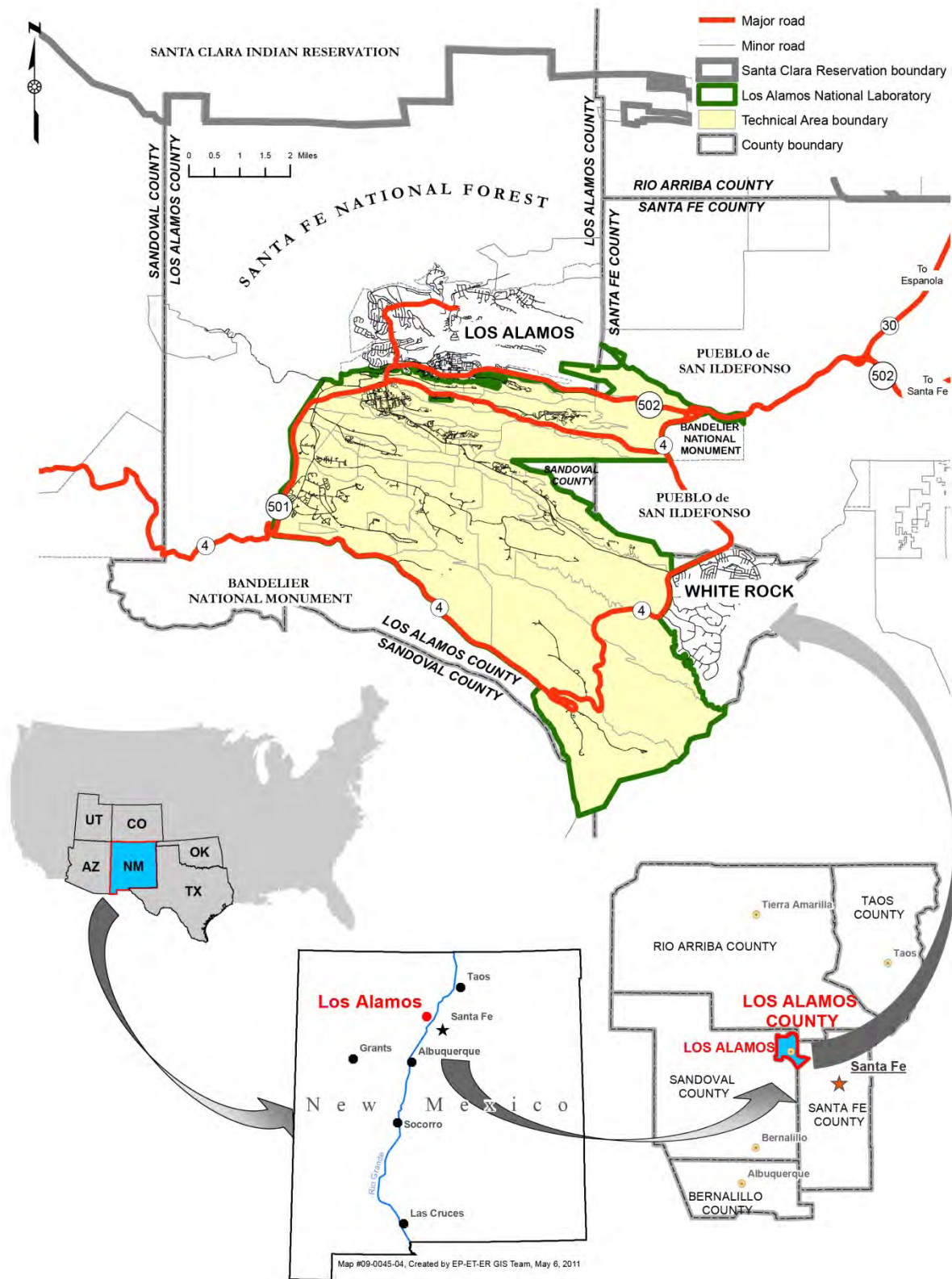


Figure ES-1 Regional location of Los Alamos National Laboratory.

Table ES-1
Approximate Number of Environmental
Samples, Locations, and Analytes Collected in 2011

Sample Type or Media	No. of Locations	Frequency of Sampling ^a	No. of Analytes or Measurements
Ambient air	59	Biweekly	7,300 ^b
Stack monitoring	28	Weekly	22,000
Biota	22	Annually	2,290
Routine soil surveillance sampling	25	Annually	820
Sediment	128	Annually	23,000
Foodstuffs	19	Annually	16,750
Groundwater	215	Quarterly/semi-annually/annually	162,130
National Pollutant Discharge Elimination System (NPDES) outfalls	11	Weekly	2,680
Surface water base flow	13	Quarterly/semi-annually/annually	4,420
Surface water storm runoff	129	Following rains	37,450
Neutron radiation	47	Quarterly	190
Gamma radiation	98	Quarterly	390
Environmental remediation soil/rock investigation sampling	987	Annually	244,260
Subsurface vapor monitoring	85	Monthly/quarterly/annually	121,040
Totals	1,866		644,720

Note: Not all the data counted in the table above are reported in this document. Totals include duplicate samples but do not include additional samples and results from the extensive quality assurance/quality control program, which are normally 10% to 20% more but can be over 60% more, depending on the media.

^a Sampling frequency is location dependant, when more than one frequency is listed.

^b Does not include particulate (in air) measurements made by four tapered element oscillating microbalance instruments that calculate particulate concentrations every half hour.

Environmental Protection Programs

The US Department of Energy (DOE) has established a series of orders directing each DOE site to implement sound stewardship practices that are protective of natural and cultural resources. These orders require the implementation of an Environmental Management System (EMS), a Site Sustainability Plan, Radiation Protection of the Public, and Radioactive Waste Management.

As part of its commitment to protect the environment and improve its environmental performance, LANL continued the implementation of its EMS pursuant to DOE Order 450.1A and the international standard from the International Organization for Standardization (ISO), ISO 14001:2004. The EMS is a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals. In 2011 there was one routine surveillance external audit (in March) and two internal assessments of the LANL EMS program. A three-year cycle recertification external audit was held early in 2012 with no major findings and a determination to extend LANL's 14001:2004 certification.

Directorates at LANL annually identify the environmental impacts associated with their work scope, prioritize these risks for significance, and develop an Environmental Action Plan to manage or prevent those risks. Combined, all of the above activities composed the LANL EMS and supported the Laboratory in meeting several milestones during fiscal year (FY) 2011 (October 2010 to September 2011) and calendar year 2011. LANL identified six high-level objectives to support our goal of establishing excellence in environmental stewardship during FY11. These objectives and our FY11 accomplishments associated with them are presented in Table ES-2. The Laboratory maintained a high level of environmental compliance

performance in FY11, completed a major environmental remediation project at Technical Area 21 (TA-21), performed multiple public involvement events, and maintained a fully compliant EMS.

Table ES-2
FY11 Environmental Objectives and Accomplishments

Objective	Example Accomplishments
Improve environmental and safety performance through improved integration and communication at the work level	LANL managers performed frequent management observation and verification (MOV) walkarounds in employee workspaces. Managers documented the results in LANL's new MOV Module to share information with others in the organization.
Reduce cost and increase efficiency and operating capacity through systematic implementation of pollution prevention	The Clean Fill Management database was established so that generators and users can efficiently transfer clean fill without costs related to disposal or procurement.
Reduce cost and increase efficiency and operating capacity through energy conservation and reductions in fuel, electricity, and water consumption	As reported in LANL's Strategic Sustainability Performance Plan (SSPP), LANL reduced its energy intensity by 12.9% since FY03 and its fleet petroleum usage by 6.7% since FY10.
Enhance workplace environment, safety, and security through implementation of Laboratory-wide cleanout activities to disposition unneeded equipment, materials, chemicals, and waste	In FY11, LANL disposed of over 3,500 kilograms of unwanted chemicals during cleanouts.
Ensure operational capacity through implementation of the NPDES Outfall Reduction Program by 2012	The US Environmental Protection Agency (EPA), which issues permits for industrial and sanitary wastewater discharges, approved the removal of four more outfalls from the Laboratory's permit. Only 11 outfalls remain.
Reduce long-term impacts, increase operational capacity, and ensure Laboratory sustainability through an integrated approach to site-wide planning and development	The Sanitary Effluent Reclamation Facility (SERF) treats effluent from LANL's sanitary wastewater plant to be used in various cooling towers at LANL. The effluent is cleaned to higher standards than even drinking water, and less groundwater needs to be pumped to provide water for the cooling towers. Less wastewater is generated because it can be reused in the cooling towers.

The Pollution Prevention Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risk to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions.

The DOE required its subcontractors to publish Site Sustainability Plans as part of meeting the requirements set forth in its SSPP. The Laboratory published an FY12 Site Sustainability Plan, and Table ES-3 shows the Laboratory's performance status toward meeting the sustainability goals.

Table ES-3
Sustainability Performance Status

DOE/NNSA* Goal	Performance Status	Planned Actions & Contribution
28% Scope 1 and 2 greenhouse gas (GHG) reduction by FY20 from an FY08 baseline	Due to increased computing, LANL has increased GHG emissions by 3%.	LANL will pursue Renewable Energy Certificate (REC) purchases and explore renewable energy power purchase agreements.
30% energy intensity reduction by FY15 from an FY03 baseline	Due to efforts in footprint reduction and energy conservation, LANL has reduced energy intensity by 15% (12.9% without the REC off-set).	LANL will continue to pursue High Performance Sustainable Building implementation; lighting retrofits; heating, ventilation, and air conditioning recommissioning; building setback scheduling; outreach; and footprint reduction efforts.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015) where life cycle cost effective. The site may also report on potable water and chilled water as applicable.	LANL has installed electric meters to account for 91% electricity at the building level.	LANL estimates a 25% completion rate for steam and a 5% completion rate for gas by the end of FY12. LANL will focus on installing DOE-funded thermal meters in FY12 and needs to identify the meter installations necessary to meet the SSPP goals.
Cool roofs, unless uneconomical, for roof replacements unless project already has Critical Decision (CD)-2 approval. New roofs must have thermal resistance of at least R-30.	All new roofs meet cool roof requirements. In FY 2011, LANL replaced 53,027 square feet of roof space meeting the cool roof requirements.	LANL standards currently implement cool roof requirements, and all new roofs currently meet this standard.
7.5% of annual electricity consumption from renewable sources by FY13 and thereafter (5% FY10–FY12)	LANL exceeded the 5% renewable energy goal. LANL purchased 45,571 RECs in FY11. The new annual request represents a 25% increase over previously contracted levels.	The landfill photovoltaic (PV) array will produce approximately 2,200 megawatt-hour (MWh) per year, and the Abiquiu low flow turbine will produce approximately 7,000 MWh per year (18,400 MWh with double credit for on-site production). The Laboratory used approximately 421,000 MWh in FY10, and the estimated percentage for federal on-site renewable energy is 4.4% once the PV is operational. LANL will support NNSA to renegotiate the Los Alamos County Electric Coordination Agreement to support further third party development of long-term renewable and carbon neutral energy on-site generation.
10% annual increase in fleet alternative fuel consumption by FY15 relative to an FY05 baseline	LANL has increased alternative fuel consumption by 82%, using FY05 as a baseline.	LANL will continue to purchase and use alternative fuel for security force vehicles. In addition, LANL has purchased B5 biodiesel blend for use in equipment and plans to increase the percentage of biodiesel within the blend over time.

*NNSA = National Nuclear Security Administration.

The Laboratory met all DOE public and biota dose limits, as low as reasonably achievable (ALARA) assessments, and clearance of real and personal property requirements during 2011.

Laboratory operations generate four types of radioactive wastes: low-level waste (LLW), mixed low-level waste (MLLW), transuranic (TRU) waste, and mixed TRU waste. (Waste definitions are provided in Appendix E, the glossary). MLLW is LLW that also contains a hazardous (Resource Conservation and Recovery Act [RCRA]-regulated) component, and mixed TRU waste is TRU waste with a hazardous component. Only LLW is disposed of at LANL; all other radioactive wastes are shipped off site for final treatment, if required, and disposal. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 and DOE Manual 435.1. The hazardous component of MLLW and mixed TRU wastes is also regulated under RCRA and the LANL Hazardous Waste Facility Permit. During FY11, eight Laboratory Facility Operation Directorates were approved to generate, treat, or dispose of radioactive waste. During FY11, 272 internal inspections were conducted at LANL generation, storage, treatment, and

disposal facilities. Six findings were identified; corrective actions were implemented and closed out. The DOE Los Alamos Site Office participates as an observer of internal inspections to ensure continued compliance.

Compliance with State and Federal Regulations

The EPA and the New Mexico Environment Department (NMED) regulate Laboratory operations under various environmental statutes (e.g., Clean Air Act, Clean Water Act, etc.) through operating permits, construction approvals, and the Compliance Order on Consent (Consent Order). These permits are designed by the regulatory agencies to allow Laboratory operations to be conducted while ensuring that the public, air, land, soils, water, and biota are protected. The Laboratory's compliance performance is an assessment of our protection of the environment. Table ES-4 presents a summary of the Laboratory's status in regard to environmental statutes and regulations for 2011.

The federal and state laws regulate management of hazardous wastes based on a combination of the facility's status, the quantities of waste generated, and the types of waste management conducted by the facility. Certain operations require a hazardous waste facility permit, often called a RCRA permit. The LANL hazardous waste facility permit was initially granted in 1989 for storage and treatment operations and was renewed in 2010. All of the permits or approvals the Laboratory operates under are listed in Table ES-4.

Compliance Order on Consent

The March 2005 Consent Order among DOE and its Operations and Management Contractor and NMED is the principal regulatory driver for LANL's environmental remediation programs. The Consent Order contains requirements for investigation and cleanup of solid waste management units (SWMUs) and areas of concern (AOCs) at the Laboratory. The major activities conducted by the Laboratory included investigations and cleanup actions. All major deliverables of the Consent Order were met by the Laboratory during 2011. In 2011, the Laboratory submitted 177 deliverables (plans and reports) required by the Consent Order on time to NMED (see Chapter 9). The Laboratory performed significant groundwater compliance work in 2011 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and installation of monitoring wells in support of various groundwater investigations and corrective measures evaluations (CMEs).

- ❖ The Consent Order governs the Laboratory's environmental remediation. It specifies actions that the Laboratory must complete to characterize and remediate sites.
- ❖ In 2011, LANL installed one monitoring well in the perched/intermediate aquifer and five monitoring wells (with six screens) in the regional aquifer.

The status of Consent Order investigations and remediations is presented in Figure ES-2. For those aggregate areas presented as complete, all investigation activities have been completed, and no additional field sampling campaigns, investigation reports, or corrective measures activities are anticipated. Aggregate areas listed as in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, or investigation reports are being prepared or finalized. Aggregate areas listed as pending include sites or areas where work plan preparation and field sampling campaigns have not yet started.

Site-specific storm water control measures that reflect best industry practice, considering their technological availability, economic achievability, and practicability, are required for each of the 405 permitted sites to minimize or eliminate discharges of pollutants. These controls are referred to as Best Management Practices.

The local storm water drainage around sites (called Site Monitoring Areas) has been hydrologically analyzed, and sampling locations have been identified to most effectively sample runoff from sites.

Table ES-4
Environmental Permits or Approvals under which the Laboratory Operated during 2011

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA Permit	Hazardous Waste Facility Permit: Permitted hazardous waste storage units: TA-3, TA-50, TA-54, and TA-55	November 1989, renewed November 2010	December 2020	NMED
	40 Code of Federal Regulations 265 Standards: Interim Status hazardous waste storage and treatment facilities: TA-14, TA-16, TA-36, TA-39, and TA-54. Permit applications to be submitted to NMED.	Post-1980 hazardous waste units; Post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised April 20, 2012	September 20, 2015	NMED
CWA ^a /NPDES	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA
	MSGP ^b for the discharge of storm water from industrial activities	September 29, 2008	September 29, 2013	EPA
	NPDES Individual Permit for storm water discharges from SWMUs and AOCs	November 1, 2010	October 31, 2015	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	June 30, 2008	July 31, 2011 (proposed extension until January 31, 2012)	EPA
CWA Sections 404/401	COE ^c Nationwide Permits (five)	Not applicable	Not applicable	COE/NMED
Groundwater Discharge Permit, TA-46 SWWS ^d Plant	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted on July 2, 2010	January 7, 2003 ^e	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid Waste Treatment Facility	Discharge to groundwater	Submitted August 20, 1996	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Tank/Leachfield Systems	Discharge to groundwater	Submitted April 27, 2006 Application resubmitted on June 25, 2010	Approval pending	NMED

Table ES-4 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC ^a)	LANL air emissions Renewal 1	August 7, 2009	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification 1, Revision 1	July 30, 2004		
	Permit modification 1, Revision 2	March 5, 2009		
	1600-kW generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two 20-kW generators and one 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement, Radiological Laboratory, Utility, Office Building	September 16, 2005	None	NMED
Air Quality (NESHAP ^g)	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED

^a CWA = Clean Water Act.^b MSGP = Multi-Sector General Permit.^c COE = US Army Corps of Engineers.^d SWWS = Sanitary Wastewater System (Plant).^e Permit was administratively continued through 2011.^f NMAC = New Mexico Administrative Code.^g NESHAP = National Emission Standards for Hazardous Air Pollutants.

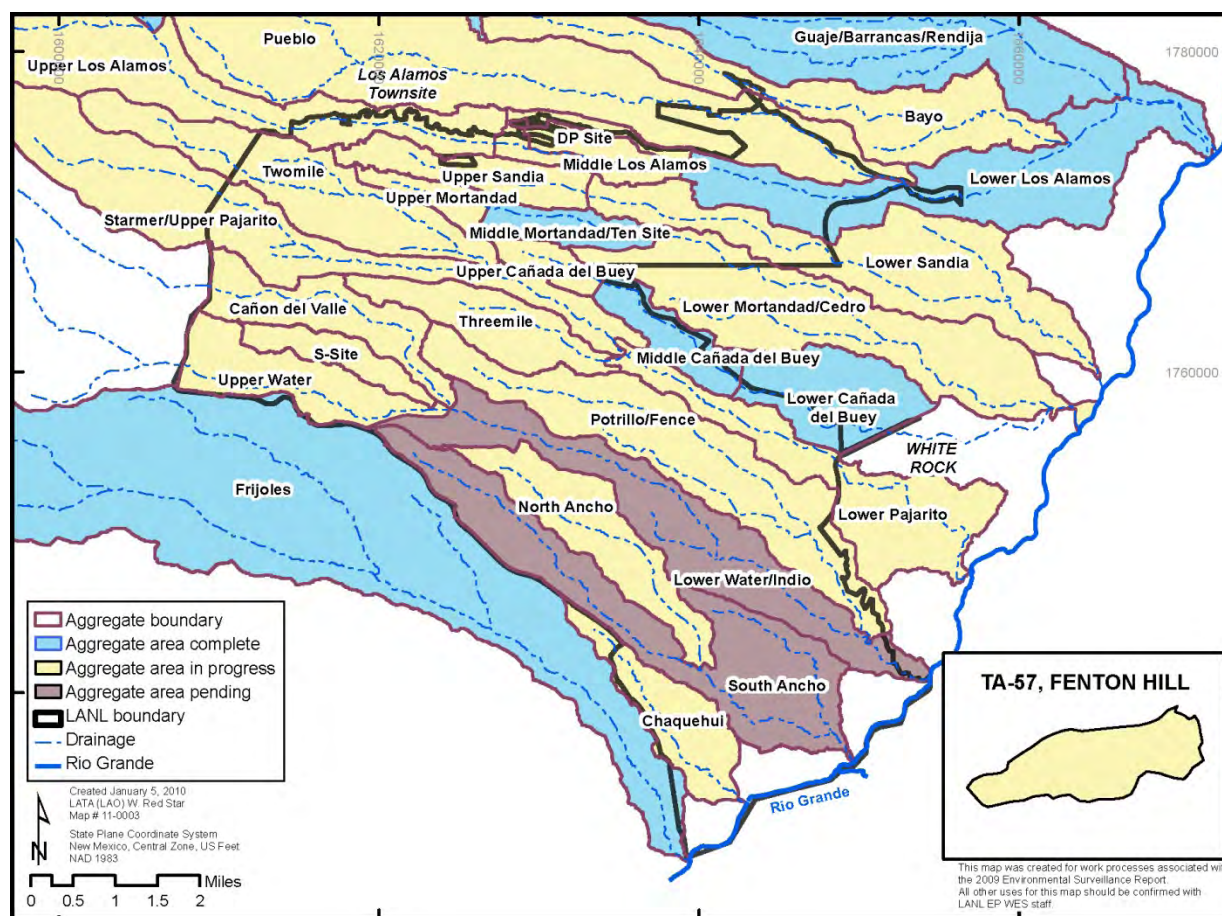


Figure ES-2 Aggregate areas as defined for the Consent Order and their status. Status is shown as aggregate area activities complete, activities in progress, or activities pending.

Unplanned Releases

There were no unplanned airborne releases and no unplanned releases of radioactive liquids from LANL in 2011. There were 20 releases of non-radioactive liquids, most of which were potable water, hydraulic fluid, or domestic wastewater. Other liquids included reuse water, steam condensate, sanitary wastewater, and fire-suppression water. LANL reported all liquid releases to NMED. In 2011, the Laboratory was in the process of administratively closing all releases for 2011 with the NMED and the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

Radiological Dose Assessment

Humans, plants, and animals potentially receive radiation doses from various Laboratory operations (Table ES-5). The DOE dose limits for the public and biota are the mandated criteria that are used to determine whether a measurement represents a potential exposure concern. The effective dose equivalent, or “dose,” is calculated using radiation-weighting factors and tissue-weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. Federal government standards limit the dose that the public may receive from Laboratory operations.

- ❖ During 2011, the Laboratory contributions to the airborne pathway dose at an average Los Alamos and White Rock residence were less than 0.1 mrem.

Table ES-5
LANL Radiological Doses for Calendar Year 2011

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	Percent of DOE 100-mrem/yr Limit	Estimated Population Dose (person-rem)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	3.53 ^a	3.5	0.58	n/a ^b	n/a
Water	< 0.1	< 0.1	0	n/a	n/a
Other pathways (foodstuffs, soils, etc.)	< 0.1	< 0.1	0	n/a	n/a
All pathways	0.9 ^c	0.9	0.58	~343,000	~268,000 ^d

^a Rad-NESHAP (NESHAP for Emissions of Radionuclides Other than Radon from DOE Facilities) for the maximally exposed individual (MEI) dose determined at 278 DP Road.

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

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

^d Based on 270 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 29 mrem/yr from potassium-40, 300 mrem/yr from medical and dental uses of radiation, and 13 mrem/yr from man-made products (see Chapter 3, Section B.4).

Biota Dose

The DOE biota dose limits are intended to protect populations of plants and animals, especially with respect to preventing the impairment of reproductive capability within the biota population. Most collected water, soil, and biota samples from the many locations at LANL in 2011 were well below all applicable screening levels.

As a result of the Las Conchas Fire, suspended sediment in storm water was above screening levels at some locations. The highest concentrations consisted of natural uranium and global fallout in ephemeral storm water. Detailed analysis using RESRAD-Biota includes consideration of maximum and mean concentrations; natural radioactive material, global fallout, and material from LANL; terrestrial, riparian, and aquatic habitats; and bioaccumulation factors. These considerations and analyses conclude that biota doses were below the DOE limits.

Radiological Air Emissions

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks) and categorizes these radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous air activation products (radioactive elements created by the Los Alamos Neutron Science Center [LANSCE] particle accelerator beam). In addition, the Laboratory collects air samples at general locations within LANL boundaries, at the LANL perimeter, and regionally to estimate the extent and concentration of radionuclides that may be released from Laboratory operations. These radionuclides include isotopes of plutonium, americium, uranium, and tritium.

Measurements of LANL stack emissions during 2011 totaled approximately 328 curies (Ci) (compared with nearly 300 Ci in 2010). Of this total, tritium emissions contributed approximately 101 Ci (compared with 87 Ci in 2010), and air activation products from LANSCE stacks contributed nearly 228 Ci (compared with nearly 211 Ci in 2010). LANSCE diffuse emissions of air activation products contributed another 15 Ci of gaseous mixed air activation products. Combined airborne emissions of particulate materials such as plutonium, uranium, americium, and thorium were less than 0.000025 Ci. Emissions of particulate matter plus vaporous activation products were about 0.012 Ci, which is slightly lower than recent years.

Non-Radiological Air Emissions and Air Quality

LANL demonstrated full compliance with all Clean Air Act monitoring and reporting requirements. Emissions of criteria pollutants (nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter, VOCs,

and hazardous air pollutants) were similar to the previous five years. The TA-3 power plant and boilers located across the Laboratory were the major contributors of nitrogen oxides, carbon monoxide, and particulate matter. Science research and development activities were responsible for most of the VOC and hazardous air pollutant emissions.

The Laboratory analyzed air filter samples from 38 sites for beryllium, aluminum, and calcium. These sites are located near potential beryllium sources at LANL and in nearby communities. All concentrations measured this year were at or below 2% of the NESHAP standard of 10 nanograms per cubic meter (ng/m³) and were similar to those of recent years. Past studies closely correlated beryllium concentrations with aluminum concentrations, which indicates that all measurements of beryllium are from naturally occurring beryllium in resuspended dust. Aluminum and calcium are used to evaluate elevated uranium measurements, and no unusual concentrations were measured.

Groundwater Monitoring

Groundwater at the Laboratory occurs as a regional aquifer (water-bearing rock capable of yielding significant quantities of water to wells and springs) at depths ranging from 600 to 1,200 feet and as perched groundwater of limited thickness and horizontal extent, either in canyon alluvium or at intermediate depths of a few hundred feet (Figure ES-3). All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater. The results of all 2011 studies on groundwater are presented in Chapter 5.

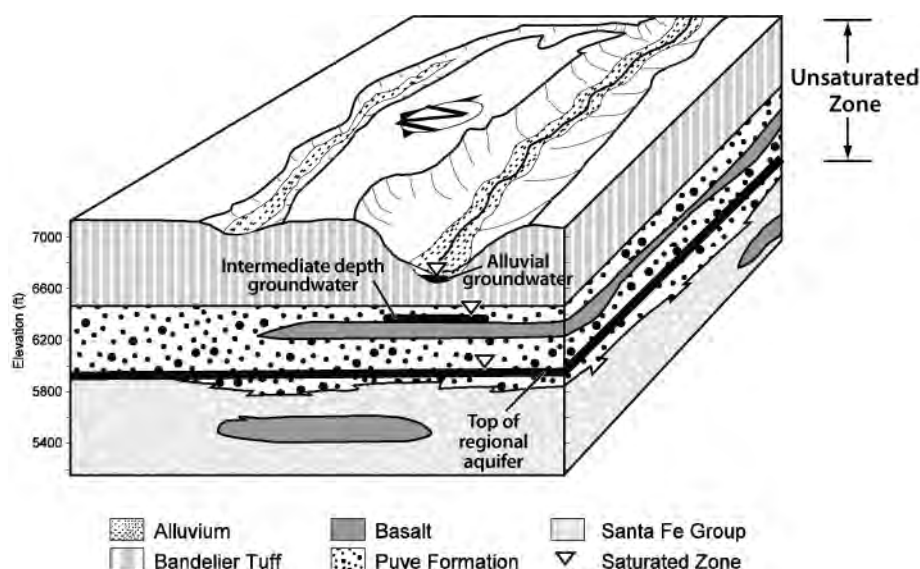


Figure ES-3 Three modes of groundwater occurrence

Most of the groundwater monitoring conducted during 2011 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (LANL 2010, 2011b, 2011c) approved by NMED under the Consent Order. The LANL Environmental Programs Directorate collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

The Laboratory has changed groundwater quality through liquid effluent disposal, with the greatest impact on alluvial groundwater. Laboratory contaminants have also affected the intermediate perched zones and the regional aquifer. The alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so infiltration from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer, and impacts on the regional aquifer are reduced.

In 2011, LANL sampled 215 groundwater wells, well screens, and springs in 813 separate sampling events. The samples collected were analyzed for about 206,026 separate results. If results for field parameters (for example, temperature or pH) and field quality control blanks are excluded, the samples were analyzed for 151,197 results. Table ES-6 summarizes ground water analytes detected above screening levels in portions of the groundwater system.

Table ES-6
Groundwater Analytes with Results above Screening Levels in 2011
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
General Inorganic Chemistry	31			
Chloride	1	250	mg/L ^a	NM groundwater standard
Perchlorate	30	4	µg/L ^b	Consent Order
High Explosives	24			
RDX ^c	24	6.11	µg/L	EPA regional screening level for tap water
Metals	113			
Aluminum	3	5,000	µg/L	NM groundwater standard
Arsenic (dissolved and total)	9	10	µg/L	EPA MCL ^d
Barium	10	1,000	µg/L	NM groundwater standard
Boron	4	750	µg/L	NM groundwater standard
Chromium (dissolved)	26	50	µg/L	NM groundwater standard
Iron	21	1,000	µg/L	NM groundwater standard
Lead (total)	4	15	µg/L	EPA drinking water system action level
Manganese	34	200	µg/L	NM groundwater standard
Nickel	2	200	µg/L	NM groundwater standard
Radioactivity	16			
Gross Alpha	3	15	pCi/L ^e	EPA MCL
Gross Beta	1	50	pCi/L	EPA drinking water screening level
Strontium-90	3	8	pCi/L	EPA MCL
Uranium	5	30	µg/L	NM groundwater standard
Uranium-234	4	4	pCi/L	DOE 4-mrem DCG ^f
Semivolatile Organic Compounds	17			
Benzo(a)pyrene	2	0.2	µg/L	EPA MCL
Benzo(b)fluoranthene	1	0.29	µg/L	EPA regional screening level for tap water
Bis(2-ethylhexyl)phthalate	1	6	µg/L	EPA MCL
Dibenz(a,h)anthracene	3	0.029	µg/L	EPA regional screening level for tap water
Dioxane[1,4-]	8	6.7	µg/L	EPA regional screening level for tap water
Indeno(1,2,3-cd)pyrene	2	0.29	µg/L	EPA regional screening level for tap water
Volatile Organic Compounds	10			
Acrolein	1	0.042	µg/L	EPA regional screening level for tap water
Dichloroethene[1,1-]	4	5	µg/L	NM groundwater standard
Tetrachloroethene	1	5	µg/L	EPA MCL
Trichloroethane[1,1,1-]	4	60	µg/L	NM groundwater standard

^a mg/L = milligrams per liter.

^b µg/L = micrograms per liter.

^c RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

^d MCL = Maximum contaminant level.

^e pCi/L = Picocuries per liter.

^f DCG = DOE derived concentration guide.

It is important to note that, in many cases, the given screening level may not apply to a particular groundwater sample. For example, some of the screening levels (the EPA maximum concentration levels and EPA Regional Screening Levels for Tap Water) apply specifically to drinking water and not to a sample result from

a non-drinking water source. Moreover, for a particular sampling event, multiple measurements made for an analyte may be included in the total. The multiple measurements could include both filtered and unfiltered sample results, multiple analytical laboratory analyses (e.g., made on diluted samples to improve analytical accuracy), and results from field duplicate samples. The monitoring results are described in detail in the following sections.

- ❖ Permitted outfalls have been reduced from over 100 in 2000 to only 15 in 2011.
- ❖ LANL's outfall reduction efforts are still underway. Watershed-scale approaches to control sediment are being implemented to reduce sediment transport.

In 2011, the high explosives (HE) compound RDX continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. The RDX concentration was at 19% of the EPA tap water screening level of 6.1 µg/L. RDX was also detected in a new Cañon de Valle regional aquifer well, R-63 (to the south of R-18), at 23% of the screening level. RDX continues to be detected in the upper two regional aquifer screens of R-25 (also near Cañon de Valle) at up to 8% of the screening level. Earlier detection of RDX at higher values in the regional aquifer screens of R-25 was probably because of cross-contamination from shallower well screens that occurred for several months before the sampling system was installed, allowing flow between the screens.

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at high concentrations in springs and wells throughout the Rio Grande valley. Other radioactivity in groundwater samples comes from members of the decay chains for naturally occurring uranium-235, uranium-238 (including radium-226 and uranium-234), and thorium-232 (including radium-226). Potassium-40 is also a source of natural radioactivity.

No 2011 activity or concentration value for a radioactivity analyte in a Los Alamos County water supply well exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water. The 2011 samples from water supply wells used by the City of Santa Fe and Pueblo de San Ildefonso had background levels of uranium and gross alpha results near or above screening levels, as described in Chapter 5.

No 2011 radioactivity results for intermediate groundwater or regional aquifer wells within or immediately adjacent to LANL were above screening levels.

Watershed Monitoring

Los Alamos National Laboratory monitors the quality of surface water, including storm water, and canyon bottom sediment to evaluate effects associated with transport of legacy contaminants and ongoing Laboratory operations. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. The sampling results are compared with various screening criteria to protect human health and the aquatic environment.

Laboratory lands contain all or parts of seven primary watersheds that drain directly into the Rio Grande, each defined by a master canyon. Listed from north to south, the master canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui Canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water Canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains (the Sierra de los Valles), which burned in the Las Conchas Fire. The remainder of the primary watersheds head on the Pajarito Plateau, in areas not burned by the Las Conchas Fire. Only the Ancho Canyon watershed is entirely located on Laboratory land. The Las Conchas Fire burned areas of Santa Fe National Forest upgradient of Laboratory property resulting in increased sediment and ash transport into Water, Pajarito, and Los Alamos Canyon watersheds in 2011. Following the Cerro Grande Fire in May 2000, ash and sediment transport returned to pre-fire levels in three to five years. A similar return to pre-fire conditions is expected for the Las Conchas Fire.

Sediment and surface water monitoring and assessments at the Laboratory in 2011 occurred following the annual summer monsoon season. Extensive sampling of storm water occurred in Los Alamos and Pueblo Canyons under a plan to monitor the effectiveness of sediment transport mitigation activities. Control and monitoring of storm water discharges associated with SWMUs and AOCs occurred under the Individual

Permit with the EPA. Sampling of storm water at gage stations occurred as part of the Laboratory's environmental surveillance activities.

In 2011, snowmelt runoff only crossed the eastern Laboratory boundary in Pueblo Canyon, estimated at 62 acre-feet (ac-ft), however 29 ac-ft of the runoff was effluent from the Los Alamos County Waste Water Treatment Plant. Continuous runoff was present at that location for 65 days. Total storm water runoff at downstream gages in the canyons leaving the Laboratory is estimated at 154 ac-ft, approximately 87% of this occurring in Los Alamos and Pueblo Canyons and the remaining 13% in Pajarito, Potrillo, Water, and Ancho Canyons above White Rock.

Storm water samples collected in 2011 downgradient of burned areas contained increased concentrations of ash and sediment. These samples contained correspondingly increased concentrations of background and fallout constituents transported with sediment and ash in storm water. In storm water, elevated concentrations of inorganic and organic chemicals and radionuclides were observed, including aluminum, arsenic, barium, copper, cyanide, manganese, selenium, zinc, polychlorinated biphenyls (PCBs), gross alpha, radium-226, radium-228, americium-241, cesium-237, plutonium-238, plutonium-239/240, strontium-90, uranium-234, and uranium-238.

Concentrations of constituents in storm water decrease as sediment and ash are deposited on floodplains and at other LANL-constructed and -maintained flood and sediment control features such as wetlands, detention basins, sediment traps, and weirs. In 2011, the Pueblo Canyon wetlands reduced storm water discharge such that the gage station downstream of the wetland and grade control structure did not measure discharges over 5 cfs. The Los Alamos Canyon low-head weir reduced storm water concentrations for almost all constituents, particularly those elevated because of ash and sediment from Las Conchas burn areas. Sediment and ash were trapped upstream of the Pajarito Canyon flood control structure, reducing sediment transport downstream.

Human health and ecological assessments have been conducted for each of the Canyons Investigation Reports conducted under the Consent Order. The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyons media are within acceptable limits for applicable exposure scenarios. Sediment data presented in this report are used to verify the conceptual model that the scale of storm water related contaminant transport observed in LANL canyons generally results in lower concentrations of contaminants in the new sediment deposits than previously existed in deposits in a given reach. The results of the comparisons of sediment data collected from flood-affected canyons in 2011 verify the conceptual model and support the premise that the risk assessments presented in the Canyons reports represent an upper bound of potential risks in the canyons.

Soil Monitoring

LANL conducts large-scale soil sampling within and around the perimeter of LANL every three years. The most recent comprehensive soil survey that included the analysis of radionuclides, target analyte list (TAL) inorganic elements (mostly metals), PCBs, semivolatile organic compounds (SVOCs), and HE was conducted in 2009. In general, all radionuclides and TAL elements were far below industrial screening levels (ISLs) for on-site soils or far below residential screening levels (RSLs) for perimeter soils. Moreover, no HE was detected above the reporting level of quantification in any soil collected from on-site, perimeter, or regional locations. And only trace amounts of a few PCB Aroclors (Aroclor-1254 and Aroclor-1260) and SVOCs (aniline and fluoranthene) in soil from a few sites were detected; however, all levels were far below either ISLs or RSLs, and no increasing trends were evident. The next planned full-scale institutional soil assessment will occur in 2012.

LANL also annually collects soil samples from two locations on the Pueblo de San Ildefonso land downwind of TA-54, Area G. Radionuclides and metals in the 2011 soil samples were below background or near background and were consistent with levels measured in previous years. To evaluate potential Laboratory impacts from radionuclides and chemicals in surface soil, LANL first compares the analytical results of samples collected from the Laboratory's on-site and perimeter areas with regional statistical reference levels (RSRLs).

The only radionuclide that was detected in higher concentrations than the RSRL was plutonium-238 in the Pueblo de San Ildefonso soil location closest to Area G. The amount of plutonium-238 in soil from the “San Ildefonso” site, however, was far below the RSL and generally did not increase over time (the overall long-term pattern showed normal variability along the RSRL line over time). Other radionuclides associated with Area G operations, like tritium and plutonium-239/240 in the “San Ildefonso” soil sample, were very similar to past years, are not increasing over time, and remain below the RSL.

- ❖ Four elk and two deer killed on the road were collected on or near LANL, and radionuclides in both muscle and bone were either not detected or below the RSRLs.

The Laboratory began using containment vessels for HE testing in 2007 (of which there were three detonations in 2011) at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility. The Laboratory has conducted facility-specific soil and sediment monitoring on an annual basis at DARHT since 1996. Most radionuclides in soil and sediment collected from within and around the perimeter of the DARHT facility were either not detected or

below the statistical reference levels. Tritium, americium-241, and uranium-238 in only one soil sample on the south side were detected above the statistical reference level, but the amounts were far below the ISLs and do not pose an unacceptable dose to any site workers.

Foodstuffs Monitoring

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains, are grown and/or harvested at many locations surrounding the Laboratory. Also, many food products from domestic livestock (e.g., milk, eggs, and meat) and apiaries (honey) are available, and fishing in waters downstream of the Laboratory (e.g., Rio Grande) and hunting (e.g., rabbits, turkey, deer, and elk) on neighboring properties around LANL are a common occurrence. While the many years of data collected to date do not demonstrate LANL impacts above screening levels on these resources, the ingestion of these foods might conceptually constitute an exposure pathway and are subject to monitoring.

The collection of surface soil–/native vegetation–related samples was completed in 2009, and the collection of agriculture–related samples (produce crops, goat milk, chicken eggs, and honey) from the neighboring communities surrounding the Laboratory was accomplished in 2010. This report presents the results of Rio Grande–related samples (fish, crayfish, and benthic macroinvertebrates) downstream of the Laboratory.

Fish have been collected for radionuclide analysis from two general reaches as they relate to the location of LANL since 1984; these locations are upstream of LANL (background) on the Rio Chama/Rio Grande and downstream of LANL on the Rio Grande (Figure ES-4). In 2011, samples were mostly collected during and after the Las Conchas Fire, which burned much of the watershed above and adjacent to LANL on the western side. As a result of the fire, several flooding events occurred from many canyon confluences upstream and downstream of LANL to the Rio Grande during the fish sampling period; this included the Los Alamos Canyon, as evidenced by ash residue at the Los Alamos Canyon/Rio Grande confluence.

All radionuclide concentrations (activities) in both predator and bottom-feeding fish collected on the Rio Grande at all locations downstream of LANL, including Cochiti Reservoir, were either not detected (majority of results) or were similar to RSRLs. These results indicate no effects from the runoff of stormwater and sediments from LANL on radionuclide concentration in fish downstream of LANL.

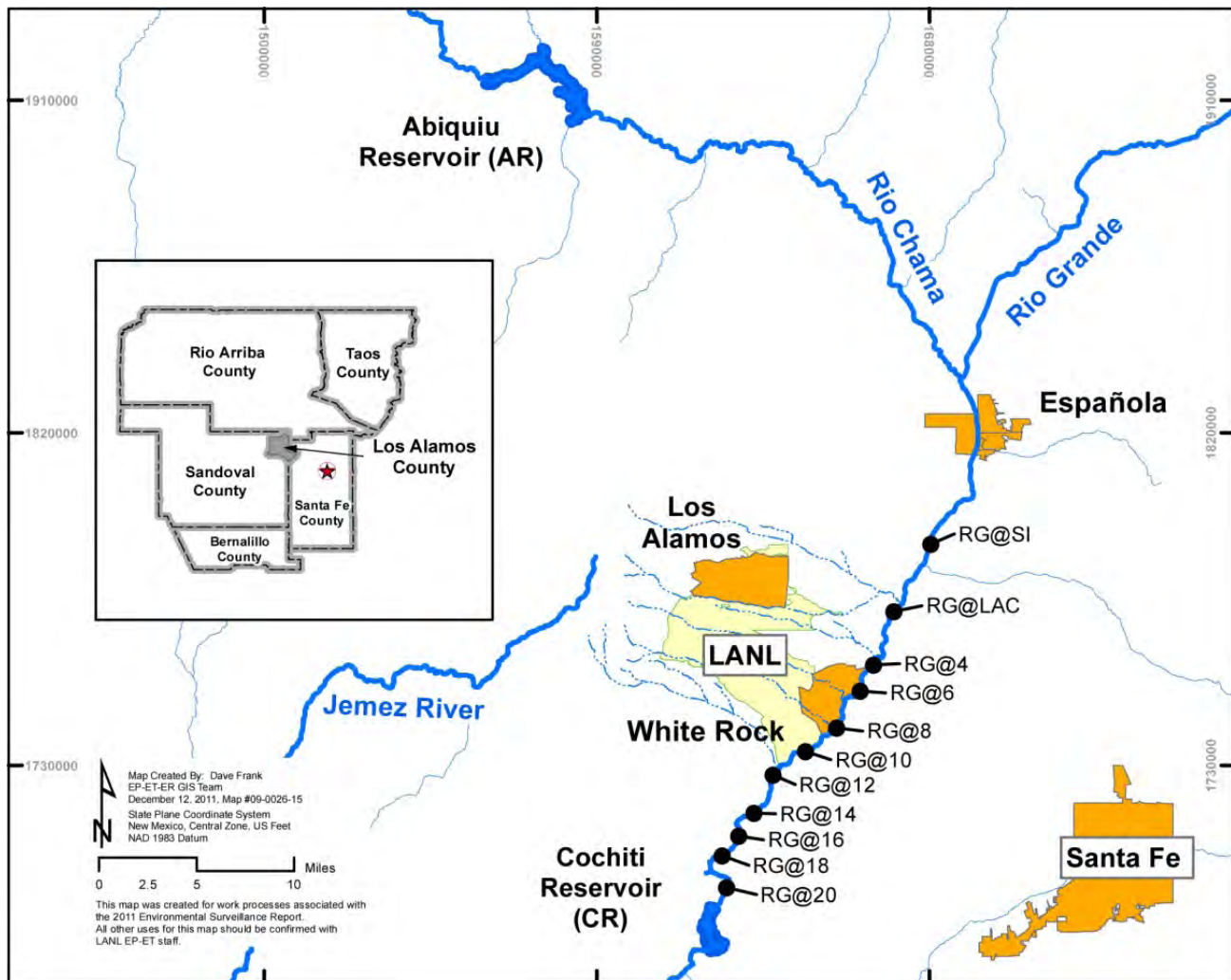


Figure ES-4 Locations of fish collected upstream and downstream of LANL on the Rio Chama and Rio Grande

Bottom-feeding fish were chosen for this example over predator fish because they are the more sensitive of the two fish types—they feed on the bottom where radionuclides readily bind to the sediment.

Most of the 23 TAL elements in the muscle fillet of both predator and bottom-feeding fish collected along the Rio Grande downstream of LANL to Cochiti Reservoir were either not detected or were below the RSRLs (based on 2005–2011 data; $n = 50$). Although the amounts of mercury in both fish types collected upstream and downstream of LANL were similar to each other, the level of mercury in many fish samples, and primarily in predator fish from Cochiti Reservoir, exceeded the EPA standard level of 0.30 milligrams per kilogram wet. The main sources of mercury into the water systems in New Mexico are natural sources and the burning of fossil fuels.

In general, total PCBs (all congeners combined) in predator and bottom-feeding fish from all locations are lower and in some cases an order of magnitude lower than what were measured in past surveys. Total PCB concentrations in muscle fillet tissue of the bottom feeders are higher than in muscle fillet tissue of the predator fish. The PCB data from 2011, particularly those directly upstream and downstream of LANL, are in agreement with other studies, mainly the following: (1) the placement of stationary semipermeable membrane devices (e.g., artificial fat bags) upstream and downstream of LANL that showed similar PCB concentrations between locations and (2) the collection of sediment samples along the same general reach of waters upstream and downstream of LANL in previous years that showed mean PCB concentrations and

homolog patterns generally similar to those of the present data. These results indicate no effects from the runoff of stormwater and sediments from LANL on PCB concentrations in fish downstream of LANL.

Crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp) samples were collected along the Rio Grande within two reaches (upstream and downstream) relative to the location of LANL from August 10 to 15, 2011 (Figure ES-5). These samples were collected after the Las Conchas Fire.

Whole-body crayfish were analyzed for tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Edible (meat) and nonedible (head, gut, claws, and shell) portions of crayfish were analyzed for 23 TAL elements, and PCBs were analyzed for 209 possible chlorinated congeners.

Most radionuclides in a composite whole-body crayfish sample ($n = 7$) collected from the Rio Grande directly downstream of the Los Alamos Canyon confluence were either not detected (most results) or were detected below the RSRLs (based on 2009 and 2011). The only radionuclides in a composite whole-body crayfish sample collected downstream of LANL that were detected in higher concentrations than the RSRLs were uranium-234, uranium-238, and strontium-90.



Figure ES-5 Collection of crayfish samples from the Rio Grande

All of the TAL elements in the edible portions of the crayfish collected along the Rio Grande directly downstream of the confluence of Los Alamos Canyon were below or similar to the RSRLs. In general, the total PCBs (picograms per gram wet) in whole-body crayfish from both upstream and downstream reaches were markedly lower than the PCB levels in bottom-feeding fish collected from these same reaches, and only one out of the seven crayfish from the downstream reach was higher than the RSRL. Overall, the mean total PCB concentrations in whole-body crayfish from the downstream reach are similar to those amounts reported in the last survey conducted in 2009 and are below the EPA risk-based screening level for unrestricted fish consumption.

Biota Monitoring

No wide-scale monitoring of vegetation was conducted in 2011. However, sampling in 2009 and in previous years shows that, in general, all concentrations of radionuclides and inorganic constituents in vegetation are very low and indistinguishable from regional background levels.

As in previous years, results at TA-54, Area G, for all radionuclides, with the exception of tritium, in native overstory vegetation (branches and needles) were either not detected or below the RSRLs. Tritium is detected above RSRLs in vegetation collected on the south side of TA-54, Area G, near tritium waste disposal shafts.

In vegetation around the DARHT facility, concentrations of radionuclides and metals were either not detected or below RSRLs. In the past, uranium-238 was usually the only radionuclide to be detected in overstory vegetation around the DARHT facility (probably as a result of foliar deposition more than by root uptake), but since 2007 the concentrations have generally decreased from all sides of the DARHT perimeter. This general decrease in uranium-238



Virginia's Warbler

concentrations with respect to the RSRL was probably because of the change in contaminant mitigation procedures from open-air to closed steel containment.

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2011 were compared with samples collected in 1999 (pre-operational phase). The purpose of the bird monitoring project is to determine the general ecological stress levels around the vicinity of DARHT that may be associated with facility operations (e.g., noise, disturbance, traffic, etc.). The number of birds, number of bird species, diversity, and evenness (distribution) collected in 2011 are similar to those collected before the start-up of operations at DARHT in 1999. In general, there are a large number of birds and types of birds located in the vicinity of the DARHT complex (see Figure ES-6).

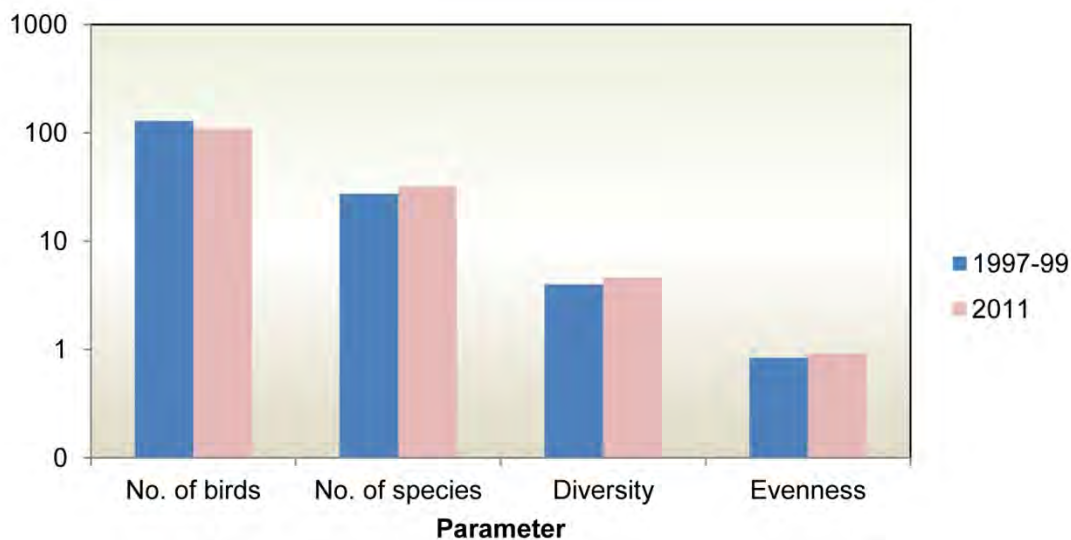


Figure ES-6 Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2010) operations at DARHT. Note the logarithmic scale on the vertical axis.

In general, special studies are conducted when there is a lack of biological data (populations, composition, and diversity) or data concerning a contaminant(s) that has the potential to impact human health and/or the environment. Ten special studies were conducted in 2011 in support of mitigation action plans, the Biological Resources Management Plan, and the Environmental Surveillance Program. The special studies included “Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Basins: Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure,” “Winter and Breeding Bird Surveys at LANL,” “Los Alamos National Laboratory Fall Avian Migration-Monitoring Report 2010” and the 2011 report, “Small Mammal Sampling at Open-Detonation Firing Sites,” “Preliminary Results of Chytrid Fungus Testing of Amphibians at LANL” “Road-Crossing Behavior of Mule Deer in a Wildland-Urban Interface,” and “Bat and Small Mammal Use of Burned and Unburned Ponderosa Pine Forest following the Cerro Grande Fire in Los Alamos, New Mexico.”

Environmental Remediation Program

Corrective actions proposed and/or conducted at LANL in 2011 follow the requirements of the Consent Order. The goal of the investigation efforts is to ensure that waste and contaminants from past operations do not threaten human or environmental health and safety. The investigation activities are designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, canyons, and watersheds. The characterization activities conducted include surface and subsurface sampling, drilling boreholes, geophysical studies, and installation of monitoring wells. Corrective action activities performed included the removal of structures (e.g., buildings, septic systems, sumps, and drain lines), excavation of media, and confirmatory sampling. These activities define the nature and extent of contamination and determine the potential risks and doses to human health and the environment. The Environmental Programs Directorate developed and/or

revised 18 investigation work plans and 27 investigation reports, which were submitted to NMED during 2011.

The Laboratory developed a Phase III investigation work plan for Material Disposal Area (MDA) C, which was approved by NMED. During 2010 and 2011, Phase III investigation activities were conducted to better define the lateral and vertical extent of subsurface volatile organic compound (VOC) and tritium pore-gas contamination at MDA C, to install downgradient regional groundwater monitoring wells, and to characterize background concentrations of inorganic chemicals detected in dacite rocks.

The DP Site Aggregate Area includes container storage areas, surface disposal areas, PCB container storage areas, septic systems, sumps, drain lines, outfalls, a waste treatment laboratory, a sewage treatment plant, and seepage pits at TA-21. The 2010–2011 investigation activities included collecting 368 surface and subsurface soil and tuff samples from 173 locations to define the extent of contamination. Structures, waste lines, debris, and/or asphalt (approximately 30 cubic yards) were removed.

Subsurface Vapor Monitoring

Subsurface vapor (pore-gas) monitoring is implemented as part of corrective action investigations at LANL. Vapor monitoring is conducted beneath and surrounding several historic MDAs at the Laboratory. The data collected from vapor monitoring wells are used to help characterize the nature and extent of VOCs and tritium in the vadose zone. Analysis of pore gas also assists in evaluating whether VOCs and tritium may be a potential threat to the groundwater.

Periodic monitoring of pore gas was required in 2011 by the Consent Order at MDAs G, H, L, T, and V (Figure ES-7).

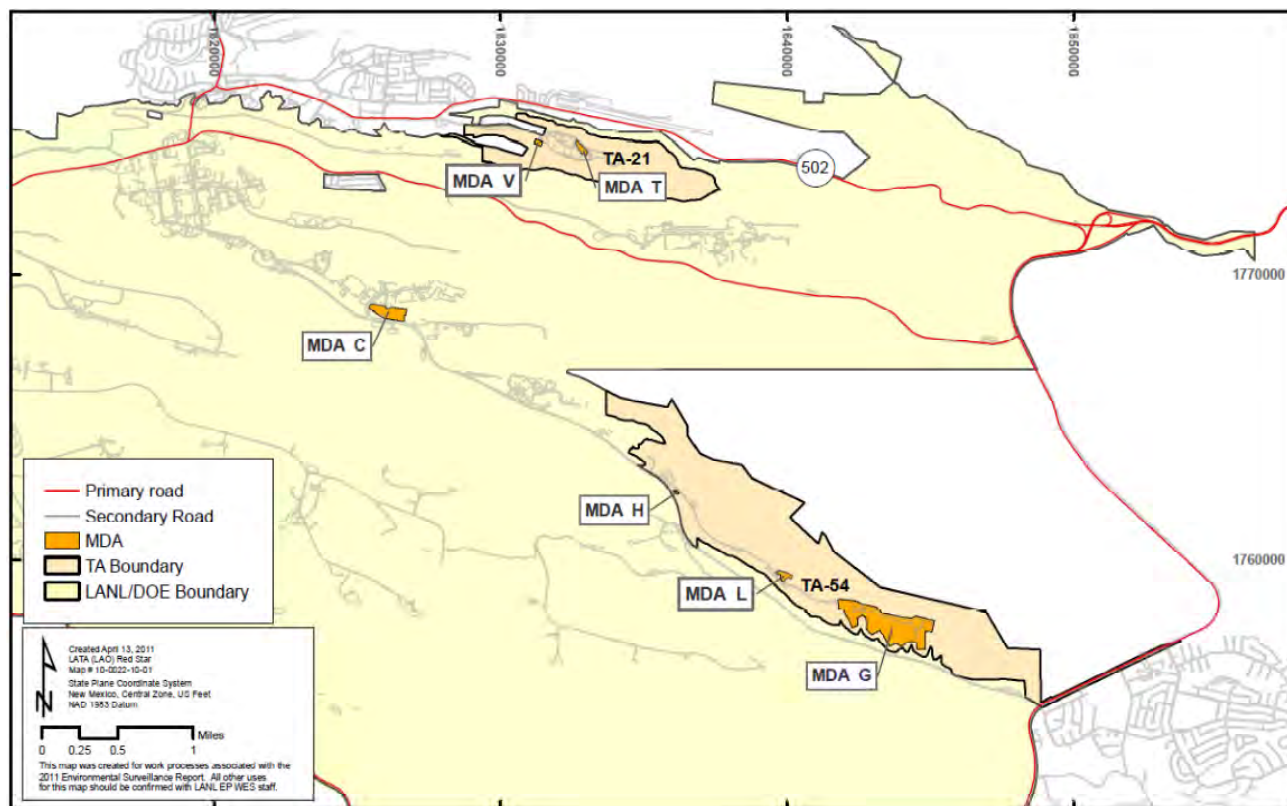


Figure ES-7 Locations of MDAs where subsurface vapor monitoring was performed in 2011

Table ES-7 shows the VOCs at MDAs C and L that exceeded the more realistic Tier II screening values developed in the Phase III investigation report for MDA C and the CME report for MDA L, respectively. No VOCs exceeded the Tier II screening values developed for MDA G during 2011.

Table ES-7
VOCs that Exceeded Tier I and Tier II Screening Values during 2011

Location	VOC	Maximum Pore-Gas Concentration ($\mu\text{g}/\text{m}^3$)	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard ($\mu\text{g}/\text{m}^3$)	Tier I Screening Ratio (unitless)
MDA C	Benzene	4,100	1,140	3.6
	Hexanone[2-]	1,500	180	8.3
	Methylene Chloride	3,900	650	6.0
	Trichloroethene*	93,000	2,000	46.5
MDA G	Dichloroethane[1,1-]	24,000	5,750	4.2
	Dichloroethane[1,1-]	25,000	5,500	4.6
	Tetrachloroethene	32,000	3,600	8.9
	Trichloroethane[1,1,1-]	740,000	42,300	17
	Trichloroethene	11,000	2,000	28
MDA L	Benzene	3,300	1,140	2.9
	Butanol [1-]	1,700	1,332	1.3
	Carbon tetrachloride	11,000	5,500	2.0
	Chloroform	120,000	15,000	8.0
	Dichloroethane [1,1-]	71,000	5,750	12.3
	Dichloroethane [1,2-]*	600,000	240	2500
	Dichloroethene [1,1-]*	65,000	5,500	11.8
	Dichloropropane [1,2-]*	280,000	600	467
	Dioxane [1,4-]	11,000	12.2	900
	Methylene chloride*	120,000	650	185
	Tetrachloroethene*	760,000	3,600	211
	Trichloroethane[1,1,1-]*	2,300,000	42,300	54.4
	Trichloroethane[1,1,2-]	1900	170	11.2
	Trichloroethene*	1,500,000	2,000	750
	Trimethylbenzene [1,2,4-]	16,000	3,750	4.3
MDA T	Methylene chloride	2,600	650	4.0
	Trichloroethane[1,1,2-]	210	170	1.2

*Denotes the VOC concentration exceeded the Tier II screening value; analysis performed for MDAs C, G, and L only.

Analytical Laboratory Quality Assurance

Environmental samples collected by the Laboratory are processed and analyzed by commercial independent analytical chemistry laboratories to determine contaminant concentrations in the samples. Each analytical laboratory must follow EPA-approved analysis methods to determine contaminant concentrations and implement a stringent quality assurance/quality control program to ensure the accuracy of the results. All analytical laboratory results undergo validation by a LANL subcontractor. If data validation identifies analytical results that do not meet EPA or LANL requirements, then LANL will perform a follow-up assessment with the analytical laboratory to identify issues and corrective actions. Finally, LANL requires each analytical laboratory to participate in third-party independent review and certification programs as a further quality assurance requirement.

There was no analytical laboratory data quality issues related to the soil, foodstuffs, and biota sampling program during 2011. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 11. Analytical data completeness for all soil, foodstuffs, and biota sampling programs was 99% in 2011.

To Read About	Turn to Page
<i>Background and Report Purpose</i>	1-1
<i>Environmental Setting</i>	1-2
<i>Laboratory Activities and Facilities</i>	1-7
<i>Management of Environment, Safety, and Health</i>	1-9
<i>References</i>	1-17

A. BACKGROUND AND REPORT PURPOSE

1. Background

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world’s first nuclear weapon. Although planners originally expected that the task would require only 100 scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California through the Los Alamos Site Office of the US Department of Energy (DOE). In June 2006, a new management organization, Los Alamos National Security, LLC (LANS), took over management of the Laboratory.

The Laboratory’s original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, priorities, and the world community have changed. LANL defines its vision as “Los Alamos, the premier national security science laboratory.” The current mission is to develop and apply science and technology to

- Ensure the safety and reliability of the United States’ nuclear deterrent,
- Reduce global threats, and
- Solve other emerging national security challenges (LANL 2005).

Inseparable from the Laboratory’s commitment to excellence in science and technology is its commitment to complete all work in a safe, secure, and environmentally responsible manner. The Laboratory uses an International Organization for Standardization (ISO) 14001:2004–registered Environmental Management System (EMS) to focus on environmental performance, protection, and stewardship. The foundation of the EMS and the demonstrated commitment of the Laboratory combine to inform the LANL environmental policy:

- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.
- We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public.
- We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

2. Report Purpose

As part of the Laboratory’s commitment to our environmental policy, we monitor and report on how Laboratory activities are affecting the environment. The objectives of this environmental report, as directed by DOE Order 231.1B (DOE 2011a), are to

- Characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials at DOE sites;
- Summarize environmental occurrences and responses reported during the calendar year;

- Confirm compliance with environmental standards and requirements; and
- Highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs.

B. ENVIRONMENTAL SETTING

1. Location

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 36-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west-oriented canyons cut by streams. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet at the edge of White Rock Canyon. Most Laboratory and community developments are confined to the mesa tops.



The surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. The Pueblo de San Ildefonso borders the Laboratory to the east.

2. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. A local fault system, composed of a master fault and three subsidiary faults, constitutes the modern rift boundary in the Los Alamos area. Studies have investigated the seismic surface rupture hazard associated with these faults (LANL 2007). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2 to 1.6 million years ago, the tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. In the central Pajarito Plateau and near the Rio Grande, the Bandelier Tuff is underlain by the Puye Formation. The Cerros del Rio basalts interfinger with the Puye Formation along the river and extend beneath the Bandelier Tuff to the west. These formations overlie the sediments of the Santa Fe Group, which extend across the basin between the Laboratory and the Sangre de Cristo mountains and are more than 3,300 feet thick.

Surface water in the Los Alamos region occurs primarily as ephemeral or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flow across the Laboratory property before the water is lost to evaporation, transpiration, and infiltration.

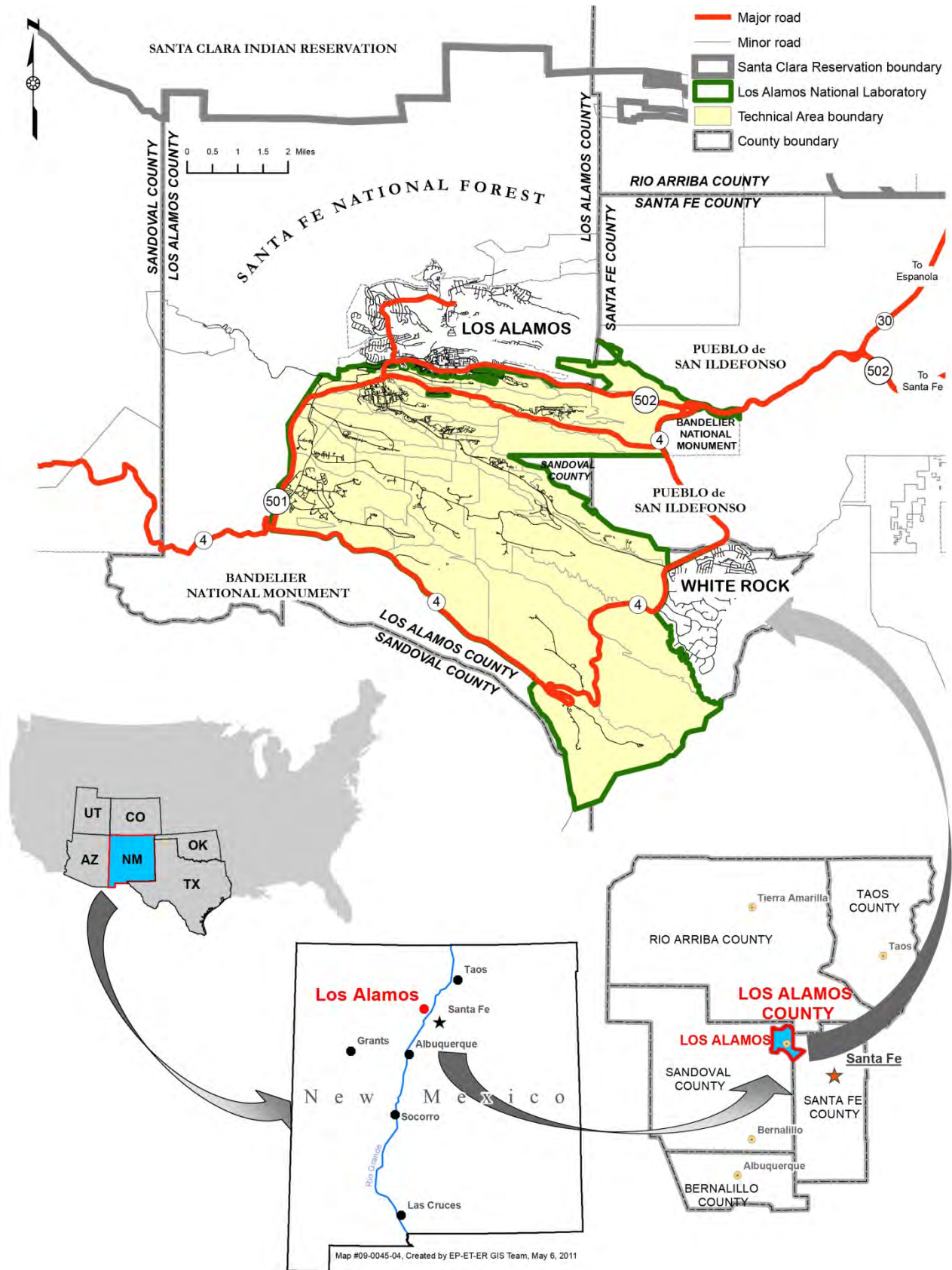


Figure 1-1 Regional location of Los Alamos National Laboratory

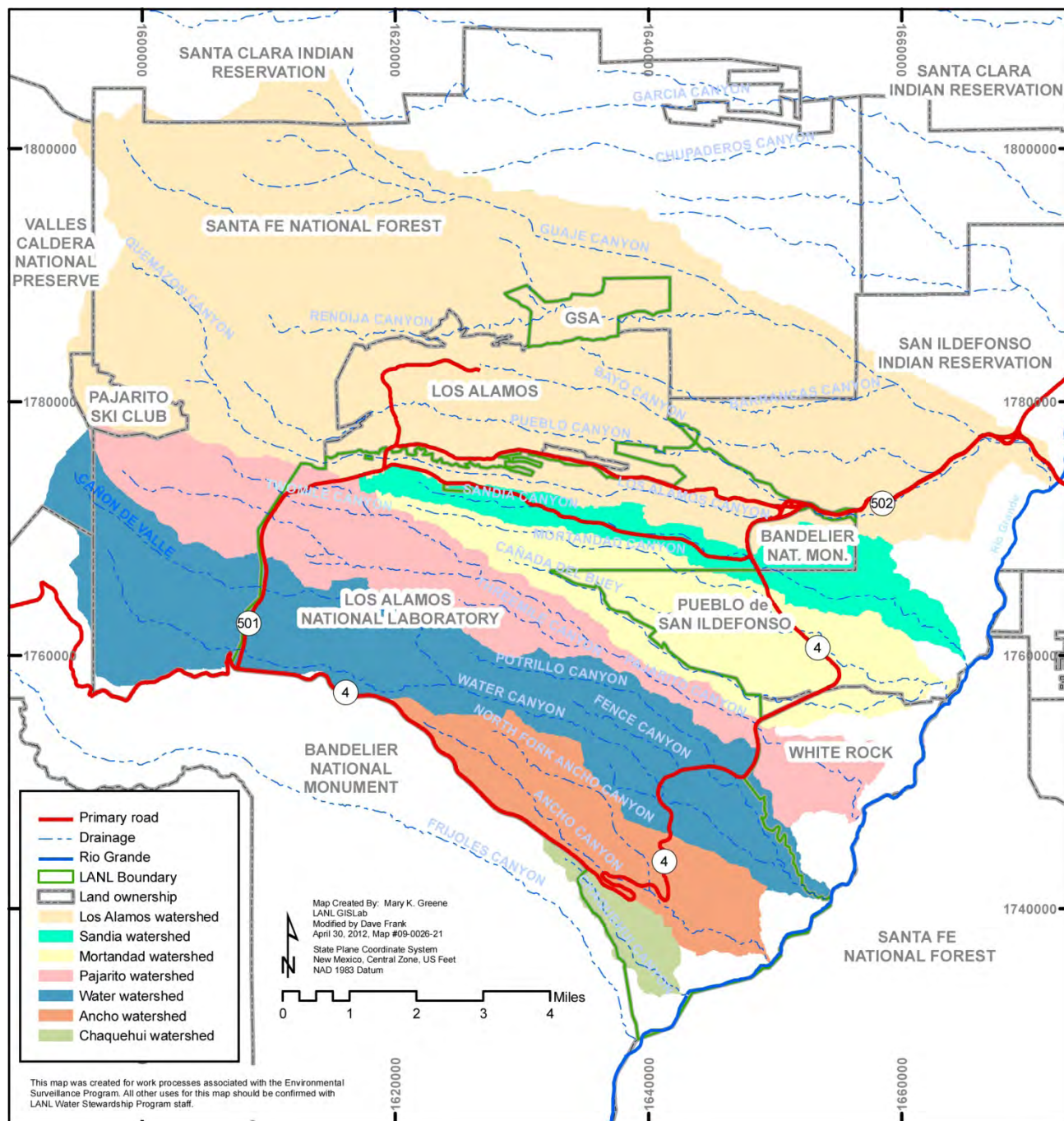


Figure 1-2 Primary watersheds at Los Alamos National Laboratory

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) intermediate perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is in artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande and under phreatic conditions beneath most of the Pajarito Plateau (Purtymun and Johansen 1974). The source of most recharge to the regional aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. A secondary source is localized infiltration in canyons on the Pajarito Plateau (Birdsell et al. 2005). The upper portion of the regional aquifer beneath the Laboratory discharges into the Rio Grande through springs in White Rock Canyon.

3. Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is partly because of the dramatic 5,000-foot elevation gradient from the Rio Grande on the east of the plateau up to the Jemez Mountains 12 miles (20 kilometers) to the west and partly because of the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper (*Juniperus monosperma* Engelm. Sarg.)-savanna community is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons at elevations between 5,600 and 6,200 feet. The piñon (*Pinus edulis* Engelm.)-juniper cover type, generally between 6,200 to 6,900 feet in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (*Pinus ponderosa* P. and C. Lawson) communities are found in the western portion of the plateau between 6,900 and 7,500 feet in elevation. These three vegetation types predominate the plateau, each occupying roughly one-third of the Laboratory site. The mixed conifer cover type, at an elevation of 7,500 to 9,500 feet, overlaps the Ponderosa pine community in the deeper canyons and on north-facing slopes and extends from the higher mesas onto the slopes of the Jemez Mountains. The spruce (*Picea* spp.)-fir (*Abies* spp.) cover type is at higher elevations of 9,500 to 10,500 feet. Several wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

In May 2000, the Cerro Grande Fire burned more than 43,000 acres of forest in and around LANL. Most of the habitat damage occurred on US Forest Service property to the west and north of LANL. Approximately 7,684 acres, or 28% of the vegetation at LANL, was burned to varying degrees by the fire. However, few areas on LANL property were burned severely.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 through 2003 resulted directly and indirectly in the mortality of many trees. Between 2002 and 2005, more than 90% of the piñon trees greater than 10 feet tall died in the Los Alamos area. Lower levels of mortality also occurred in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations experienced widespread mortality.

Tree mortality has leveled off since 2005, as much through lack of live trees as an improvement in forest health (LANL 2010). Understory plant species have thrived during the wetter years but show a neutral or negative response during dry years. It is unlikely that there will be an appreciable increase in tree species until current climate trends improve (Munson et al. 2011).

In June of 2011, the Las Conchas Fire and related back burns burned approximately 133 acres (52 hectares) of LANL/DOE/National Nuclear Security Administration (NNSA) property. Approximately 131 acres were intentionally back burned to help limit the spread of the wild fire, a small spot fire in Technical Area 49 (TA-49) burned about one acre, and a small wildlife-related fire burned another acre. As preparation for limiting fire spreading onto LANL property, trees were thinned in the forest in Los Alamos, fuels were reduced, and defensible space was created in some areas of the Laboratory and DOE. All of this work was expedited during the Las Conchas Fire. Fuel reduction was conducted at TA-49, TA-54, TA-70, TA-71, Rendija Canyon, and along the LANL perimeter during the Las Conchas Fire to prevent/limit the spread of the fire onto Laboratory property. Mitigation actions included mastication, thinning, and the creation of firebreaks. All actions were reviewed for environmental impacts. No impacts to biological resources occurred as a result of LANL's mitigation activities. Following the fire, sites in the canyons were armored to protect from potential flooding. Flooding, erosion, and transport of debris, ash, and sediment became a significant issue at LANL. Post-fire flooding of roads and drainages created safety and environmental hazards. In response, LANL crews acted quickly and removed post-fire debris, ash, and sediment from culvert inlets and outlets along NM 501 and Anchor Ranch Road. Crews pumped accumulated ash-laden runoff out of the area, removed debris, and re-established the flow of the culvert under NM 501 at the Water Canyon drainage crossing. Blockage of storm water runoff and damming by debris also caused storm water to pond and ash to accumulate along NM 501. Ponding resulted from soil saturation, which then resulted in roadbed failure. In addition, the ice rink and other resources, such as wells and power poles, were armored with Jersey barriers and soil to protect from flooding. As a response to the actions during the fire, a biological assessment (LANL 2011a) and floodplain assessment (LANL 2011b) were prepared and submitted to regulatory agencies.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 88% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1,800 sites have been recorded. Nearly 73% of the resources are ancestral pueblo and date from the 13th, 14th, and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with more than 77% located between 5,800 and 7,100 feet. A majority (59%) of all cultural resources are found on mesa tops. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places, and more than 300 buildings have been evaluated to date. In addition, facilities considered of national historic significance, dating from 1963 to the end of the Cold War in 1990, are being evaluated.

a. The National Park Service National Historical Park Study and Los Alamos Properties

In 2004, congressional legislation directed the National Park Service to examine historical areas associated with the Manhattan Project and to make recommendations concerning the possibility of establishing a new national park (see Manhattan Project National Historical Park Study Act or Public Law 108-340). Potential Los Alamos park properties include buildings in the town of Los Alamos associated with the Manhattan Project but built as part of the Los Alamos Ranch School (circa 1921–1942). Six areas (nine individual properties in total) located at LANL are also part of the proposed park unit at Los Alamos. These include buildings and structures associated with the design and assembly of the “Gadget” (tested at Trinity Site), the “Little Boy” weapon (the gun-assembled device detonated over Hiroshima), and the “Fat Man” weapon (the implosion device detonated over Nagasaki), as well as two buildings that supported Laboratory work and an experimental plutonium recovery structure. Additional Manhattan Project-era properties at LANL that may be part of the proposed park include several under consideration for inclusion in the revised Los Alamos Scientific Laboratory National Historic Landmark District.

5. Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1,000-foot elevation change across the Laboratory site and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional snow storms. Spring is the windiest season. Summer is the rainy season, with occasional afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable (with a range of 23°F). On average, winter temperatures range from 30°F to 50°F during the daytime and from 15°F to 25°F during the nighttime. The Sangre de Cristo Mountains to the east of the Rio Grande valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. On average, summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime.

From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of frozen precipitation) was 18.97 inches, and the average annual snowfall amount was 58.7 inches (Note: By convention, full decades are used to calculate climate averages [WMO 1984].) The months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico is convectively and/or



orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the United States, is estimated at 15 strikes per square mile per year. Lightning is most commonly observed between May and September (about 97% of the local lightning activity).

The complex topography of the Pajarito Plateau influences local wind patterns. Often a distinct diurnal cycle of winds occurs. Daytime winds measured in the Los Alamos area are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande Valley. Nighttime winds (sunset to sunrise) on the Pajarito Plateau are lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope flow of cooled mountain air. Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, mainly because of the prevailing mid-latitude westerly winds.

C. LABORATORY ACTIVITIES AND FACILITIES

The Laboratory is divided into TAs used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-3 and Appendix C, Description of Technical Areas and their Associated Programs). However, these uses account for only a small part of the total land area; much of the LANL land provides buffer areas for security and safety or is held in reserve for future use. The Laboratory has about 2,800 structures, with approximately 8.6 million square feet under roof, spread over an area of approximately 36 square miles.

DOE/NNSA issued a new Site-Wide Environmental Impact Statement (SWEIS) in May 2008 (DOE 2008a) and two Records of Decision in September 2008 (DOE 2008b) and June 2009 (DOE 2009). In the SWEIS, 15 Laboratory facilities are identified as “Key Facilities” for the purposes of facilitating a logical and comprehensive evaluation of the potential environmental impacts of LANL operations (Table 1-1). Operations in the Key Facilities represent the majority of environmental impacts associated with LANL operations.

The facilities identified as key are those that house activities critical to meeting work assignments given to LANL. These facilities also

- House operations that could potentially cause significant environmental impacts,
- Are of most interest or concern to the public based on scoping comments received, or
- Would be the facilities most subject to change as a result of programmatic decisions.

In the SWEIS, the remaining LANL facilities were identified as “Non-Key Facilities” because these facilities do not meet the above criteria. The Non-Key Facilities comprise all or the majority of 30 of LANL’s 49 TAs and approximately 14,224 acres of LANL’s 26,480 acres. The Non-Key Facilities also currently employ about 74% of the total LANL workforce (LANL 2010). The Non-Key Facilities include such important buildings and operations as the Nonproliferation and International Security Center; the new National Security Sciences Building, which is now the main administration building; and the TA-46 sewage treatment facility.

Table 1-1
Key Facilities*

Facility	Technical Areas
Plutonium complex	TA-55
Tritium facilities	TA-16
Chemistry and Metallurgy Research (CMR) building	TA-03
Sigma Complex	TA-03
Materials Science Laboratory (MSL)	TA-03
Target Fabrication Facility	TA-35
Machine shops	TA-03
Nicholas C. Metropolis Center for Modeling and Simulation	TA-03
High-explosives processing	TA-08, TA-09, TA-11, TA-16, TA-22, TA-37
High-explosives testing	TA-14, TA-15, TA-36, TA-39, TA-40
Los Alamos Neutron Science Center (LANSCE)	TA-53
Biosciences Facilities (formerly Health Research Laboratory)	TA-43, TA-03, TA-16, TA-35, TA-46
Radiochemistry Facility	TA-48
Radioactive Liquid Waste Treatment Facility (RLWTF)	TA-50
Solid radioactive and chemical waste facilities	TA-50, TA-54

*Data from 2008 SWEIS.

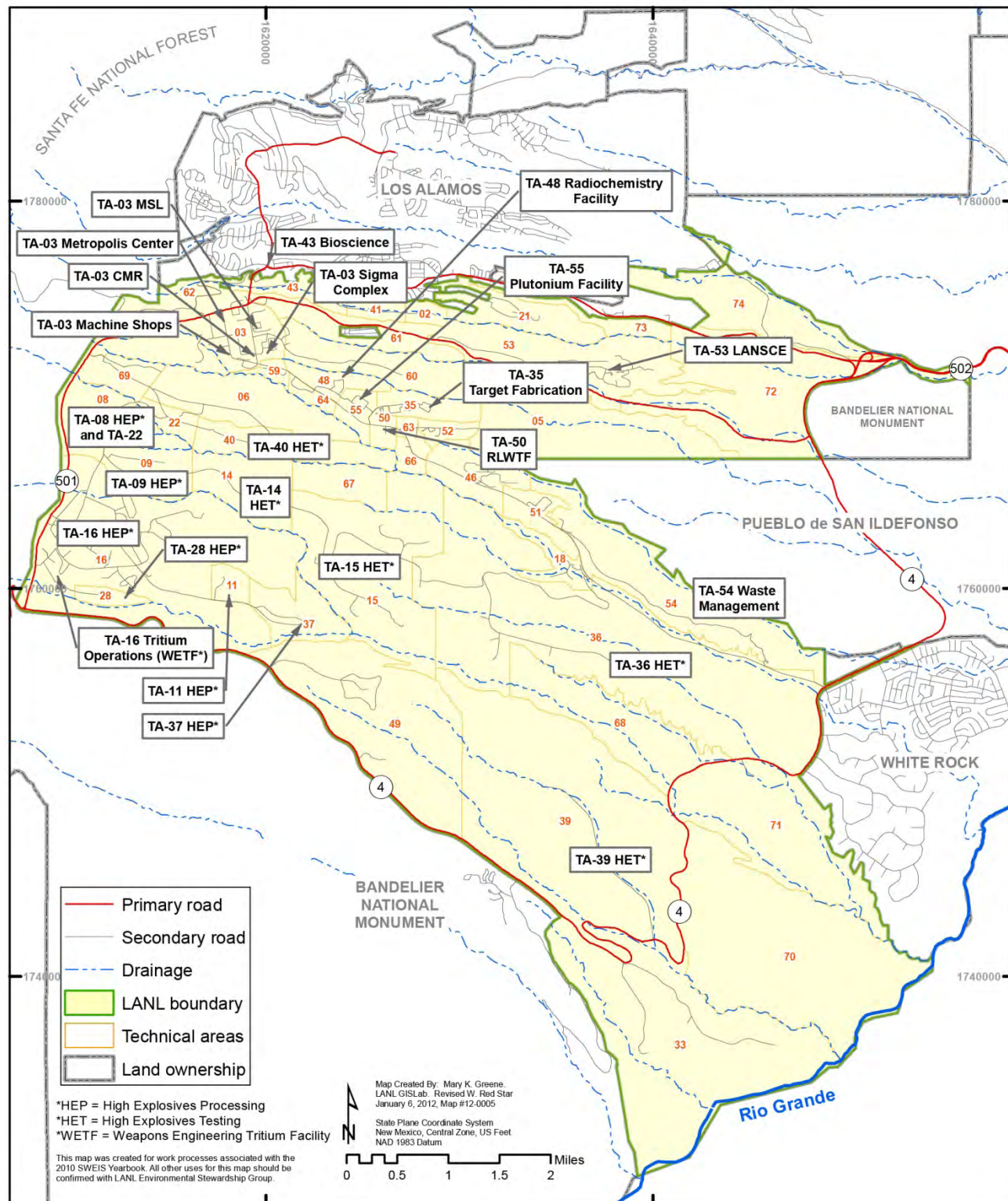


Figure 1-3 Technical areas and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Safety, environmental protection, and compliance with environmental, safety, and health laws and regulations are underlying values of all Laboratory work. The Laboratory uses Integrated Safety Management (ISM) to create a worker-based safety and environmental compliance culture in which all workers commit to safety, security, and environmental protection in their daily work. Each Laboratory organization is responsible for its own environmental management and performance. Line management provides leadership and ensures that performance is within the context of the Laboratory's values and mission. Laboratory managers establish and manage environmental initiatives, determine and communicate expectations, allocate resources, assess performance, and are held accountable for safety performance.

Environmental management system, compliance, surveillance, and waste management operational support are managed within the Associate Directorate for Environment, Safety and Health (ADESH). Environmental characterization, remediation, and waste management programs are part of the Associate Directorate for Environmental Programs. An organizational chart and description is available at <http://www.lanl.gov/organization/>. The major environmental programs and management system are described below.

1. Environmental Management System

LANL maintains an EMS that meets the DOE Order 436.1 requirement to have an EMS "...certified to or conforming to the International Organization for Standardization's (ISO) 14001:2004...." An EMS is a systematic method for assessing mission activities, managing controls, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. LANL pursued and initially achieved registration to the ISO 14001:2004 standard in April 2006 and successfully renewed this registration at three-year intervals in 2009 and 2012.

A key feature of the Laboratory EMS is a focus on integrating environmental management with existing procedures and systems wherever possible. This allows existing programs to support and participate in a systematic process for environmental performance improvement. ISM provides an important foundation for the five core elements of the EMS:

1. Policy and commitment
2. Planning
3. Implementation and operation
4. Checking and corrective action
5. Management review

More information about the EMS is available at <http://www.lanl.gov/environment/risk/ems.shtml>.

2. Waste Management Program

As part of the Laboratory's mission, the Laboratory generates

- Resource Conservation and Recovery Act-regulated non-radioactive hazardous waste;
- Toxic Substances Control Act-regulated waste (primarily polychlorinated biphenyl [PCB]-contaminated waste);
- Low-level radioactive waste (LLW), both solid and liquid;
- Mixed low-level waste;
- Transuranic waste;
- Mixed transuranic waste;
- Administratively controlled waste;

- Medical waste;
- New Mexico Special Waste; and
- Sanitary solid and liquid waste.

ADESH provides regulatory compliance support and technical assistance to waste generators to ensure compliance with state, federal, and DOE requirements.

LANL disposes of wastes on site and off site. LANL releases liquid effluents from the RLWTF and the Sanitary Wastewater Systems Plant into Mortandad and Sandia Canyons. Some LLW is disposed of on site at TA-54 Area G. Waste acceptance criteria have been developed for each of these facilities to ensure that all wastes disposed of on site meet state, federal, and DOE requirements. All other operational wastes, including the majority of LLW, are disposed of off site.

3. Pollution Prevention Program

The Pollution Prevention Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risks to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions.

"Sustainable acquisition" is mandated by an executive order and calls for considering environmental factors in purchasing decisions in addition to traditional factors such as performance, price, health, and safety.

4. Environmental Restoration Programs

The Laboratory is characterizing and remediating, as necessary, sites to ensure that chemicals and radionuclides in the environment associated with past operations do not pose a potential unacceptable risk or dose to human health or the environment. The corrective actions at the Laboratory are subject to the requirements of a Compliance Order on Consent (Consent Order). Certificates of Completion are granted to indicate corrective actions were complete with or without controls, meaning either (1) no further corrective actions are needed, but some type of institutional controls (e.g., land use) must be in place to maintain current conditions (with controls), or (2) no additional corrective actions or conditions are necessary (without controls).

The environmental restoration and cleanup work at LANL is organized into several projects that have responsibility for different aspects of environmental restoration:

- Corrective Actions Program (includes investigations and remediations in canyons)
- TA-21 Closure Project
- TA-54 Closure Project

Program accomplishments for calendar year 2011 are presented in Chapter 9, Environmental Restoration.

5. Compliance and Surveillance Programs

LANL's environmental compliance and surveillance programs identify possible environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. The Laboratory routinely collects samples of air particles and gases, water, soil, sediment, foodstuffs, and associated biota from approximately 1,800 locations (Table 1-2). Program results for each of these monitoring programs are presented in Chapters 4 through 9 of this report. The Laboratory also works with and assists neighboring communities and pueblos in performing environmental monitoring.

Table 1-2
Approximate Numbers of Environmental
Samples, Locations, and Analytes Collected in 2011

Sample Type or Media	No. of Locations	Frequency of Sampling ^a	No. of Analytes or Measurements
Ambient air	59	Biweekly	7,300 ^b
Stack monitoring	28	Weekly	22,000
Biota	22	Annually	2,290
Routine soil surveillance sampling	25	Annually	820
Sediment	128	Annually	23,000
Foodstuffs	19	Annually	16,750
Groundwater	215	Quarterly/semi-annually/annually	162,130
National Pollutant Discharge Elimination System outfalls	11	Weekly	2,680
Surface water base flow	13	Quarterly/semi-annually/annually	4,420
Surface water storm runoff	129	Following rains	37,450
Neutron radiation	47	Quarterly	190
Gamma radiation	98	Quarterly	390
Environmental restoration soil/rock investigation sampling	987	Annually	244,260
Subsurface vapor monitoring	85	Monthly/quarterly/annually	121,040
Totals	1,866		644,720

Note: Not all the data counted in the table above are reported in this document. Totals include duplicate samples but do not include additional samples and results from the extensive quality assurance/quality control program, which are normally 10% to 20% more but can be over 60% more, depending on the media.

^a Sampling frequency is location dependant, when more than one frequency is listed.

^b Does not include particulate (in air) measurements made by four Tapered Element Oscillating Microbalance instruments that calculate particulate concentrations every half hour.

All monitoring data collected at LANL is available through the Intellus New Mexico database. This tool was developed to provide public access to the same data that the New Mexico Environment Department (NMED) and LANL use in making remediation and other environmental management decisions.

The Laboratory is regulated under 27 separate environmental regulatory permits issued by NMED and the US Environmental Protection Agency. These permits govern air emissions, liquid effluents, waste generation/treatment/storage/disposal, and environmental restoration. The Laboratory's environmental compliance programs and results are presented in Chapter 2.

6. Las Conchas Fire

The Las Conchas wildfire started on June 26, 2011, in the Jemez Mountains, approximately 10 miles west of the Laboratory. The fire ultimately burned approximately 156,600 acres, making it the largest wildfire in New Mexico history at the time; the fire was not 100% contained until August 1, 2011. Figure 1-4 presents a map showing the extent of the Las Conchas Fire.

The Las Conchas Fire burned to the west, south, and northwest of the Laboratory but did not cross over NM 501 near the Laboratory's western boundary. A 1-acre spot fire in TA-49 next to NM 4 was quickly extinguished. The fire burned portions of three of the major watersheds that drain onto Laboratory property, including the Los Alamos Canyon, Pajarito Canyon, and Water Canyon/Cañon de Valle watersheds. Burning in the upper portions of these watersheds greatly increased the risk of flash floods and flood damage

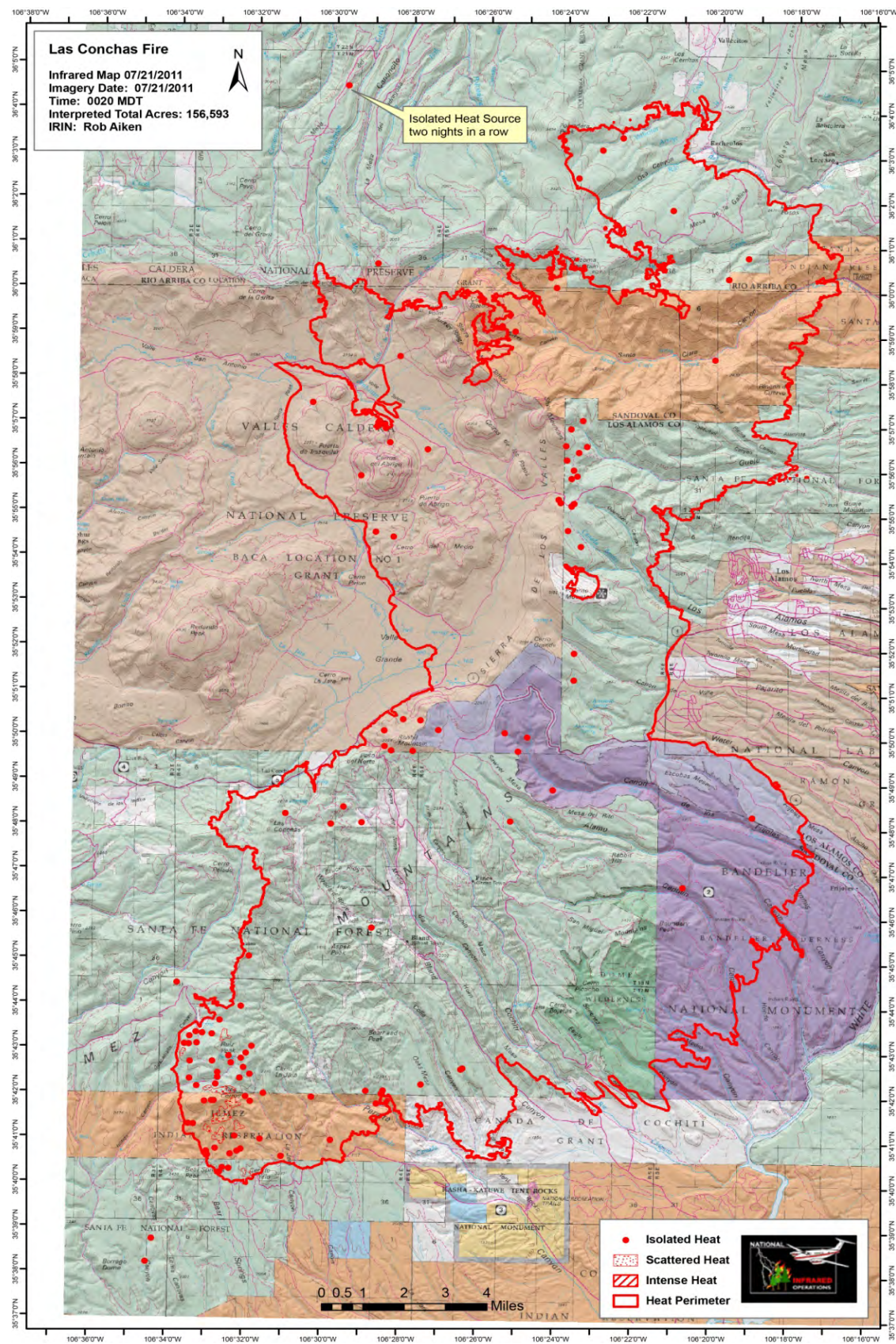


Figure 1-4 Extent of the Las Conchas Fire

in the downstream canyons. In response to this increased flood risk, the Laboratory implemented mitigation actions following the fire to lessen the potential for flood damage and to control the potential for mobilization of contamination. Although these efforts were effective in reducing the impacts of floods, several heavy rainfall events in August resulted in flooding significant enough to cause damage to Laboratory property. Flood mitigation, fire mitigation, and restoration activities were completed in the Los Alamos, Pajarito, and Water Canyon watersheds during and after the Las Conchas Fire.

The flood damage, as well as flood and fire mitigation activities associated with the Las Conchas Fire, are described in “Las Conchas Wildfire Effects and Mitigation Actions in Affected Canyons” (LANL 2011c) and in “Fiscal Year 2011 Actions Taken in Response to the Las Conchas Fire at Los Alamos National Laboratory, Los Alamos, New Mexico” (LANL 2012).

a. Flood Damage

Flooding associated with rainfall events in August 2011 damaged some components of the corrective measures implemented for surface-water and alluvial groundwater contamination associated with the 260 Outfall at TA-16. The floods specifically affected the permeable reactive barrier (PRB) and associated alluvial groundwater monitoring wells in Cañon de Valle.

Heavy rainfall events on August 21 and August 22, 2011, caused flooding that damaged or destroyed 10 gage stations in the affected watersheds. In addition, roads were damaged in Pajarito and Water Canyons, limiting access to several gage stations.

Several sediment control structures were constructed in Los Alamos and Pueblo Canyons as part of the work to mitigate contaminated sediment transport in Los Alamos and Pueblo Canyons. The grade-control structure in DP Canyon was slightly damaged by flooding from storms and has been repaired.

b. Flood Mitigation

A low-head weir was installed in Los Alamos Canyon near the downstream boundary of the Laboratory after the Cerro Grande Fire to collect sediment mobilized by floodwater. In anticipation of increased sediment load following the Las Conchas Fire, sediment was removed from the basins upstream of the weir to provide additional storage capacity. Approximately 1,200 cubic yards of sediment was removed and staged in Los Alamos Canyon in a borrow pit well above the active stream channel and floodplain. The staging area was lined with plastic before the sediment was emplaced, and the sediment pile was sprayed with tackifier to prevent wind or water erosion.

At the time of the fire, various investigation-derived wastes were being stored in Los Alamos, Pajarito, and Water Canyons and Cañon de Valle. These wastes were generated from investigation and remediation activities conducted in these canyons. To prevent possible damage to the waste containers caused by flooding or mobilization of wastes, the containers were removed from the canyons and transferred to a mesa-top storage area. Wastes removed from these canyons included more than 100 drums, 8 rolloff bins, and more than 13,000 gallons of purge and development water stored in 40 polyethylene tanks.

Two sediment retention basins were constructed in Los Alamos Canyon as part of the interim measure for Solid Waste Management Unit 01-001(f). These basins were constructed to capture sediment contaminated with PCBs. Because the retention basins are located in the canyon bottom, the berms that form the basins could potentially be damaged by flooding. To prevent possible transport of PCB-contaminated sediment, the sediment that had accumulated in the basins was removed. Approximately 25 cubic yards of sediment was excavated from the basins, placed into rolloff bins, and removed from the site for off-site disposal. In addition to removing the sediment, the retention basins were protected to reduce the potential for damage from flooding. Concrete Jersey barriers were placed on the canyon floor in a configuration that should divert flood water around the basins.

Actions were taken to protect groundwater monitoring wells located in Los Alamos Canyon from flooding. A major concern was to prevent floodwater and debris from entering the wells in the event the wells were overtopped by flooding. Casings of alluvial groundwater monitoring wells were sealed using expanding well plugs, if possible. If expanding plugs could not be used, the casings were sealed using inflatable plugs. Some

wells were equipped with Victaulic wellheads, which already have seals. For these wells, the seals were inspected and repaired, if necessary, to ensure they would seal. With several exceptions, if wells were equipped with transducers or pumps, these were removed before sealing. A total of 39 alluvial wells were sealed in this manner. Four intermediate and three regional groundwater monitoring wells in Los Alamos Canyon and two alluvial wells in Pajarito and Twomile Canyons were also sealed in a similar manner.

Wells located in canyons are also subject to potential physical damage from water and debris during flooding. To provide protection from such damage, concrete Jersey barriers were placed upstream of monitoring and water supply wells to divert floodwaters.

c. Fire Mitigation

Tree thinning and mastication was performed in Los Alamos Canyon to reduce the potential for fire spreading down canyon toward the Los Alamos townsite. Thinning was performed from the Los Alamos County ice rink west to the Laboratory boundary.

Potential fuels in Pajarito Canyon were removed from along each side of Pajarito Road in the vicinity of TA-54. Fuel reduction was accomplished by removing trees and by mowing to provide additional fire protection to TA-54. Fuel reduction was also performed beneath power lines near the western Laboratory boundary along the eastern side of NM 501.

Back burning was performed along the western boundary of the Laboratory to help prevent potential spreading of the Las Conchas Fire eastward onto Laboratory property. Back burning was performed along the western side of NM 501. In addition, fire-suppression activities on LANL property included creation of fire lines and the use of helicopter water and slurry drops.

d. Post-Fire Sampling

Sampling of numerous stormwater events following the Las Conchas Fire has been conducted within as well as outside of Laboratory boundaries. In addition, numerous locations where ash was deposited following stormwater runoff/flooding (primarily outside of Laboratory boundaries) have been sampled. The post-fire sampling is discussed in Chapter 6.

e. Wildlife and Habitat Impacts

Following the Las Conchas Fire, mitigations were put in place in the canyons to protect from potential flooding. As with the Cerro Grande Fire that occurred in May 2000, flooding, erosion, and transport of debris, ash, and sediment were significant issues for the canyon areas of the Laboratory. Post-fire flooding of roads and drainages created safety and environmental hazards. In response, LANL crews acted quickly and removed post-fire debris, ash, and sediment from culvert inlets and outlets along NM 501 and Anchor Ranch Road. Crews pumped accumulated ash-laden runoff out of the area, removed debris, and re-established the flow of the culvert under NM 501 at the Water Canyon drainage crossing. Blockage of storm water runoff and damming by debris also caused storm water to pond and ash to accumulate along NM 501. Ponding resulted from soil saturation, which then resulted in roadbed failure. In addition, the Los Alamos County ice rink and other resources in Los Alamos Canyon, such as wells and power poles, were armored with Jersey barriers and soil to protect from flooding.

Extensive tree thinning occurred in the canyon bottom of upper Los Alamos Canyon between the ice rink, which is on DOE land that is leased to Los Alamos County, and the upper boundary shared with Santa Fe National Forest. Numerous large conifer trees, greater than 9 inches in diameter at chest height, were cut down, along with much of the smaller undergrowth. Active wildfire and human-ignited back burns around LANL's immediate boundary impacted approximately 65 hectares of Mexican spotted owl (*Strix occidentalis*)-restricted foraging habitat, but no core or buffer nesting habitat was removed. Storm water runoff through several Mexican spotted owl areas of environmental interest occurred as well but was not large enough to permanently remove any habitat. During the first eight days of the Las Conchas Fire (June 26 to July 3, 2011), 38% of the active nests for the LANL avian nest box monitoring network contained western bluebird (*Sialia mexicana*) nestlings; although the fire burned around trees with nest boxes, none burned. As a

result of the Las Conchas Fire, a biological assessment (LANL 2011a) and floodplain assessment (LANL 2011b) were prepared and submitted to regulatory agencies.

f. Other Impacts

Forty-one alluvial monitoring wells, four intermediate monitoring wells, and three regional monitoring wells in the Los Alamos Canyon and Pajarito Canyon watersheds were plugged to prevent damage during flooding. Because 21 of these wells have been temporarily plugged, they were not included in sampling activities conducted since the fire. Monitoring data for these 21 wells will not be included in periodic monitoring reports for monitoring events that occur while the wells are plugged.

The PRB in Cañon de Valle and several associated monitoring wells were damaged by flooding that occurred in August 2011. Continued operation of the barrier and associated groundwater monitoring is not possible.

Several gage stations have been repaired, but stream channels are continuing to shift, periodically isolating the gages from stormwater flow or burying sampling lines and stilling wells in sediment. These changing stream conditions are contributing to increased uncertainty in gage measurements and decreased likelihood of sample collection.

Flooding since the Las Conchas Fire has resulted in partial erosion and redistribution of sediment in Los Alamos, Pajarito, and Water Canyons and Cañon de Valle. As a result, the current distribution of contaminants in sediment in these canyons may be different from that reported in the investigation reports. Site visits, however, have found that sediment deposits with the highest measured concentrations of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) and barium in Cañon de Valle are still in place. Transport of some contaminated sediment is not expected to result in deposits with higher concentrations because of the mixing of sediment from different sources; therefore, the potential risk or dose associated with sediment contamination would not have increased.

7. 50-Year Environmental Stewardship Plan for Los Alamos National Laboratory

As reflected by the nearly 70-year history of LANL, the next 50 years will bring significant changes to the mission and operations of the Laboratory. Regardless of inevitable changes in mission and environmental requirements, the Laboratory is committed to operating the site sustainably. The intent of the “50-Year Environmental Stewardship Plan for Los Alamos National Laboratory” (the Plan) is fourfold:

- To clearly define Laboratory environmental policy and strategies to execute that policy
- To set objectives and targets for environmental stewardship and establish metrics to accurately monitor and measure environmental performance
- To integrate stewardship efforts across organizations and programs to ensure that the entire life-cycle of work at the Laboratory is designed and executed in a manner that is protective of human health and the environment
- To provide transparent and relevant communication on the Plan, the strategy, and the Laboratory’s performance to surrounding neighbors, regulators, and the public

The Plan looks at a 50-year time frame to consider the nature of environmental stewardship after cleanup activities focused on the environmental legacy of the Manhattan Project and Cold War have been completed. For this initial Plan, environmental stewardship focuses on the cleanup or stabilization of legacy contamination, waste management, control of emissions from existing mission operations, and the development and implementation of approaches to site sustainability. Future plans will have additional scope and will depend on greater input from surrounding neighbors, regulators, and the public.

a. Vision, Goals, and Objectives

The Plan sets forth the following long-term goals and objectives, which will be achieved through integration of the Laboratory’s environmental and operational programs to provide a coordinated approach to environmental stewardship. Each goal is accompanied by a series of objectives and strategies that will enable successful attainment. Consistent with the Laboratory EMS, goals 1 and 2 focus on cleaning up waste from

past operations, goals 3 and 4 focus on controlling emissions from present operations, and goals 5 and 6 endeavor to create a sustainable future.

- Goal 1: Effectively manage and clean up legacy waste
- Goal 2: Ensure groundwater quality to protect drinking water
- Goal 3: Maintain excellent air quality
- Goal 4: Manage lands with confidence that human health and the environment are protected
- Goal 5: Minimize radioactive, hazardous, liquid, and solid waste
- Goal 6: Improve surface water quality and meet all New Mexico Water Quality Control Commission standards protecting surface waters for their designated uses

b. Policy

Environmental stewardship requires an active management system to provide a framework for setting environmental policy, planning, implementation, corrective actions, and management review. To manage these processes, the Laboratory uses an EMS that is compliant with DOE Order 436.1, Departmental Sustainability (DOE 2011b). The Laboratory has been certified to the ISO 14001:2004 standard for EMS since April 2006.

The first element of an ISO 14001 EMS is to define the institution's senior management commitment as expressed in a policy communicated to all workers and the public. The Laboratory's environmental policy is the following:

We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

c. Overarching Strategies

The Plan provides a set of long-term goals and supporting objectives for effective environmental stewardship at the Laboratory. Key strategies described in the Plan include the following:

- “Defenses-in-Depth”: This strategy is implemented through an extensive monitoring system coupled with a series of administrative and physical controls that restrict access and the movements of potential contaminants off site.
- Environmental ALARA: The Laboratory evaluates all new and modified operations that involve radioactive materials and ensures that impacts to human health are as low as reasonably achievable (ALARA). This concept will also be applied to environmental stewardship and sustainability.
- Off-site Disposal: The Laboratory will discontinue on-site disposal of wastes whenever possible. The intent is to not create any additional future remediation liabilities.
- Pollution Prevention: A Laboratory strategy is to prevent pollution whenever and wherever possible. This approach not only serves to protect the environment, it is a sound business strategy to improve mission processes and safety as well as to avoid significant waste management costs.
- Management Integration: An integrated schedule of projects is presented that, in support of the Plan's objectives and strategies, addresses legacy issues and current operations to achieve the future Laboratory goals of zero-waste strategies and environmental sustainability.

d. Communications and Decision Support

To provide the public with a comprehensive picture of the Laboratory's integrated environmental strategy and performance, the Laboratory will use multiple communication tools that provide information on our environmental protection actions and results and address the public's major concerns about past, present, and

future Laboratory operations. In addition, a decision-support application has been developed that provides spatial and analytical information to decision-makers to compare alternatives and to keep environmental impacts ALARA. The “50-Year Environmental Stewardship Plan for Los Alamos National Laboratory” was developed during 2011 and will be implemented in 2012.

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To Read About**Turn to Page**

<i>Introduction</i>	2-1
<i>DOE Orders and Executive Orders</i>	2-1
<i>Compliance Status</i>	2-8
<i>Unplanned Releases</i>	2-31
<i>References</i>	2-32

A. INTRODUCTION

Many operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain non-radioactive hazardous and/or radioactive materials. These operations, emissions, and effluents are regulated by US Department of Energy (DOE) orders and federal and state laws. DOE Orders require management systems for environmental protection, resource conservation and protection, and control of radionuclides. Federal and state environmental laws address (1) handling, transporting, releasing, and disposing of contaminants and wastes; (2) protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and (3) conducting environmental impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental quality. The US Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. Los Alamos National Security, LLC (LANS), operates LANL for the National Nuclear Security Administration (NNSA), an agency of DOE, and is a co-permittee, with DOE and/or NNSA on all EPA- or NMED-administered permits. This chapter provides a summary of LANL compliance and status with respect to DOE environmental requirements and state and federal environmental regulations.

B. DOE ORDERS AND EXECUTIVE ORDERS**1. DOE Order 231.1B, Environment, Safety, and Health Reporting**

DOE Order 231.1B, Environment, Safety, and Health Reporting, requires the timely collection and reporting of information on environmental issues that could adversely affect the health and safety of the public and the environment (DOE 2011). This Environmental Report fulfills DOE Order 231.1B requirements to publish an annual site environmental report. The objectives of this report are to

- Characterize site environmental management performance, including effluent releases, environmental monitoring, types and quantities of radioactive materials emitted, and radiological doses to the public;
- Summarize environmental occurrences and responses reported during the calendar year;
- Confirm compliance with environmental standards and requirements;
- Highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs; and
- Summarize property clearance activities.

The Laboratory began environmental monitoring in the 1940s and published the first comprehensive environmental monitoring report in 1970.

2. DOE Order 436.1, Departmental Sustainability

Issued in May 2011, DOE Order 436.1, Departmental Sustainability, replaced DOE Order 450.1A (Environmental Protection Program) and DOE Order 430.2B (Departmental Energy, Renewable Energy, and Transportation Management). DOE Order 436.1 requires all DOE sites to manage “sustainability within the DOE to (1) ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient, and reliable energy for the future, (2) institute wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions, and (3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan (SSPP) pursuant to applicable

laws, regulations and Executive Orders (EO), related performance scorecards, and sustainability initiatives. The order further states that these objectives must be accomplished within the framework of the site Environmental Management System (EMS), which must be compliant with International Standards Organization (ISO) 14001:2004.

LANL pursued and achieved registration to the ISO 14001:2004 standard in April 2006. In 2011, there was one routine surveillance external audit (in March 2011) and two internal assessments of the LANL EMS program. A three-year cycle recertification external audit was held early in 2012 with no major findings and a determination to extend LANL's 14001:2004 certification.

The LANL EMS promotes regulatory compliance and operations management for all of its environmental requirements and risks across a wide range of environmental areas, including air, water, waste, cultural resources, biota, and wildlife, to name a few. Institutional programs are in place for each of these environmental areas. In response to DOE Order 436.1, LANL also creates and manages an annual, fiscal-year based Site Sustainability Plan (SSP) to focus on energy and long-term sustainability milestones (see Section B2.b, below, for more detail). Also in 2011, at the request of the Los Alamos Site Office (LASO), LANL initiated development of a 50-Year Environmental Stewardship Plan to assist managers in identifying longer-term stewardship goals and initiatives.

In addition, multi-disciplinary teams from each LANL directorate annually identify the environmental impacts associated with their work scope, prioritize these risks, and develop an Environmental Action Plan to manage those risks. Combined, all of the above activities supported the Laboratory in meeting several milestones during fiscal year (FY) 2011 (October 2010 to September 2011) and calendar year (CY) 2011. LANL identified six high-level objectives to support our goal of establishing excellence in environmental stewardship during FY11. These objectives and our FY11 accomplishments associated with them are presented in Table 2-1. Many additional accomplishments are cited in the following sections in greater detail. The Laboratory maintained a high level of environmental compliance performance in FY11, completed a major environmental remediation project at Technical Area 21 (TA-21), and maintained a fully compliant EMS.

Table 2-1
FY11 Environmental Objectives and Accomplishments

Objective	Example Accomplishments
Improve environmental and safety performance through improved integration and communication at the work level.	LANL managers performed frequent Management Observation and Verification (MOV) walkarounds in employee workspaces. Managers documented the results in LANL's new MOV Module to share information with others in the organization.
Reduce cost and increase efficiency and operating capacity through systematic implementation of pollution prevention.	The Clean Fill Management database was established so that generators and users can efficiently transfer clean fill without costs related to disposal or procurement.
Reduce cost and increase efficiency and operating capacity through energy conservation and reductions in fuel, electricity, and water consumption.	As reported in LANL's SSPP, LANL reduced its energy intensity by 12.9% since FY03 and its fleet petroleum usage by 6.7% since FY10.
Enhance workplace environment, safety, and security through implementation of Laboratory-wide cleanout activities to disposition unneeded equipment, materials and chemicals, and waste.	In FY11, LANL disposed of more than 3,500 kilograms (kg) of unwanted chemicals during cleanouts.
Ensure operational capacity through implementation of the NPDES Outfall Reduction Program by 2012.	The EPA, which issues permits for industrial and sanitary wastewater discharges, approved the removal of four more outfalls from the Laboratory's permit. Only 11 outfalls remain.
Reduce long-term impacts, increase operational capacity, and ensure Laboratory sustainability through an integrated approach to site-wide planning and development.	The Sanitary Effluent Reclamation Facility (SERF) treats effluent from LANL's sanitary wastewater plant to be used in various cooling towers at LANL. The effluent is cleaned to higher standards than even drinking water, and less groundwater needs to be pumped to provide water for the cooling towers. Less wastewater is generated since it can be reused in the cooling towers.

a. Pollution Prevention Program

The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risks to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions.

P2 projects in FY11 yielded millions of dollars in cost avoidances to the Laboratory and allowed hundreds of hours of labor to be spent more productively. DOE gave the P2 Program an overall performance rating of "outstanding" for FY11. The rating system was established by DOE and is based on progress in six categories including hazardous waste generation, low-level waste (LLW) generation, mixed low-level waste (MLLW) generation, transuranic (TRU)/mixed (MTRU) waste generation, recycling percentage, and weight of sanitary trash generated per person. For 2011, LANL's goals were to generate less routine waste in each category than in 2010 and increase the percentage of recycling. In FY11, LANL generated less routine hazardous waste and MLLW waste than in FY10. In FY11, the amount of routine sanitary waste generated per person increased over FY10 levels, and the recycling percentage of solid waste dropped. The differences in routine waste generation and recycling percentage are shown in Table 2-2.

Table 2-2
Comparison of FY10 and FY11 Routine
Waste Generation and Recycling Percentage

FY10 LANL P2 Performance Index	FY10 Generation Baseline	FY11 Generation
Routine hazardous waste	15 metric tons	8.3 metric tons
Routine low-level waste	809 cubic meters	975 cubic meters
Routine mixed low-level waste	3.7 cubic meters	2.5 cubic meters
Routine sanitary waste	141 kg/person	142 kg/person
Recycling	58% of solid waste	50% of solid waste
Routine TRU/MTRU waste	38.2 cubic meters	82.1 cubic meters

Sustainable acquisition refers to the practice of purchasing items that contain recycled content. The EPA designated seven categories of products that are known to offer many items that contain recycled content. These categories include paper and paper products, vehicular products, construction products, transportation products, park and recreation products, landscaping products, and non-paper office products. DOE requires LANL to review new contract actions each year and to have a plan to "ensure 95% of new contract actions, including task and delivery orders under new contracts and existing contracts, require the supply or use of products and services that are energy efficient, water efficient, bio-based, environmentally preferable, non-ozone depleting, contain recycled content, or are non-toxic or less toxic alternatives."

b. Energy, Transportation, and Water Stewardship

The Laboratory's energy conservation, transportation, and water conservation activities are governed by DOE Order 436.1, Departmental Sustainability, and EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management, and EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance. These orders provide requirements for managing sustainability within the Laboratory to ensure operations incorporate energy, water, and GHG reduction strategies and commit to implementing an SSP. Site sustainability seeks to reduce consumption of natural resources so that LANL can expand and increase mission growth. An environmentally sustainable organization seeks to participate within its community and seeks to balance economy, society and environment within its operations.

The Laboratory's SSP identifies appropriate projects that will contribute to meeting the DOE's sustainability goals. Performance goals have been established for the Laboratory in these directives, including reductions in energy intensity, potable and industrial water use, GHG emissions, and waste generation. The Laboratory is dependent on the success of a number of projects, including the Energy Savings Performance Contract (ESPC), the SERF expansion, High Performance Sustainable Building (HPSB) implementation, communication and outreach in conjunction with metering efforts, building automation system night setback scheduling, and the associated footprint reduction efforts to achieve our energy, water, and GHG management goals.

The DOE required its subcontractors to publish SSPs as part of meeting the requirements set forth in its SSPP. The Laboratory published an FY12 SSP, and Table 2-3 shows the Laboratory's performance status toward meeting the sustainability goals.

Table 2-3
Sustainability Performance Status

DOE/NNSA Goal	Performance Status	Planned Actions & Contribution
28% Scope 1 and 2 GHG reduction by FY20 from an FY08 baseline.	The FY11 data (272,477.579 metric tons of carbon dioxide equivalent [MTCO ₂ e]) shows a 4.5% decrease from the FY08 baseline year (285,327.680 MTCO ₂ e) due to the inclusion of Renewable Energy Certificate (REC) purchases.	LANL will pursue REC purchases and explore renewable energy power purchase agreements.
30% energy intensity reduction by FY15 from an FY03 baseline.	Due to efforts in footprint reduction and energy conservation, LANL has reduced energy intensity by 15% (12.9% without the REC off-set).	LANL will continue to pursue HPSB implementation, lighting retrofits, heating, ventilation, and air conditioning (HVAC) recommissioning, building setback scheduling, outreach, and footprint reduction efforts.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015) where life cycle cost effective. The site may also report on potable water and chilled water as applicable.	LANL has installed electric meters to account for 91% electricity at the building level.	LANL estimates a 25% completion rate for steam and a 5% completion rate for gas by the end of FY12. LANL will focus on installing DOE-funded thermal meters in FY12 and needs to identify the meter installations necessary to meet the SSPP goals.
Cool roofs, unless uneconomical, for roof replacements unless project already has Critical Decision (CD)-2 approval. New roofs must have thermal resistance of at least R-30.	All new roofs meet cool roof requirements. In FY11, LANL replaced 53,027 square feet of roof space meeting the cool roof requirements.	LANL standards currently implement cool roof requirements and all new roofs currently meet this standard.
7.5% of annual electricity consumption from renewable sources by FY13 and thereafter (5% FY10–FY12).	LANL exceeded the 5% renewable energy goal. LANL purchased 45,571 RECs in FY11. The new annual request represents a 25% increase over previously contracted levels.	The landfill photovoltaic (PV) array will produce approximately 2,200 megawatt-hour (MWh) per year and the Abiquiu low flow turbine will produce approximately 7,000 MWh per year (18,400 MWh with double credit for on-site production). The Laboratory used approximately 421,000 MWh in FY10, and the estimated percentage for federal on-site renewable energy is 4.4% once the PV is operational. LANL will support NNSA to renegotiate the Los Alamos County (LAC) Electric Coordination Agreement to support further third party development of long-term renewable and carbon neutral energy on-site generation.
10% annual increase in fleet alternative fuel consumption by FY15 relative to an FY05 baseline.	LANL has increased alternative fuel consumption by 82%, using FY05 as a baseline.	LANL will continue to purchase and use alternative fuel for security force vehicles. In addition, LANL has purchased B5 biodiesel blend for use in equipment and plans to increase the percentage of biodiesel within the blend over time.

Table 2-3 (continued)

DOE/NSA Goal	Performance Status	Planned Actions & Contribution
2% annual reduction in fleet petroleum consumption by FY20 relative to an FY05 baseline.	LANL reduced fleet petroleum use by 6.7% from FY10. Overall, using FY05 as a baseline, LANL has reduced fleet petroleum use by 21%.	LANL will continue to right-size the fleet and expand alternative fuel use to reduce petroleum consumption.
75% of light duty vehicle purchases must consist of alternative fuel vehicles (AFV) by FY00 and thereafter.	LANL met this goal for FY11. Fleet management developed an FY09 policy that states all new vehicle leases must be AFVs.	LANL will continue to replace vehicles with AFVs.
Reduce fleet inventory by 35% within the next three years relative to an FY05 baseline	LANL fleet baseline is 1,570 vehicles and we currently have 1,550.	LANL will evaluate the path necessary to meet this goal.
13% Scope 3 GHG reduction by FY20 from an FY08 baseline.	Recent investigation revealed that employee commuting comprises the majority of LANL's Scope 3 GHG emissions.	LANL is exploring reduced commuting options in order to reduce GHG emissions and to increase work productivity and employee retention.
15% of existing buildings greater than 5,000 gross square feet (GSF) are compliant with the Guiding Principles (GPs) of HPSB by FY15.	Overall, LANL has implemented 38% of the HPSB GPs within 31 facilities.	LANL plans to achieve HPSB compliance by FY15 in 31 selected facilities.
All new construction, major renovations, and alterations of buildings greater than 5,000 GSF must comply with the GPs and where the work exceeds \$5 million, each are LEED® – NC Gold certified or equivalent.	Chemistry and Metallurgy Research Replacement Facility (CMRR)/Radiological Laboratory Utility Office Building (RLUOB) is anticipated to achieve at least LEED Silver as the first LANL facility to achieve LEED certification. Projects in design and conceptual design phases are incorporating LEED requirements.	LANL will continue to implement and manage efforts to address the requirement for achieving LEED Gold and the 35% improvement over the American Society of Heating, Refrigerating and Air Conditioning Engineers requirement for new projects using cost effective capital outlay strategies to achieve long-range operational benefits.
26% water intensity reduction by FY20 from an FY07 baseline.	In FY11, LANL's total water use was approximately 426 million gallons. Water intensity has increased by over 34% due to cooling towers supporting increasing supercomputing.	SERF Expansion will reuse 114 million gallons of water/year. In addition, DOE funded a site-wide water assessment.
20% water consumption reduction of industrial, landscaping, and agricultural (ILA) water by FY20 from an FY10 baseline.	LANL has written and implemented a Landscape Implementation Plan in order to decrease water used for landscape irrigation.	Currently, all of LANL's water use is potable water and is, therefore, considered part of the 26% water intensity reduction goal reporting.
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris, by FY15.	In FY11, LANL recycled or diverted 22% (455 of 2,063 metric tons) of non-hazardous solid waste, excluding construction and demolition waste.	LANL will continue to identify and implement opportunities for improvement in non-hazardous solid waste recycling/diversion in FY12–FY15.
Divert at least 50% of construction and demolition materials and debris by FY15.	In FY11, LANL recycled or diverted 84% (2,029 of 2,410 metric tons) of reported construction and demolition (C&D) waste. In FY11, LANL initiated a Six Sigma Project to improve the accuracy and completeness of C&D waste data.	LANL will complete the C&D Waste Six Sigma Project in FY12 and will implement improvement initiatives in FY13–FY15.
Procurements meet sustainability requirements and include sustainable acquisition clause (95% each year).	LANL published its sustainable acquisition plan that includes creation of a sustainable acquisition policy and a number of deliverables, including ones that address the inclusion of sustainable acquisition provisions or clauses in all new procurements.	LANL will develop a plan to address identified gaps in sustainable acquisition reporting capability, enter appropriate budget requests and an implementation schedule for the plan, and develop/assemble an information technology (IT)-related work package.
All data centers are metered to measure a monthly Power Utilization Effectiveness (PUE) (100% by FY15)	An Environmental and Power Monitoring System is in place at the Strategic Computing Complex (SCC) and measures PUE on a real-time basis.	LANL will install an Environmental and Power Monitoring System at the LDCC, and LANL will also be able to measure environmental conditions and power in real-time. This system will enable LANL to continually trend power and temperature measurements and systematically optimize efficiencies in the data centers.

Table 2-3 (continued)

DOE/NNSA Goal	Performance Status	Planned Actions & Contribution
Maximum annual weighted average PUE of 1.4 by FY15	The PUE at the SCC is currently averaging 1.35, and this number can be improved. The PUE at the Laboratory Data Communications Center (LDCC) is averaging at 1.65.	LANL will continue efforts to reduce this average to 1.4 or below by FY15. LANL will continue to use the Environmental Monitoring Systems at both the SCC and the LDCC to achieve this goal.
Electronic Stewardship - 100% of eligible PCs, laptops, and monitors with power management actively implemented and in use by FY12	LANL is currently piloting the central management of Windows desktops and laptops using SCCM, but does not expect to meet the FY12 goal.	LANL has a goal of 100% of eligible PCs, laptops, and monitors with power management actively implemented and in use by FY15.

3. DOE Order 5400.5 and 458.1, Radiation Protection of the Public and the Environment

During 2011, the Laboratory operated under DOE Order 5400.5, Radiation Protection of the Public and the Environment. During 2012, the Laboratory will implement its replacement, DOE Order 458.1. Both of these orders establish the requirements to protect the public and the environment against undue risk from radiation associated with activities conducted by DOE facilities. Protections include the all-pathway public dose limit of 100 mrem, requirements for clearance of real and personal property, as low as reasonably achievable (ALARA) public exposure requirements, requirements for environmental monitoring, and all-pathway dose limits for the protection of biota.

The Laboratory was in compliance with DOE Order 5400.5 during 2011. Public and biota dose assessments, ALARA assessments, and the clearance of real and personal property are presented in Chapter 3, Radiological and Non-Radiological Dose Assessment.

4. DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of radioactive wastes: LLW, MLLW, TRU waste, and MTRU waste. (Waste definitions are provided in the glossary.) MLLW is LLW that also contains a hazardous (Resource Conservation and Recovery Act [RCRA]-regulated) component, and mixed TRU waste is TRU waste with a hazardous component. Only LLW is disposed at LANL; all other radioactive wastes are shipped off-site for final treatment, if required, and disposal. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1-1 and DOE Manual 435.1-1. The hazardous component of MLLW and mixed TRU wastes is also regulated under RCRA and the LANL Hazardous Waste Facility Permit.

a. Institutional Requirements

All LANL operations that generate, store, treat, or dispose radioactive waste must have a DOE/LASO-approved Radioactive Waste Management Basis (RWMB). DOE/LASO approved the most recent RWMB on February 29, 2012, for continued facility operations. The RWMB identifies the physical and administrative controls to ensure the protection of workers, the public, and the environment. The RWMB documents that generated wastes (a) will meet the acceptance requirements for a disposal facility, (b) will meet LANL on-site storage requirements, and (c) can be transported to a disposal facility. Registration, facility self-inspections, and surveillance of radioactive staging and storage areas ensure LANL radioactive waste management practices are consistent with the requirements in DOE Order/Manual 435.1.

During FY11, eight Laboratory Facility Operation Directorates (FODs) were approved to generate, treat, or dispose of radioactive waste. During FY11, 272 internal inspections were conducted at LANL generation, storage, treatment, and disposal facilities. Six findings were identified; corrective actions were implemented and closed out. DOE/LASO participates as an observer on internal inspections to monitor continued compliance with the RWMB.

b. Low-Level Waste

The Laboratory disposes LLW off-site at the Nevada Nuclear Security Site (NNSS), at a commercial site located near Clive, Utah, and on-site at TA-54, Area G. In order to dispose of LLW at Area G, DOE Order 435.1 requires the Laboratory to have an approved operational Closure Plan and Performance Assessment/Composite Analysis (PA/CA). The Closure Plan demonstrates the Laboratory's plan for decommissioning LLW disposal operations at TA-54, Area G. The TA-54, Area G, Performance Assessment demonstrates that a reasonable expectation exists that the potential doses to representative future members of the public and potential releases from the facility will not exceed performance objectives established in DOE Order 435.1 during a 1,000-year period after closure. The TA-54 Area G Composite Analysis accounts for all sources of radioactive material that are planned to remain on site at LANL that may interact with the LLW disposal facility, contributing to the dose projected to a hypothetical member of the public from Area G. As with the Area G PA, the CA demonstrates a reasonable expectation of compliance with DOE Order 435.1 performance objectives. The status of Laboratory documents demonstrating DOE approval to dispose of LLW at TA-54, Area G is presented in Table 2-4. The Laboratory received authorization from DOE for continued operations from DOE on March 17, 2010.

Table 2-4
DOE Approval to Dispose of LLW at TA-54, Area G

DOE Order 435.1 Requirement	LANL Document	LANL or DOE Approval
Closure Plan	Closure Plan for Los Alamos National Laboratory Technical Area 54, Area G, LA-UR-09-02012	LANL approval March 2009
PA/CA	Performance Assessment and Composite Analysis for Los Alamos National Laboratory Technical Area 54, Area G, LA-UR-08-06764	DOE approval; September 15, 2009, via letter from Thad T. Konopnicki (DOE/Headquarters [HQ]) to Donald L. Winchell (DOE/LASO)
PA/CA Maintenance Plan	Area G Performance Assessment and Composite Analysis Maintenance Program Plan, LA-UR-11-01522, March 2011	LANL approval March 2011
Authorization to Dispose of LLW at Area G	Disposal Authorization Statement for the Department of Energy Los Alamos National Laboratory Area G in Technical Area 54	Issued March 17, 2010, via letter from James J. McConnell and Randal S. Scott (DOE HQ) to Donald L. Winchell (DOE/LASO)

During FY11, LANL processed and disposed of approximately 37,000 m³ of LLW. This amount includes waste generated during routine operations and by campaigns, such as environmental restoration cleanups. During FY11, LLW generation continued at levels much higher than in previous years because of American Recovery and Reinvestment Act (ARRA) funded decontamination and decommissioning (D&D) of TA-21 buildings and excavation of waste from Material Disposal Area B at TA-21 (Figure 2-1). Approximately 38 percent of this LLW was buried at TA-54 Area G.

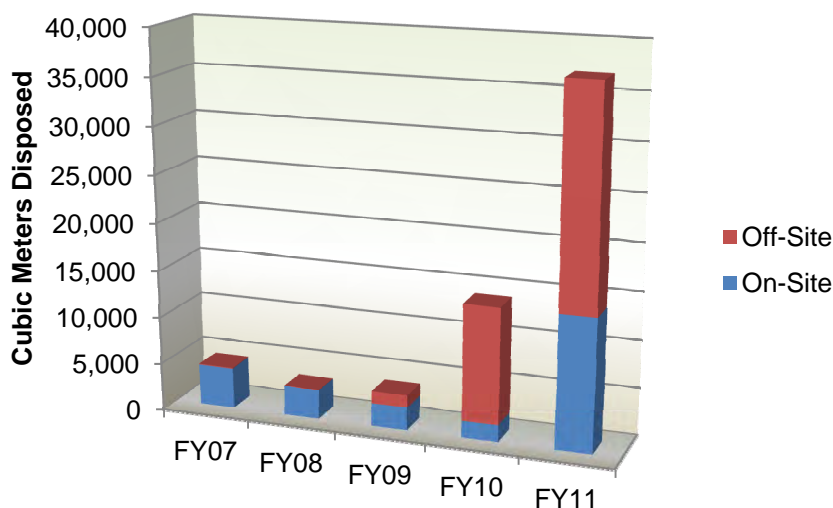


Figure 2-1 LANL LLW disposition

During FY11, LANL generated and processed approximately 98 cubic meters (m^3) of MLLW and shipped these wastes to approved disposal facilities at the NNSS and near Clive, Utah. LANL maintained compliance with all aspects of its RWMB during 2010.

The Laboratory is implementing a strategy to shift to off-site LLW disposal where feasible and cost-effective, but continues to dispose of some LLW at TA-54, Area G.

c. Transuranic Waste

The LANL TRU Program manages disposition of transuranic waste in storage and newly-generated transuranic waste to the Waste Isolation Pilot Plant (WIPP) located east of Carlsbad, New Mexico. The program also ensures appropriate facilities and equipment are available to prepare legacy and current TRU for disposal at WIPP. Figure 2-2 presents the cumulative inventory of TRU wastes that have been shipped from Los Alamos. Most of this TRU waste was shipped to WIPP, but some TRU waste was reclassified to MLLW after radioassay showed the waste does not meet the current definition of TRU waste and the waste was shipped to commercial treatment facilities and disposed at the NNSS. During FY11, 522 m^3 of TRU (including MTRU) were shipped to WIPP, and 99 m^3 of TRU reclassified to

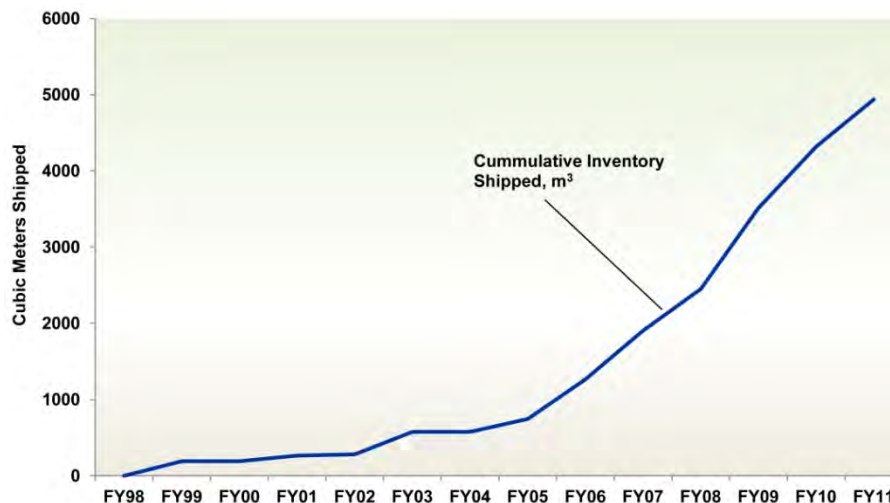


Figure 2-2 TRU waste shipping profile

MLLW were shipped. The DOE/NNSA and NMED

announced a Framework Agreement for Realignment of Environmental Priorities in early January 2012 that contains several important commitments for TRU waste at LANL. These commitments include (1) complete removal of all non-cemented aboveground TRU waste stored at Area G as of October 1, 2011 (defined as a total of 3,706 m^3 of waste material) by no later than June 30, 2014; (2) complete removal of all newly generated TRU received at Area G during FY12 and FY13 by no later than December 31, 2014; and (3) based on projected funding profiles, develop by December 31, 2012, a schedule with pacing milestones for disposition of the below-ground TRU requiring retrieval at Area G. DOE/NNSA also committed to complete removal of the aboveground cemented TRU in an efficient and effective manner protective of the health and safety of workers and the public.

C. COMPLIANCE STATUS

The EPA and NMED regulate Laboratory operations under various environmental statutes (e.g., Clean Air Act [CAA], Clean Water Act [CWA]) through operating permits, construction approvals, and the DOE/NMED Consent Order. These permits are designed by the regulatory agencies to allow Laboratory operations to be conducted while assuring that the public, air, land, soils, water, and biota are protected. The Laboratory's compliance performance is an assessment of our protection of the environment. Table 2-5 presents the environmental permits or approvals the Laboratory operated under in 2011 and the specific operations and/or sites affected. Table 2-6 lists the various environmental inspections and audits conducted at the Laboratory during 2011. The following sections summarize the Laboratory's regulatory compliance performance during 2011.

Table 2-5
Environmental Permits or Approvals under which the Laboratory Operated during 2011

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA ^a Permit	Hazardous Waste Facility Permit: Permitted hazardous waste storage units: TA-3, TA-50, TA-54, and TA-55	November 1989, renewed November 2010	December 2020	NMED ^b
	40 CFR 265 Standards: Interim Status hazardous waste storage and treatment facilities: TA-14, TA-16, TA-36, TA-39, and TA-54. Permit applications to be submitted to NMED.	Post-1980 hazardous waste units; Post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised April 20, 2012	September 20, 2015	NMED
CWA ^c /NPDES ^d	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA ^e
	MSGP ^f for the discharge of storm water from industrial activities	September 29, 2008	September 29, 2013	EPA
	NPDES Individual Permit for storm water discharges from Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs)	November 1, 2010	October 31, 2015	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	June 30, 2008	July 31, 2011 (proposed extension until January 31, 2012)	EPA
CWA Sections 404/401	COE ^g Nationwide Permits (five)	Not applicable	Not applicable	COE/NMED
Groundwater Discharge Permit, TA-46 SWWS ^h Plant	Discharge to groundwater	July 20, 1992; Renewed January 7, 1998; Renewal application submitted on July 2, 2010	January 7, 2003 ⁱ	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid Waste Treatment Facility	Discharge to groundwater	Application submitted August 20, 1996; Application resubmitted February 16, 2012	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Tank/Leachfield Systems	Discharge to groundwater	Application submitted April 27, 2006; Application resubmitted on June 25, 2010	Approval pending	NMED
Groundwater Discharge Plan, Land Application of Treated Groundwater From A Pumping Test At Well R-28	Discharge to groundwater	Submitted December 20, 2011	Approval Pending	NMED

Table 2-5 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC ^j)	LANL air emissions Renewal 1	August 7, 2009	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification 1, Revision 1	July 30, 2004		
	Permit modification 1, Revision 2	March 5, 2009		
	1600-kilowatt (kW) generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two 20-kW generators and one 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	CMRR, RLUOB	September 16, 2005	None	NMED
Air Quality (Beryllium NESHAP ^k)	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED

^a RCRA = Resource Conservation and Recovery Act.

^b NMED = New Mexico Environment Department.

^c CWA = Clean Water Act.

^d NPDES = National Pollutant Discharge Elimination System.

^e EPA = US Environmental Protection Agency.

^f MSGP = Multi-Sector General Permit.

^g COE = US Army Corps of Engineers.

^h SWWS = Sanitary Wastewater System (Plant).

ⁱ Permit was administratively continued through 2011.

^j NMAC = New Mexico Administrative Code.

^k NESHAP = National Emission Standards for Hazardous Air Pollutants.

Table 2-6
Environmental Inspections and Audits Conducted at the Laboratory during 2011

Date	Purpose	Performing Entity
3/8/11–3/10/11	Environmental Management System audit	Third Party Certifier
9/8/2011	TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) Groundwater Discharge Plan	NMED
9/27/11–9/28/11	Title V Operating Permit compliance inspection	NMED
9/7/11–9/21/11	Environmental Management System audit	Internal Assessment
8/23/11–8/25/11	Evaluation of Radionuclide NESHAP compliance program	Third Party Evaluator

1. Resource Conservation and Recovery Act

a. Introduction

As a research facility, the Laboratory produces a wide variety of hazardous wastes. Wastes are generated primarily from research and development (R&D) activities, processing and recovery operations, D&D projects, and environmental restoration activities. Most of these waste streams are in small quantities compared with industrial facilities of comparable size because of the relatively diverse activities and the many research projects at the Laboratory.

RCRA, as amended by Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and regulations found in the NMAC, Title 20, Chapter 4, Part 1, as revised.

The federal and state laws regulate management of hazardous wastes based on a combination of the facility's status, the quantities of waste generated, and the types of waste management conducted by the facility. Certain operations require a hazardous waste facility permit, often called a RCRA permit. The LANL hazardous waste facility permit was initially granted in 1989 for storage and treatment operations and was renewed in 2010.

b. RCRA Permitting Activities

The LANL Hazardous Waste Facility Permit was issued by NMED on November 30, 2010, and became effective December 30, 2010. The Permit, which regulates 22 container storage units, one storage tank system, and one stabilization unit, included new operating requirements for the units, as well as increased reporting and notification requirements to the New Mexico Environment Department - Hazardous Waste Bureau (NMED-HWB) and the public.

As part of fulfillment of permit notification requirements, on January 11, 2011, LANL provided confirmation to NMED-HWB that the contingency plan was distributed to all entities that have emergency memorandums of understanding or mutual assistance agreements with DOE/LASO. Additionally, in accordance with Permit Section 2.4.7(4) a notice of a resolved manifest discrepancy with WIPP was sent to NMED-HWB on April 7, 2011. Notification to NMED-HWB and a public notice about the establishment of an electronic information repository and the location of the physical repository for the LANL Hazardous Waste Facility Permit was transmitted in July 2011. The electronic version of the repository will be known as the Electronic Public Reading Room (EPRR) and the Hardcopy Public Reading Room (HPRR) is located at J. Robert Oppenheimer Study Center and Research Library, 4200 West Jemez Road at Casa Grande in Los Alamos. Training on use and access to documents within the Public Reading Rooms was conducted in October 2011; public notice was given via electronic mail, newspaper, and mailing.

As required by Permit Section 1.17, four quarterly and one annual demolition activity notifications were submitted to NMED-HWB. Responses to comments that arose during the NMED-HWB review of the notifications also occurred on three occasions. These reviews included requests for 30-day notification on

demolition activities for buildings, changing in format and descriptions within the notification table, and corrections of errors.

Reporting requirements associated with the Permit included the submittal of a summary of instances of noncompliance and releases during fiscal year 2011 and a report of waste minimization at LANL for fiscal year 2011 in November 2011. A Community Relations Plan was also established, published on the LANL environmental web page, and submitted to NMED-HWB after comments were solicited and incorporated from the public.

In July 2011, per Section 1.4.1 of the renewed LANL Hazardous Waste Permit, the Laboratory submitted documents associated with numerous interim status units to the NMED-HWB. The submittal of these documents occurred on July 18, 2011 after a two-week extension was granted by the NMED-HWB due the closure of the Laboratory during the Las Conchas Fire. The documents submitted to meet the requirements of Section 1.4.1 of the Permit included two closure plans, a request for alternative closure requirements, a request to review and approve a previously submitted closure certification report, and a permit modification request to add two units to the Permit. Closure plans were submitted for the TA-39 open detonation unit (TA-39-57) and the TA-14 open burning and open detonation units (TA-14-23). The closure plan and request for alternative closure requirements was submitted for the TA-54, Area G, Shafts 145 and 146 interim status container storage unit, and a request for review and approval of closure documentation for the TA-54, Area L Storage Shafts 36 and 37 Interim Status Container Storage Unit. Lastly, a Class 3 permit modification request was submitted to add two interim status open detonation treatment units to the LANL Hazardous Waste Facility Permit. An informational public pre-meeting was conducted prior to submittal of the permit modification request; and a public notice, public comment period, and an additional public information meeting commenced after the submittal of the permit modification request.

In March 2011, the Laboratory submitted a request for review and approval of 11 Class 1 permit modifications to the LANL Hazardous Waste Facility Permit. The modifications revised the emergency equipment lists, clarified permit conditions, and inspection activities, added and removed structures from permitted units, and revised figures and text associated with these clarifications, additions, and removals. A public notice was sent out via mailing in March 2011 and the proposed modifications were approved on June 3, 2011.

Two additional Class 1 permit modification packages were submitted in August 2011. One included changes associated with units at TA-3 and TA-55. The modifications revised the descriptions in Sections A.1 and A.5 in Attachment A, Section E.1 in Attachment E, and Section 2.0 in Attachment G.18. The other permit modification submitted included changes to Table D-1 within Attachment D (Contingency Plan) and Section F.1 within Attachment F (Personnel Training Plan). Public notice of these changes was sent out via mailing in August 2011, and both modifications were approved by NMED-HWB in October 2011.

On August 18, 2011, the Laboratory submitted a Class 2 permit modification request to add the Transuranic Waste Facility at TA-63 to the LANL Hazardous Waste Facility Permit. An informational public pre-meeting was held prior to the submittal of the modification request in June 2011, and a public notice, public comment period and an additional public information meeting were conducted after the submittal of the permit modification request. On October 24, 2011, NMED requested the modification be changed to a Class 3 Permit Modification and determined that all of the administrative requirements of the modification request were complete.

No hazardous waste management units at the Laboratory underwent full closure activities in 2011.

c. Other RCRA Activities

The compliance assurance program performed Laboratory self-assessments to determine whether hazardous waste and mixed waste are managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. The program communicated findings from these self-assessments to waste generators, waste-management coordinators, and waste managers who help line managers implement appropriate actions

to ensure continual improvement in LANL's hazardous waste program. In 2011, the Laboratory completed 1,414 self-assessments.

d. RCRA Compliance Inspections and Notices of Violation

From June 13, 2011, to June 16, 2011, NMED conducted a hazardous waste compliance inspection at the Laboratory. NMED noted one violation from this inspection. In August 2011, NMED-HWB issued LANS and DOE a Notice of Violation and Resolution identifying three counts on the single violation that was noted during the June 2011 inspection. A penalty was not assessed because it was determined that the violation was adequately addressed and no further action was required.

e. Site Treatment Plan

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to DOE and the University of California (UC), requiring compliance with the Site Treatment Plan (STP). On June 1, 2006, LANS replaced UC as the operating contractor at LANL, and LANS assumed responsibility for compliance with the order. The plan documents the use of off-site facilities for treating and disposing of mixed waste generated at LANL and stored for more than one year. In fiscal year 2011, the Laboratory shipped approximately 73 m³ of STP-covered MLLW and approximately 203 m³ of covered MTRU waste for treatment and disposal.

f. Compliance Order on Consent

The Compliance Order on Consent (Consent Order) is an enforcement document that prescribes the requirements for corrective action at the Laboratory. The purposes of the Consent Order are (1) to define the nature and extent of releases of contaminants at, or from, the facility; (2) to identify and evaluate, where needed, alternatives for corrective measures to remediate contaminants in the environment and prevent or mitigate the migration of contaminants at, or from, the facility; and (3) to implement such corrective measures. The Consent Order supersedes the corrective action requirements previously specified in Module VIII of the Laboratory's Hazardous Waste Facility Permit and applies to SWMUs and AOCs subject to RCRA and HSWA requirements, but not to sites that are regulated by DOE under the Atomic Energy Act, such as those containing or releasing radionuclides. The Consent Order does not apply to those SWMUs and AOCs that received "no further action" decisions from EPA when it had primary regulatory authority. A description of the Consent Order work done in 2011 is presented in Chapter 9 of this report.

In 2011, the Laboratory submitted 177 deliverables (plans and reports) required by the Consent Order on time to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report).

Figure 2-3 shows each aggregate area, as defined by the Consent Order, and indicates the status of LANL investigation activities in these aggregate areas as (1) complete, (2) in progress, or (3) pending. For those aggregate areas presented as complete in Figure 2-3, all investigation activities have been completed, and no additional field sampling campaigns, investigation reports, or corrective measures activities are anticipated. Aggregate areas listed as in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, or investigation reports are being prepared or finalized. Aggregate areas listed as pending include sites or areas where work plan preparation and field sampling campaigns have not yet started. As of December 2011, scheduled investigation activities are complete at six aggregate areas, in progress at 21 aggregate areas, and pending at two aggregate areas.

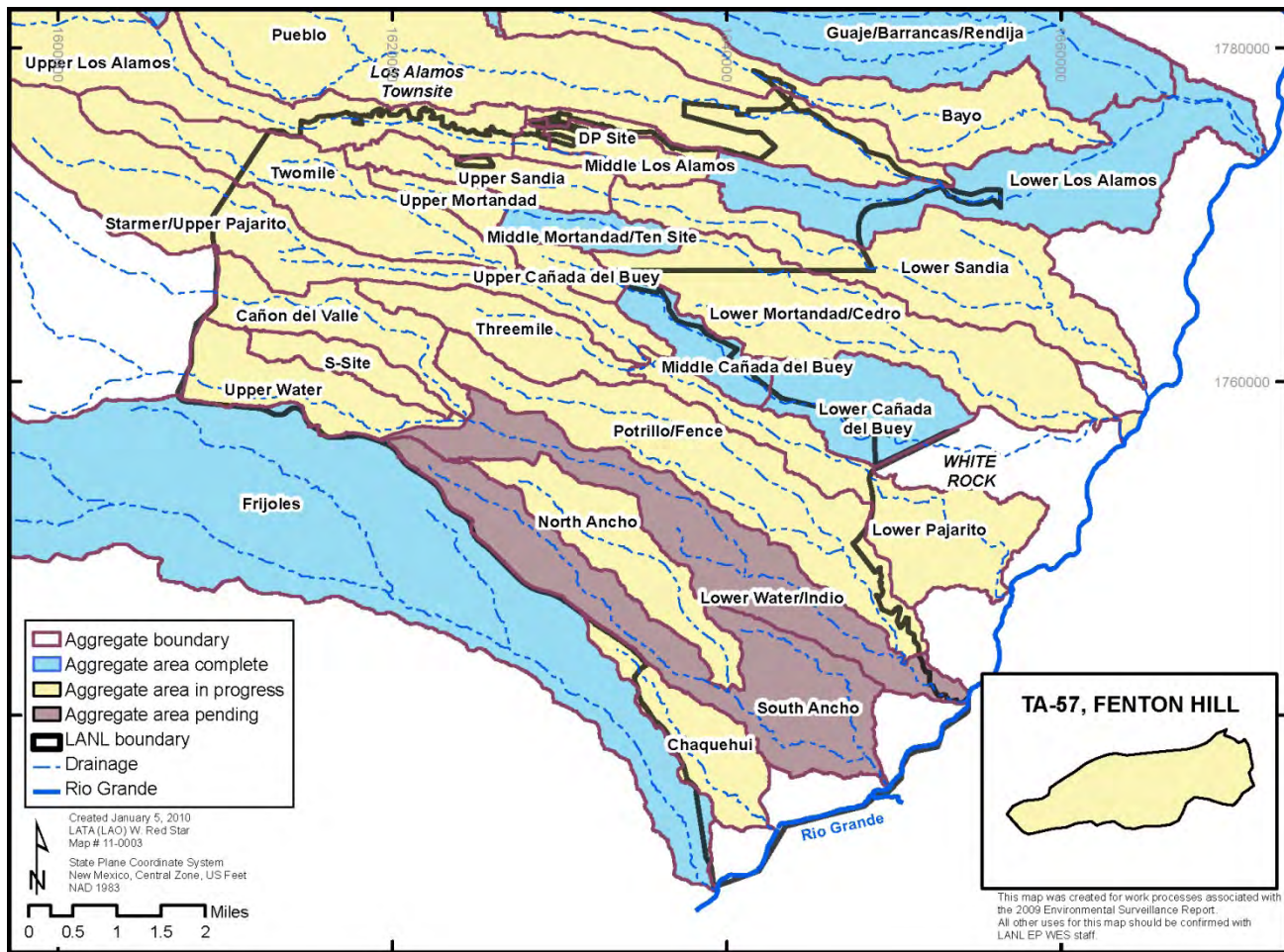


Figure 2-3 Aggregate areas as defined for the NMED Consent Order and their status. Status is shown as aggregate area activities complete, activities in progress, or activities pending.

g. Solid Waste Disposal

LANL sends sanitary solid waste (trash) and construction and demolition debris for transfer through the Los Alamos County Eco-Station on East Jemez Road. The DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County operates this transfer station and is responsible for obtaining all related permits for this activity from the state. The transfer station is registered with the NMED Solid Waste Bureau. Laboratory trash sent to the transfer station in 2011 included 1,596 metric tons of trash and 108 metric tons of construction and demolition debris. Through LANL's recycling efforts in 2011, 2,569 metric tons of material was recycled and did not go to a landfill.

h. Other RCRA Non-Compliances

In December 2011, a report that is required by Permit Section 1.9.14 of the LANL Hazardous Waste Facility Permit was submitted to NMED-HWB. The report listed instances of non-compliance with the Permit and any releases from or at a permitted unit that did not pose a threat to human health or the environment. From December 30, 2010, through September 30, 2011, there were no releases of hazardous waste or hazardous waste constituents from or at a permitted unit. The report detailed 12 instances of non-compliance that were recorded from the effective date of the permit through September 30, 2011. The instances of non-compliance included five occurrences that damaged/missing equipment or damaged structures were not mitigated within 24 hours, one case of multiple drums requiring relabeling, an occasion in which a required inspection was missed, one example of a drum that was not overpacked within 24 hours, one instance of storage of an ignitable waste container in a structure that did not have lightning protection, and two instances in which a required notification or distribution did not occur within the permit-required time frame. None of these

incidents resulted in any actual or potential hazards to the environment and human health outside the facility, and no material was lost or had to be recovered as a result of any of these incidents.

2. Toxic Substances Control Act

Given that the Laboratory's activities are focused on R&D rather than the manufacture of commercial chemicals, the Laboratory's main concerns under the Toxic Substances Control Act (TSCA) are the regulations covering polychlorinated biphenyls (PCBs) and the import/export of R&D chemical substances. The PCB regulations govern substances including, but not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills.

During 2011, the Laboratory shipped 148 containers of PCB waste off site for disposal or recycling. The quantities of waste disposed of included 2.4 lb (1.1 kg) of capacitors and 70,902 lb (32,155 kg) of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 Code of Federal Regulations (CFR) 761 manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and treatment facilities. Light ballasts go off-site for recycling. The primary compliance document related to 40 CFR 761.180 is the annual PCB document log that the Laboratory maintains on file for possible inspection by EPA Region 6. The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2011, EPA did not perform a PCB site inspection. Approximately five TSCA reviews were conducted on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

3. Comprehensive Environmental Response, Compensation, and Liability Act

a. Land Transfer

No new land transfer activities took place during 2011. Land transfers and conveyances have been put on hold until DOE and LANS implement DOE Order 458.1, Radiation Protection of the Public and the Environment.

b. Natural Resource Damage Assessment

Under a memorandum of agreement established in 2008, the DOE and several other federal, state, and tribal entities in the region continued to work towards completing a natural resources damages assessment (NRDA) for LANL. Participating entities include the DOE, the Department of Interior, the Department of Agriculture, the State of New Mexico, and the Pueblo de San Ildefonso, Santa Clara Pueblo, and Jemez Pueblo (collectively known as the Trustee Council).

The Trustee Council assesses injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances from LANL. The final objective of the NRDA process is to restore, rehabilitate, or replace services provided by injured natural resources.

The LANL Natural Resource Trustee Council released a pre-assessment screen in January 2010. In September 2010, the DOE completed procurement of an NRDA contractor to support Trustee Council development of an assessment plan for a full-scale assessment. Completion of the assessment plan is anticipated in 2012.

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

a. Emergency Planning Notification

The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management. Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees (1) if any changes at the Laboratory might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2011.

b. Emergency Release Notification

Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment if these chemicals exceed specified reporting quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2011.

c. Material Safety Data Sheet/Chemical Inventory Reporting

Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals above specified thresholds present at the facility. The inventory includes hazard information and the storage location for each chemical. The Laboratory submitted a report to the State Emergency Response Commission and the Los Alamos County Fire and Police Departments listing 28 chemicals and explosives at the Laboratory stored on site in quantities that exceeded reporting threshold limits during 2011.

d. Toxic Release Inventory Reporting

Executive Order 13423 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases to the environment of listed toxic chemicals that exceed activity thresholds. LANL operations exceeded the threshold for use of lead in 2011 and, therefore, was required to report the uses and releases of this chemical. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-7 summarizes the reported releases in 2011.

Table 2-7
Summary of 2011
Reported Releases under EPCRA Section 313

Reported Release	Lead (lb)
Air Emissions	5.51
Water Discharges	0.39
On-Site Land Disposal	5,706
Off-Site Waste Transfers	5,775

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides and protection of workers who use these chemicals. Sections of this act that apply to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act. The New Mexico Pesticide Control Act applies to the licensing and certification of pesticide workers, record keeping, equipment inspection, as well as application, storage, and disposal of pesticides.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2011.

Table 2-8 shows the amounts of pesticides and herbicides the Laboratory used in 2011.

6. Clean Air Act

In 2010, a revision to the Title V Operating Permit was requested by LANL. The revision will incorporate conditions from NSR permit 2195-N, the construction permit for RLUOB, which is part of CMRR. The Operating Permit will be taking on a new NMED standardized format, so all sections within the permit will be revised. With the permit open for revision, NMED will also include the permit conditions from the recently revised New Source Review (NSR) Permit 2195B-M2, which is the permit for the TA-3 Power Plant and Combustion Turbine Generator. The revised permit is expected to become effective in 2012.

The Title V Operating Permit requires the Laboratory to submit an Annual Compliance Certification to NMED. As the name implies, the report is signed by Laboratory management certifying compliance with the Title V Operating Permit. As part of this report, any permit deviations are also included. In 2011, the Laboratory had five deviations from Operating Permit conditions. The deviations consisted of two with Asphalt Plant conditions and three with TA-33 1,600-kW generator conditions. The Asphalt Plant had two occasions during 2011 when deviations occurred regarding visible emissions of fugitive dust. The condition

Table 2-8
Herbicides and Pesticides Used at LANL in 2011

Herbicides	Amount
Velossa (5905-579)	142 gal.
Roundup Pro (Liquid)	36 oz.
Velpar L (Liquid)	12 gal.
Insecticides	Amount
Advion ANT Bait (Gel)	7 g
Maxforce Ant Bait (granular)	12.75 oz.
Maxforce Ant Bait Stations (Bait)	35.5
Maxforce Ant Bait (gel)	0.42 oz.
Suspend SC	4.56 oz.
Wasp Freeze	8 oz.
Water Treatment Chemicals	Amount (lb)
Houghton Purobrom (granular)	2,981
Garratt-Callahan 316-T	6.5
Sump Buddy	7
Repellant	Amount
Bird-X Bird Proof (Liquid)	10 oz.

(CH₄) for the 2010 calendar year. The amount of these two gases emitted during 2010 was approximately 60,460 metric tons of CO₂ equivalents from the combustion of fossil fuels. The 2011 emissions for these two gases were approximately 59,327 metric tons of CO₂ equivalents from the combustion of fossil fuels. The Laboratory also completed the first EPA required GHG emissions report in 2011, for emissions during calendar year 2010. The DOE has set aggressive goals to reduce GHG emissions; the data submitted in the annual emission reports will be used to track progress made towards these goals.

Under the Title V Operating Permit program, LANL is considered a major source of pollutants, based on the potential to emit NO_x, CO, and volatile organic compounds (VOCs). In 2011, the TA-3 power plant and boilers located across the Laboratory were the major contributors of NO_x, CO, and particulate matter (PM). However, LANL's highest emissions are still significantly lower than the permit limits, for example NO_x emissions contributed to approximately 22% of the permit limit, 17% for CO, and 0.4% for PM. R&D activities were responsible for most of the VOC and hazardous air pollutant emissions. Table 2-9 summarizes these data.

Table 2-9
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2011

Emission Units	Pollutants ^a (tons)					
	NO _x	SO _x	PM	CO	VOCs	HAPs
Asphalt Plant	0.03	0.003	0.02	1.17	0.005	0.005
TA-3 Power Plant (3 boilers)	13.0	0.32	1.8	9.0	1.2	0.42
TA-3 Power Plant (combustion turbine)	1.76	0.13	0.24	0.37	0.08	0.05
Regulated Boilers	6.7	0.0424	0.6	4.8	0.40	0.13
R&D Chemical Use	NA ^b	NA	NA	NA	6.4	2.6

where the deviations occurred requires that no visible dust emissions occur for greater than 2 minutes in a 10 minute period.

The three deviations from the TA-33 generator permit conditions were due to the operation of the unit outside of the hours listed in the permit. The unit operated outside of the permitted hours (7 a.m. to 5 p.m.) on three consecutive days to complete a project involving national security. In addition, the unit has a condition to not operate more than eight hours per day. On two of the three days when the national security project was being performed, the eight hour operation condition was exceeded. No excess emissions occurred as a result of these deviations or from any of the Laboratory permitted sources during 2011.

LANL met all required reporting deadlines during 2011.

In 2011, LANL provided the third annual GHG emissions report to NMED, as required by 20.2.87 NMAC. The 2011 report provided emissions of carbon dioxide (CO₂) and methane

Table 2-9 (Cont.)

Emission Units (cont.)	Pollutants ^a (tons)					
	NO _x	SO _x	PM	CO	VOCs	HAPs
Degreaser	NA	NA	NA	NA	0.011	0.011
Data Disintegrator	NA	NA	0.06	NA	NA	NA
Carpenter Shops	NA	NA	0.07	NA	NA	NA
Stationary Standby Generators ^c	6.2	0.18	0.30	1.45	0.25	0.002
Miscellaneous Small Boilers ^c	27.6	0.17	2.2	22.3	1.55	0.53
TA-33 Generators (4 units)	4.95	0.74	0.17	4.03	0.09	< 0.001
TOTAL	60.24	1.589	5.46	43.12	9.986	3.618

^a NO_x = Nitrogen oxides; SO_x = Sulfur oxides; PM = Particulate matter; CO = Carbon monoxide; VOCs = Volatile organic compounds; HAPs = Hazardous air pollutants.

^b NA = Not applicable.

^c Emissions units in these categories are exempt from construction permitting and annual emission inventory reporting requirements and are not included in Figure 2-4.

LANL staff calculates air emissions using emission factors from source tests, manufacturer's data, and EPA documents. Calculated emissions are based on actual production rates, fuel usage, and/or material throughput. To satisfy requirements found in 20.2.73 NMAC, Notice of Intent and Emissions Inventory Requirements, and the Title V Operating Permit, LANL submits an annual Emissions Inventory Report and semi-annual Emissions Reports, respectively, to NMED. Figure 2-4 depicts a five-year history of criteria pollutant emissions. Emissions from 2007 through 2011 are very similar and remain relatively constant.

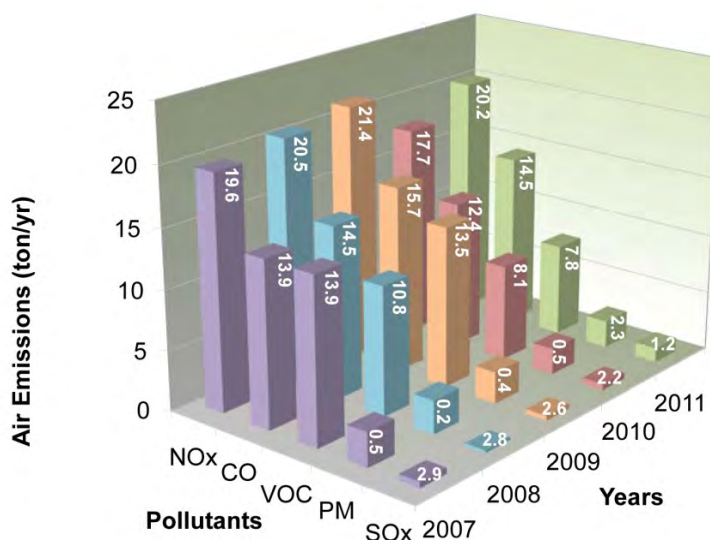


Figure 2-4 LANL criteria pollutant emissions from 2007 through 2011 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.

a. New Mexico Air Quality Control Act

i. Permits

LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to apply for construction permits or to submit notifications to NMED. In August 2009, NMED renewed and issued the Title V Operating Permit. During 2010, the Laboratory requested a Title V Operating Permit revision. The permit revision will include requirements from the CMRR-RLUOB NSR permit as well as conditions from the TA-3 Power Plant NSR permit, which was revised and issued in 2011. LANL submitted eight exemption notifications to NMED during 2011. The exemptions were for boilers, heaters, a cooling tower, an evaporator, and a small electrical generator. During 2011, LANL operated under the air permits listed in Table 2-5.

ii. Open Burning

LANL may perform open burning under 20.2.60 NMAC (Open Burning) or 20.2.65 NMAC (Smoke Management) to thin vegetation and reduce the threat of fire. LANL did not perform any open burning during 2011.

iii. *Asbestos*

The NESHAP for Asbestos requires that LANL provide advance notice to NMED for large renovation jobs that involve asbestos and for all demolition projects. The asbestos NESHAP further requires that all activities involving asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed of properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the asbestos NESHAP. In 2011, 29 large renovation and demolition projects were completed. NMED was provided advance notice on each of these projects. All waste was properly packaged and disposed of at approved landfills. To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly.

b. **Federal Clean Air Act**

i. *Ozone-Depleting Substances*

Title VI of the CAA contains specific sections that establish regulations and requirements for ozone-depleting substances (ODS), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting or otherwise releasing into the environment any refrigerant or refrigerant substitute during maintenance, repair, service, or disposal of halon fire-suppression systems and air conditioning or refrigeration equipment. All technicians who work on refrigerant systems must be EPA-certified and must use certified recovery equipment. The Laboratory is required to maintain records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants. The Laboratory's standards for refrigeration work are covered under Criterion 408, EPA Compliance for Refrigeration Equipment, of the LANL Operations and Maintenance Manual.

The Laboratory continued to work at eliminating the use of Class I and Class II ODS. Class I and Class II ODS are the refrigerants that have high ozone-depleting potentials. In 2011, the Laboratory removed approximately 210 lb of Class I ODS and 4,063 lb of Class II ODS from the active inventory.

ii. *Radionuclides*

Emissions of airborne radionuclides (other than radon) are regulated under the Radionuclide NESHAP. This rule limits to 10 mrem/yr the effective dose equivalent of airborne releases of radioactive material from a DOE facility, such as LANL, to any member of the public. The 2011 annual dose to the maximally exposed individual (MEI), as calculated using EPA-approved methods, was 3.53 mrem. The location of the highest dose was a business on DP Road. Emissions of radionuclides from the environmental remediation work at Materials Disposal Area B, as measured on environmental air monitoring stations, contributed the majority of off-site dose. See Chapter 4 for more information about these emissions.

7. **Clean Water Act**

a. **NPDES Industrial and Sanitary Point Source Outfall Self-Monitoring Program**

The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for NPDES permits for point-source effluent discharges to the nation's waters. The NPDES Industrial Point Source outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

LANS and DOE/NNSA are co-permittees of the NPDES permit covering Laboratory operations. EPA Region 6 in Dallas, Texas, issues and enforces the permit. NMED certifies the EPA-issued permit and performs some compliance-evaluation inspections and monitoring for the EPA. From January 1, 2010, through October 10, 2011, the Laboratory's point-source NPDES permit contained 15 permitted outfalls that include one sanitary outfall and 14 industrial outfalls. The EPA deleted four outfalls from the permit on October 11, 2011, bringing the total to 11 (Table 2-10). To facilitate full compliance with the requirements in the current permit, the Laboratory is planning to eliminate outfalls and to add additional treatment

technologies. The Laboratory's NPDES permit is available online at http://www.lanl.gov/environment/h2o/docs/NM0028355_NPDESPermitMod_070717.pdf. Outfalls listed on the current permit that did not discharge in CY11 include the following.

- *Outfall 02A129*: The TA-21 Steam Plant has not been used since 2007 and was deleted October 11, 2011.
- *Outfall 03A021*: Air washers at CMR that were engineered to operate without discharging in late 2007 were deleted October 11, 2011.
- *Outfall 03A130*: The TA-11 cooling tower has not discharged since January 2010 and was deleted October 11, 2011.
- *Outfall 03A185*: The DARHT cooling tower has not discharged since July 2010 and was deleted October 11, 2011.
- *Outfall 05A055*: The High Explosives Wastewater Treatment Facility (HEWTF) currently uses a thermal evaporator.
- *Outfall 051*: The RLWTF currently uses a thermal evaporator.

Table 2-10
Volume of Effluent Discharge from NPDES Permitted Outfalls in 2011

Outfall Number	TA-Bldg	Description	Watershed (Canyon)	2011 Discharge (gal.)
02A129	21-357	TA-21 Steam Plant (deleted October 11, 2011)	Los Alamos	0
03A048	53-963/978	LANSCE Cooling Tower	Los Alamos	22,867,400
051	50-1	TA-50 Radioactive Liquid Waste Treatment Facility	Mortandad	0
03A021	3-29	CMR Building Air Washers (deleted October 11, 2011)	Mortandad	0
03A022	3-2238	Sigma Cooling Tower	Mortandad	839,560
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	263,496
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	1,224,015
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	106,586,000
001	3-22	Power Plant (includes treated effluent from Outfall 13S)	Sandia	111,154,200
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	13,971,700
03A113	53-293/952	LANSCE Cooling Tower	Sandia	762,565
03A199	3-1837	Laboratory Data Communications Center	Sandia	12,974,800
03A130	11-30	TA-11 Cooling Tower (deleted October 11, 2011)	Water	0
03A185	15-312	DARHT Cooling Tower (deleted October 11, 2011)	Water	0
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
2011 Total:				164,057,736

The Laboratory's current NPDES outfall permit requires weekly, monthly, quarterly, and yearly sampling to demonstrate compliance with effluent quality limits. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2011, none of the 78 samples collected from the SWWS Plant's outfall exceeded effluent limits; however, seven of the 1,335 samples collected from industrial outfalls exceeded effluent limits (described below). Monitoring data obtained from sampling at NPDES permitted outfalls are in Supplemental Data Tables S2-1 and S2-2 available online at <http://www.intellusnmdata.com>.

The following is a summary of the corrective actions the Laboratory took during 2011 to address the NPDES outfall permit non-compliances cited above:

- *03A022 May 5, 2011 Copper = 50.5 µg/L:* Possible piping contamination from historical use. The outfall was tied in to the sanitary collection system on November 15, 2011.
- *03A022 July 14, 2011 Copper = 138 µg/L:* The float on the large interior basement sump has been reset to prevent overflow into the outfall pipe when the building cooling system calls for make-up water. The outfall was tied in to the sanitary collection system on November 15, 2011.
- *03A027 August 9, 2011 Total Residual Chlorine (TRC) = 0.19 mg/L:* The observed flow at Outfall 03A027 at the time of the exceedance was approximately 1 gpm. Upon investigation, this unexpected discharge (~1 gpm) was traced to a leaking valve on the fire suppression system for the inactive TA-3-285 cooling tower. A dechlorination mat was installed at the end of the outfall pipe at 4:45 p.m. on August 9, 2011, and will remain in place until the leaking valve can be repaired. The leaking valve was examined and tightened as much as possible. The leak is potable water. The fire suppression system continues to drip, so in the future, whenever the discharge from the SCC is diverted away from Outfall 03A027 because of the on-going line plug investigation, the dechlorination mat will be installed.
- *03A027 August 9, 2011 Total Residual Chlorine (TRC) = 0.19 mg/L:*
Original Report: The observed flow at Outfall 03A027 at the time of the exceedance was approximately 1 gallon per minute (gpm). The facility had diverted the normal effluent discharge (~ 20–30 gpm) from the SCC cooling tower to the sanitary collection system in order to examine the effluent discharge line for possible plugs. Upon investigation, this unexpected discharge (~1 gpm) was traced to a leaking valve on the fire suppression system for the inactive TA-3-285 cooling tower. A dechlorination mat was installed at the end of the outfall pipe at 4:45 p.m. on August 9, 2011, and will remain in place until the leaking valve can be repaired.
Update to Original Report: The leaking valve was examined and tightened as much as possible. The leak is potable water. The fire suppression system continues to drip. When the effluent from the SCC cooling tower is directed back to the outfall (~ 20–30 gpm), the dechlorination mat will be removed because there is sufficient dechlorination chemical in the effluent to neutralize the drip of potable water from the fire suppression system. There are plans to continue investigating the integrity of the line that will require diverting the normal effluent discharge (~ 20–30 gpm) from the SCC cooling tower to the sanitary collection system. Whenever the discharge from the SCC is diverted away from Outfall 03A027, the dechlorination mat will be installed to neutralize any chlorine coming from the continuous potable water drip (~1 gpm) from the fire suppression system.
- *03A199 August 31, 2011 TRC = 0.97 mg/L:* The cooling tower's water treatment system ran out of chlorine neutralizer. The facility was notified of the TRC exceedance at 11:16 a.m. The discharge was diverted to the sanitary collection system at 11:44 a.m. until more neutralizer was delivered to the facility. Chlorine neutralizer was delivered to the facility. Discharge to Outfall 03A199 was restored at approximately 12:50 p.m. on August 31, 2011.
- *001 September 8, 2011 E. Coli = > 2,420 cfu/100 mL:* The weekly compliance E. Coli result was > 2,420 cfu/100 mL from a sample collected September 8, 2011, at 1:54 p.m. This exceeds the daily maximum permit limit of 410 cfu/100 mL. Three E. Coli operational samples were collected from the old cooling tower basin (TA-3-0058) with results of 3.1, 13.4, and < 1.0 cfu/100 mL. The cause of the high reading at the outfall was investigated but not determined.
- *03A048 September 6, 2011 TRC = 1.50 mg/L:* The cause of the exceedance was an air bubble in the sulfite feed line. The primary pump normally releases approximately 6 gallons/day into blow down water to dehalogenate the water. For a period of time, this bubble blocked addition of sulfite into the blow down, resulting in the exceedance. Corrective actions included venting the sulfite feed lines to prevent air blockages, ensuring sulfite backup pumps are on hand to replace pumps as needed, installation of chlorine loops on both cooling towers, inspection by vendor to help ensure system is

working as designed, and future installation of a paging system to notify facility operations staff of all alarms at the cooling towers related to analyzers/probes measuring NPDES parameters such as chlorine, arsenic, and pH.

- *03A160 December 15, 2011 Copper = 0.0404 mg/L:* Upon notification that the effluent exceeded the total copper limit, the facility stopped further discharges from NPDES Outfall 03A160. The ion exchange resins were changed out on January 10, 2012. Operational sampling continues to confirm the treatment system is operating properly.

b. NPDES Sanitary Sewage Sludge Management Program

The Laboratory's TA-46 SWWS Plant is an extended-aeration, activated-sludge sanitary wastewater treatment plant. The activated-sludge treatment process requires periodic disposing of excess sludge (waste-activated sludge) from the plant's clarifiers to synthetically lined drying beds. After air-drying for a minimum of 90 days to reduce pathogens, the dry sludge is characterized and disposed of as a New Mexico Special Waste. During 2011, the SWWS Plant generated approximately 23.5 dry tons (46,901 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

c. NPDES Storm Water Construction Permit Program

The NPDES Construction General Permit (CGP) Program regulates storm water discharges from construction activities disturbing one or more acres, including those construction activities that are part of a larger common plan of development collectively disturbing one or more acres.

LANL and the general contractor apply individually for NPDES CGP coverage and are co-permittees at most construction sites. Compliance with the NPDES CGP includes developing and implementing a Storm Water Pollution Prevention Plan (SWPPP) before soil disturbance can begin and conducting site inspections once soil disturbance has commenced. A SWPPP describes the project activities, site conditions, best management practices (erosion control measures), and permanent control measures required for reducing pollution in storm water discharges and protecting endangered or threatened species and critical habitat. Compliance with the NPDES CGP is demonstrated through periodic inspections that document the condition of the site and also identify corrective actions required to keep pollutants from moving off the construction site. Data collected from these inspections are tabulated weekly, monthly, and annually in the form of Site Inspection Compliance Reports.

During 2011, the Laboratory implemented and maintained 45 construction site SWPPPs and addendums to SWPPPs and performed 596 storm water inspections. The Laboratory uses a geographic information system to manage project information and generate status reports that facilitate reporting under the Director's Portfolio Reviews. The overall CGP inspection compliance record in 2011 was 97.7%, which is 582 of the 596 inspections.

d. NPDES Industrial Storm Water Program

Section 402(p) of the CWA directed EPA to develop a phased approach to regulate storm water discharges under the NPDES program. In November of 1990, EPA published a final regulation establishing permit application requirements for storm water discharges associated with industrial activity. "Storm water discharges associated with industrial activity" was defined by EPA in a comprehensive manner to cover a wide variety of facilities. EPA issued the most recent version of the Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activity on September 29, 2008 (hereinafter referred to as the 2008 MSGP). LANS submitted its Notice of Intent to Discharge under the 2008 MSGP in January 2009. The 2008 MSGP authorization to discharge expires at midnight on September 29, 2013.

The LANS Permit Tracking Number under the 2008 MSGP is NMR05GB21. The types of industrial activities conducted at LANS covered under the 2008 MSGP include metal and ceramic fabrication; hazardous waste treatment and storage; vehicle and equipment maintenance; recycling activities; electricity generation; warehousing activities; and asphalt manufacturing.

The 2008 MSGP requires the implementation of control measures, development of SWPPPs, and monitoring storm water discharges from permitted sites. In 2011, LANL implemented and maintained 11 SWPPPs covering 14 facilities. Compliance with the requirements for these sites is achieved primarily by implementing the following activities:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and nonstructural controls to limit the impact of those contaminants,
- Developing and implementing facility-specific SWPPPs,
- Implementing corrective actions identified during inspections throughout the year,
- Monitoring storm water runoff at facility stand-alone samplers for industrial sector-specific benchmark parameters, impaired water constituents, and effluent limitations, and
- Visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

The 2011 calendar year monitoring data indicate that LANS exceeded the effluent limitation guideline (ELG) for Total Suspended Solids (TSS) at the TA-60 Asphalt Batch Plant. Since the entire facility is covered with gravel or asphalt except the detention pond that discharges storm water into a flume (the discharge from which would trigger the automatic storm water sampler during a qualifying storm event), the source of the TSS is presumed to be the pond. Therefore, corrective actions relative to this exceedance included the following:

- Excavating the pond approximately one foot deeper to provide additional storage of storm water during a typical rainy season with back-to-back storm events
- Installing filter fabric over the entire earthen areas within the pond (bottom and side slopes) to provide a barrier between the clay fines and storm water within the pond
- Installing river rock to protect the fabric from ultraviolet (UV) light degradation and wildlife

All of these corrective actions were completed within 14 calendar days of the exceedance.

The water quality standard for copper was exceeded at two facilities. Administrative changes have been implemented to address these exceedances.

Since LANS started monitoring under the 2008 MSGP in April 2009 to the end of CY11, LANS has discontinued monitoring for 439 of the original 485 individual outfall/parameter requirements. The permit allows discontinuation of monitoring under the following circumstances:

- Constituents are found to not be present,
- Constituents/parameters are found to be present below permit defined levels, or
- Changes to impaired water constituents (i.e., no longer requiring specific constituent monitoring for impaired water).

e. NPDES Individual Permit for Storm Water Discharges from SWMUs/AOCs

On February 13, 2009, EPA Region 6 issued NPDES Individual Permit (IP) No. NM0030759 to co-permittees LANS and the DOE. Immediately following issuance of the IP by the EPA, the IP was appealed. Following permit modification negotiations in 2009, the EPA issued a new modified IP that was effective on November 1, 2010. The IP authorizes discharges of storm water from certain SWMUs, and AOCs (sites) at the Laboratory.

The IP lists 405 permitted sites that must be managed to prevent the transport of contaminants to surface waters via storm water runoff. Potential contaminants of concern within these sites are metals, organics, high

explosives and radionuclides. These contaminants are present in soils near the top of the soil profile and are susceptible to storm-event-driven erosion and transport through storm water runoff.

The IP is a technology-based permit and relies, in part, on non-numeric technology-based effluent limits (storm water control measures). Site-specific storm water control measures that reflect best industry practice considering their technological availability, economic achievability, and practicability are required for each of the 405 permitted sites to minimize or eliminate discharges of pollutants in storm water. These control measures include run-on, runoff, erosion, and sedimentation controls, which are routinely inspected and maintained as required.

For purposes of monitoring and management, sites were grouped into small watersheds called Site Monitoring Areas (SMAs). The SMAs have sampling locations identified to most effectively sample storm water runoff. Storm water is monitored from these SMAs to determine the effectiveness of the controls. When target action levels (TALs), which are based on New Mexico water quality standards, are exceeded, corrective actions are required. In summary, the process of complying with the IP can be broken down into five phases: (1) installation and maintenance of baseline controls; (2) storm water confirmation sampling in support of baseline controls; (3) corrective action (if TAL exceeded); (4) confirmation sampling in support of enhanced controls for corrective actions; and (5) certification of corrective action complete or application for alternative compliance.

In 2011, the Laboratory completed the following tasks:

- Developed a Site Discharge Pollution Prevention Plan for SWMUs/AOCs that describes three main objectives: identification of pollutant sources, description of control measures, and monitoring that determines the effectiveness of controls at all regulated SWMUs/AOCs
- Fieldwork
- Completed more than 1,000 rain event inspections on all 250 SMAs
- Conducted BMP maintenance at 140 SMAs
- Completed installation of baseline controls at all 250 SMAs
- Decommissioned/removed sampler and equipment at 45 previous Federal Facilities Compliance Agreement locations

f. Aboveground Storage Tank Compliance Program

The Laboratory's Aboveground Storage Tank (AST) Compliance Program is responsible for ensuring compliance with the requirements established by EPA (Clean Water Act, 40 CFR, Part 112) and NMED's Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2011, the Laboratory was in full compliance with both EPA and NMED requirements.

Spill Prevention Control and Countermeasures (SPCC) Plans fulfill the federal requirements for the AST Compliance Program, as required by the CWA (Oil Pollution Prevention Regulations, 40 CFR, Part 112). Comprehensive SPCC Plans are developed to meet EPA requirements that regulate water pollution from oil spills.

EPA proposed additional extensions to compliance deadlines for meeting new regulatory requirements under the federal Clean Water Act (40 CFR, Part 112). New regulations required the Laboratory to modify and implement its SPCC Plans by November 10, 2011. Primary modifications address AST storage capacity, inspection frequency, integrity testing requirements, and equipment. The Laboratory completed four modifications to existing and new SPCC Plans, and implementation of those modifications is in process. In 2011 ENV-RCRA conducted approximately 35 annual inspections/assessments of facilities with SPCC Plans.

The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC of the NMED-PSTB regulations. The Laboratory paid annual AST registration fees of \$100 per AST. The Laboratory has

four tank systems that are operational pursuant to 20.5 NMAC. The remaining four tanks systems are under permanent closure status pursuant to 20.5 NMAC. In 2012, it is expected that nine to 10 additional tank systems will be registered with NMED due to a New Mexico Environmental Improvement Board (NMEIB) regulation change that will remove an exemption from regulation for ASTs associated with emergency generator systems.

During 2011, the Laboratory continued to work on removing and decommissioning ASTs that are no longer in service. Written closure notices for four AST systems were submitted to NMED-PSTB pursuant to 20.5 NMAC in 2011. It is expected that two or three of the closed systems will have tanks and piping removed in 2012.

g. Dredge and Fill Permit Program

Section 404 of the Clean Water Act requires the Laboratory to obtain permits from the US Army Corps of Engineers to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by the Corps of Engineers will not prevent attainment of state-mandated stream standards. NMED reviews Section 404/401 joint permit applications and issues separate Section 401 certification letters, which may include additional permit requirements to meet state stream standards for individual Laboratory projects. In addition, the Laboratory must comply with 10 CFR 1022, which specifies how DOE sites comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.

During 2011, Section 404/401 permits were issued for four construction projects at the Laboratory:

- Emergency Culvert Replacement Project, Cañon de Valle (Nationwide Permit No. 3, Maintenance)
- Emergency Bank Stabilization Project, Los Alamos Canyon (Nationwide Permit No. 13, Bank Stabilization)
- Temporary Utility Line Crossing, Water Canyon (Nationwide Permit No. 12, Utility Line Activities)
- Culvert Replacement Project and Erosion Protection Repairs, Water Canyon (Nationwide Permits Nos. 14 and 3, for Linear Transportation Projects and Maintenance, respectively).

In addition, LANL reviewed 521 excavation permits and 169 project profiles for potential impacts to watercourses, floodplains, or wetlands. One Floodplain/Wetland Assessment was prepared in June 2011 for the emergency fire breaks installed to protect the Laboratory during the June 2011 Las Conchas Fire. No violations of the DOE Floodplain/Wetland Environmental Review Requirements were recorded in 2011. NMED and the Corps of Engineers did not inspect any sites permitted under the Section 404/401 regulations during 2011.

8. Safe Drinking Water Act

Los Alamos County, as owner and operator of the Los Alamos water supply system, is responsible for compliance with the requirements of the federal Safe Drinking Water Act (SDWA) and the New Mexico Drinking Water Regulations (NMEIB 2007). The SDWA requires Los Alamos County to collect samples from various points in the water distribution systems at the Laboratory, Los Alamos County, and Bandelier National Monument to demonstrate compliance with SDWA maximum contaminant levels (MCLs). EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The State of New Mexico has adopted these standards in the New Mexico Drinking Water Regulations (<http://www.nmenv.state.nm.us/dwb/regulations/>). EPA has authorized NMED to administer and enforce federal drinking water regulations and standards in New Mexico. Information on the quality of the drinking water from the Los Alamos County water supply system is in the County's annual Consumer Confidence Report, available online at <http://www.losalamosnm.us/>.

In 2011, the Laboratory conducted additional confirmation monitoring of the Los Alamos County water supply system for quality assurance purposes. The data are presented in Chapter 5 of this report and at the

online Intellus New Mexico Environmental Database (<http://www.intellusnmdata.com>). Drinking water supplied by Los Alamos County has not been impacted by any LANL contaminants.

9. Groundwater

a. Groundwater Protection Regulations

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in New Mexico. Under the regulations, when required by NMED, a facility must submit a discharge plan and obtain a permit from the NMED (or approval from the New Mexico Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge permit. In 2011, the Laboratory had one discharge permit and three discharge plans pending NMED approval (see Table 2-5).

i. TA-46 SWWS Plant Discharge Permit DP-857

On July 20, 1992, the Laboratory was issued a discharge permit for the TA-46 SWWS Plant. The permit was renewed on January 7, 1998, and modified by the NMED on October 1, 2002. The permit requires quarterly sampling of the SWWS Plant's effluent, NPDES Outfalls 001 and 03A027, and Cañada del Buey alluvial groundwater well CDBO-6 to demonstrate compliance with NMWQCC groundwater standards. The Laboratory reports the analytical results to the NMED quarterly. During 2011, none of samples collected exceeded NMWQCC groundwater standards. Monitoring data are available online at the Intellus New Mexico Environmental Database (<http://www.intellusnmdata.com>). On April 6, 2010, the NMED requested an application for renewal and modification of discharge permit DP-857. Accordingly, the Laboratory submitted a renewal application on July 2, 2010. The NMED did not conduct a site inspection of the TA-46 SWWS Plant in 2011. Approval of the renewal application was pending at the end of 2011.

ii. TA-50 RLWTF Discharge Plan DP-1132

On August 20, 1996, at the NMED's request, the Laboratory submitted a discharge permit application for the RLWTF at TA-50; NMED approval was pending at the end of 2011. On November 18, 2011, the NMED requested a new, comprehensive and up-to-date discharge permit application for the TA-50 RLWTF and the TA-52 Zero Liquid Discharge Solar Evaporation Tanks. (After construction is completed in 2012, the tanks will evaporate treated effluent from the TA-50 RLWTF.)

Since 1999, the Laboratory has conducted voluntary quarterly sampling of the RLWTF's effluent and alluvial groundwater monitoring wells MCO-3, MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon for nitrate (as N), fluoride, and total dissolved solids (TDS). The Laboratory reports the analytical results to the NMED quarterly. During 2011, none of the quarterly groundwater samples exceeded NMWQCC groundwater standards. No effluent samples were collected in 2011 because the TA-50 RLWTF did not discharge any treated effluent to Mortandad Canyon; all treated effluent was evaporated on site. Monitoring data are available online at the Intellus New Mexico Environmental Database (<http://www.intellusnmdata.com>). The NMED conducted an inspection of the TA-50 RLWTF on September 8, 2011.

iii. Domestic Septic Tank/Leachfield Systems Discharge Plan DP-1589

On April 27, 2006, at the NMED's request, the Laboratory submitted a discharge plan application for the discharge of domestic wastewater from 21 septic systems. These septic systems (a combined septic tank and leach field) are located in remote areas of the Laboratory where access to the SWWS Plant's collection system is not practicable. On April 6, 2010, the NMED requested that LANL submit a new, up-to-date septic tank/leachfield systems discharge plan application. Accordingly, on June 25, 2010, LANL submitted an updated discharge plan application for 15 septic tank/leachfield systems. Approval of the application was pending at the end of 2011.

iv. Land Application of Treated Groundwater from a Pumping Test at R-28 Discharge Plan DP-1793

On December 20, 2011, at the NMED's request, the Laboratory submitted a discharge plan application for the discharge of treated groundwater produced during a 10-day pumping test at regional aquifer monitoring well R-28. Approval of the application was pending at the end of 2011.

b. Groundwater Monitoring Activities

The Laboratory performed significant groundwater compliance work in 2011 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and installation of monitoring wells in support of various groundwater investigations and corrective measures evaluations (CMEs).

In 2011, LANL installed one monitoring wells in the perched/intermediate aquifer and five monitoring wells (with six screens) in the regional aquifer (Table 2-11). Figure 2-5 shows the locations of the new wells; maps of all monitoring well locations can be found in Chapter 5.

Table 2-11
Monitoring Wells Installed in 2011

Type ^a	Identifier	Watershed (Canyon)	Total Completed depth ^b (ft bgs)	Screened interval(s) (ft bgs)	Initial Water level (famsl ^b)	Comments
I	R-55i	Mortandad	565.0	510.0–531.1	6036.7	TA-54 monitoring group well completed in perched intermediate groundwater east of MDA G. Monitors for potential contaminant releases from MDA G and other sources in Pajarito Canyon. Completed on 1/18/11.
R	R-61	Mortandad	1265.0	1125.0–1135.0 (sc 1) 1220.4–1241.0 (sc 2)	5838.7 (composite)	Chromium Investigation monitoring group well located on the mesa south of Mortandad Canyon. Primary objective was to define the western extent of the flow path for chromium migration. Completed on 5/3/11.
R	R-62	Mortandad	1260.0	1158.4–1179.1	5839.2	Chromium Investigation monitoring group well located on a ridge between Sandia and Mortandad canyons at the east end of Sigma Mesa. Completed on 10/03/11.
R	R-63	Water	1367.0	1325.0–1345.3	6194.0	TA-16 260 monitoring group well completed in the regional aquifer approximately 1,430 feet east of R-25 near Cañon de Valle. Completed on 2/9/11.
R	R-64	Los Alamos	1380.0	1285.0–1305.5	5852.5	TA-21 monitoring group well located immediately northeast of MDA T on the mesa between Los Alamos and Pueblo canyons. Completed on 5/15/11.
R	R-66	Los Alamos	910.4	819.4–839.7	5833.1	TA-21 monitoring group well installed near Los Alamos County production well Otowi-4. Well monitors for potential contaminants from upper Los Alamos and DP canyons. Completed on 11/16/11.

^a I = Perched intermediate aquifer well; R = regional aquifer well.

^b Total depth refers to the completed well; bgs = below ground surface; famsl = feet above mean sea level.

Sample analytical and other groundwater data can be reviewed online at Intellus New Mexico (<http://www.intellusnmdata.com>). Periodic monitoring reports and water-level and well construction data can be found on the Laboratory's Environment Website at <http://www.lanl.gov/environment/h2o/reports.shtml>.

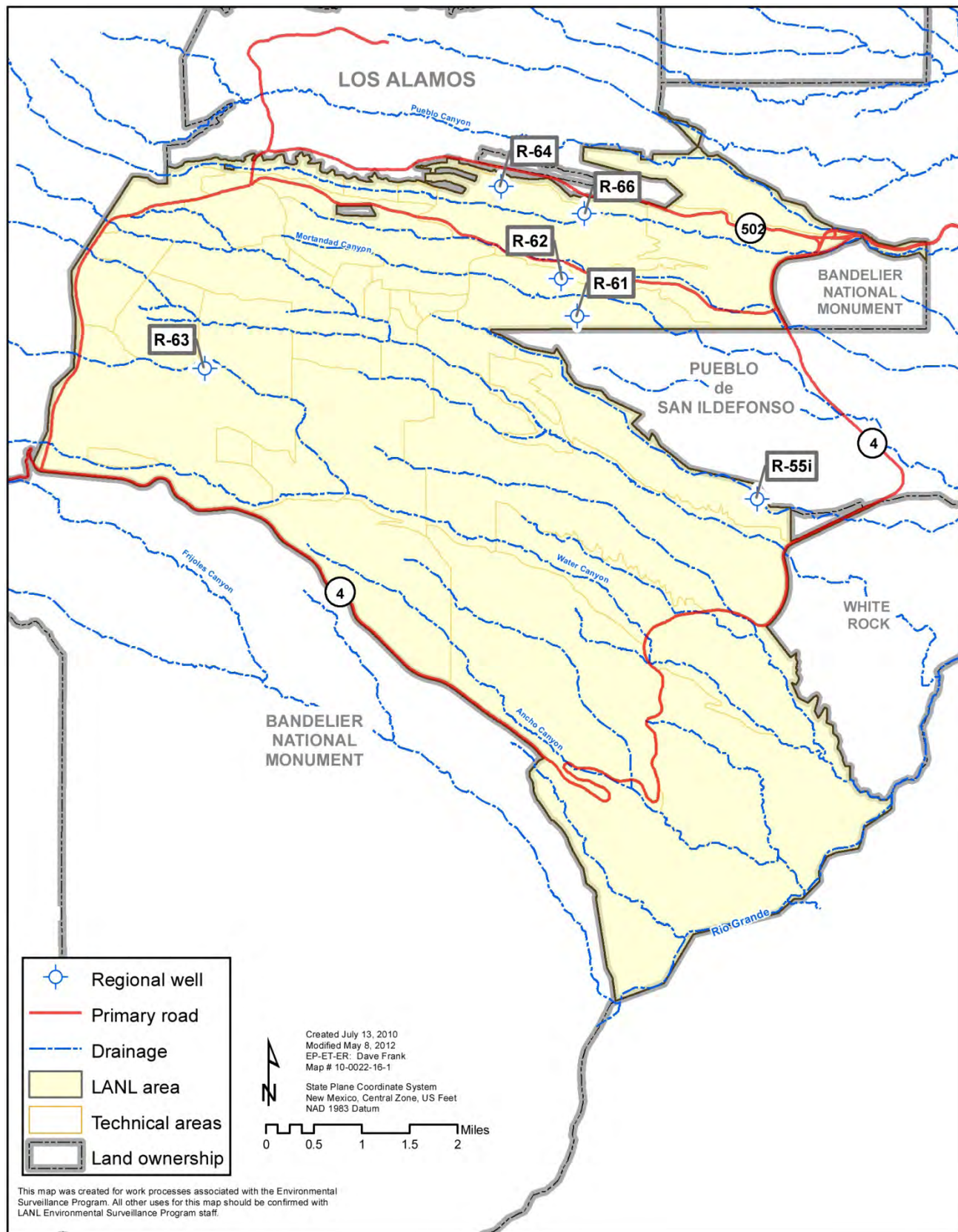


Figure 2-5 Groundwater monitoring wells installed during 2011

10. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA) (42 U.S.C. 4331 et seq.), federal agencies such as DOE/NNSA must consider the environmental impacts of proposed projects and ensure public participation as part of the decision-making process. The Laboratory's Environmental Stewardship Group devotes considerable resources to assist NNSA in compliance with NEPA, pursuant to DOE Order 451.1B. Proposed projects and actions at LANL are reviewed to determine potential resource impacts and the appropriate coverage under NEPA, and these recommendations are reported to NNSA.

The current Site-Wide Environmental Impact Statement (SWEIS) was issued in May 2008 (DOE 2008a). Two Records of Decision (ROD) have been issued to date; the first in September 2008 (DOE 2008b) and another in June 2009 (DOE 2009). In both RODs, DOE/NNSA decided to implement the No Action Alternative with the addition of some elements of the Expanded Operations Alternative analyzed in the SWEIS.

The first Supplement Analysis (SA) to the 2008 SWEIS was issued by DOE in October 2009 (DOE/EIS-0380-SA-01). This SA was prepared to determine if the 2008 SWEIS adequately bounded the off-site transportation of low-specific activity and low-level waste by a combination of truck and rail to EnergySolutions in Clive, Utah. DOE/NNSA concluded that the proposed shipments of waste to EnergySolutions by truck and rail were bounded by 2008 SWEIS transportation analysis. The second SA was issued by DOE in April 2011 (DOE/EIS-0380-SA-02). It was prepared to assess DOE/NNSA activities of the Off-Site Source Recovery Project (OSRP) to recover and manage high-activity beta/gamma sealed sources from Uruguay and other locations. DOE/NNSA issued an amended SWEIS ROD in response to the SA on OSRP in July 2011.

During 2011, DOE/NNSA began work on the Supplemental Environmental Impact Statement for the Nuclear Facility Portion of the CMRR at LANL (CMRR-NF SEIS), DOE/EIS-0350-S1. This document supplements the CMRR EIS (DOE/EIS-0350) completed in 2003 (which was followed by a ROD issued in 2004). This supplement addresses new geologic information regarding seismic conditions at the site and examines the potential environmental impacts associated with NNSA's proposed action to complete the CMRR Project at LANL. An amended ROD was issued on October 12, 2011.

LANL reviews all proposed projects and verifies that they will be compliant with the existing SWEIS or other NEPA documents. In some cases, further NEPA analysis is done, and NEPA documents are prepared. While there were no Environmental Assessments prepared in CY11, there were three categorical exclusions issued by DOE/NNSA during CY11: Replacement of LANSCE Operational Equipment (LAN-11-0001), Construction of Protective Force Indoor Live Fire Range at TA-16 (LAN-11-0002), and Modifications to the CLEAR Line at TA-55-4 at LANL (LAN-11-0003).

In October 2011, LANL submitted the FY11 Mitigation Action Plan Annual Report (MAPAR) for the 2008 SWEIS to DOE/NNSA. The annual report was revised in December 2011 and again in March 2012 at the request of DOE/NNSA. This fulfilled the FY11 annual reporting requirements under the LANS Prime Contract. The MAPAR included an appendix that described actions taken during the Las Conchas Fire.

11. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. LANL implements these requirements through the Biological Resources Management Plan (LANL 2007) and the Habitat Management Plan (LANL 2011a).

The Laboratory contains potential habitat for one federally endangered species (Southwestern willow flycatcher, *Empidonax traillii extimus*), one federally threatened species (Mexican spotted owl, *Strix occidentalis lucida*), and three candidate species (yellow-billed cuckoo, *Coccyzus americanus*; Jemez Mountains salamander, *Plethodon neomexicanus*; and New Mexico meadow jumping mouse, *Zapus hudsonius luteus*). The Southwestern willow flycatcher and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within LANL (Table 2-12).

Table 2-12
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL

Scientific Name	Common Name	Protected Status ^a	Potential to Occur ^b
<i>Empidonax traillii extimus</i>	Southwestern Willow Flycatcher	E	Moderate
<i>Mustela nigripes</i>	Black-footed Ferret	E	Low
<i>Strix occidentalis lucida</i>	Mexican Spotted Owl	T	High
<i>Coccyzus americanus</i>	Yellow-billed Cuckoo	C, NMS	Moderate
<i>Zapus hudsonius luteus</i>	New Mexico Meadow Jumping Mouse	C, NME	Moderate
<i>Haliaeetus leucocephalus</i>	Bald Eagle	NMT, S1	High
<i>Cynanthus latirostris magicus</i>	Broad-billed Hummingbird	NMT	Low
<i>Gila pandora</i>	Rio Grande Chub	NMS	Moderate
<i>Plethodon neomexicanus</i>	Jemez Mountains Salamander	C, NME	High
<i>Falco peregrinus anatum</i>	American Peregrine Falcon	NMT, FSOC	High
<i>Falco peregrinus tundrius</i>	Arctic Peregrine Falcon	NMT, FSOC	Moderate
<i>Accipiter gentiles</i>	Northern Goshawk	NMS, FSOC	High
<i>Lanius ludovicianus</i>	Loggerhead Shrike	NMS	High
<i>Vireo vicinior</i>	Gray Vireo	NMT	Moderate
<i>Myotis ciliolabrum melanorhinus</i>	Western Small-footed Myotis Bat	NMS	High
<i>Myotis volans interior</i>	Long-legged Bat	NMS	High
<i>Euderma maculatum</i>	Spotted Bat	NMT	High
<i>Corynorhinus townsendii pallescens</i>	Townsend's Pale Big-eared Bat	NMS, FSOC	High
<i>Nyctinomops macrotis</i>	Big Free-tailed Bat	NMS	High
<i>Bassariscus astutus</i>	Ringtail	NMS	High
<i>Vulpes vulpes</i>	Red Fox	NMS	Moderate
<i>Ochotona princeps nigrescens</i>	Goat Peak Pika	NMS, FSOC	Low
<i>Cynomys gunnisoni</i>	Gunnison's Prairie Dog	C, NMS	Low
<i>Lilium philadelphicum</i> var. <i>andinum</i>	Wood Lily	NME	High
<i>Cypripedium calceolus</i> var. <i>pubescens</i>	Greater Yellow Lady's Slipper	NME	Moderate
<i>Speyeria Nokomis nitocris</i>	New Mexico Silverspot Butterfly	FSOC	Moderate

^a E = Federal Endangered; T = Federal Threatened; C = Federal Candidate Species; NMS = New Mexico Sensitive Taxa (informal); S1 = Heritage New Mexico: Critically Imperiled in New Mexico; NMT = New Mexico Threatened; NME = New Mexico Endangered; FSOC = Federal Species of Concern.

^b Low = No known habitat exists on LANL; Moderate = Habitat exists, though the species has not been recorded recently; High = Habitat exists, and the species occurs at LANL.

The Laboratory meets its requirements for threatened and endangered species protection through implementation of its Threatened and Endangered Species Habitat Management Plan and review of excavation permit requests and project profiles. During 2011, LANL reviewed 521 excavation permits, 169 project profiles in the Permits Requirements Identification (PRID), and 12 storm water profiles for potential impacts to threatened or endangered species. The Laboratory conducted surveys for the Mexican spotted owl, Southwestern willow flycatcher, Jemez Mountains salamander, and gray vireo. Mexican spotted owls and Jemez mountain salamander surveys by LANL biologists had positive results. Willow flycatchers were found during surveys. However, they did not nest, so it could not be determined if they were the Southwestern endangered subspecies. The Laboratory also updated its Sensitive Species Best Management Practices Source Document (LANL 2011b).

12. Migratory Bird Treaty Act

Under the provisions of the Migratory Bird Treaty Act, it is unlawful “by any means or manner to pursue, hunt, take, capture [or] kill” any migratory birds except as permitted by regulations issued by the US Fish and

Wildlife Service. In the project review process, LANL biologists provided specific comments for projects with the potential to impact migratory birds, their eggs, or nestlings if, for example, a project proposed an electrical power line or a project disturbed vegetation during the bird nesting season. During 2011, LANL biologists continued annual surveys in all major habitat types in each season. In addition, biologists completed a second year of bird netting to monitor the bird populations during fall migration in Pajarito Canyon. The Laboratory also updated its Migratory Bird Best Management Practices Source Document (LANL 2011c).

13. Cultural Resources

The goal of the National Historic Preservation Act (NHPA) of 1990 is to have federal agencies act as responsible stewards of the nation's resources when their actions affect historic properties. NHPA Section 106 requires federal agencies to take into account the effects projects may have on historic properties and to allow for comment by the Advisory Council on Historic Preservation. Section 106 regulations outline a project review process conducted on a project-by-project basis. LANL describes its implementation of Section 106 in the Cultural Resources Management Plan (LANL 2004) available online (<http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964>).

In 2011, the Laboratory conducted 35 projects that required some field verification of previous cultural surveys. Thirteen new archaeological sites were identified in 2011. Fourteen archaeological sites were determined eligible for the National Register of Historic Places. As part of Section 106, LANL conducts public outreach and provides site tours of historic and cultural sites for stakeholders, DOE/NNSA, and representatives of other federal agencies.

The Laboratory continued the Land Conveyance and Transfer Project (C&T) in 2011. The DOE/NNSA is in the process of conveying and transferring approximately 4,000 acres of excess DOE lands to Los Alamos County and to the Bureau of Indian Affairs to be held in trust for Pueblo de San Ildefonso under Public Law 105-119. During 2011, no land was transferred. The Resources Management Team continued to conduct the annual inspection of the curation facility (Museum of Indian Arts and Cultural in Santa Fe, New Mexico) in 2011 where the artifacts from the excavation of 39 C&T archaeological sites along with collections from other earlier projects conducted at LANL are housed.

In support of LANL's 2011 D&D program, square footage reduction, and Laboratory consolidation, the Laboratory completed final documentation reports for two D&D projects and initiated work on another two proposed projects as required under the provisions of the NHPA. Buildings included in these projects are located at TA-3, TA-18, TA-21, and TA-22. This work included field visits to historic properties (including interior and exterior inspections), digital and archival photography, and architectural documentation (using standard LANL building recording forms). Additional documentation included the production of location maps for each of the evaluated projects. Historical research was also conducted using source materials from the LANL archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews.

The Laboratory continues to consult with the Pueblos with respect to identifying and protecting traditional cultural properties, human remains, and sacred objects in compliance with the NHPA and Native American Graves Protection and Repatriation Act. During FY11, consultations with the Pueblo de San Ildefonso were initiated regarding the culturally affiliated human remains discovered in TA-54 during 2011.

D. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred at LANL during 2011.

2. Water Releases

No unplanned releases of radioactive liquids occurred on Laboratory lands in 2011. There were 20 unplanned releases of non-radioactive liquids in 2011 that were reported to NMED pursuant to 20.6.2.1203 NMAC (Table 2-13). In addition, there were 12 reports for groundwater detections in excess of New Mexico Groundwater Quality Standards and one well packer failure that were reported pursuant to 20.6.2.1203 NMAC.

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations 20.6.2.1203 NMAC. Upon cleanup, the NMED and the DOE Oversight Bureau inspected the unplanned release sites as required to ensure adequate cleanup. In 2011, the Laboratory was in the process of administratively closing all releases for 2011 with the NMED and the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

Table 2-13
2011 Unplanned Non-Radioactive Releases

Material Released	Instances	Approximate Total Release (gal.)
Potable water	14	238,400
Diesel fuel	1	10
Sanitary wastewater	1	1,500
Fire suppression water	1	1,000
Gear lubricant	1	10
Steam condensate	2	70,000

E. REFERENCES

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- DOE 2008a: "Final Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico," US Department of Energy report DOE/EIS-0380 (May 16, 2008).
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- NMEIB 2007: "Drinking Water Regulations" (as amended through April 2007), found at 20.7.10 NMAC, New Mexico Environmental Improvement Board, State of New Mexico (2007).

To Read About

Turn to Page

<i>Introduction</i>	3-1
<i>Radiological Dose Assessment for Humans</i>	3-1
<i>Biota Dose Assessment</i>	3-10
<i>Non-Radiological Risk Assessment</i>	3-11
<i>Summary</i>	3-13
<i>References</i>	3-13

A. INTRODUCTION

This chapter presents the results of the calculation of radiological dose to the public and biota from Los Alamos National Laboratory (LANL or the Laboratory) operations in 2011 and reports whether the doses are below specified limits. This chapter also provides a measure of the significance of environmental radioactivity in the context of its potential dose to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The calculated human dose is received near the publicly accessible Laboratory boundaries, whereas the calculated biota dose is potentially received throughout the interior of Laboratory property, usually at locations rarely visited by humans. In addition, the potential risks from non-radiological materials detected during 2011 and previous years' sampling activities are summarized.

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

B. RADIOLOGICAL DOSE ASSESSMENT FOR HUMANS

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented are calculated using standard methods specified in guidance documents (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The effective dose equivalent, referred to here as "dose," is calculated using radiation-weighting factors and tissue-weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. For example, from a human health risk perspective, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium. In addition, the dose results within this chapter reflect potential dose to hypothetical people and biota and are not to be construed as a dose assessment for any specific individual or organism.

Federal government standards limit the dose that the public may receive from Laboratory operations. The primary risk of receiving radiation dose is cancer. For low doses of radiation, the risk of contracting cancer is 8×10^{-7} per mrem received (DOE 2003).

The DOE dose limit to a member of the public is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which a person can be exposed to radiation, such as inhalation, ingestion, and direct radiation). Furthermore, doses to members of the public must be reduced to low levels consistent with a documented "as low as reasonably achievable" (ALARA) process (LANL 2008a) and generally should not exceed a dose constraint of one-quarter of the primary dose limit, or 25 mrem/yr (DOE 1999). The dose received from airborne emissions of radionuclides is further restricted by the US Environmental Protection Agency (EPA) dose standard of 10 mrem/yr (EPA 1986), also known as the National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon from DOE Facilities (Rad-NESHAP) dose limit. These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are limited in accordance with

the Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides or by dose rate (4 mrem/yr for man-made radionuclides) (EPA 2004).

2. Public Dose Calculations

a. Scope

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

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

1. The entire population within 80 km of the Laboratory
2. The maximally exposed individual (MEI) for the airborne pathway dose only and compared with the EPA Rad-NESHAP dose limit of 10 mrem/yr
3. The MEI for the all-pathways dose and compared with the DOE Order 5400.5 dose limit of 100 mrem/yr
4. Residents in Los Alamos and White Rock

b General Considerations

As discussed in Section B.4 below, the US per capita dose rate from naturally occurring radioactivity is 311 mrem/yr (NCRP 2009). Additional man-made sources of radiation, such as medical/dental uses of radiation, and building products, such as stone walls, raise the total US per capita background dose to about 620 mrem/yr on average (NCRP 1975, 1987a, 1987b, 2009). It is extremely difficult to measure doses from LANL that are less than 0.1% of natural doses. As the dose rates become lower, the estimates become less certain and less significant. Generally, we conclude that a dose rate of less than 0.1 mrem/yr is essentially zero and cannot be distinguished from natural background radiation.

We begin with environmental measurements of radionuclides in air, water, soil, foodstuffs, sediment, and non-foodstuffs biota. We compare the concentrations of these radionuclides in the various media with pre-determined radionuclide-specific screening levels that are equivalent to 0.1 mrem/yr for specific exposure pathways, such as ingestion of drinking water, ingestion of foodstuffs, and exposure to residual contamination in soil (LANL 2003). If the concentrations do not exceed the screening levels, no further assessment is required, and the doses are assumed to be essentially zero. If the concentrations do exceed the screening levels, further dose assessment is required, and specific numerical dose values are reported in this chapter (LANL 2008b).

i. Direct Radiation Exposure

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

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

To estimate the dose to the public near TA-54, we multiply the measurements of neutron dose by an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We followed

standard guidance and assumed continuous occupancy for residences, schools, and places of business. For all other locations, we multiplied the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway)

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

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

iii. Water (Ingestion Pathway)

The majority of radionuclides detected in groundwater samples collected from known or potential drinking water sources (i.e., Los Alamos County drinking water supply wells, Buckman wells, and natural springs) in 2011 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226.

iv. Soil (Direct Exposure Pathway)

We report measurements of radionuclide concentrations in surface soil in Chapter 7. As described in Chapter 7, Section C.1, soil samples are collected on the perimeter of the Laboratory and at regional and on-site locations on a triennial basis (every three years). Routine soil samples were previously collected in 2006 and were collected again in 2009. No regional samples have had radionuclide concentrations detected above the regional statistical reference levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediment, and crops, collected or harvested in regional areas far from the influence of the Laboratory, averaged over a period of five years. In 2011, soil samples were collected on Pueblo de San Ildefonso lands, at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, and at TA-54, Area G.

v. Food (Ingestion Pathway)

We report measurements of the radioactive content of food, mostly crops, fish, and native vegetation, in Chapter 8. The food is collected on a triennial basis, rotating with the collection of soils. In 2011, emphasis was placed on the collection of fish, upstream and downstream of the Laboratory.

vi. Release of Items and Real Property

The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public, following Laboratory requirements for release of such items (LANL 2011). All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with the procedures of LANL's Health Physics Operations Group. Any items with surface contamination or dose levels above the authorized release limits for uncontrolled use are not released to the public. In addition, items are not released if they are from a known or potentially contaminated area that cannot be completely surveyed. The authorized release limits for items (LANL 2011) are the limits in Figure IV-1 of DOE requirements (DOE 1993, 1995).

The Land Conveyance and Transfer Project is a DOE, National Nuclear Security Administration project for which LANL provides technical and project management support under Public Law 105-119. On November 26, 1997, Congress passed Public Law 105-119, the Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriations Act. Section 632 of that law directed the Secretary of Energy to convey or transfer parcels of DOE land in the vicinity of the Laboratory to the incorporated county of Los Alamos, New Mexico, and to the Secretary of the Interior, in trust for the

Pueblo de San Ildefonso. Such parcels or tracts of land are required to meet the suitability criteria established by the law:

- They are not required for the national security mission before the end of November 26, 2012.
- They could be restored or remediated by November 26, 2012 (now extended to 2022).
- They are suitable for historic, cultural, or environmental preservation, economic diversification, or community self-sufficiency.

In 1998, DOE identified 10 tracts of land, totaling approximately 4,800 acres, for potential transfer to the County of Los Alamos or to the Pueblo de San Ildefonso. The original 10 tracts have been subdivided into 32 tracts. Some of the tracts withdrawn because of mission needs or remediation activities may be conveyed to Los Alamos County upon cleanup of TA-21. The 2011 National Defense Authorization Act extended the public law to September 2022. To date, 20 parcels have been conveyed or transferred to the County of Los Alamos, the Los Alamos Public Schools, and to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso. All parcels were transferred with concentrations of residual radioactive material in the soil attributable to Laboratory operations less than the radionuclide screening levels for the residential scenario, which is the most conservative scenario. This approach results in a potential dose to the public of 15 mrem/yr or less. In addition, the ALARA concept has been applied to these transfers such that the potential dose is much less than 15 mrem/yr.

3. Dose Calculations and Results

a. Collective Dose to the Population within 80 Kilometers

We used the local population distribution to calculate the dose from 2011 Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 343,000 persons live within an 80-km radius of the Laboratory (McNaughton et al. 2012a).

The collective population dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL. For example, if two persons each receive 3 mrem, the collective dose is 6 person-mrem. This collective dose results from airborne radioactive emissions only. Other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2011 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory is 0.58 person-rem, which is greater than the collective population dose of 0.22 person-rem reported for 2010. Tritium contributed 12% of the dose, short-lived air activation products such as carbon-11 from LANSCE contributed 27% of the dose, and transuranic radionuclides, primarily from Material Disposal Area (MDA) B, contributed 52% of the dose. LANSCE has historically been the major contributor to the collective population dose. However, it is not surprising that transuranic radionuclides contributed to the majority of the collective dose in 2011, given that releases from MDA B also resulted in a change in the Rad-NESHAP MEI location. Collective population doses for the past 16 years have generally declined from a high of 4 person-rem in 1994 to less than 1 person-rem in 2011 (Figure 3-1). It is expected that future collective population doses will be less than 1 person-rem. No observable health effects in the local population are expected from this dose.

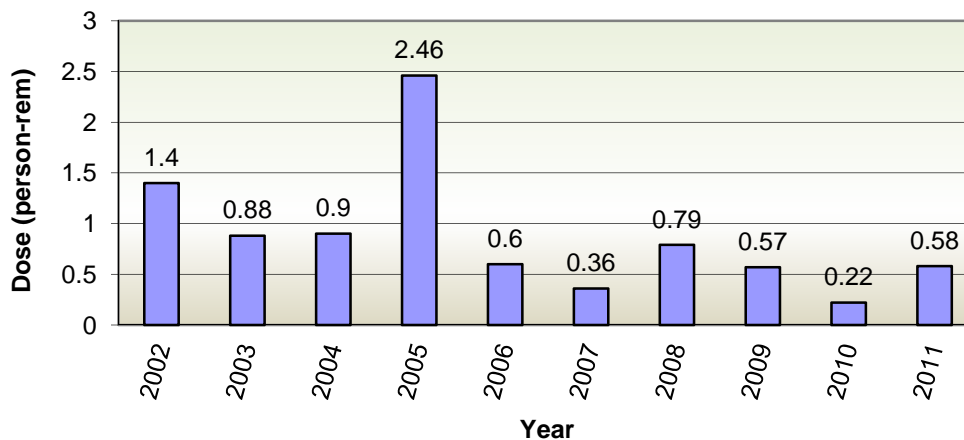


Figure 3-1 Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 years

b. Dose to the Maximally Exposed Individual

The MEI is a hypothetical member of the public who, while not on DOE/LANL property, receives the greatest dose from LANL operations while located at a residence, school, or business. For most of the past 10 years, the airborne pathway (Rad-NESHAP) MEI location has been at 2470 East Road, usually referred to as “East Gate.” East Gate has normally been the location of greatest exposure because of its proximity to LANSCE and the prevailing wind direction. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

i. Airborne Pathway (Rad-NESHAP) MEI Dose

Because the LANSCE emissions have been so low in recent years, the location of the MEI is not as readily apparent as in the past and requires more detailed evaluation, as follows. We know that the dose from LANSCE emissions can be a significant contributor at its facility critical receptor location (East Gate), but much less so at other possible MEI locations. To evaluate different MEI locations, we normally start by determining the LANSCE doses at the East Gate location, and combine that with the AIRNET measurements at East Gate to determine a comparison point. We then examine all other AIRNET measurements at receptor locations that match or exceed this comparison point. At these locations, AIRNET measurements are summed with doses from the LANSCE facility emissions and modeled with CAP88 to determine the dose at each location. The MEI location must be a residence, school, or business.

In 2011, the MDA B cleanup resulted in relatively high measurements of ambient air concentrations of plutonium-239. AIRNET Station 317 measured over 3 mrem, based on summed biweekly measurements. We knew that this level of dose would dominate anything emitted by LANSCE in 2011. Therefore, the business adjacent to Station 317, with an address of 278 DP Road, was clearly the MEI location for 2011 operations. For Station 317, we compared the air concentration measurements as measured by the biweekly “operational trending” analysis and the normal quarterly analysis. The biweekly measurements measured plutonium only because this was the primary pollutant of concern from MDA B. The sum of biweekly analyses results was higher than the quarterly sums for plutonium, so the more conservative biweekly sum value for plutonium isotopes was used for compliance calculations. Quarterly AIRNET measurements were used for other nuclides and added to the plutonium value to determine the final ambient air dose measured at Station 317.

The highest dose to any member of the public at any off-site point where there is a residence, school, or business was 3.53 mrem for radionuclides released by LANL in 2011 (Fuehne 2012). This dose was calculated by adding (1) the dose contributions for each of the point sources at LANL, modeled to the MEI

location using CAP88; (2) the diffuse/fugitive gaseous activation products from LANSCE, modeled to the MEI location using CAP88; (3) the dose measured by the ambient air sampler in the vicinity of the public receptor location; and (4) the potential dose contribution from unmonitored stacks, modeled using CAP88. The annual airborne pathway (Rad-NESHAP) dose in millirem to the MEI over the past ten years, including 2011, is shown in Figure 3-2. Except in 2005, because of a leak from LANSCE, and 2011, the annual airborne pathway dose has been relatively low in comparison with the 10-mrem/yr dose limit.

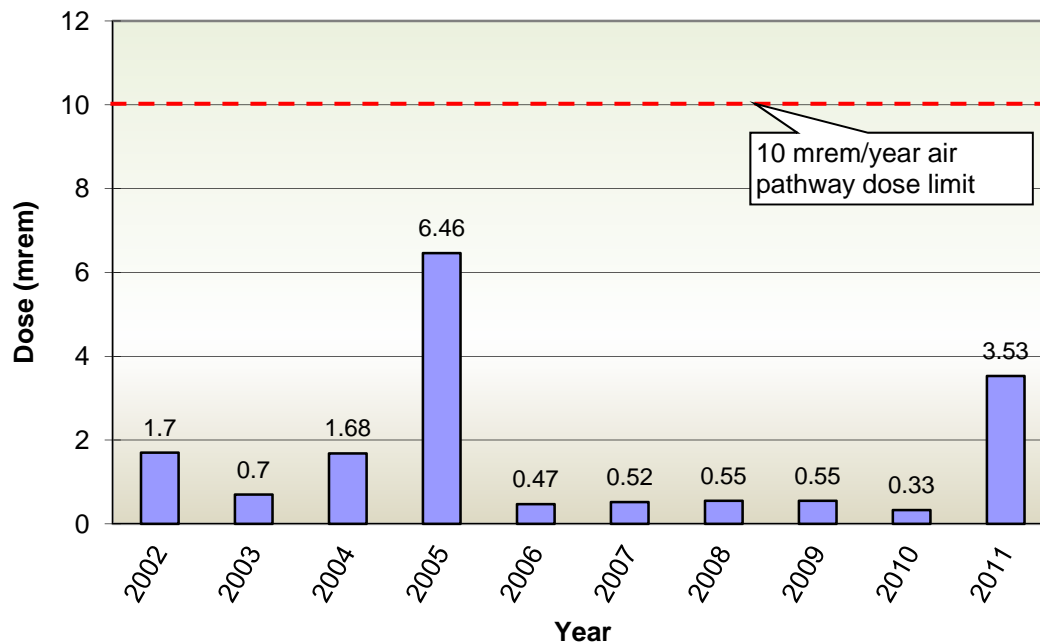


Figure 3-2 Annual airborne pathway (Rad-NESHAP) dose (mrem) to the MEI over the past 10 years

ii. All-Pathways MEI Dose

The location evaluated in 2011 as the potential all-pathways MEI (in accordance with DOE Order 5400.5) is the Laboratory boundary near the Pueblo de San Ildefonso sacred area north of TA-54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, emits neutrons. The measured neutron dose at the boundary was 10 mrem/yr for 2011. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose is 0.5 mrem/yr (8 mrem/16). The gamma dose is calculated to be less than 0.01 mrem and is not included because it cannot be distinguished from the much higher gamma background measured at this and other nearby monitoring locations. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks and diffuse emissions as 0.001 mrem/yr (0.01 mrem/16). We added the dose derived from measurements at the highest-dose AIRNET station along the northern boundary of Area G (7 mrem/yr) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.4 mrem/yr. This resulted in a total dose at this location of approximately 0.9 mrem/yr, which is less than the Rad-NESHAP MEI dose at the 278 DP Road location.

iii. MEI Dose Summary

The Rad-NESHAP MEI dose of 3.53 mrem/yr at the 278 DP Road location is below the 10-mrem/yr EPA airborne emissions dose limit for the public (EPA 1986), and based on previous studies, we conclude it causes no observable health effects (BEIR 2006). The dose of 0.9 mrem/yr at the Laboratory boundary of the Pueblo de San Ildefonso sacred area north of Area G is below the 100-mrem/yr DOE limit for all pathways and the 25-mrem/yr dose constraint (DOE 1993, 1999). We conclude this dose will not result in observable human health effects.

In most past years, LANSCE has been the major contributor to the Rad-NESHAP MEI dose. Future operations of the facility and associated emissions are expected to stay consistent with recent past years' levels. The 2010 Rad-NESHAP MEI was located at Los Alamos Inn, south. The 2009 and 2008 Rad-NESHAP MEIs were located at East Gate and were primarily because of short-lived air activation emissions from LANSCE. The 2007 Rad-NESHAP MEI was located on DP Road and was primarily because of the re-suspension of plutonium-239 in soil from MDA B.

c. Doses in Los Alamos and White Rock

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

i. Los Alamos

During 2011, the Laboratory contributions to the airborne pathway dose at an average Los Alamos residence were less than 0.1 mrem.

ii. White Rock

During 2011, the Laboratory contributions to the airborne pathway dose at an average White Rock residence were also less than 0.1 mrem.

iii. Dose Summary

The dose contributions from food, water, and soil are discussed in Section B.3.d. and are considered to be essentially a zero dose. In summary, the total annual dose in 2011 to an average White Rock/Los Alamos resident from all pathways was less than 0.1 mrem and is well below the all-pathways dose limit of 100 mrem/yr and the 25-mrem/yr dose constraint. No observable human health effects are expected from this dose.

d. Pathway-Specific Doses

While the maximum airborne pathway dose for 2011 is described above in Section B.3.b.i., other pathway-specific doses are presented below.

i. Water (Ingestion Pathway)

Natural uranium and its decay products are present in the drinking water throughout the region. For further information regarding Los Alamos County drinking water quality in 2011, refer to the Los Alamos Department of Public Utilities "2011 Drinking Water Quality Report" (Los Alamos County 2011). Similarly, for further information regarding the City of Santa Fe drinking water quality in 2011, refer to the City of Santa Fe Water Division "2011 Water Quality Report" (Santa Fe 2011).

ii. Soil (Direct Exposure Pathway)

Because soil samples are collected every three years and the focus of the 2011 collection period was on fish, only a small number of soil samples were collected during this time frame. Radionuclide concentrations measured in soil samples collected from Pueblo de San Ildefonso lands (Tsankawai/PM-1 and San Ildefonso) during 2011 were all well below the 0.1-mrem/yr screening levels (LANL 2003). Screening of these off-site soil concentrations indicates that the annual dose from the soil exposure pathway would result in less than 0.1 mrem/yr to a member of the public residing in these areas.

Only six sample results, from locations in and around TA-54, Area G, and the DARHT facility, exceeded the 0.1-mrem/yr screening criteria: two for transuranic radionuclides (Area G), one for tritium (Area G), and three for uranium-238 (DARHT). However, because these locations are not accessible to the public, there is no public dose through the soil exposure pathway.

In summary, we conclude that the dose from soil at the off-site locations is less than 0.1 mrem/yr (essentially zero), and the anthropogenic radionuclides detected at those locations are primarily from worldwide fallout.

iii. Food (Ingestion Pathway)

In 2011, we focused our analysis on predator and bottom-feeding fish caught upstream (Abiquiu Reservoir and Rio Grande at San Ildefonso) and downstream (Rio Grande and Cochiti Reservoir) from the Laboratory. Although not considered a foodstuff in this region, crawfish were also caught upstream (Rio Grande at San Ildefonso) and downstream (Rio Grande at Los Alamos Canyon) of the Laboratory and analyzed. Screening of the fish muscle and bone radionuclide concentrations indicates that eating these fish would result in an annual dose of less than 0.1 mrem to a member of the public. Initial screening of composite samples of the whole-body crawfish indicated essentially the same outcome, except for the downstream strontium-90 result, which slightly exceeded its screening value. This is not surprising, given that strontium is a homologue of calcium, which are both taken up into crustacean exoskeletons in competition with each other (Rosenthal et al. 1969). Ash from the Las Conchas Fire may have also concentrated strontium-90, a fallout radionuclide, in runoff into the Rio Grande, thus making it available for uptake (refer to Chapter 8, Section A.4.c. for further information). It should also be noted that the upstream and downstream strontium-90 results were not distinguishable from each other, taking into account the total propagated uncertainties (3) of the measurements. Subsequent dose assessment following the screening yielded an annual dose of much less than 0.1 mrem to a member of the public consuming these crawfish.

Road-killed elk and deer were also collected and analyzed during 2011. Screening of the detected radionuclide concentration results from the muscle and bone indicates that the dose from consumption of similar animals would be less than 0.1 mrem/yr to a member of the public.

In conclusion, the food ingestion doses are very low relative to the all-pathways dose limit of 100 mrem/yr and the 25-mrem/yr dose constraint.

iv. Release of Items and Real Property

As part of the TA-21 closure program (refer to Chapter 9, Section D.2. for further information), several lots of decontamination and decommissioning (D&D) debris were shipped to industrial landfills (200 cubic yards to US Ecology in Idaho and 580 cubic yards to Waste Control Specialists in Texas) for disposal in 2011. This debris contained radioactive surface contamination below the authorized release limits in Figure IV-1 of DOE requirements (DOE 1993, 1995). This debris met the waste acceptance criteria of each industrial landfill, and each state's regulatory authority approved the acceptance of the waste. Given the levels of the surface contamination, the potential dose to the public from this pathway is expected to be negligible.

No items were released to the public with radioactive contamination above the authorized release limits in Figure IV-1 of DOE requirements (DOE 1993, 1995) during 2011. This ensured that potential doses to the public from this pathway were negligible.

The transfer of real property (land) from DOE to the public is allowed if the modeled dose is no greater than the authorized release limit of 15 mrem/yr and the modeled dose is ALARA. Pending full implementation of DOE Order 458.1, Radiation Protection of the Public and the Environment, (DOE 2011) (replacement for DOE Order 5400.5), no real property was transferred into the public domain in 2011.

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the potential LANL dose contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b, 2009).

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

The highest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average dose from radon is about 200 mrem/yr to 300 mrem/yr (NCRP 1987b.) In Los Alamos County, the average residential radon concentration results in a dose of 270 mrem/yr and is within the range of the national average (Whicker 2010). An additional 29 mrem/yr results from naturally

occurring radioactive materials in the body, primarily potassium-40, which is present in all food and living cells.

In addition, members of the US population receive an average dose of 300 mrem/yr from medical and dental uses of radiation. Compared with estimates used in previous years, this is a significant increase and is attributable to new information about the average medical dose received by members of the US population (NCRP 2009). About 13 mrem/yr comes from man-made products, such as stone or adobe walls. Therefore, the average total annual dose from sources other than LANL is 782 mrem for a typical Los Alamos resident. Figure 3-3 compares the average natural radiation background (and other sources) in Los Alamos with the average background dose in the United States. The estimated LANL-attributable 2011 all-pathways MEI dose, 0.9 mrem/yr, is about 0.1% of the average US background radiation dose from all sources.

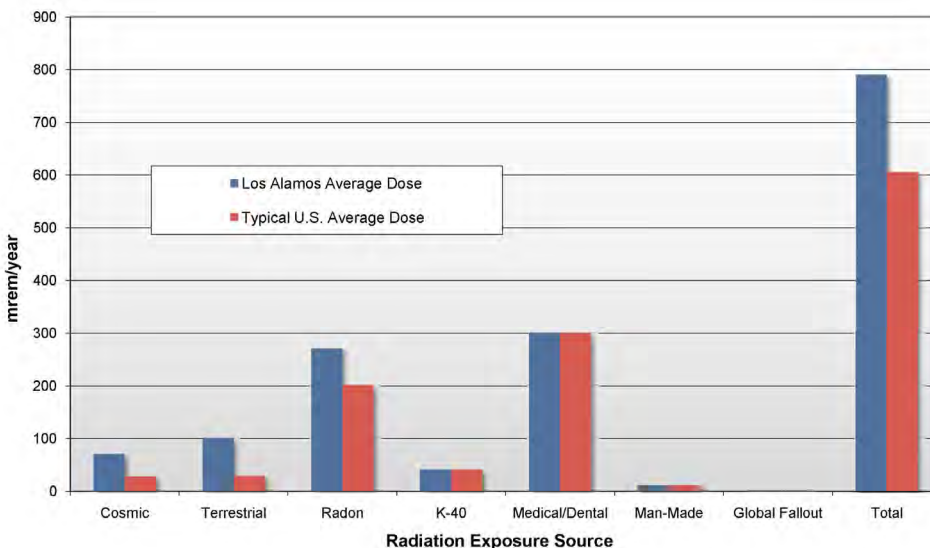


Figure 3-3 Average Los Alamos County radiation background dose compared with average US radiation background dose. Los Alamos County-specific background doses have not been determined for potassium-40, man-made radiation, and global fallout and are assumed to be the same as the US average in this figure.

5. Conclusion

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem), and as low as 1 rem (1,000 mrem) for the in utero fetus (BEIR 2006). However, doses to the public from LANL operations are much lower (Table 3-1). Therefore, the doses presented in this chapter do not cause observable human health effects.

Table 3-1
LANL Radiological Doses for Calendar Year 2011

Pathway	Dose to MEI (mrem/yr)	Percent of DOE 100-mrem/yr Limit	Estimated Population Dose (person-rem)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	3.53 ^a	3.5	0.58	n/a ^b	n/a
Water	< 0.1	< 0.1	0	n/a	n/a
Other pathways (foodstuffs, soils, etc.)	< 0.1	< 0.1	0	n/a	n/a
All pathways	0.9 ^c	0.9	0.58	~343,000	~268,000 ^d

^a Rad-NESHAP MEI dose determined at 278 DP Road.

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

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

^d Based on 270 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 29 mrem/yr from potassium-40, 300 mrem/yr from medical and dental uses of radiation, and 13 mrem/yr from man-made products (see Section B.4).

C. BIOTA DOSE ASSESSMENT

1. Biota Dose Assessment Approach

a. Overview

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

b. Biota Dose Limits

The biota dose limits (DOE 2002) are applied to biota populations rather than to individuals.

The DOE dose limits to biota populations include the following:

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

c. Methods

Annually, the environmental teams measure more than a million analytes from thousands of locations (Table 1-2 in Chapter 1), so we begin with a screening process to focus on the locations where the biota dose could approach the DOE limits. According to the DOE standard, the biota concentration guide (BCG) “provides users with a place to start” and “Exceedance of BCGs leads the user to the more detailed tiers of analysis as needed in a stepwise manner.”

We use screening levels that are a small fraction of the BCGs to ensure we do not overlook unusual combinations of data that might be significant. Water is initially screened against the EPA drinking water standards for humans and further screened against 10% of the applicable BCGs. Soil is screened against 10% of the BCGs, and biota samples are screened against 10% of the values in Module 3 of the DOE standard (DOE 2002.)

2. Biota Dose Results

As summarized in Table 1-2 and described in subsequent chapters, we collected water, soil, and biota samples from many locations in 2011. Most were well below all applicable screening levels. Data that were above a screening level are discussed below.

As reported in Chapter 5, the concentration of strontium-90 in the alluvial groundwater of DP Canyon was 65 pCi/L, which is above the EPA drinking water standard for humans and above 10% of the generic BCG for aquatic systems. However, this is not an aquatic system, so the applicable BCG is 50,000 pCi/L for terrestrial systems. The measured concentration is less than 0.2% of the applicable BCG and therefore passes the screening assessment.

As a result of the Las Conchas Fire, suspended sediment in storm water was above screening levels at some locations. The highest concentrations consisted of natural uranium and global fallout in ephemeral storm water. Detailed analysis using RESRAD-Biota includes consideration of maximum and mean concentrations; natural radioactive material, global fallout, and material from LANL; terrestrial, riparian, and aquatic habitats; and bioaccumulation factors. These considerations are described in a detailed report that concludes that biota doses were below the DOE limits (McNaughton 2012b).

All the soil samples reported in Chapter 7 were far below screening levels. As discussed by McNaughton (2005), previous soil samples at isolated locations have, in the past, exceeded the screening levels, but the more detailed tiers of analysis corresponding to level 2 and level 3 of RESRAD-Biota showed that the biota dose is far below the DOE limits (McNaughton 2005, 2008a, 2008b).

Chapter 8 reports measurements of radionuclides in the tissue and on the surfaces of biota. These data provide direct confirmation of biota doses, either by comparing with Table 2.4 of Module 3 of the DOE standard (2002), or by entering tissue concentrations into the latest versions of RESRAD-Biota. These data confirm the conclusions based on the underlying media of ground water, surface water, soil, and sediment.

3. Conclusion

In conclusion, the extensive data reported in Chapters 6 through 9 demonstrate that biota doses at LANL are well below the DOE limits.

D. NON-RADIOLOGICAL RISK ASSESSMENT

1. Overview

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

This section assesses the potential human health risk from non-radiological materials released from LANL during 2011 and, in some cases, during the previous 65 years of operations at LANL. The Clean Air Act regulates non-radiological air pollutants, as discussed in Chapter 2, Section C.6. The applicable standards for other media are summarized in Table 5-1 (Chapter 5), Table 8-1 (Chapter 8), and Appendix A. Air emissions data are reported in Chapter 2, ambient air data are reported in Chapter 4, and the data for other environmental media are reported in Chapters 5 through 8. The resulting potential human health risks are summarized below.

2. Results

a. General Considerations

Off-site concentrations of non-radiological contaminants in air, water, soil, and food described elsewhere in this report are well below the applicable standards or risk-based concentrations (NMED 2009). The results from LANL monitoring and their potential human health impacts are summarized below.

i. Air (Inhalation Pathway)

Assessments of ambient air quality of non-radiological constituents, as reported in Chapter 4, Section D, indicate that LANL operations are not adversely impacting public health. Ambient PM-10 and PM-2.5

aerosol concentrations, though elevated during the Las Conchas Fire when the townsite was evacuated, were within EPA regulatory standards (Chapter 4, Section D.3). The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4, Section D.4, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.5, are less than 2% of the National Emission Standards for Hazardous Air Pollutants' recommended concentration of 10 nanograms per cubic meter and were similar to previous years.

ii. Groundwater (Ingestion)

Past liquid effluent discharges have affected groundwater quality but primarily in shallow perched alluvial aquifers in a few canyons. These aquifers are separated from deeper regional aquifers by hundreds of feet of dry rock preventing or minimizing the impact of these contaminants on drinking water quality. LANL sampled groundwater at numerous depths and in locations both within and beyond LANL boundaries. The details and a summary of the results of all groundwater measurements are provided in Chapter 5.

Regarding drinking water supplies, LANL collected water samples from 12 Los Alamos County water supply wells. These wells supply water for county residents and the Laboratory. These samples showed no impact from past LANL operations, and we conclude that the water meets all NMED and EPA standards and is safe to drink.

Additional well water sampling was done in the City of Santa Fe's Buckman well field. No evidence of LANL impact was found in this drinking water supply.

In non-drinking groundwater within Laboratory boundaries, LANL has detected hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at levels 19 times the New Mexico groundwater standard (50 µg/L of any dissolved form of chromium) and at about 74% of the New Mexico standard in a Sandia Canyon regional aquifer monitoring well. However, hexavalent chromium has not been detected in Los Alamos County and Santa Fe Buckman drinking water supply wells above natural levels, so there is no unacceptable human health risk from ingestion of water from the drinking water supply wells.

iii. Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals of LANL origin were detected off site. We conclude there is no current risk to the public from surface water and sediment exposure due to LANL operational releases.

Polychlorinated biphenyls (PCBs) are present in the on-site surface water and sediment at levels consistent with previous years. However, there are no aquatic organisms within the LANL boundaries that are part of a food ingestion pathway to humans. PCBs are carried in sediment by storm water runoff to the Rio Grande, so in 2010, sediment samples from the Rio Grande and the Abiquiu and Cochiti reservoirs were analyzed for PCBs using the Aroclor method. Results from upstream and downstream sampling locations show that sources for PCBs are primarily non-LANL (LANL 2012). Looking at these data together, we conclude that there is no measurable contribution of PCBs from LANL to the Rio Grande; therefore, no detrimental human health impacts exist from PCBs.

iv. Soil

Soil concentrations are reported in Chapter 7. The mean contaminant concentrations are below conservative soil screening levels and therefore do not pose a potential unacceptable human health risk.

v. Foodstuffs (Ingestion)

The concentrations of non-radioactive materials in foodstuffs are reported in Chapter 8. No impact of LANL operations was found through foodstuffs like fish, crayfish, elk, and deer. Mercury and PCBs were found in some foodstuffs, and in the case of mercury, the concentrations in fish were above EPA limits. However, mercury levels in fish were similar in both upstream and downstream for both bottom-feeding and predator fish, suggesting sources outside LANL operations. Concentrations of PCBs in fish were lower than in previous years and not significantly different than previous years. Concentrations of other target analyte list (TAL) metals in the edible portions of downstream fish and crayfish represent a negligible contribution to human health risk, and the levels are substantially below consumption limits for fish.

Concentrations of TAL metals and PCBs in several road-killed deer and elk from the Pajarito Plateau were measured. Concentrations of PCBs in the muscle and bone are low and consistent with previous years' measurements. Human health risk from TAL metals and PCBs in deer and elk are negligible.

vi. Biota Sampling

Metal concentrations were measured in several important indicator species to assess potential impacts of particular LANL operations. Specifically, vegetation, deer mice, and bee honey were sampled near the DARHT facility (Chapter 8, Section B.5.b.). Results show concentrations of TAL metals in vegetation were either not detected or were below the RSRL. Several TAL elements were above RSRLs but were below ESLs for other indicator receptor species (no ESL for bee honey). Concentrations of TALs and dioxin and furans in field mice were either not detected or similar to RSRLs.

vii. Potential Future Risks

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

3. Conclusion

The environmental data collected in 2011 show that there is no potential human health or biota risk from non-radiological materials released from LANL.

E. SUMMARY

The following chapters describe a comprehensive program of environmental monitoring and demonstrate that there is no measurable public health or biota risk from LANL materials in the air, water, soil, or foodstuffs.

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To Read About

Turn to Page

<i>Ambient Air Sampling</i>	4-1
<i>Stack Sampling for Radionuclides</i>	4-14
<i>Gamma and Neutron Radiation Monitoring Program</i>	4-20
<i>Non-radiological Ambient Air Monitoring</i>	4-22
<i>Meteorological Monitoring</i>	4-23
<i>References</i>	4-32

A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air sampling network (AIRNET) measures levels of airborne environmental radionuclides, such as plutonium, americium, uranium, tritium, and some activation products. Most regional airborne radioactivity is from fallout (from past nuclear weapons tests worldwide), natural radioactive constituents in particulate matter, terrestrial radon and its decay products, and cosmic radiation products. Table 4-1 summarizes regional levels of airborne radioactivity for the past five years.

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

Analyte	Units ^b	EPA Concentration Limit ^c	Annual Averages				
			2007	2008	2009	2010	2011
Tritium ^d	pCi/m ³	1,500	0.2	0.8	0.2	-0.2	1.3
Am-241	aCi/m ³	1,900	-0.1	-0.3	-0.6	-0.4	0.5
Pu-238	aCi/m ³	2,100	-0.3	0.1	0.4	1.2	1.5
Pu-239	aCi/m ³	2,000	0.6	-0.1	1.0	0.0	0.3
U-234	aCi/m ³	7,700	15	18	17	16	16
U-235	aCi/m ³	7,100	0.8	1.3	0.7	0.6	0.9
U-238	aCi/m ³	8,300	15	17	16	15	16

^a Regional air sampling stations operated by Los Alamos National Laboratory (LANL); locations can vary by year.

^b pCi/m³ = picocuries per cubic meter; aCi/m³ = attocuries per cubic meter.

^c Each US Environmental Protection Agency (EPA) Concentration Limit is from 10 Code of Federal Regulations (CFR) 40 and corresponds to 10 mrem/year.

^d Tritium values have been corrected for the tritium lost to bound water in the silica gel.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days increase soil entrainment; precipitation washes particulate matter out of the air. Meteorological conditions cause large daily and seasonal fluctuations in airborne radioactivity concentrations.

LANL staff compared ambient air concentrations and resulting off-site dose equivalents with the EPA (EPA 1989) 10-millirem (mrem) annual dose equivalent concentration limit. On-site air concentrations and resulting dose equivalents are compared with the US Department of Energy (DOE) 100-mrem annual dose equivalent concentration limit (DOE 1993).

2. Air Monitoring Network

During 2011, LANL operated 59 environmental air stations to sample radionuclides by collecting particulate matter. Some of these stations (35) also collected water vapor.

AIRNET sampling locations (Figures 4-1 through 4-4) are categorized as “regional”, “pueblo”, “perimeter”, “waste site” (Technical Area 54 [TA-54]), “decontamination and decommissioning” (D&D) at Material Disposal Area (MDA) B, or “on-site.”

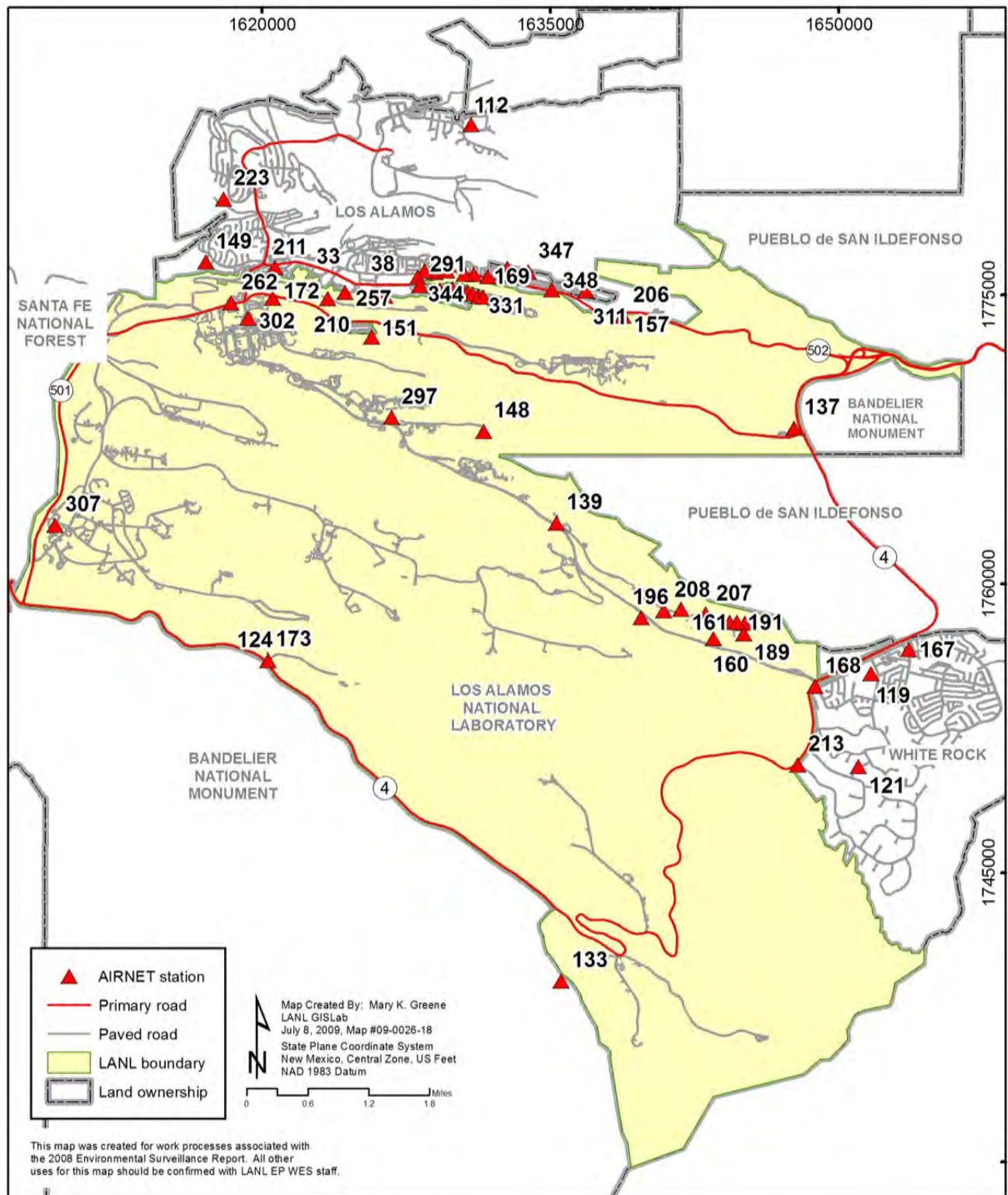


Figure 4-1 AIRNET locations at and near Los Alamos National Laboratory

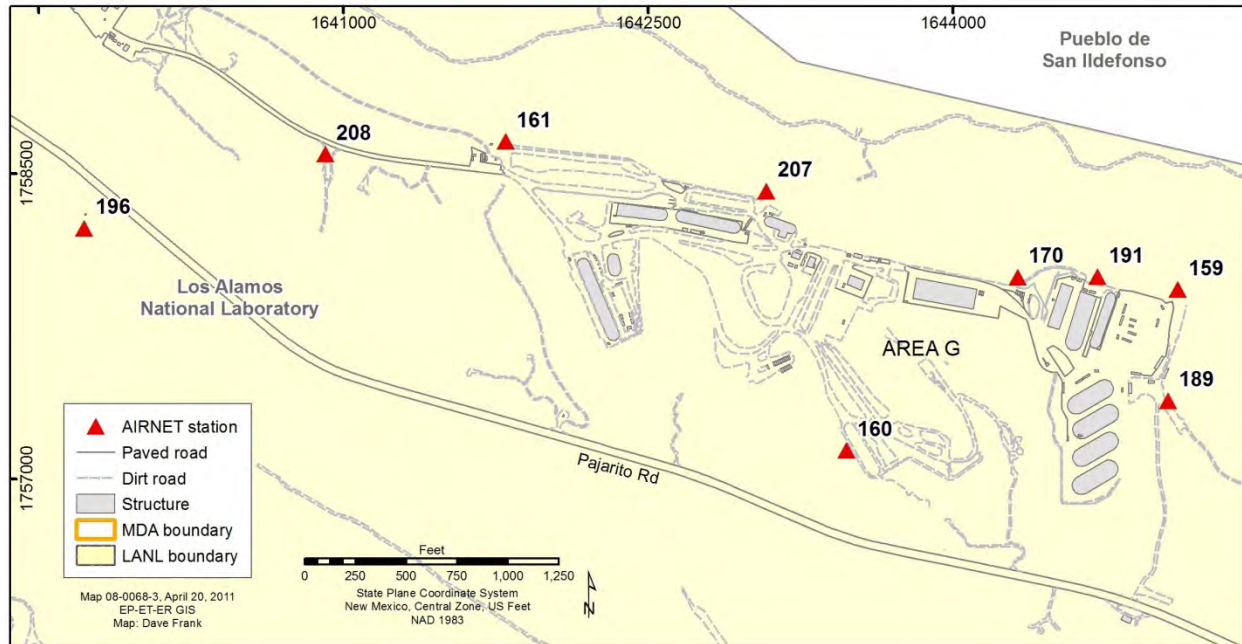


Figure 4-2 AIRNET station locations at TA-54, Area G, Los Alamos National Laboratory

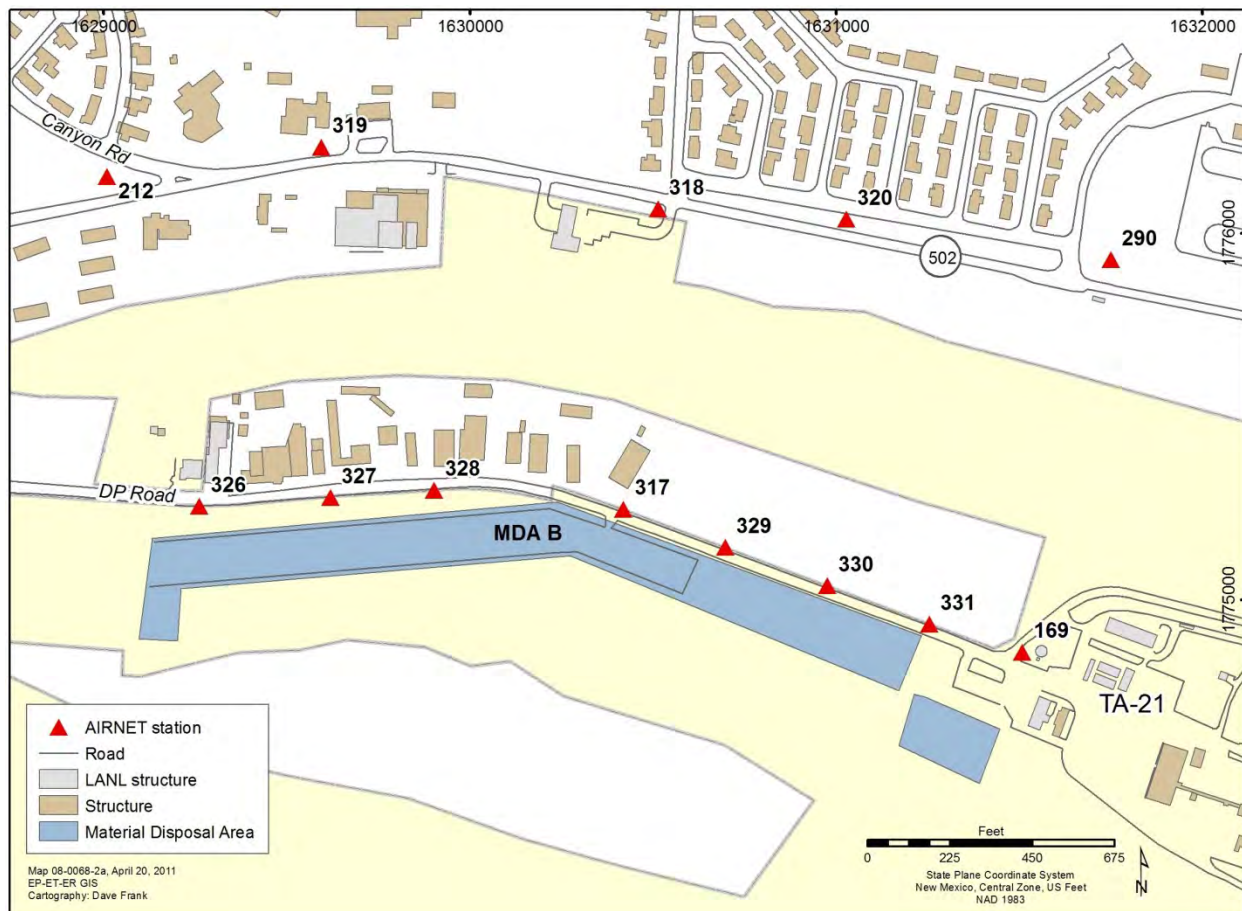


Figure 4-3 AIRNET station locations near TA-21, MDA B

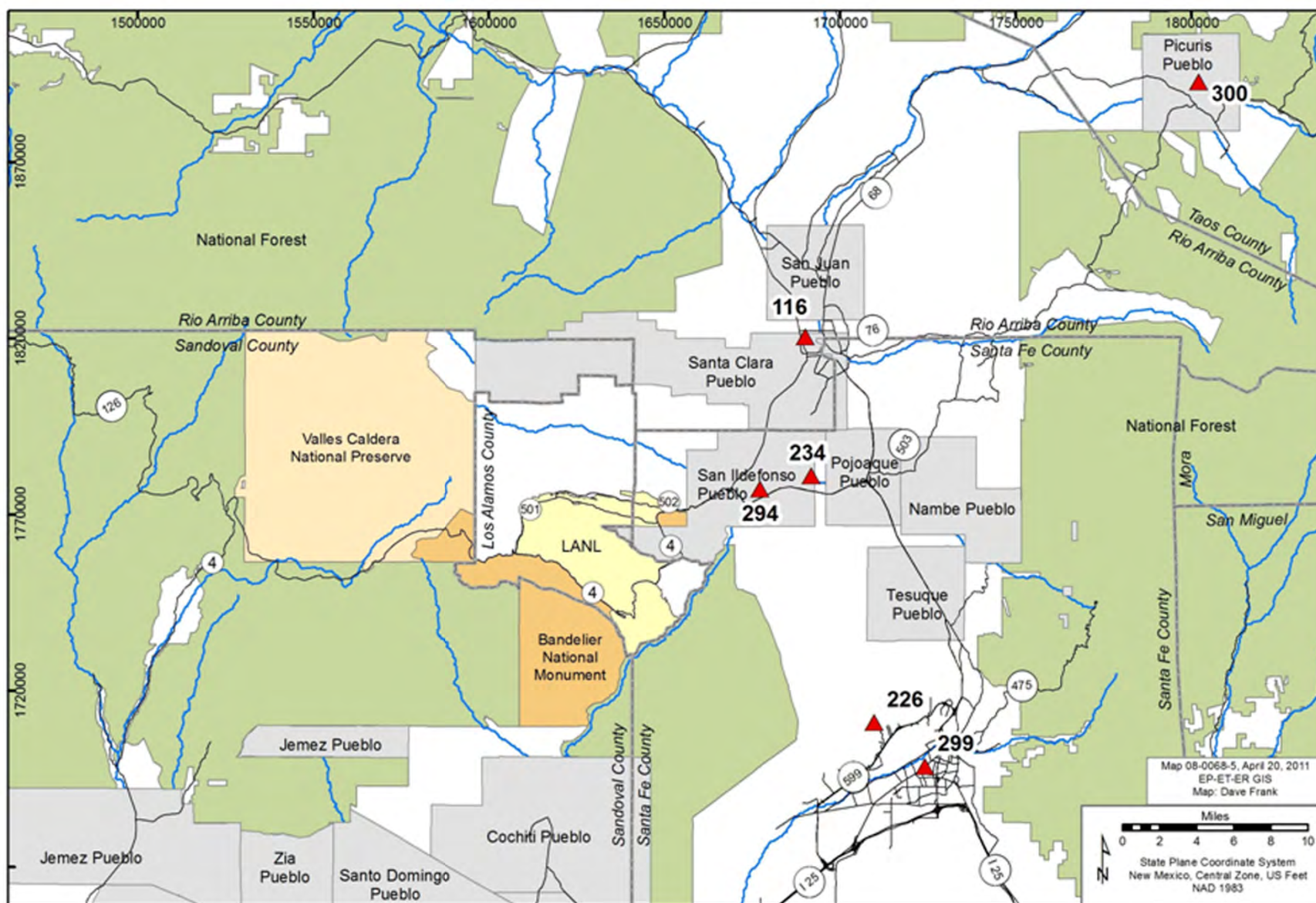


Figure 4-4 Regional and Pueblo AIRNET locations

3. Sampling Procedures, Data Management, Chemical Analysis, and Quality Assurance

The AIRNET quality assurance project plan and implementing procedures provide details about sample collection, sample management, chemical analysis, and data management. These documents are available at www.lanl.gov/environment/air/qa.shtml.

a. Sampling Procedures

Particulate and water-vapor samples are collected from commercially available media of known performance; collected under common chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors; and prepared in a secure and radiologically clean laboratory for shipment. We deliver the samples to all internal and external analytical laboratories under full chain of custody, including secure FedEx shipment, and track them at all stages of their collection and analysis through the AIRNET database. Field sampling and analytical completeness in AIRNET are assessed for each collection period. The AIRNET run time for compliance stations averaged 99.3% for the year.

A station collects a continuous two-week sample. Particulate matter is collected on 47-millimeter polypropylene filters at airflow rates around 110 liters per minute. Cartridges containing about 135 grams of desiccant (silica gel) collect water vapor samples at some stations, with an airflow rate of 0.2 liters per minute. The silica gel is dried in an oven before use. After use in the field, the silica gel is removed from the cartridge and shipped to the analytical laboratory where the moisture is distilled and then analyzed for tritium.

b. Data Management

In the field, personnel record the sampling data on a palm-held microcomputer, including timer readings, volumetric flow rates at the beginning and end of the sampling period, and comments pertaining to these data. These data are later transferred to a database and checked thereafter.

c. Chemical Analysis and Quality Assurance

A commercial laboratory analyzes the filters. Filters are grouped by geographical location into “clumps” and screened for gamma-emitting radionuclides. At the end of the quarter, a composite for each station is made up of six or seven half-filters. Analysts at the laboratory dissolve the composites, conduct a chemical separation, and then analyze for americium, plutonium, and uranium isotopes using alpha spectroscopy. Liquid scintillation spectrometry is used to analyze the gel distillate for tritium. Analytical procedures satisfy Title 40 CFR Part 61, Appendix B. The AIRNET quality assurance project plan specifies the target minimum detectable activities for all samples.

AIRNET maintains a program of blank, spike, duplicate, and replicate analyses. This program provides information on the quality of the data received from the analytical laboratory. These data are reviewed to ensure they meet all quality assurance requirements.

Electronic analytic data are uploaded into the AIRNET databases and promptly checked for quality and consistency. Analytical completeness is calculated, tracking and trending of all blank and control-sample data are performed, and all tracking information documented in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in the database, and periodic reports to management are prepared.

Analytical data completeness was 100% for AIRNET filters and 98.8% for AIRNET silica gel. These numbers indicate that the analytical laboratory continues to perform at the same high level of control as seen in the past several years.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-10 summarize measured 2011 ambient air concentrations. AIRNET concentrations do not have background subtraction but do include blank corrections for radioactivity in the filter

material, acids used to dissolve the filter, and tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Uncertainties for all data in this ambient air sampling section represent a 95% confidence (two standard deviations [2 sigma (s)]) interval. Since confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurements and analytical errors but also seasonal and spatial variations. The 95% confidence intervals are overestimated for the average concentrations and may represent confidence intervals closer to 99%. Negative values are included in averages as their omission would bias averages.

Concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. A control limit of 3s is widely used for statistical quality control charts (Duncan 1986, Gilbert 1987) since the rate of false positives or detections is 5% at 2s but only 0.3% at 3s.

b. Investigation of Elevated Air Concentration Measurements

We have established two action levels to determine the potential impact of an unplanned release. The “investigation” action level, or screening level, is triggered when an air concentration exceeds a five-year average plus 3s at that location. “Alert” action levels are higher concentrations that are based on allowable EPA and DOE annual doses and require a more thorough and immediate follow-up.

When a measured air concentration exceeds an action level, we verify that the calculations were done correctly and that the sampled air concentrations are representative. If measurements are valid and recur, we work with LANL operations personnel to assess potential sources and implement possible mitigation plans.

During the year, investigation levels for americium-241, plutonium-238 and -239, uranium-234, -235 and -238, tritium, and select gamma-emitters were exceeded 187 times. These occurrences, at the Los Alamos Airport hangars and Los Alamos Inn, were brief, and the annual doses at these locations were significantly below the EPA-mandated 10-mrem level. Many concentrations that required further investigation (48%) were related to D&D work at MDA B, and a further 17% were related to operations at Area G. The Fukushima release accounted for 13% of all concentrations requiring further investigations (see Section 5a, Special Monitoring).

c. Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural cosmogenic processes (Eisenbud and Gesell 1997). We measure tritiated water (HTO) because the dose impact is about 25,000 times higher than from gaseous tritium, HT or T₂ (ICRP 1978). We used water-vapor concentrations in the air and tritium concentrations in the water vapor to calculate ambient levels of tritium, including corrections for blanks, bound water in the silica gel, and isotopic distillation effects.

During 2011, all annual mean concentrations were well below EPA and DOE guidelines (Table 4-2). The highest off-site annual tritium concentration at any station was about 0.2% of the EPA public dose limit. We measured elevated tritium concentrations at a number of on-site stations, with the highest annual mean concentration near a known source at TA-54 but at about 2% of the on-site worker exposure limit. Concentrations reflect operations, showing no distinctive trends (Figure 4-5).

Table 4-2
Airborne Tritium as Tritiated Water Concentrations for 2011—Group Summaries

Station Grouping*	Number of Biweekly Samples	Mean \pm 3 standard deviations (pCi/m ³)	Maximum Annual Station Concentration (pCi/m ³)
Regional	102	1.3 \pm 0.7	1.8
Pueblo	48	1.3 \pm 1.0	1.6
Perimeter	564	1.5 \pm 0.3	3.1
D&D	78	1.1 \pm 0.7	2.2

* EPA 40, CFR Part 61, Appendix E, public concentration limit is 1,500 pCi/m³.

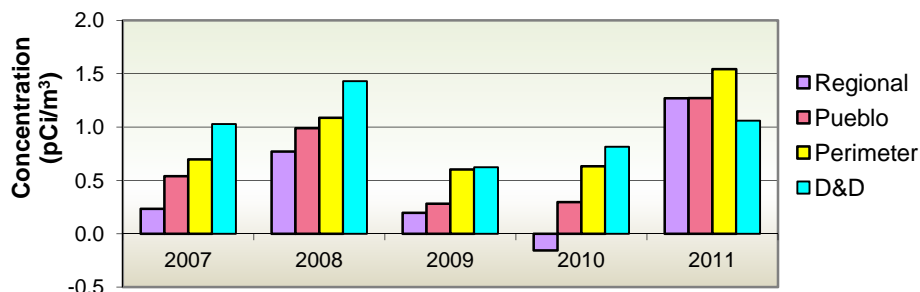


Figure 4-5 Annual average concentrations of tritium by group

d. Americium-241

Americium is present in very low concentrations in the environment. Table 4-3 summarizes 2011 sampling data. The highest annual off-site and on-site averages for any station were below 0.5% of the public and worker limits, respectively. Concentrations show no distinctive trends (Figure 4-6).

Table 4-3
Airborne Americium-241 Concentrations for 2011—Group Summaries

Station Grouping	Number of Quarterly Samples	Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	0.5 \pm 0.9	0.9
Pueblo ^a	8	-0.2 \pm 1.5	0.1
Perimeter ^a	102	0.4 \pm 0.4	2.0
Waste site ^b	32	11 \pm 18	56
On-site ^b	20	0.7 \pm 0.6	1.0
D&D ^a	46	2.4 \pm 2.0	8

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 1,900 aCi/m³.

^b Worker concentration limit is 19,000 aCi/m³.

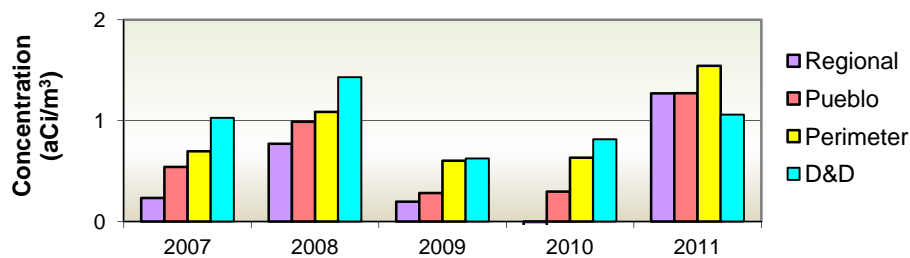


Figure 4-6 Annual average concentrations of americium-241 by group

e. Plutonium

Plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997). Measurable sources in air are usually plutonium research activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, fallout from atmospheric testing of nuclear weapons is the primary source of plutonium in ambient air.

Table 4-4 summarizes the plutonium-238 data for 2011. The highest annual off-site and on-site averages were below 0.5% of the public and worker limits, respectively. Table 4-5 summarizes the plutonium-239/240 data. The highest annual off-site and on-site averages were about 33% and 7% of the public and worker limits, respectively. Higher than usual on- and off-site concentrations are due to work at the MDA B cleanup site and associated operations at Area G. Maximum values for D&D in Tables 4-4 and 4-5 reflect extra monitoring of Pu-238 and Pu-239 done around MDA B.

Table 4-4
Airborne Plutonium-238 Concentrations for 2011—Group Summaries

Station Grouping	Number of Quarterly Samples	Group Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	1.5 \pm 1.1	2
Pueblo ^a	8	1.7 \pm 1.5	2
Perimeter ^a	102	1.3 \pm 0.3	2
Waste site ^b	32	12 \pm 30	80
On-site ^b	20	1.3 \pm 0.7	2
D&D ^a	46	3.1 ^c \pm 0.7	20 ^c

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 2,100 aCi/m³.

^b Worker concentration limit is 21,000 aCi/m³.

Table 4-5
Airborne Plutonium-239/240 Concentrations for 2011—Group Summaries

Station Grouping	Number of Quarterly Samples	Group Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	0.3 \pm 0.3	1.4
Pueblo ^a	8	1.0 \pm 1.0	1.2
Perimeter ^a	102	12 \pm 15	155
Waste site ^b	32	300 \pm 530	1350
On-site ^b	20	4 \pm 5.5	8
D&D ^a	46	130 ^c \pm 100	650 ^c

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 2,000 aCi/m³.

^b Worker concentration limit is 20,000 aCi/m³.

Figures 4-7 and 4-8 show the annual grouping average concentrations. The increased concentration of plutonium-239 in 2011 was due to MDA B cleanup and associated operations.

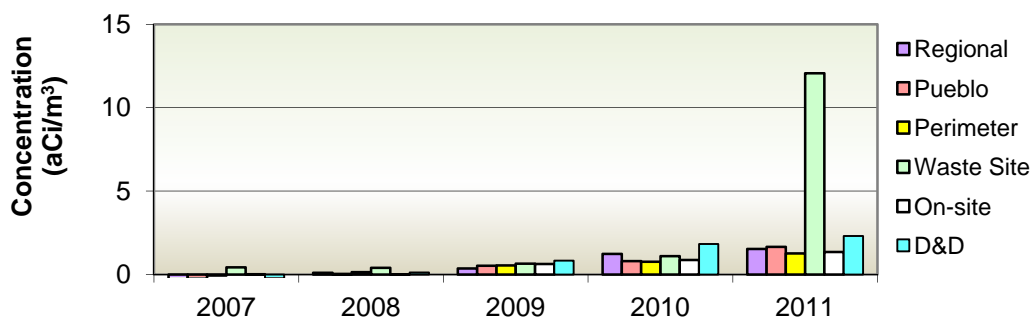


Figure 4-7 Annual average concentrations of plutonium-238 by group

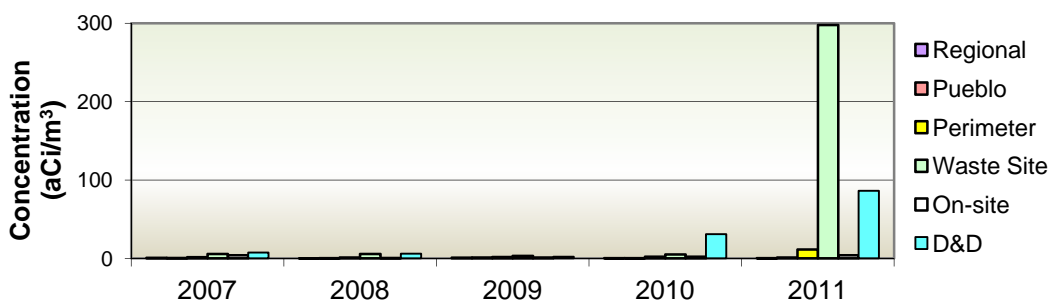


Figure 4-8 Annual average concentrations of plutonium-239/240 by group

f. Uranium

Uranium-234, -235, and -238 are found in nature. Natural uranium has constant and known relative isotopic abundances. Uranium-238 activity is generally equal to uranium-234 (Walker et al. 1989). LANL emissions over the past 60 years have been either enriched in uranium-234 and uranium -235 (EU) or depleted uranium (DU). If uranium-234 and -238 concentrations differ by more than 3s, we note an EU or DU presence. No EU or DU was detected in 2011. Off-site annual mean concentrations of uranium isotopes (Tables 4-6 to 4-8) were below 0.5% of the EPA guidelines; the on-site concentrations were below 0.1% of the EPA guidelines. The highest annual uranium concentrations are typically at dusty locations.

**Table 4-6
Airborne Uranium-234 Concentrations for 2011—Group Summaries**

Station Grouping	Number of Quarterly Samples	Group Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	16 \pm 8	20
Pueblo ^a	8	22 \pm 15	25
Perimeter ^a	102	10 \pm 3	35
Waste site ^b	32	20 \pm 15	45
On-site ^b	20	10 \pm 5	15
D&D ^a	46	20 \pm 5	35

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 7,700 aCi/m³.

^b Worker concentration limit is 77,000 aCi/m³.

Table 4-7
Airborne Uranium-235 Concentrations for 2011—Group Summaries

Station Grouping	Number of Quarterly Samples	Group Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	0.9 \pm 0.9	1
Pueblo ^a	8	0.9 \pm 3.5	2
Perimeter ^a	102	0.5 \pm 0.5	4
Waste site ^b	32	1.1 \pm 0.7	2
On-site ^b	20	0.1 \pm 0.7	1
D&D ^a	46	0.8 \pm 0.5	2

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 7,100 aCi/m³.

^b Worker concentration limit is 71,000 aCi/m³.

Table 4-8
Airborne Uranium-238 Concentrations for 2011—Group Summaries

Station Grouping	Number of Quarterly Samples	Group Mean \pm 3 standard deviations (aCi/m ³)	Maximum Annual Station Concentration (aCi/m ³)
Regional ^a	16	16 \pm 8	20
Pueblo ^a	8	22 \pm 20	30
Perimeter ^a	102	10 \pm 3	35
Waste site ^b	32	20 \pm 15	45
On-site ^b	20	10 \pm 5	15
D&D ^a	46	18 \pm 5	35

^a EPA 40 CFR Part 61, Appendix E, public concentration limit is 8,300 aCi/m³.

^b Worker concentration limit is 83,000 aCi/m³.

g. Gamma Spectroscopy Measurements

For gamma screening, we group filters across sites in “clumps” for each sampling period and analyze for the following: actinium-228, americium-241, beryllium-7, bismuth-212 and 214, cobalt-60, cesium-134 and 137, iodine-131, potassium-40, sodium-22, protactinium-234m, lead-212 and 214, thorium-234, and thallium-208. We investigate any measurement of these analytes above its minimum detectable activity, which we use as a screening level. Over a single two-week period, we detected iodine-131 (30 femto-curies per cubic meter), cesium-134 and 137 (each at 20 fCi/m³) following the Fukushima incident in March 2011. See Section 5a, Special Monitoring, for more detail.

We analyze for the naturally occurring radionuclides beryllium-7, potassium-40, and lead-210. We initiate investigations when elevated levels are found. None were detected during 2011.

5. Special Monitoring

During emergencies or unusual events, the routine monitoring systems described in this chapter are supplemented by special monitoring. There were two such events during 2011: the disaster at the Fukushima Daiichi nuclear power plant following the earthquake and tsunami on March 11, 2011; and the Las Conchas Fire that began on June 26, 2011.

a. Fukushima

On March 11, 2011, the Fukushima Daiichi nuclear power plant was severely damaged by the tsunami that followed the Great East Japan Earthquake, and the reactors subsequently leaked radioactive material. In response, LANL augmented the routine ambient (AIRNET) and stack (National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon [Rad-NESHAP])

measurements with three high-volume samplers: #167 at the Old White Rock Fire Station; #173 at the TA-49 gate, and #211 at the Los Alamos Medical Center.

Previous nuclear reactor accidents, such as the Three-Mile-Island accident in 1979 and the Chernobyl accident in 1986, indicated that the most likely releases were (a) the noble gases: krypton and xenon; and (b) the volatile elements: cesium, tellurium, and iodine. At the latitude of Fukushima, the predominant winds across the Pacific Ocean are from west to east, and models predicted that the plume would arrive in the Western United States after about seven to ten days. By this time, the shorter-lived isotopes had decayed, leaving the fission-product radionuclides with half-lives longer than a few days: xenon-133, krypton-85, cesium-134, cesium-136, cesium-137, tellurium-129m, tellurium-132, iodine-131, and iodine-132.

As expected, cesium-134, cesium-136, cesium-137, tellurium-129m, tellurium-132, iodine-131, and iodine-132 were all detected by all three high-volume samplers, beginning with the March 17–21 sampling period, peaking during the March 24–28 period, and continuing through the April 15–18 period. Similar results were detected by the AIRNET system, peaking during the March 15–29 period and continuing through the April 12–26 period (McNaughton et al. 2011.)

Both AIRNET and the high-volume samplers use polypropylene filters, which are not ideal for volatile elements such as radio-iodine, so the filter data were supplemented with data from the charcoal cartridges of the Rad-NESHAP stack-sampling system. These cartridges are preceded by particulate filters so they measure only radio-iodine in the vapor phase. Iodine-131 vapor was first detected during the week of March 15–22. Concentrations peaked during the week of March 22–29 and then decreased during the next week. The highest vapor concentration measured with charcoal cartridges was 0.5 pCi/m^3 , which is about twice the highest particulate concentration measured by polypropylene filters: 0.3 pCi/m^3 . The total dose from iodine-131 was less than 1 mrem, and the total dose from the combination of other radionuclides was also less than 1 mrem (McNaughton et al. 2011)

All previous releases from nuclear reactors have been dominated by noble gases, primarily krypton and xenon, which are not measured by the high-volume samplers, the AIRNET system, or the Rad-NESHAP stack-sampling system. However, the gamma rays from noble gases are detected by the Neighborhood Environmental Watch Network (NEWNET). All NEWNET detectors recorded an increase after March 19 (Figure 4-9). The dose rates peaked on March 25 and then declined approximately with the five-day half-life of xenon-133, returning to near normal levels after April 2. After subtracting the natural background radiation of $17.0 \text{ micro-Roentgen/hour } (\mu\text{R/h})$, the external dose indicated by NEWNET was less than 0.1 mrem.

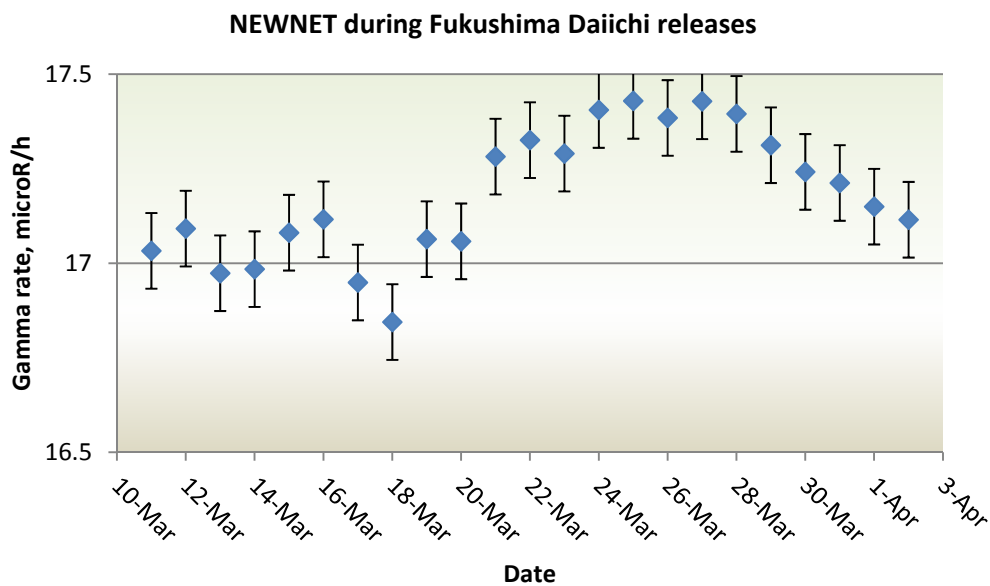


Figure 4-9 NEWNET data during the releases from Fukushima Daiichi. A statistically significant increase was observed, beginning about 10 days after the March 11 tsunami, peaking about five days later, and then decreasing for the next week.

In summary, the system of detectors in place at Los Alamos was able to measure the combination of fission products from Fukushima Daiichi and show that the concentrations were far below hazardous levels.

b. Las Conchas Fire

The Las Conchas Fire started on Sunday June 26, 2011, in the Santa Fe National Forest, approximately 12 miles southwest of LANL (www.inciweb.org/incident/2385/). Investigators believe the fire started after an aspen tree was blown down onto nearby power lines during a period of strong winds. Mandatory evacuation of the Los Alamos town site was ordered on Monday, June 27, and the Laboratory remained closed from June 27 through July 5. One spot fire occurred on the LANL property during this time period. This fire was approximately 2 acres in size, along the south boundary of TA-49. It was on the mesa top, not in the canyon. Additionally, 90 acres of LANL land burned during back burns west of State Road 501.

Air monitoring used several independent systems, some data from them are reported here and elsewhere. The standard AIRNET system was supplemented by high-volume samplers operated by the AIRNET team, by the LANL Field Monitoring Team, and by the Radiological Assistance Program (RAP) team (www.nv.doe.gov/library/factsheets/RAP.pdf). Data were also obtained by the EPA's Airborne Spectral Photometric Environmental Collection Technology (ASPECT) (www.epa.gov/NaturalEmergencies/flyinglab.htm).



Las Conchas Fire, June 2011

Approximately 9,500 analyses were done on the more than 200 air samples collected. Four sets of analyses were performed: gross alpha and gross beta counting, chemical analysis for metals, and gamma and alpha spectroscopy.

Gross alpha and gross beta measurements were elevated, consistent with those measured during the Cerro Grande Fire (LANL 2000, Dewart 2003, Eberhart 2010) and indicated no measurable LANL contamination (Figure 4-10).

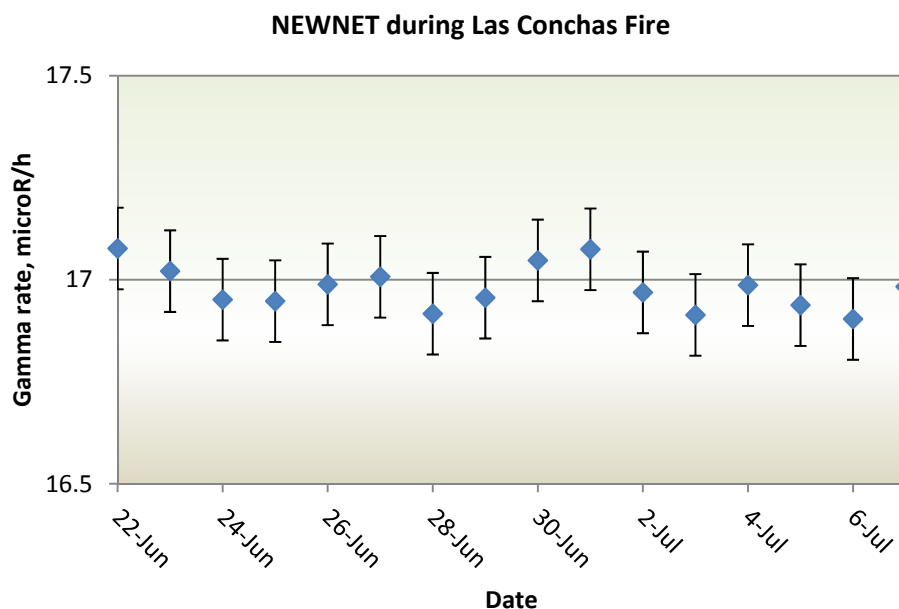


Figure 4-10 NEWNET data before and during the Las Conchas Fire. There were no statistically significant deviations from the normal gamma rate of 17.0 micro-R/h.

The analysis was conducted for the following metals: aluminum, antimony, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. No irregularities were noted. Metals detected were consistent with local geology.

The gamma-emitting isotopes analyzed were as follows: actinium-228, americium-241, beryllium-7, bismuth-212, -214, cobalt-60, cesium-134, -137, iodine-131, potassium-40, sodium-22, protactinium-234m, lead-212, -214, thorium-234, and thallium-208. Detections were made for the naturally occurring isotopes only.

Alpha spectroscopy was performed for plutonium-238, -239, uranium-234, -235, -238, and americium-241. Predictably, natural uranium was measured. No americium-241 or plutonium-238 was detected. Plutonium was measured at locations where it has been detected before: near remediation (15 instances), waste storage (two instances), and legacy waste sites (three instances).

A few observations should be made with respect to these data. Strong winds existed at times during the fire, causing resuspension of material on the ground far from burned areas. Remediation efforts at MDA B were underway in the week preceding the fire, and this period formed part of the collection time for some fire samples.

In summary, we note that the fire produced no additional dose to the public above what would have been expected from normal LANL operations.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Members of the stack monitoring team at LANL evaluate these operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information with the assumption that there are no emission controls in place, such as the high-efficiency particulate air filters that are present on all stacks. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving as much as 0.1 mrem in a year, LANL must sample the stack in accordance with 40 CFR Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities” (Rad-NESHAP) (EPA 1989). During 2011, we identified 28 stacks meeting this criterion.

2. Sampling Methodology

In 2011, we continuously sampled 28 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP). For each of these emission types, LANL employs an appropriate sampling method, as described below.

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

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

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

In previous years, we monitored stacks at LANSCE for tritium. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling for tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions. Emissions of tritium reported in 2011 from LANSCE are based on 2001 tritium generation rates.

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

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis

Analytical methods used comply with EPA requirements in 40 CFR 61, Appendix B, Method 114 (EPA 1989). Section F of this chapter presents the results of analytical quality assurance measurements. This section discusses the sampling and analysis methods for each type of LANL's emissions.

b. Particulate Matter Emissions

Each week, we remove and replace the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions, and we then ship them to an off-site analytical laboratory. Prior to shipping, we screen each sample filter with a hand-held instrument to determine if there are any unusually high levels of gross alpha or beta radioactivity. The laboratory performs analyses for the presence of alpha and beta radioactivity after the sample has been allowed to decay for approximately one week (to allow short-lived radon progeny to decay). In addition to alpha and beta analyses, the laboratory performs gamma spectroscopy analysis to identify specific isotopes in the sample. While alpha and beta counting are performed on individual glass-fiber filters, gamma spectroscopy is performed on "clumps" of filters, a group of seven or eight filters stacked together to allow quick analysis for gamma-emitting radionuclides. Subsequent analyses, if needed, are performed on individual filters.

The glass-fiber filters are composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We use the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compares the results of the isotopic analysis with gross activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; and plutonium-238 and -239/240, etc.) identify all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility, the analytical laboratory only performs gamma spectroscopy analyses based on the anticipated suite of emissions from this facility. Again, we perform hand-screening of each filter prior to shipping them to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation products emissions and ship the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes. For charcoal filters, gamma spectroscopy analyses are performed on individual filters instead of clumped filters.

d. Tritium Emissions

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

e. Gaseous Mixed Activation Products (GMAP) Emissions.

To record and report GMAP emissions, we used continuous monitoring, rather than off-line analysis, for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-line. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total GMAP emissions are measured with the ionization chamber. The real-time current that this ionization chamber

measures is recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determine the relative composition of the emissions. Decay curves are typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes are made at LANSCE, new decay curves and energy spectra are recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2011 totaled approximately 328 Ci (compared with nearly 300 Ci in 2010). Of this total, tritium emissions contributed approximately 101 Ci (compared with 87 Ci in 2010), and air activation products from LANSCE stacks contributed nearly 228 Ci (compared with nearly 211 Ci in 2010). LANSCE diffuse emissions of air activation products contributed another 15 Ci of GMAP. Combined airborne emissions of particulate materials such as plutonium, uranium, americium, and thorium were less than 0.000025 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 0.012 Ci, which is slightly lower than recent years.

Table 4-9 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-9
Airborne Radioactive Emissions (Ci) from LANL Buildings with Sampled Stacks in 2011

TA-Bldg	H-3 ^a	Am-241	Pu ^b	U ^c	Th ^d	P/VAP ^e	GMAP ^{f,i}	Sr-90 ^g
TA-03-029		2.65E-06	1.87E-05	2.64E-06	3.31E-07			5.04E-07
TA-03-102				8.81E-08	1.24E-09			
TA-16-205/450	6.27E+01							
TA-48-001				4.66E-09		1.48E-02		
TA-50-001			6.18E-09					8.17E-08
TA-50-037		<i>No measured emissions in 2011 from this building</i>						
TA-50-069		7.92E-10	5.82E-09	9.59E-10				
TA-53-003	2.00E+01					1.06E-04	5.83E+01	
TA-53-007	4.45E+00					4.19E-03	1.69E+02	
TA-54-231			3.51E-10		9.14E-10			
TA-54-412			1.23E-10		9.70E-10			
TA-55-004	1.35E+01		4.14E-09	3.31E-08	3.51E-08			
Total ^h	1.01E+02	2.65E-06	3.74E-05	5.32E-06	7.00E-07	1.91E-02ⁱ	2.43E+02	1.09E-06

Note: Some buildings have more than one sampled stack.

^a Includes both gaseous and oxide forms of tritium.

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

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

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

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

^f GMAP = Gaseous mixed activation products.

^g Strontium-90 values do not include short-lived radioactive progeny of yttrium-90.

^h Some differences may occur because of rounding.

ⁱ Total for GMAP includes 15 curies released from diffuse sources at TA-53.

Table 4-10 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP. Table 4-11 presents the half-lives of the radionuclides typically emitted by LANL. During 2011, the LANSCE facility non-point source emissions of activated air comprised approximately 15 Ci of carbon-11 and less than 1 Ci of argon-41.

Table 4-10
Detailed Listing of Activation Products
Released from Sampled LANL Stacks in 2011

TA-Building	Nuclide	Emission (Ci)
TA-48-0001	As-72	0.0000637
TA-48-0001	As-73	0.00000762
TA-48-0001	As-74	0.00000618
TA-48-0001	Br-76	0.000150
TA-48-0001	Br-77	0.0000141
TA-48-0001	Ge-68	0.00708
TA-48-0001	Ga-68	0.00708
TA-48-0001	Hg-197	0.000115
TA-48-0001	Hg-197m	0.000115
TA-48-0001	Mn-54	0.0000000170
TA-48-0001	Se-75	0.000164
TA-53-0003	Ar-41	2.33
TA-53-0003	As-73	0.00000196
TA-53-0003	Be-7	0.0000376
TA-53-0003	Br-76	0.00000500
TA-53-0003	Br-77	0.00000119
TA-53-0003	Br-82	0.0000606
TA-53-0003	C-11	55.98
TA-53-0007	Ar-41	14.9
TA-53-0007	As-73	0.0000166
TA-53-0007	Br-76	0.000301
TA-53-0007	Br-77	0.0000166
TA-53-0007	Br-82	0.00238
TA-53-0007	C-10	0.288
TA-53-0007	C-11	71.47
TA-53-0007	Hg-197m	0.000734
TA-53-0007	Hg-197	0.000734
TA-53-0007	N-13	34.81
TA-53-0007	N-16	0.621
TA-53-0007	Na-24	0.00000218
TA-53-0007	O-14	0.740
TA-53-0007	O-15	46.68
TA-53-0007	Os-191	0.00000656
TA-53-0007	Se-75	0.00000261
TA-53-0007	Ar-41	14.9
TA-53-0007	As-73	0.0000166
TA-53-0007	Br-76	0.000301
TA-53-0007	Br-77	0.0000166
TA-53-0007	Br-82	0.00238
TA-53-0007	C-10	0.288
TA-53-0007	C-11	71.47

Table 4-11
Radionuclide Half-Lives

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

5. Long-Term Trends

Figures 4-11 to 4-14 present radioactive emissions from sampled LANL stacks and illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady over recent years, varying slightly each year but staying in the low-microcurie range. Tritium emissions remained low as in recent years, reflecting minimal operations taking place at the main tritium facility during the year. In 2011, emissions of GMAP were similar to those measured in 2010. GMAP levels dropped dramatically from 2009 levels due to a change-out of the primary beam irradiation target at TA-53, Building 7, prior to the 2010 run cycle at LANSCE.

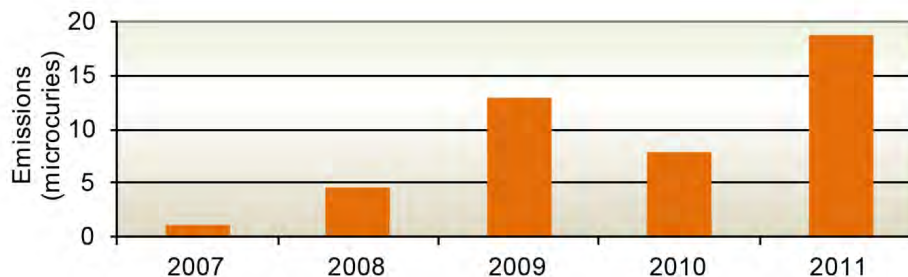


Figure 4-11 Plutonium emissions from sampled LANL stacks

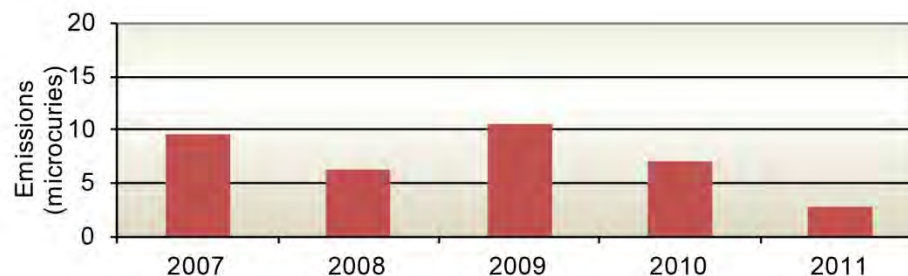


Figure 4-12 Uranium emissions from sampled LANL stacks

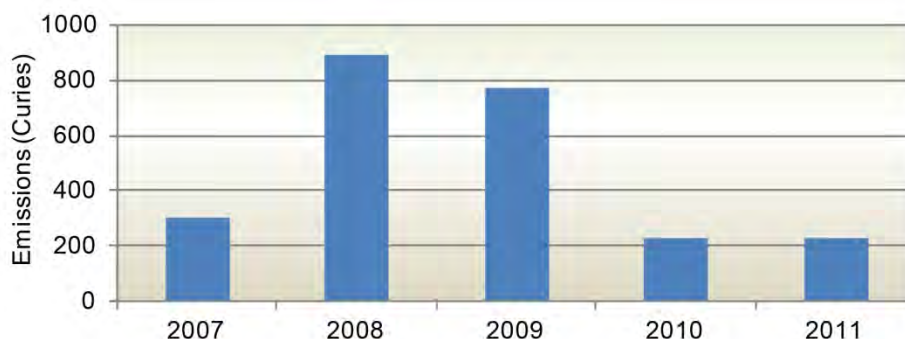


Figure 4-13 Tritium emissions from sampled LANL stacks

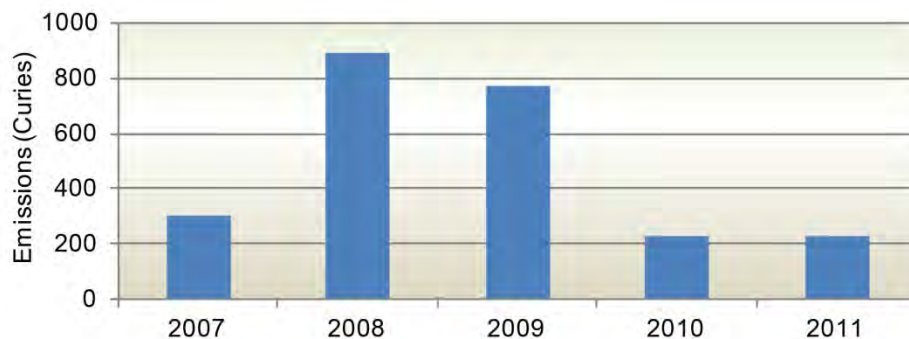


Figure 4-14 GMAP emissions from sampled LANL stacks

LANSCE operated in the same configuration as recent years, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center, causing the majority of radioactive air emissions. Operations to the 1L Target took place from late spring of 2011 through the end of the calendar year.

The emissions control system at the LANSCE 1L Target is a “delay line,” which retains the short-lived activation products for a short time before release out the stack. This time interval allows decay of the short-lived radionuclides to non-radioactive components. As mentioned, the primary beam irradiation target at TA-53, Building 7, was changed out prior to the 2010 run cycle. This resulted in a more controlled irradiation environment and less generation of activated air or other particulates and vapors.

Figure 4-15 shows the individual contribution of each emission type to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. This plot does not directly relate to off-site dose because some radionuclides have a higher dose impact per curie released than others. GMAP and tritium remain the highest contributors to the total curies released. These gas-phase nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. GMAP and tritium emissions continue to fluctuate as the major emissions type; tritium facility operations and LANSCE operations vary from year to year. GMAP emissions are normally the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL boundary.

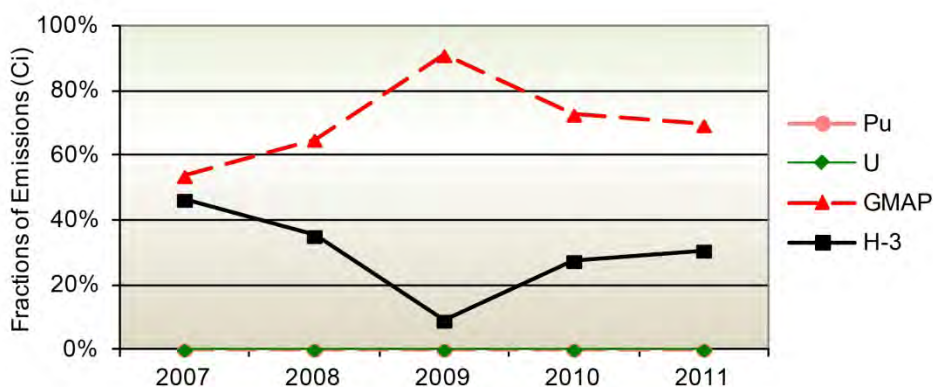


Figure 4-15 Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

The objective of the Direct Penetrating Radiation Network (DPRNET) and NEWNET is to monitor gamma and neutron radiation in the environment, outside of the workplace, as required by DOE Order 458.1, Section 4.e, and as described in McNaughton et al. (2000).

In Northern New Mexico, naturally occurring radiation varies from approximately 100 to 200 mrem/year, so it is difficult to measure the much smaller radiation from LANL. To meet the objectives, measurements are made both at public locations and close to potential sources, and the data are compared with models of radiation as a function of distance. Radiation from LANL is then apparent from the high levels close to the source, and the trend with distance establishes the levels at public locations.

Sources that are constant with time are monitored with thermo-luminescent dosimeters (TLDs). Time-varying sources are monitored by NEWNET. For example, radiation from LANSCE depends on whether the accelerator is on or off, and short-lived activation products such as carbon-11 are only detected when the wind is directed from the source to the detector. These fluctuations are apparent in the real-time NEWNET displays at newnet.lanl.gov.

For the past 10 years, neutron radiation has been a significant contributor to the all-pathway maximally exposed individual (MEI) near Area G. However, in 2011, DPRNET showed that dose rates near Area G decreased significantly (see Figures 4-16 and 4-17). These decreases are a result of waste being shipped off site to the Waste Isolation Pilot Plant (WIPP).

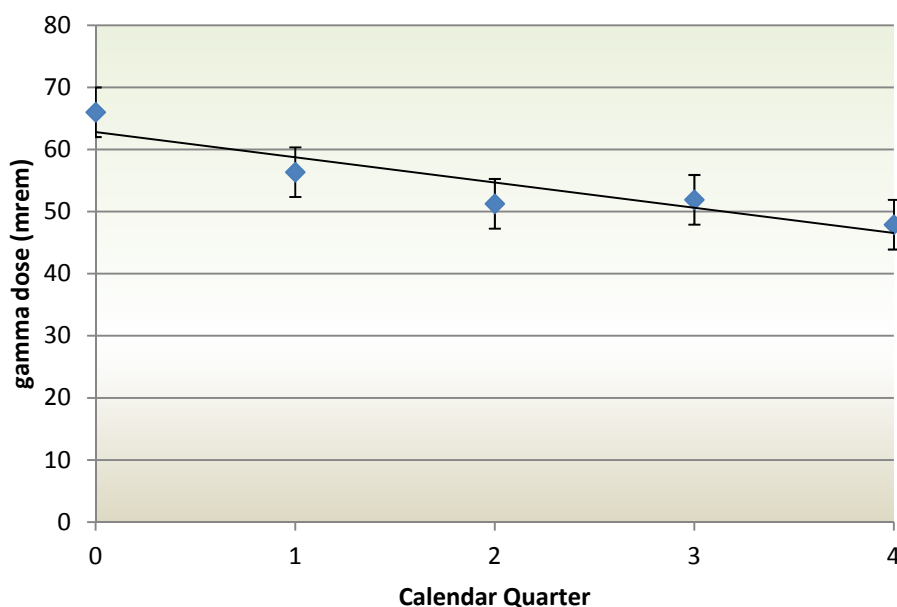


Figure 4-16 Average quarterly gamma doses (mrem) around the perimeter of Area G for calendar quarters 1, 2, 3, and 4 of 2011. The first point, 66 ± 4 mrem, is the average of the preceding 36 calendar quarters. The quarterly dose from natural background is approximately 35 mrem.

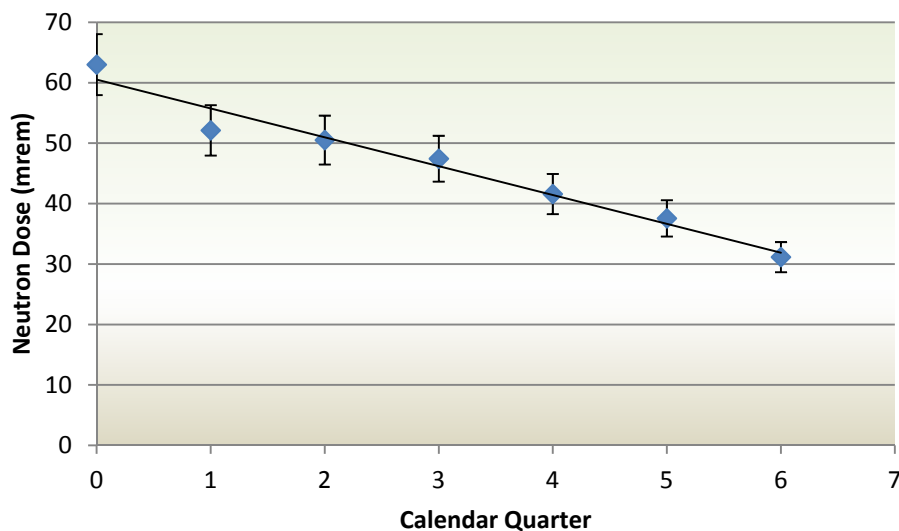


Figure 4-17 Average quarterly neutron doses (mrem) around the perimeter of Area G for the last two quarters of 2010 and the four quarters of 2011. The first point, at 63 mrem, is the average of the preceding 14 calendar quarters. Natural background contributes less than 1 mrem to each point.

a. Dosimeter Locations

We placed 98 TLD stations around LANL and in the surrounding communities. There is a TLD at every AIRNET station (shown in Figures 4-1 and 4-3). Additional stations are around TA-54, Area G (shown in Figure 4-18); at TA-53, LANSCE (eight stations); at Santa Clara Pueblo (five stations); and inside the Pueblo de San Ildefonso sacred area (two stations).

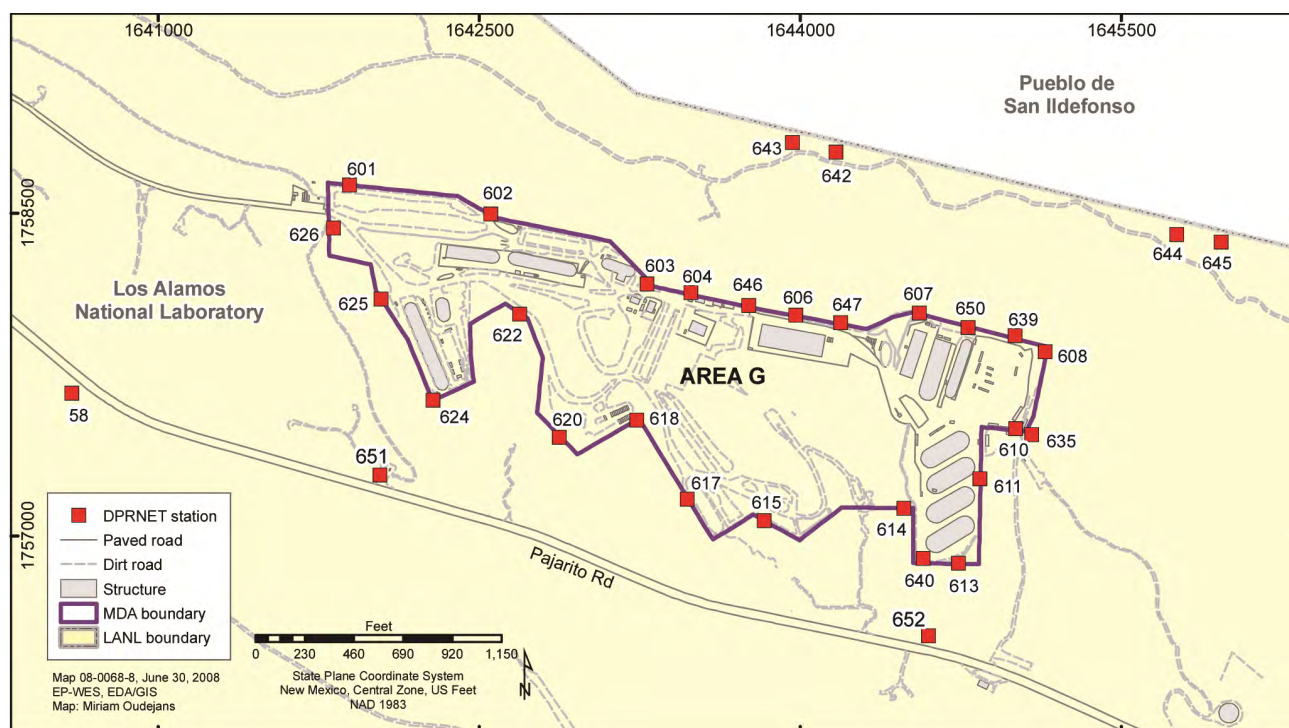


Figure 4-18 Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET)

b. Neutron Dosimeters

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

c. Neutron Background

We measure the neutron background at station #25, near Bandelier National Monument, and station #101 in Santa Fe. The average neutron background at these two stations is 2 ± 1 mrem/year.

2. Quality Assurance

The calibration laboratory at LANL's Health Physics Measurements Group (RP-2) calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that RP-2 provides, and RP-2 provides QA for the dosimeters. The uncertainty in the TLD data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall uncertainty (one standard deviation) is similar to previous data and is 8%.

3. Results

The annual dose equivalents at all stations except those within TA-53 or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data Table S4-8. The only locations with a measurable contribution from LANL operations are within the boundaries of TA-53 (LANSCE) and near TA-54 (Area G). Figure 4-18 shows the locations of the stations at TA-54, Area G.

South of the line of TLDs from TLDs #601 to #608, Area G is a controlled-access area, so these data are not representative of a potential public dose. However, TLDs #642 and #643 are close to the boundary of the Pueblo de San Ildefonso sacred area, which is accessible to members of the Pueblo. Furthermore, TLDs #133 and #134 are deployed by Pueblo staff within the boundaries of the sacred area.

After subtracting background, the annual doses measured by TLDs #134, #642, and #643 were 8 mrem, 4 mrem, and 4 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Cañada del Buey and are shielded by the rim of the canyon. These are the doses that would be received by a person who is at the location of the TLDs 24 hours per day, 365 days per year. As discussed in Chapter 3, we apply an occupancy factor of 1/16 (NCRP 1976) so the public dose near TLD #134 is calculated to be 0.5 mrem/yr, which is less than previous years.

TLD #133 is located several hundred meters farther from Area G and measures nothing above the terrestrial and cosmic-ray natural background. This is expected because of the distance and the shielding provided by the air. Annual doses of 10 and 12 mrem were measured by TLDs #651 and #652, respectively, which are located along Pajarito Road, south of Area G. This section of Pajarito Road has limited public access.

4. Conclusion

Generally, the data are similar to previous years, except for a decreasing trend at and near Area G, as shown in Figures 4-16 and 4-17. The results are far below the applicable limits; when an occupancy factor is included, the largest doses at public locations are all less than 1 mrem/year.

D. NON-RADIOLOGICAL AMBIENT AIR MONITORING**1. Introduction**

The non-radioactive ambient air monitoring network consists of two types of measurements: AIRNET total suspended particulate matter samples analyzed for selected non-radiological species and tapered-element oscillating microbalance (TEOM) samplers, which directly measure particulate matter smaller than 10 micrometers in diameter (PM-10) and particulate matter smaller than 2.5 micrometers (PM-2.5). We do not measure other regulated non-radiological species. See Chapter 2 for a full discussion of the non-radiological compliance program.

2. Air Monitoring Network and Equipment

Ambient particulate matter monitoring continued at the old White Rock Fire Station on Rover Boulevard and at the Los Alamos Medical Center. Two monitors run at each location: one for PM-10 particles and another for PM-2.5 particles. A TEOM ambient particulate monitor is fitted with an appropriate sample inlet. The microbalance has an oscillating ceramic “finger” with a filter that collects particles. The mass of accumulated particulate matter is derived and saved for later download. These data measure the dust and pollutant loadings in the atmosphere.

3. Ambient Air Concentrations

This year, the particulate matter data collection efficiency was above 97%. Annual averages, 24-hour maxima, and EPA standards are shown in Table 4-12. The Wallow and Las Conchas Fires of 2011 raised all maxima and averages.

4. Detonation and Burning of Explosives

LANL uses explosives at firing sites but also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2011, LANL consumed roughly 5,200 kilograms of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicated no adverse air-quality impacts.

5. Beryllium Sampling

We analyzed quarterly composite samples from 37 stations either in nearby communities or near potential beryllium sources at LANL. New Mexico has no ambient air quality standard for beryllium. All concentrations measured this year were below 2% of the NESHAP standard of 10 nanograms per cubic meter from 40 CFR Part 61 Subpart C (EPA 1989) and were similar to concentrations found in recent years.

E. METEOROLOGICAL MONITORING

1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, the meteorology team measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Johnson and Young 2008) provides details of the meteorological monitoring program. An electronic copy of the “Meteorological Monitoring Plan” is available online at www.weather.lanl.gov/.

2. Monitoring Network

A network of seven stations gathers meteorological data at the Laboratory (Figure 4-19). Four of the stations are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and one in Mortandad Canyon [MDCN]), and one is on top of Pajarito Mountain (PJMT). A precipitation gauge is also located in North Community (NCOM) of the Los Alamos town site. The TA-6 station is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is part of the TA-6 meteorological station and measures wind speed and direction to an elevation of approximately 2,000 meters above ground level.

Table 4-12
PM-2.5 and PM-10 Concentration Summary for 2011

Station Location	Constituent	Maximum 24 Hour ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Los Alamos Medical Center	PM-10	275	19
	PM-2.5	262	10
White Rock Fire Station	PM-10	149	17
	PM-2.5	123	8
EPA standard ^a	PM-10	150	n/a ^b
	PM-2.5	35	15

^a EPA 40 CFR Part 50 and www.epa.gov/air/criteria.html.

^b n/a = None applicable.

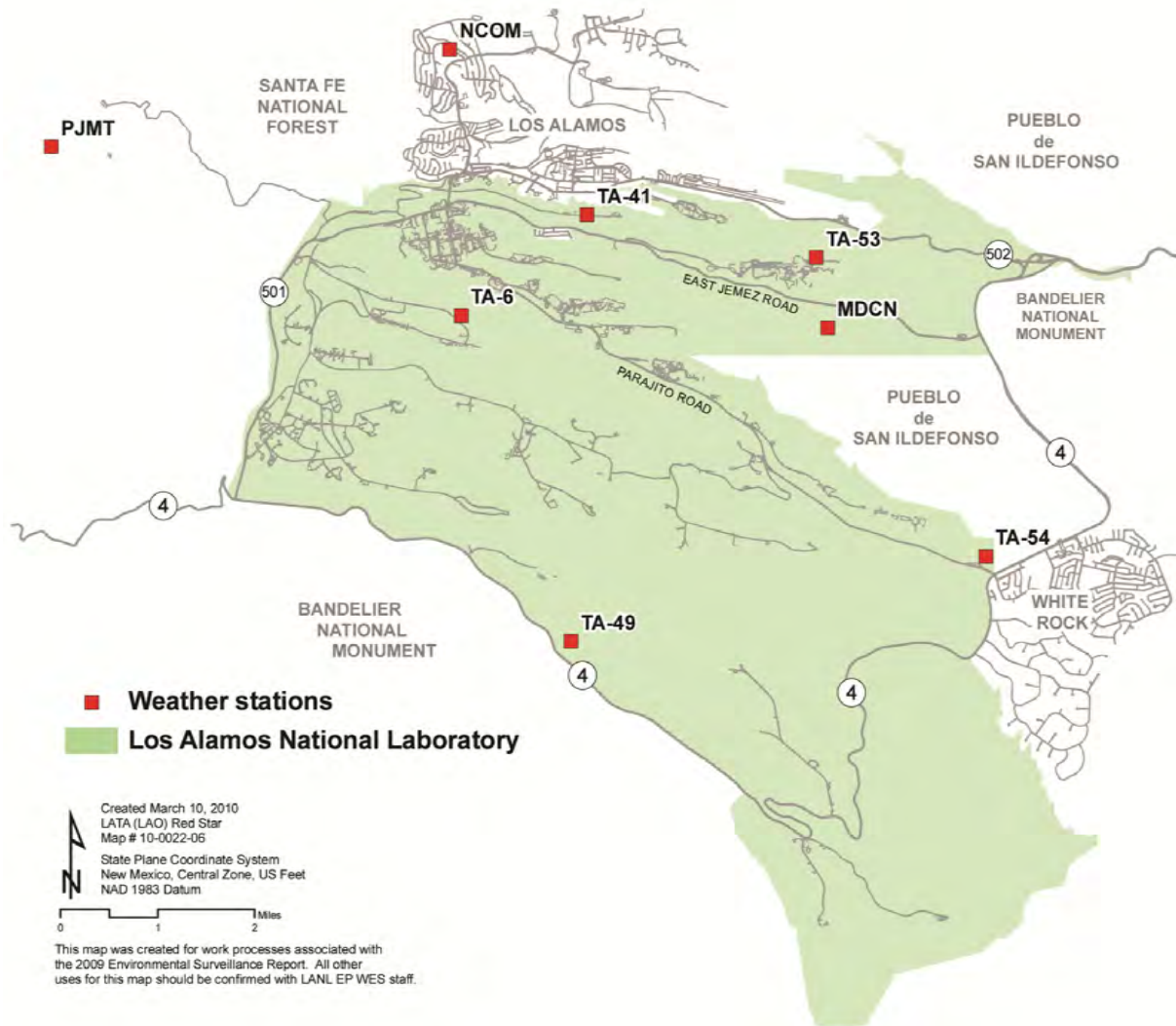


Figure 4-19 Location of meteorological monitoring towers and rain gauges

3. Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers at TA-6, TA-41, TA-49, TA-53, and TA-54. The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects. The MDCN station includes a 10-m tripod tower that measures wind at a single level (tower top). In addition, temperature and humidity are measured at ground level at all stations except the NCOM station, which only measures precipitation.

Data loggers at the station sites sample most of the meteorological variables at 0.33 Hz, store the data, average the samples over a 15-min period, and transmit the data by telephone or cell phone to a Hewlett-Packard workstation located at the Meteorology Laboratory (TA-59). The workstation automatically edits measurements that fall outside of realistic ranges. Time-series plots of the data are also generated for a meteorologist's data-quality review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. For more than 50 years, we have provided these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged three times daily.

We calibrate all meteorological instruments through the LANL Standards and Calibration Laboratory on an annual basis. An external audit of the instrumentation and methods is typically performed once every three to five years. The most recent audit was an “assist visit” by the DOE Meteorological Coordinating Council (DMCC) in August 2006. The DMCC report can be requested at www.weather.lanl.gov/. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

4. Climatology

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

The years from 1981 to 2010 represent the time period over which the climatological standard normal is defined. According to the World Meteorological Organization, the standard should be 1961–1990 until 2021 when 1991–2020 will become the standard, and so on every 30 years (WMO 1984). In practice, however, normals are computed every decade, and so 1981–2010 is generally used. Our averages are calculated according to this widely followed practice.

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

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

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.97 inches. The average annual snowfall is 57.0 inches. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 inches, which occurred between 11 a.m. on January 15, 1987, and 11 a.m. the next day. The record single-season snowfall is 153 inches set in 1986–87.

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

The complex topography of Los Alamos influences local wind patterns. Often a distinct diurnal cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow upslope along the ground. This is called anabatic flow. During the night, cool air that forms close to the ground tends to flow downslope and is known as katabatic flow. As the daytime anabatic breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerlies of the Pajarito Plateau. Nighttime katabatic flow enhances the local westerly winds. Flow in the east-west-oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night as katabatic flow and from the east during the day. Winds on the Pajarito Plateau are faster during the day than at night. This is due to vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in faster surface winds. At night, there is little mixing so wind at the surface receives less boosting from aloft.

5. 2011 in Perspective

Figure 4-20 presents a graphical summary of Los Alamos weather for 2011. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared with monthly normals (averages during the 1981–2010 time period). Table 4-13 presents a tabular perspective of Los Alamos weather during 2011.

The year 2011 was warmer and much drier than normal, with a Pacific La Niña pattern governing the weather. The average annual temperature in 2011 of 49.6°F exceeded the normal annual average of 48.4°F by 1.2°F. The total precipitation of 13.65 inches was 72% of normal (18.97 inches); this was the ninth driest year on record. The first half of the year was very warm and dry, and by the end of June, Los Alamos had received less than half of the precipitation recorded during the first six months of the driest year on record (1956). These warm and dry conditions throughout the Jemez Mountains contributed to the Las Conchas Fire becoming the largest wildfire in New Mexico history (see Chapter 1 for fire details). Fortunately, the summer monsoon began in mid to late July, and the Las Conchas Fire was fully contained by the end of July. August and September precipitation was 50% higher than average. Four snowstorms hit Los Alamos during December, giving Los Alamos 2.5 times the normal December snowfall total. Even with high December snowfall amounts, low snowfall totals during the first three months of the year resulted in a year-end snowfall total of 26.1 inches, 45% of average.

2011 Weather Summary

Los Alamos, New Mexico – TA-6 Station, Elevation 7424 ft

■ 2011 Values ▨ [Normal Values] 1981–2010

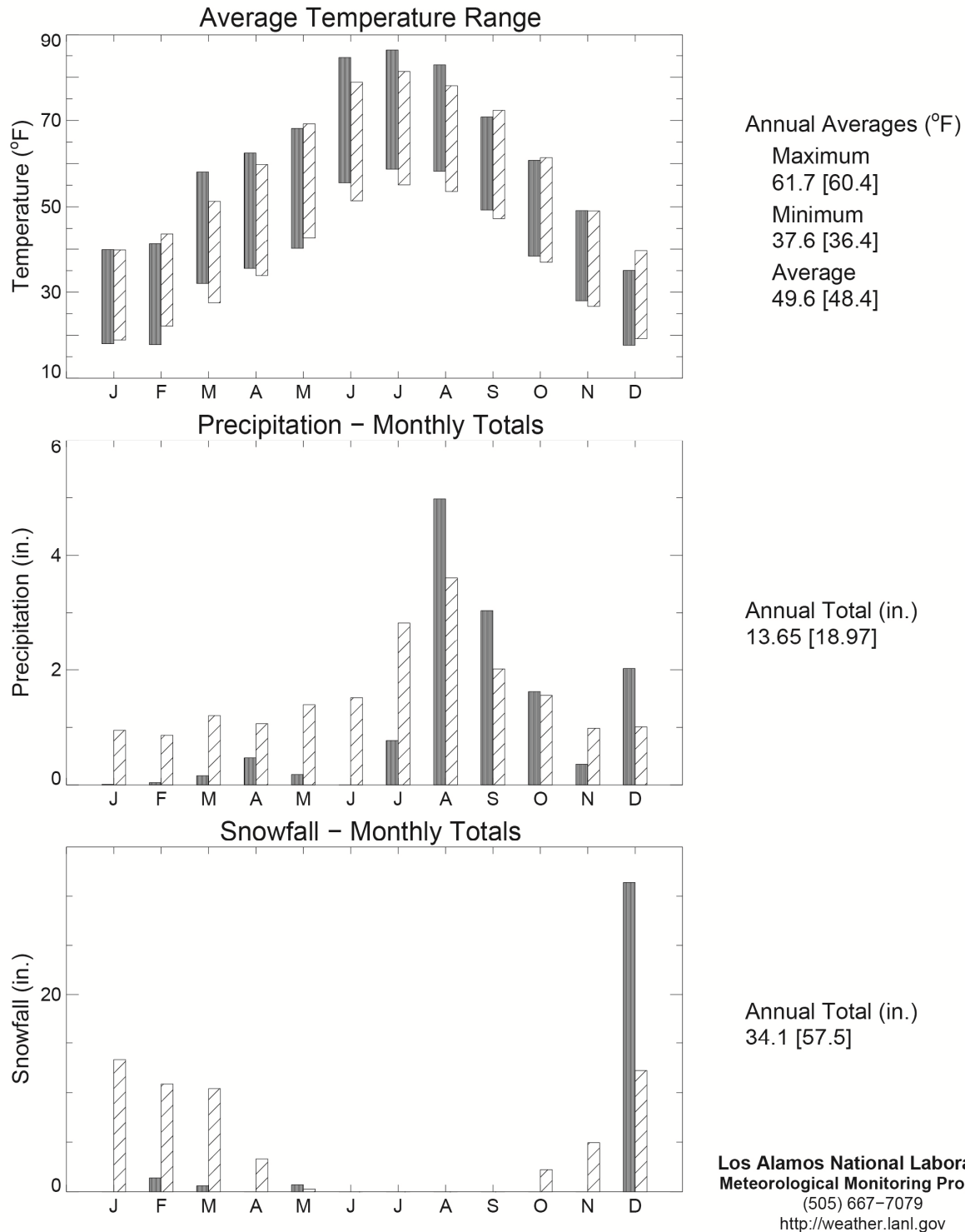


Figure 4-20 Weather summary for Los Alamos for 2011 at the TA-6 meteorology station

Table 4-13
Monthly and Annual Climatological Data for 2011 at Los Alamos

Month	Temperatures (°F) ^a								Precipitation (inches) ^a				12-meter wind (mph) ^a				
	Averages				Extremes				Total	Departure ^b	Snowfall		Average Speed	Departure ^c	Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure ^b	Highest	Date	Lowest	Date			Total	Departure ^b			Speed	From	Date
January	39.9	18.0	29.0	0.4	52	17 th	-9	1 st	0.01	-0.94	0.0	-13.3	5.1	0.1	57	WNW	17 th
February	41.3	17.8	29.5	-3.4	59	16 th	-16	3 rd	0.04	-0.82	1.4	-9.5	7.4	1.6	50	W	27 th
March	58.1	32.0	45.0	5.6	69	31 st	20	5 th	0.16	-1.04	0.6	-9.8	8.3	1.8	49	S	21 st
April	62.6	35.5	49.0	2.2	76	2 nd	20	4 th	0.47	-0.59	0	-3.3	10.7	3.1	53	NW	14 th
May	68.2	40.2	54.2	-1.8	84	28 th	25	2 nd	0.18	-1.21	0.7	0.4	9.7	2.3	59	W	24 th
June	84.6	55.5	70.1	5.0	92	23 rd	45	20 th	0.0	-1.51	0	0	10.1	3.0	58	WNW	19 th
July	86.3	58.7	72.5	4.3	90	10 th	54	12 th	0.77	-2.05	0	0	6.6	1.0	33	NW	20 th
August	82.9	58.2	70.6	4.8	91	9 th	54	21 st	4.98	1.37	0	0	5.7	0.4	39	NW	31 st
September	70.8	49.2	60.0	0.2	80	1 st	44	16 th	3.04	1.03	0	0	5.6	-0.1	39	NW	3 rd
October	60.8	38.4	49.6	0.4	74	16 th	29	28 th	1.62	0.07	0	-2.2	5.6	-0.1	42	NW	17 th
November	49.1	28.0	38.6	0.7	62	1 st	21	9 th	0.36	-0.62	0	-4.9	6.2	0.9	49	WNW	12 th
December	35.1	17.7	26.4	-3.0	49	31 st	-3	6 th	2.02	1.01	31.4	19.2	5.1	0.2	53	NW	31 st
Year	61.7	37.6	49.6	0.8	92	Jun 23	-16	Feb 3	13.65	-5.32	26.1	-31.4	7.2	1.2	59	W	May 4

^a Data from TA-6, the official Los Alamos weather station.

^b Departure columns indicate positive or negative departure from 1981–2010 (30-year) climatological average.

^c Departure column indicates positive or negative departure from 1990–2010 (21-year) climatological average.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-21 shows the historical record of temperatures in Los Alamos from 1925 through 2011. The annual average temperature is not the average temperature per se, but the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-21. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it appears that the warm spell during the past decade is not as extreme as the warm spell during the early-to-mid 1950s. On the other hand, the current warm trend is longer-lived.

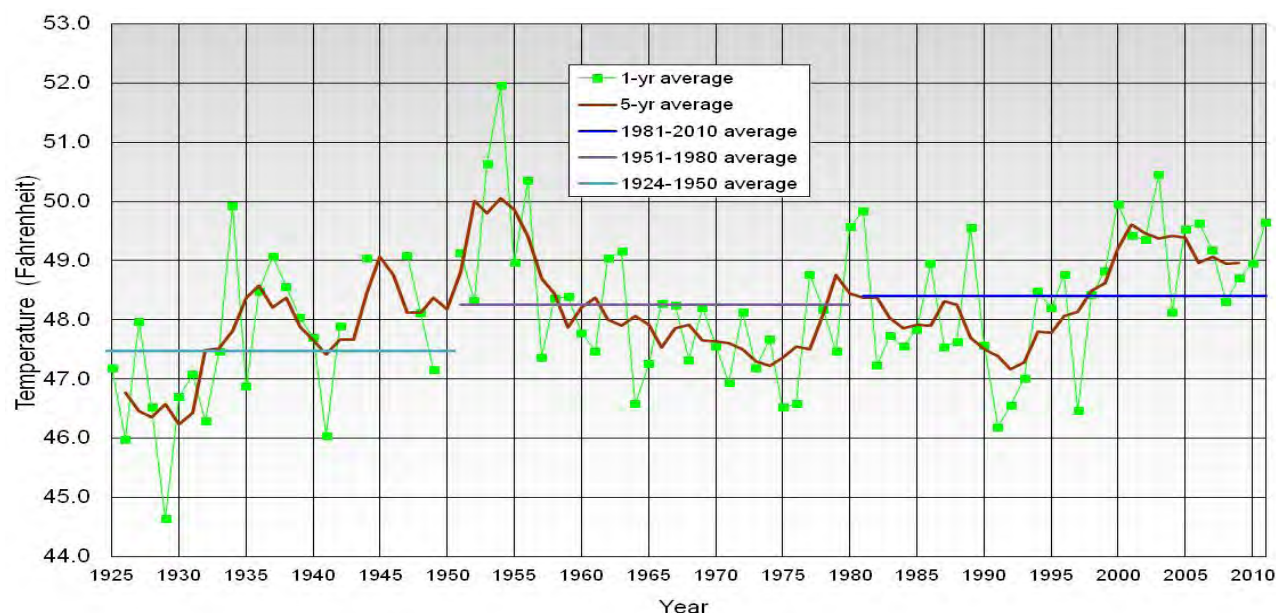


Figure 4-21 Temperature history for Los Alamos

Figure 4-22 shows the historical record of the annually summed total precipitation. The most recent drought spanned the years 1998 through 2003. The 2011 total of 13.65 inches was much below normal. As with the historical temperature profile, the five-year running mean is also shown.

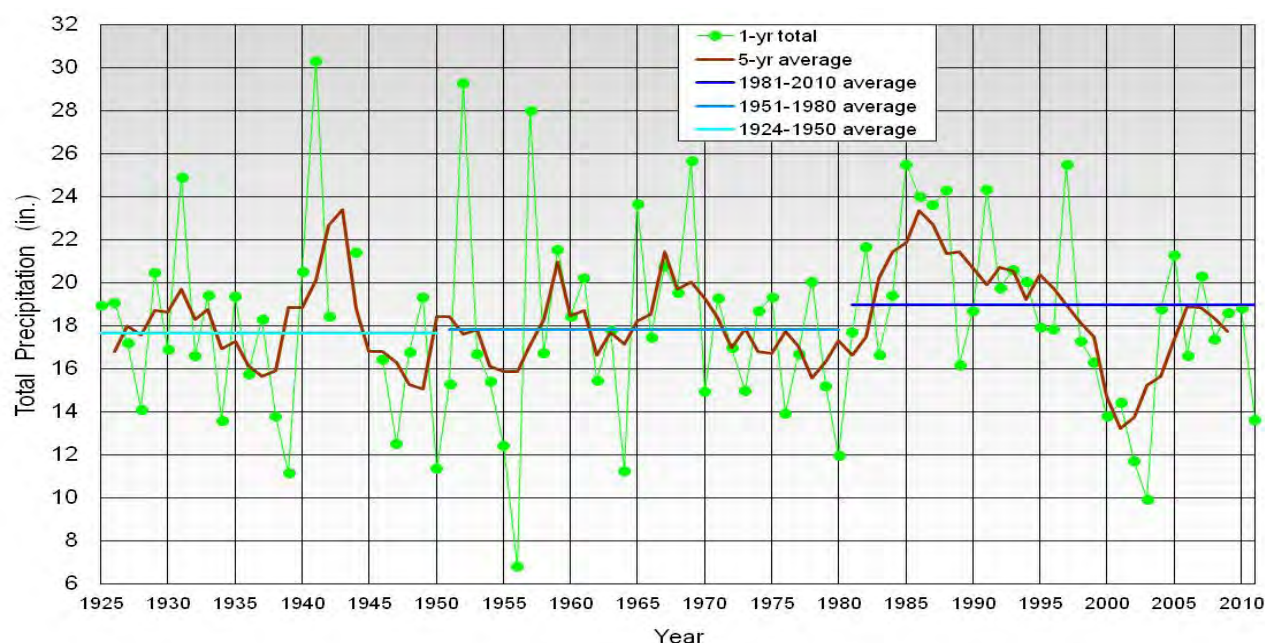


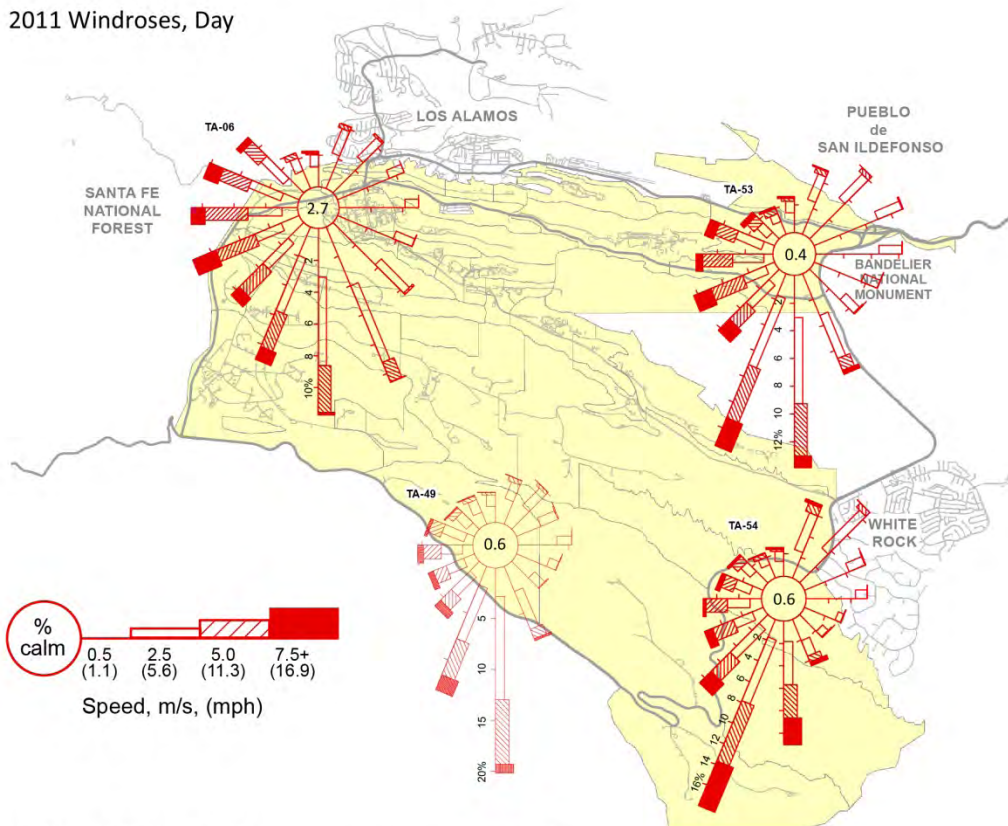
Figure 4-22 Total precipitation history for Los Alamos

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-23. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are directly from the south at TA-6 over 12% of the time during days in 2011. Winds are directly from the north just over 2% of the time during the day. Wind roses also show the distribution of wind speed. For approximately 6% of the time, for example, winds at TA-6 are from the south and range from 2.5 to 5 meters per second. Winds from the south at TA-6 exceed 7.5 meters per second only a fraction of 1% of the time, and winds are calm there 2.7% of the time.

The La Nina weather pattern that dominated the weather pattern in Los Alamos during 2011 produced higher than average winds during the year (Table 4-13). Winds during the spring and early summer were particularly high, with average wind speeds in June being 42% above normal. These high winds were a contributing factor to the severity of the Las Conchas Fire.

The wind roses are based on 15-minute-averaged wind observations for 2011 at the four Pajarito Plateau stations. Although it is not shown here, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

2011 Windroses, Day



2011 Windroses, Night

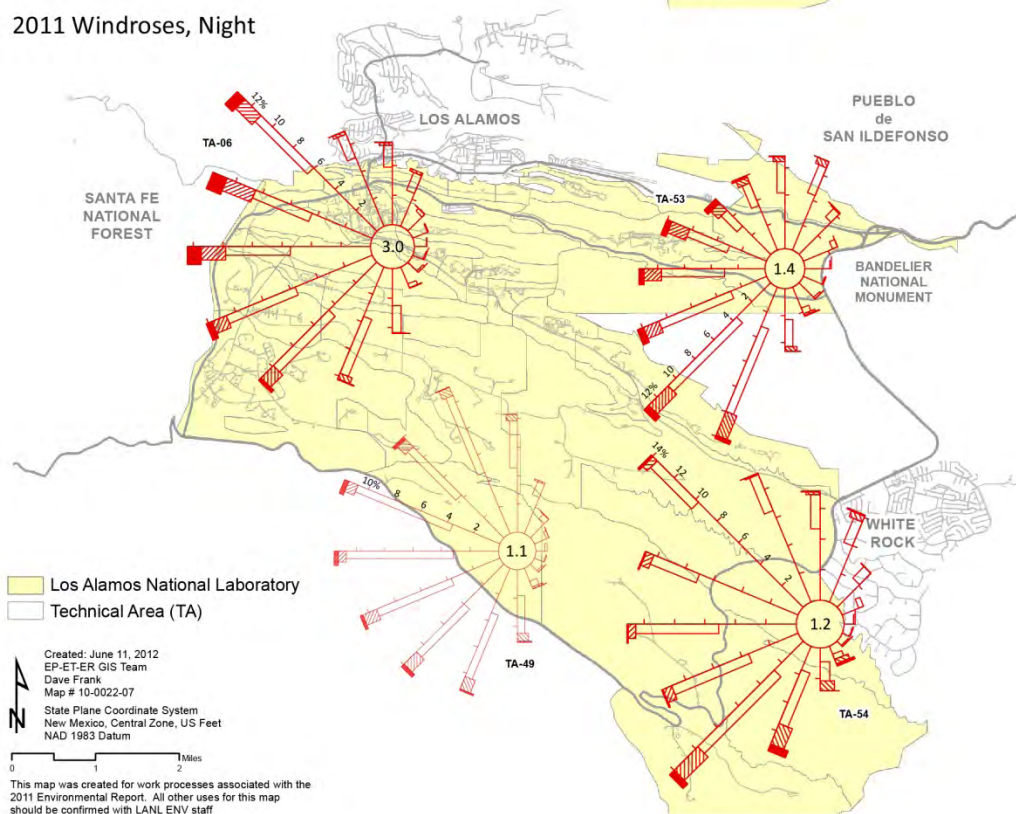


Figure 4-23 Daytime and nighttime wind roses for 2011. Wind data for TA-49 are 2010 data

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To Read About**Turn to Page**

<i>Introduction.....</i>	<i>5-1</i>
<i>Hydrogeologic Setting.....</i>	<i>5-1</i>
<i>Groundwater Standards and Screening Levels.....</i>	<i>5-4</i>
<i>Overview of Groundwater Quality.....</i>	<i>5-6</i>
<i>Monitoring Network.....</i>	<i>5-10</i>
<i>Summary of 2011 Sampling Results.....</i>	<i>5-16</i>
<i>Groundwater Sampling Results by Constituents.....</i>	<i>5-19</i>
<i>Groundwater Sampling Results by Monitoring Group.....</i>	<i>5-22</i>
<i>References</i>	<i>5-61</i>

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the US Department of Energy (DOE) Orders and New Mexico (NM) and federal regulations. The objectives of the Laboratory's groundwater programs are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources.

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

Most of the groundwater monitoring conducted during 2011 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (Interim Plans; LANL 2010a, 2011a, 2011b) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (Consent Order). The LANL Environmental Programs Directorate collects groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

The following sections describe the hydrogeologic setting of the Laboratory and include a summary of groundwater contaminant sources and distribution. Additional detail can be found in reports available at <http://www.lanl.gov/environment/outreach/prr.shtml>.

1. Geologic Setting

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

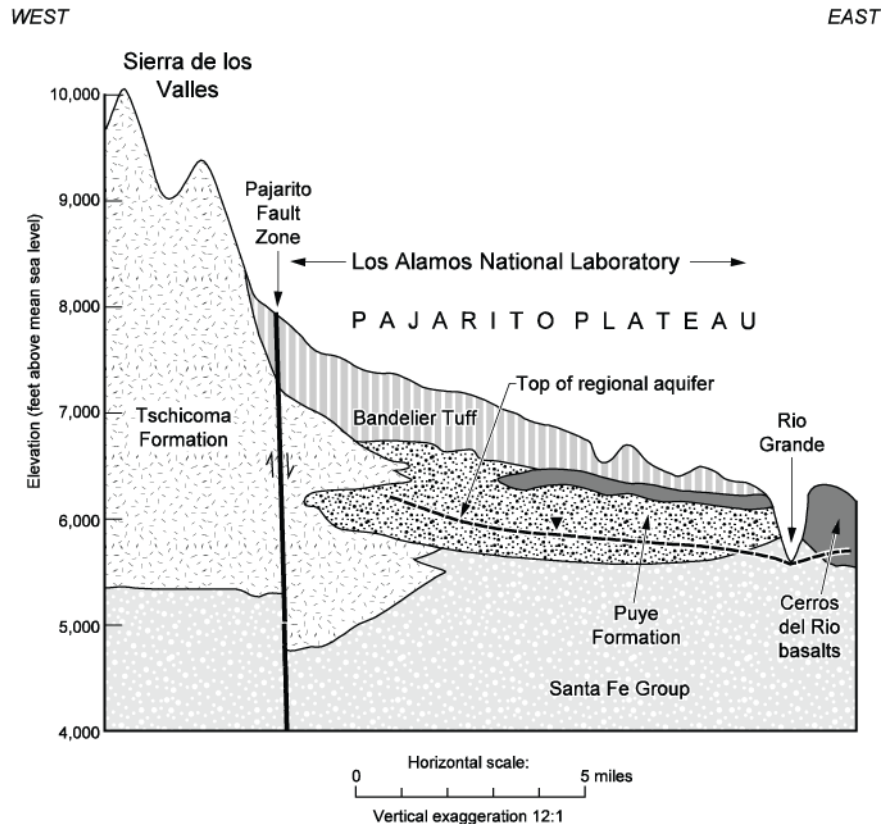


Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

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

2. Groundwater Occurrence

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

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

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

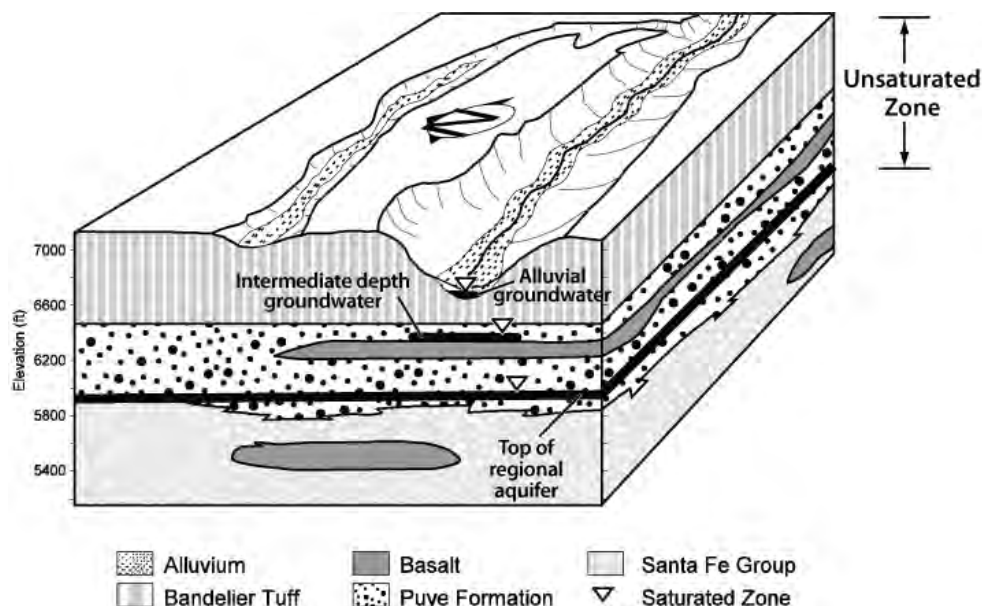


Figure 5-2 Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. The intermediate groundwater may be discontinuous or may connect with other zones across canyons. Depths of the intermediate perched groundwater vary. For example, the depth to intermediate perched groundwater is approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500 to 750 ft in Mortandad Canyon.

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

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

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

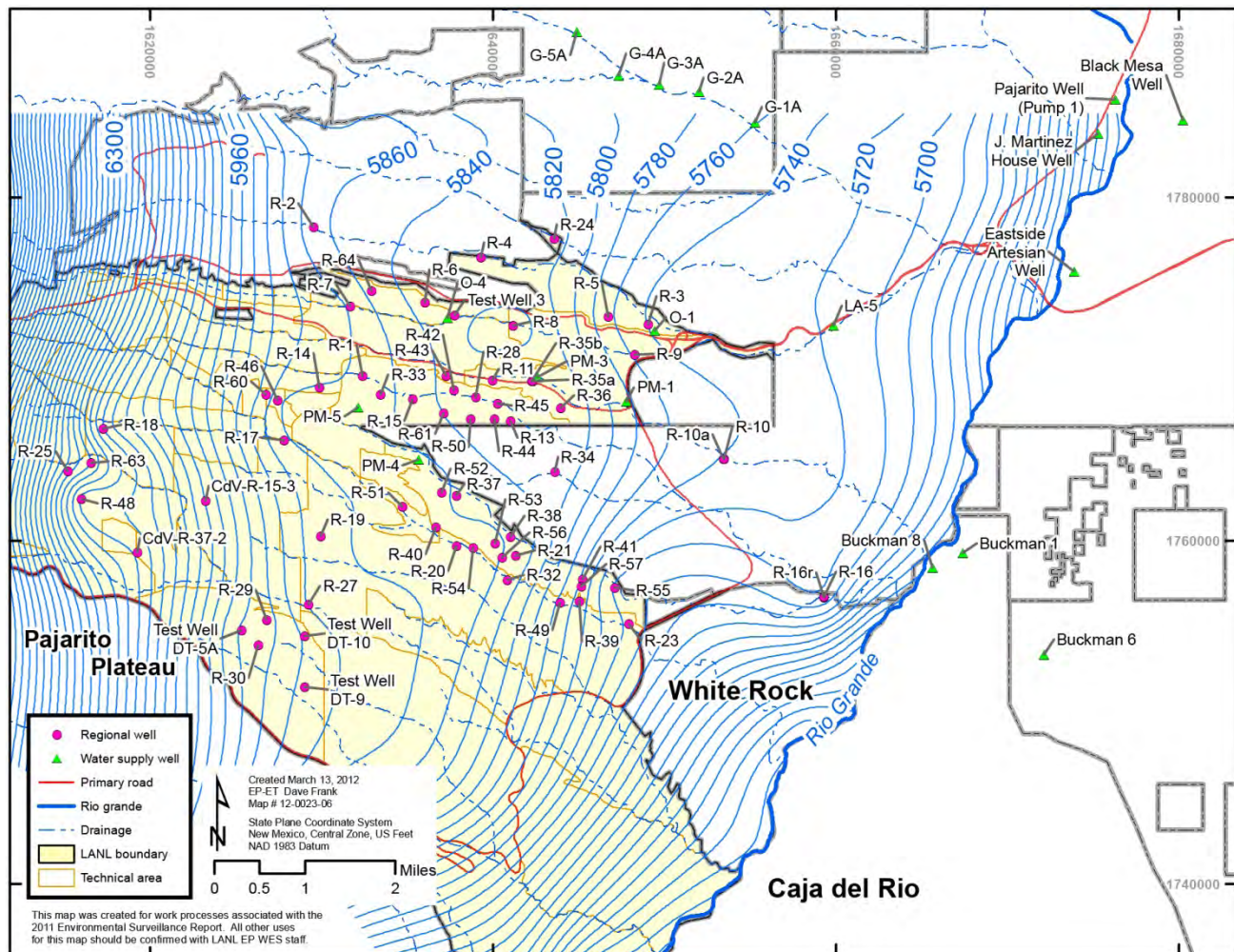


Figure 5-3 Contour map of average water table elevations for the regional aquifer (based on a map in a LANL report [2012a]). This map represents a generalization of the data; other interpretations are possible.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 600 ft of unsaturated tuff, basalt, and sediments with generally low moisture content (< 10%). Water lost by downward seepage from alluvial and intermediate groundwater zones travels through the underlying rock by unsaturated flow. This percolation is a source of certain contaminants, mobile in water, which may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, restricts their volumetric contribution to recharge reaching the regional aquifer.

C. GROUNDWATER STANDARDS AND SCREENING LEVELS

1. Regulatory Overview

The regulatory standards and screening levels listed in Table 5-1 are used to evaluate groundwater samples in this chapter.

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

Sample Type	Constituent	Standard	Screening Level	Reference	Notes
Water supply wells	Radionuclides	EPA MCLs, DOE 4-mrem/yr DCGs	None	40 Code of Federal Regulations (CFR) 141–143, DOE Order 5400.5	4-mrem/yr DCGs apply to water provided by DOE-owned drinking water systems. EPA MCLs apply to drinking water systems.
Water supply wells	Non-radionuclides	EPA MCLs, NM groundwater standards, EPA regional screening levels for tap water	None	40 CFR 141–143, 20.6.2 NMAC, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	EPA MCLs apply to drinking water systems.
Non-water supply groundwater samples	Radionuclides	NM groundwater standards	4-mrem/yr DCGs, EPA MCLs	20.6.2 NMAC, DOE Order 5400.5, 40 CFR 141–143	NM groundwater standards apply to all groundwater. The 4-mrem/yr DCGs and EPA MCLs are for comparison because they apply only to drinking water systems.
Non-water supply groundwater samples	Non-radionuclides	NM groundwater standards, EPA regional screening levels for tap water	EPA MCLs	40 CFR 141–143, 20.6.2 NMAC, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	NM groundwater standards and EPA regional screening levels for tap water apply to all groundwater. EPA MCLs apply to drinking water systems.
Effluent samples	Radionuclides	DOE 100-mrem/yr DCGs	None	DOE Order 5400.5	DOE 100-mrem/yr public dose limit applies to effluent discharges.

Groundwater standards are established by three regulatory agencies: DOE, which regulates radionuclides related to national security uses, and the US Environmental Protection Agency (EPA) and the New Mexico Water Quality Control Commission (NMWQCC), which regulate all other constituents. The Atomic Energy Act (42 US Code Sections 2011 to 2259) assigns to DOE the authority to establish standards governing possession and use of nuclear materials that the Nuclear Regulatory Commission deems necessary to promote the common defense and security. This allows DOE to set radiation protection standards for itself and its contractors for nuclear materials related to nuclear weapon production. Thus, DOE has regulatory authority over nuclear source materials, including ores, nuclear materials enriched for use in nuclear weapons, and radioactive byproduct materials from nuclear weapon production.

DOE Order 5400.5, Radiation Protection of the Public and the Environment, establishes dose limits for radiation protection and provides derived concentration guides (DCGs) for radionuclides in media, such as drinking water, that are based on the dose limits. DOE has two dose limits for radioactivity in water. The DCGs for the 100-millirem per year (mrem/yr) public dose limit apply as effluent release guidelines. For ingested water, DCGs are calculated for DOE's 4-mrem/yr drinking water dose limit.

Public drinking water systems are regulated by EPA under the Safe Drinking Water Act and by states and tribes when authority is delegated by EPA. The operator of the drinking water system must demonstrate compliance with drinking water regulations. EPA maximum contaminant levels (MCLs) are the maximum permissible level of a contaminant in water delivered to any user of a public water system. Thus, compliance with the MCL is measured after treatment; measurements in a water supply well may be higher and allow the MCLs to be met through blending of water in a distribution system.

NMWQCC groundwater standards (20.6.2 New Mexico Administrative Code [NMAC]) apply to all groundwater. These standards include numeric criteria for many contaminants and a list of toxic pollutants for which numeric criteria are determined using EPA regional screening levels for tap water (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). The regional screening levels for tap water are for either a cancer- or non-cancer-risk type. The Consent Order and NMWQCC groundwater standards specify screening at a 10^{-5} excess cancer risk. The EPA screening levels are for 10^{-6}

excess cancer risk, so the Laboratory uses 10 times the EPA 10^{-6} screening values for screening. These screening levels are updated several times each year; the June 2011 edition was used to prepare this chapter.

Section VIII.A of the Consent Order identifies NMWQCC groundwater standards and EPA MCLs as cleanup levels for groundwater when corrective action is implemented. NMWQCC groundwater standards, MCLs, and EPA regional screening levels for tap water are used as screening levels for monitoring data. Documents submitted to NMED by LANL use these values for evaluation of groundwater results.

The Consent Order groundwater cleanup level for an individual substance is the lesser of the EPA MCL or the NMWQCC groundwater standard. The groundwater cleanup level for perchlorate is the 4-micrograms per liter ($\mu\text{g/L}$) screening level established in Section VIII.A.1.a of the Consent Order.

Section VIII.A.1 of the Consent Order requires that if no NMWQCC standard or MCL has been established for a specific substance for which toxicological information is published, the EPA regional screening level for tap water is used as the groundwater cleanup level. This language extends the list of substances that have cleanup levels beyond the list of toxic pollutants in the NMWQCC groundwater standards.

The NMWQCC groundwater standards apply to the dissolved (filtered) portion of specified contaminants; however, the standards for mercury, organic compounds, and non-aqueous-phase liquids apply to the total unfiltered concentrations of the contaminants. EPA MCLs and regional screening levels for tap water are applied to both filtered and unfiltered sample results.

Because many metals are either chemically bound to or components of aquifer material that makes up suspended sediment in water samples, the unfiltered concentrations of these substances are often higher than the filtered concentrations. The EPA MCLs and regional screening levels for tap water are intended for application to water supply samples that generally have low turbidity.

2. Evaluation of Groundwater Results

For water supply wells, which draw water from the regional aquifer, concentrations of radionuclides in samples were compared with (1) the DCGs for ingested water calculated from DOE's 4-mrem/yr drinking water dose limit and (2) the EPA MCLs. For non-radioactive chemical quality parameters in water supply samples, the EPA MCLs apply as regulatory standards.

For radioactivity in groundwater other than drinking water, there are NMWQCC groundwater standards for uranium and radium. For screening of other radioactivity, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem/yr drinking water DCGs and with EPA MCLs. When used in this chapter for assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels.

The NMWQCC groundwater standards (including the toxic pollutants and their EPA regional screening levels for tap water) apply to concentrations of non-radioactive chemical quality parameters in all groundwater samples. For non-radioactive chemical quality parameters in groundwater other than drinking water, the EPA MCLs may be used as screening levels.

Groundwater is a source of flow to springs and other surface water that may be used by neighboring tribal members and wildlife. NMWQCC's surface water standards (20.6.4 NMAC), including the wildlife habitat standards, also apply to this surface water. (For a discussion of surface water, see Chapter 6.)

D. OVERVIEW OF GROUNDWATER QUALITY

All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards. With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate was found during 2011 at concentrations up to $0.96 \mu\text{g/L}$. This concentration is 24% of the $4\text{-}\mu\text{g/L}$ Consent Order screening level and 6% of the EPA's interim health advisory of $15 \mu\text{g/L}$ for perchlorate in drinking water.

Since the 1940s, liquid effluent discharge by the Laboratory has affected the shallow perched alluvial groundwater that lies beneath the floor of a few canyons (Table 5-2). Liquid effluent discharge is also the primary means by which Laboratory operations have affected intermediate perched zones and the regional aquifer. Where contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged.

Table 5-2
Alluvial Groundwater Contaminants above Screening Levels in 2011

Chemical	Location	Result	Trends
Strontium-90	DP and Los Alamos Canyons	Up to 64.5 picocuries per liter (pCi/L), above 8-pCi/L EPA MCL screening level	Steady for decades in several wells, including LAUZ-1, LAO-3a
Chloride	DP and Los Alamos Canyons	Up to 341 milligrams per liter (mg/L), above 250-mg/L NM groundwater standard (for domestic water supply)	Above standard in winter and spring for a decade because of road salt runoff
Perchlorate	Mortandad Canyon	Up to 7.9 µg/L, above 4-µg/L Consent Order screening level	Variable in several wells, decreased from > 200 µg/L in 2000
Barium	Cañon de Valle	Up to 13,600 µg/L, above 1,000-µg/L NM groundwater standard	Steady for decades in several wells, some increases in 2012
Boron	Tributary of Cañon de Valle	Up to 1,320 µg/L, above 750-µg/L NM groundwater standard (for irrigation)	Increase for four years in MSC-16-06293
RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	Cañon de Valle	Up to 10.5 µg/L, above 6.1-µg/L EPA tap water screening level	Present at similar levels for years in several wells

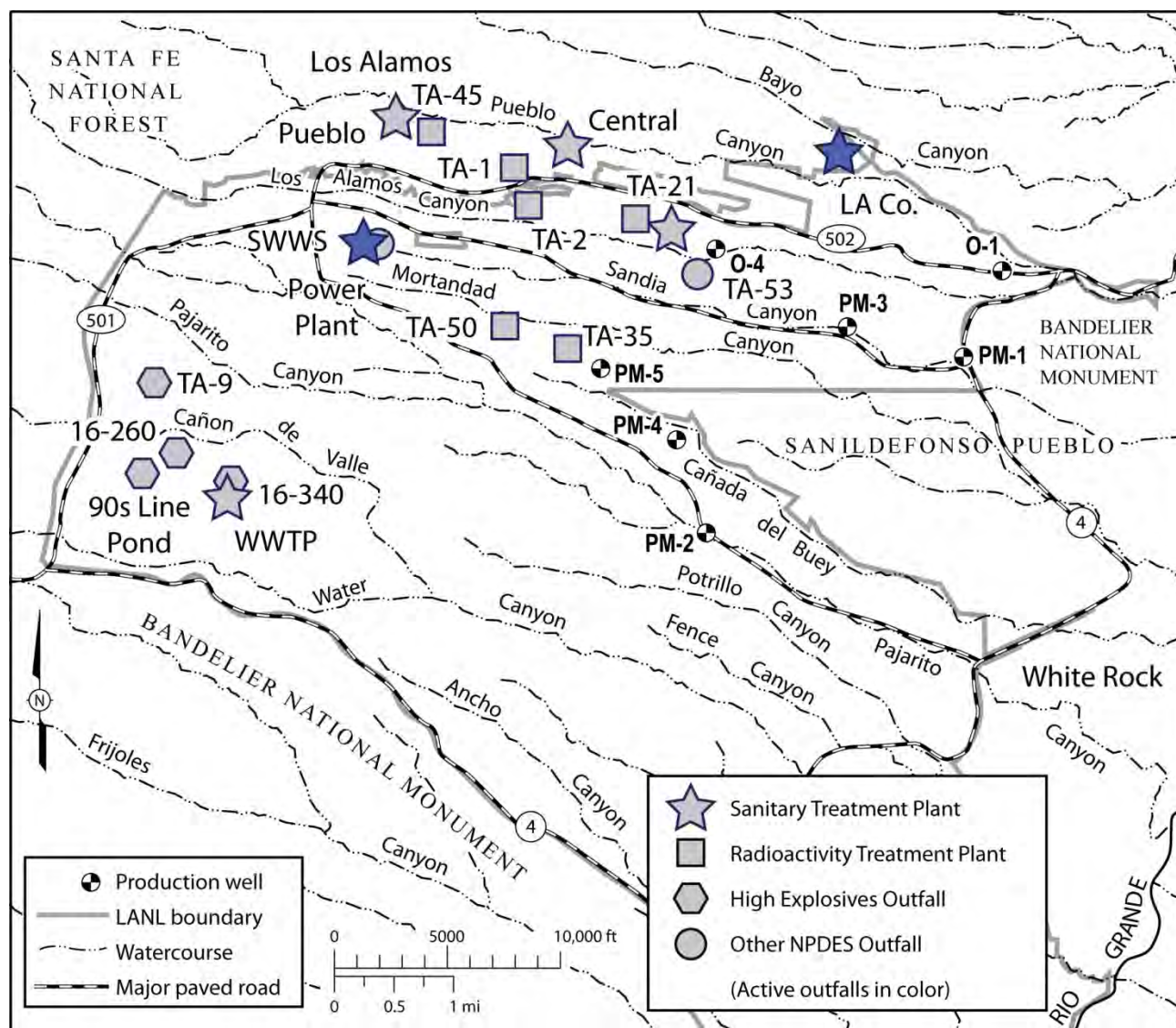
The alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than is found in the shallow perched groundwater bodies,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

Drainages that received liquid radioactive effluents during past decades include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

Sandia Canyon has received discharges of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (LANL 1993a, 1993b).

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

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.



WWTP = Waste water treatment plant.
NPDES = National Pollutant Discharge Elimination System

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

The intermediate groundwater in various locations shows localized contamination (Table 5-3). Hexavalent chromium and perchlorate have been found in regional aquifer monitoring wells (Table 5-4). In regional aquifer monitoring wells R-42 and R-28 in Mortandad Canyon, hexavalent chromium is found at concentrations above the 50- $\mu\text{g/L}$ NM groundwater standard. Beginning in 2010, LANL found chromium at concentrations up to 89 $\mu\text{g/L}$ at 1,077 ft in regional aquifer monitoring well R-50, which is about 250 ft north of the LANL/San Ildefonso boundary. At a few wells, perchlorate concentrations are above the 4- $\mu\text{g/L}$ Consent Order screening level (Table 5-4).

Table 5-3
Intermediate Groundwater Contaminants above Screening Levels in 2011

Chemical	Location	Result	Trends
Perchlorate	DP and Los Alamos Canyons	Up to 6.4 µg/L, above 4-µg/L Consent Order screening level	Generally steady in three wells for six years
Perchlorate	Lower Los Alamos Canyon	Up to 5.6 µg/L, above 4-µg/L Consent Order screening level	Rising in Basalt and Vine Tree Springs for four years
Chromium	Sandia Canyon	Up to 511 µg/L, above 50-µg/L NM groundwater standard	Steady for four years in SCI-2
Chromium	Mortandad Canyon	Up to 62 µg/L, above 50-µg/L NM groundwater standard	Increasing for five years in MCOI-6
Perchlorate	Mortandad Canyon	Up to 88 µg/L, above 4-µg/L Consent Order screening level	50% decline over four years in three wells
Dioxane[1,4-]	Mortandad Canyon	Up to 12 µg/L, above 6.7-µg/L EPA tap water screening level	> 50% decline in MCOI-6 over five years
Dioxane[1,4-], trichloroethane[1,1,1-], dichloroethene[1,1-]	Upper Pajarito Canyon	Dioxane > 100 times EPA tap water screening level, others > 2 times NM groundwater standards	Highly variable concentrations in isolated perched zone for six years
Boron	Tributary of Cañon de Valle	Up to 1,320 µg/L, above 750-µg/L NM groundwater standard (for irrigation)	Steady for more than five years in Martin Spring
Tetrachloroethene	Cañon de Valle	Just above 5-µg/L EPA MCL screening level	Highest result over two years in well 16-26644, present in several wells and springs
RDX	Cañon de Valle	Up to 186 µg/L, above 6.1-µg/L EPA tap water screening level	Present at steady levels for years in several wells and springs

Table 5-4
Regional Aquifer Groundwater Contaminants above Screening Levels in 2011

Chemical	Location	Result	Trends
Perchlorate	Pueblo Canyon	Up to 4.5 µg/L, above 4-µg/L Consent Order screening level	Steady for four years in R-4
Chromium	Mortandad Canyon	Up to 965 µg/L, above 50-µg/L NM groundwater standard	Steady for two to six years in R-50, R-28 and R-42
Perchlorate	Mortandad Canyon	Up to 8.1 µg/L, above 4-µg/L Consent Order screening level	Slight increase over several years in R-15, first year of samples in R-61

Nitrate and traces of tritium are also found in the regional aquifer. Nitrate (as nitrogen) concentrations in regional aquifer monitoring wells R-43 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon were detected at levels of up to 60% of the 10-mg/L NM groundwater standard. Tritium activities are far below the EPA MCL of 20,000 pCi/L.

Beginning in late 2008, trichloroethene was detected at 1,147 ft in Pajarito Canyon regional aquifer monitoring well R-20 and continues to be detected in every sampling event. The concentrations increased to 60% of the 5-µg/L EPA MCL screening level in late 2009 but have fallen to 12% of the screening level in 2011.

In 2011, the HE compound RDX continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. The RDX concentration was at 19% of the EPA tap water screening level of 6.1 µg/L. RDX was also detected in a new Cañon de Valle regional aquifer well, R-63 (to the south of R-18), at 23% of the screening level. RDX continues to be detected in the upper two regional aquifer screens of R-25 (also near Cañon de Valle) at up to 8% of the screening level.

E. MONITORING NETWORK

In 2005, DOE and its Operations and Management Contractor and NMED signed a Consent Order, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory annually submit an Interim Plan to NMED for its approval. Groundwater monitoring conducted during calendar year 2011 was carried out according to two Interim Plans and a revision under the Consent Order (LANL 2010a, 2011a, 2011b). The monitoring locations, analytical suites, and frequency of monitoring reflect the technical and regulatory status of each area and are updated annually in the Interim Plan. In some cases, when monitoring results demonstrate little change or no impacts, sampling frequency has decreased.

The 2011 Interim Plan submitted in August 2011 was modified to address the realigned environmental priorities presented in the framework agreement between DOE/National Nuclear Security Administration and NMED (http://www.nmenv.state.nm.us/documents/LANL_Framework_Agreement.pdf). The revised 2011 Interim Plan (LANL 2011b) was submitted to NMED in December 2011.

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: perched alluvial groundwater beneath the floor of some canyons, localized intermediate-depth perched groundwater systems, and the regional aquifer.

Most of the monitoring wells discussed in the Interim Plan are assigned to area-specific monitoring groups related to project areas that may be located in more than one watershed (Figures 5-5a and b). Area-specific monitoring groups are defined for Technical Area 54 (TA-54) in Pajarito and Mortandad Canyons; TA-21, primarily in Los Alamos Canyon; Material Disposal Area (MDA) AB, primarily in Ancho Canyon; MDA C, primarily in Mortandad Canyon; the chromium investigation area in Sandia and Mortandad Canyons; and the TA-16 260 Outfall in Water Canyon and Cañon de Valle. Locations that are not included within one of these six area-specific monitoring groups are assigned to the General Surveillance monitoring group (Figures 5-6a and b). This report uses monitoring group assignments in the 2010 Interim Plan (LANL 2010a).

Monitoring outside the Laboratory boundaries (Figure 5-7) is conducted in areas (1) where Laboratory operations have been conducted in the past (e.g., Guaje and Rendija Canyons) or (2) that have not been affected by Laboratory operations. To ensure water leaving the Laboratory does not pose an unacceptable risk to human and ecological receptors, this plan also includes monitoring in areas downgradient of the Laboratory and outside Laboratory boundaries (e.g., the Rio Grande and springs in White Rock Canyon).

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, DOE signed a memorandum of understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on Pueblo land. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-7 and mainly sample the regional aquifer. Vine Tree Spring (near former location Basalt Spring) and Los Alamos Spring are intermediate groundwater sampling points, and well LLAO-4 samples alluvial groundwater. The Laboratory also monitors Los Alamos County water supply wells and three City of Santa Fe supply wells.

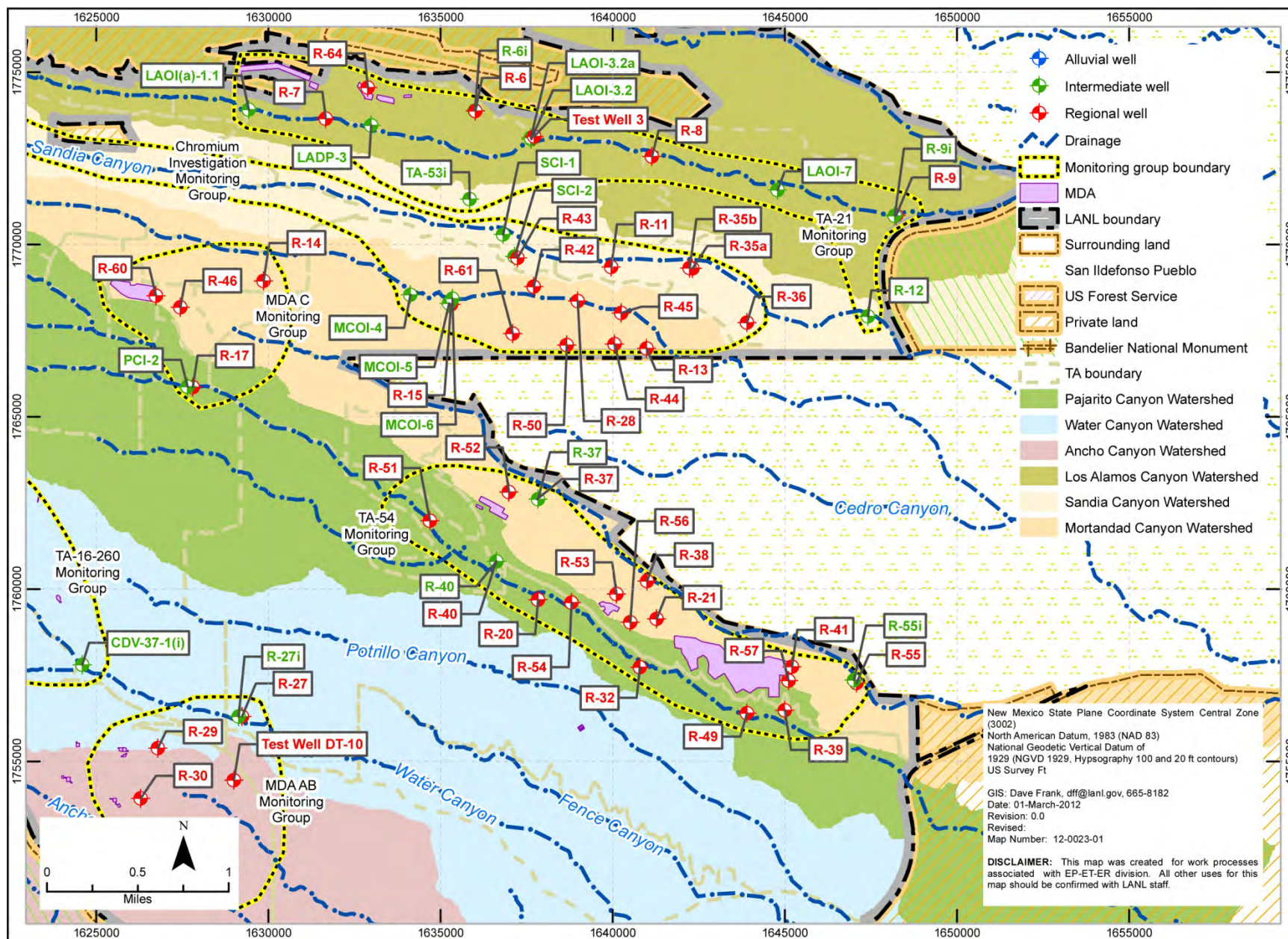


Figure 5-5a Groundwater monitoring wells assigned to area-specific monitoring groups

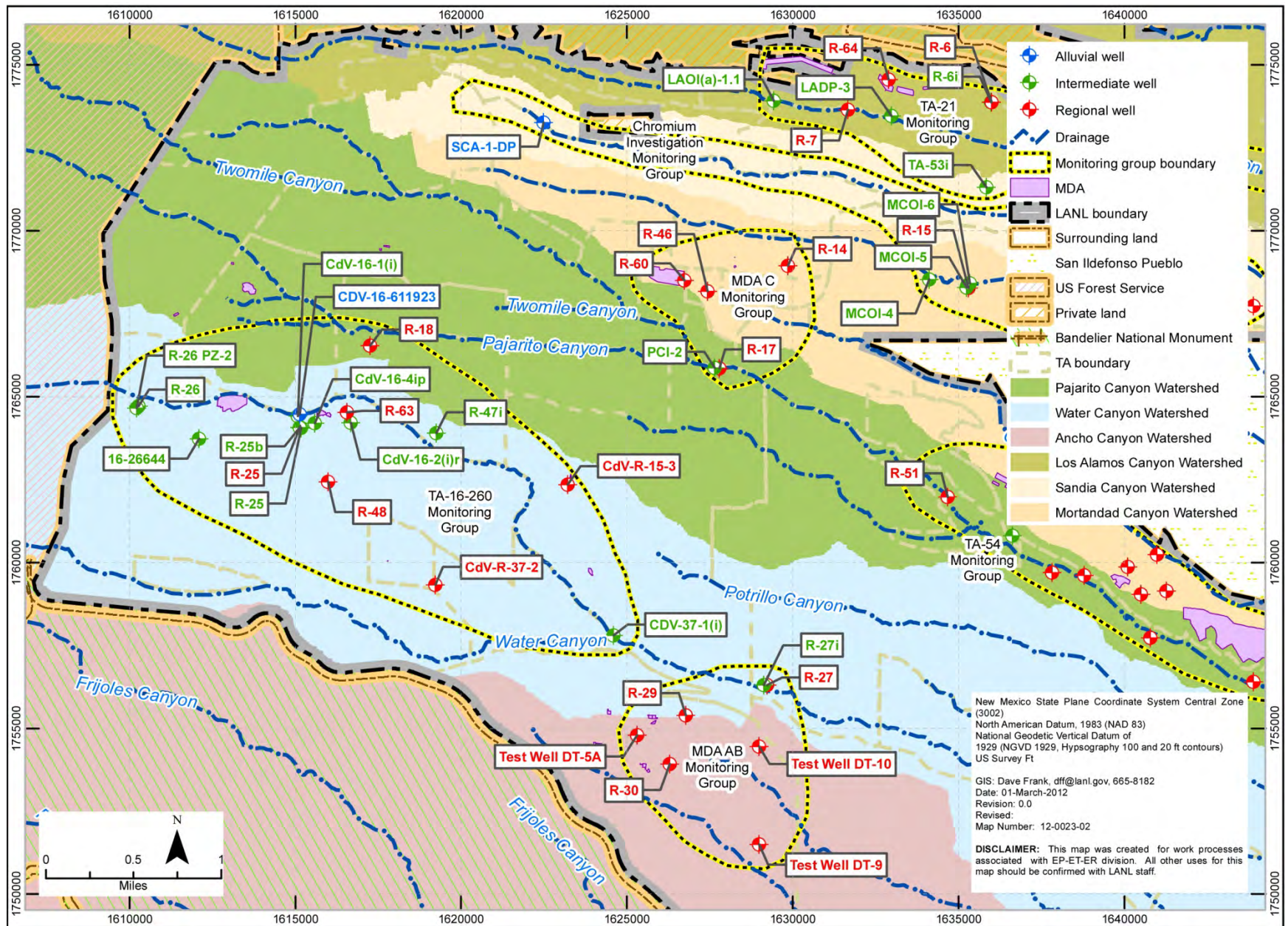


Figure 5-5b Groundwater monitoring wells assigned to area-specific monitoring groups



Figure 5-6a Groundwater monitoring wells and springs assigned to general surveillance monitoring



Figure 5-6b Groundwater monitoring wells and springs assigned to general surveillance monitoring

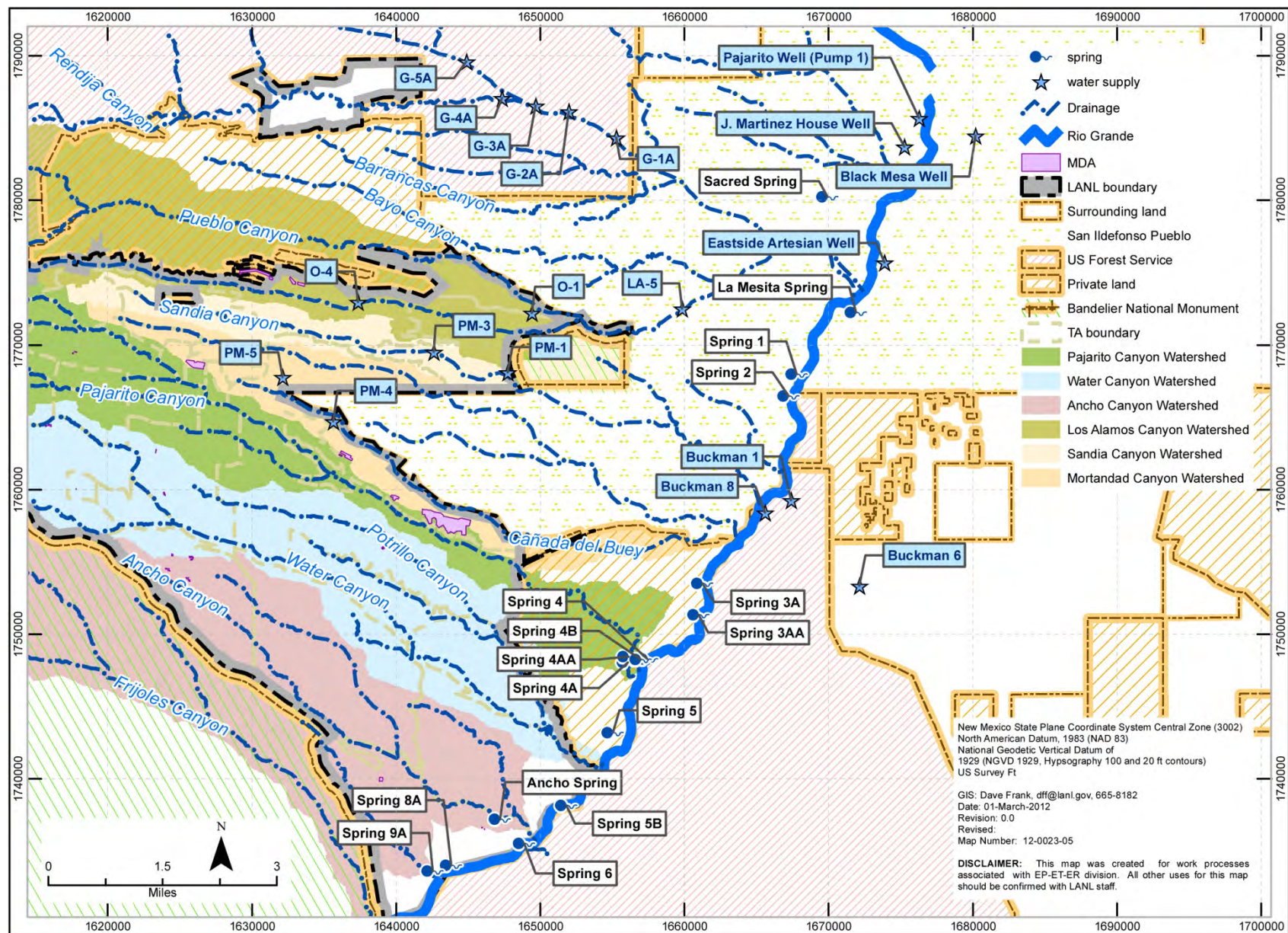


Figure 5-7 Water supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon

1. Regional Aquifer and Intermediate Perched Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. The majority of the monitoring network consists of wells constructed since the Hydrogeologic Workplan (LANL 1998). The Laboratory added several new wells to the monitoring well network in 2011, as described in Chapter 2, Section C.9.b. A column in the supplemental data tables for Chapter 5 (available online at the Intellus New Mexico Environmental Database, <http://www.intellusnmdata.com>) identifies the groundwater zones sampled by well screens and gives the depth of the top of the of the screen.

The Laboratory collects samples from 12 Los Alamos County water supply wells in three well fields that produce drinking water for the Laboratory and the community. Additional regional aquifer samples came from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe. This chapter reports on supplemental sampling of those wells by the Laboratory.

LANL also samples numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al. 1980). Sampling the springs allows detection of possible discharge of contaminated groundwater from underneath the Laboratory into the Rio Grande.

2. Alluvial Groundwater Monitoring

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

In 2011 many alluvial wells could not be sampled. Many wells were dry because of severe drought conditions. In Cañon de Valle, flooding following the Las Conchas Fire created adverse field conditions that prevented collection of numerous groundwater samples. These samples could not be collected because damage to roads prevented access to the wells, wells were overtopped by floodwater, or wells were either destroyed or buried by flood debris.

3. Monitoring Network Modifications

During 2011 and early 2012, the Laboratory plugged and abandoned Test Well 3; Borehole H-19; Test Holes 5 and 6 in Pajarito Canyon; Seismic Hazard Boreholes 1, 3, and 4; TA-21 Distillation Hole; a US Geological Survey (USGS) Test Hole east of MDA C; Beta Hole in Water Canyon; and Test Holes 1, 2, 3, and 5 at TA-49.

New regional and intermediate wells drilled in 2011 include R-55i (completed January 18, 2011), R-63 (completed February 9, 2011), R-61 (completed May 3, 2011), R-64 (completed July 11, 2011), R-62 (completed October 3, 2011), and R-66 (completed November 16, 2011).

Some wells located in canyons impacted by the Las Conchas Fire were temporarily plugged after the fire to prevent post-fire flood waters from potentially entering the wells. These wells were not sampled during the latter part of 2011 but will be returned to service once flood hazards have been mitigated.

F. SUMMARY OF 2011 SAMPLING RESULTS

In 2011, LANL sampled 215 groundwater wells, well screens, and springs in 813 separate sampling events. The samples collected were analyzed for about 206,026 separate results. If results for field parameters (e.g., temperature or pH) and field quality control blanks are excluded, the samples were analyzed for 151,197 results. The total number of results for each analytical suite and groundwater zone are given in Table 5-5. The bottom row of the table gives the number of sample results, not including field quality control blanks or field parameters.

Table 5-5
Total Number of Groundwater Sample Results Collected by LANL in 2011

Groundwater Zone	Total Results	Dioxins and Furans	Diesel Range Organics	General Inorganic Chemistry	Gasoline Range Organics	HE	Isotopes	Metals	Pesticides and PCBs ^a	Radioactivity	SVOCs ^b	VOCs ^c
Alluvial	8,497	25		1,025		270		1,254	16	227	1,520	4,160
Intermediate	44,105	775	2	5,306	2	1,243	80	8,624	899	1,014	7,920	18,240
Intermediate spring	3,477			332		264		536	16	89	480	1,760
Regional	133,642	3,500	2	16,879	2	3,912	280	27,183	4,084	3,160	24,640	50,000
Regional spring	6,442	125		584		340		833	145	255	1,440	2,720
Water supply	8,192		5	822		500		784	200	681	1,360	3,840
Not specified	1,671			363		158	22	592		136	160	240
Total	206,026	4,425	9	25,311	4	6,687	382	39,806	5,360	5,562	37,520	80,960
Number of Groundwater Sample Results Omitting Field Parameters and Field Quality Control Blanks												
Total	151,197	3,575	8	20,501	4	6,394	382	39,476	4,403	5,334	31,680	39,440

^a PCB = Polychlorinated biphenyl.

^b SVOC = Semivolatile organic compound.

^c VOC = Volatile organic compound.

Table 5-6 gives the total number of sample results that were above the screening levels described in Section C. About 0.16% of the results had values greater than a screening level. These totals are based on omitting field quality control blanks, field parameters, and measurements made at an in-house analytical laboratory. Samples analyzed in-house are used mainly for evaluating water quality in newly drilled wells or in wells affected by drilling fluids; these samples are not used for compliance monitoring. The analytes, number of times above the screening level, and the screening level values are given in Table 5-7.

Table 5-6
Total Number of Groundwater Sample Results above Screening Levels in 2011
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

	Total Results	Analytical Suite									
		Dioxins and Furans	Diesel Range Organics	General Inorganic Chemistry	Gasoline Range Organics	HE	Metals	Pesticides and PCBs	Radioactivity	SVOCs	VOCs
Number of results	129,292	3,575	8	13,482	4	6,394	24,972	4,403	5,334	31,680	39,440
Number above screening level	211	0	0	31	0	24	113	0	16	17	10
Percent above screening level	0.16	0.00	0.00	0.23	0.00	0.38	0.45	0.00	0.30	0.05	0.03

Table 5-7
Groundwater Analytes with Results above Screening Levels in 2011
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
General Inorganic Chemistry	31			
Chloride	1	250	mg/L	NM groundwater standard
Perchlorate	30	4	µg/L	Consent Order
HE	24			
RDX	24	6.11	µg/L	EPA regional screening level for tap water
Metals	113			
Aluminum	3	5,000	µg/L	NM groundwater standard
Arsenic (dissolved and total)	9	10	µg/L	EPA MCL
Barium	10	1,000	µg/L	NM groundwater standard
Boron	4	750	µg/L	NM groundwater standard
Chromium (dissolved)	26	50	µg/L	NM groundwater standard
Iron	21	1,000	µg/L	NM groundwater standard
Lead (total)	4	15	µg/L	EPA drinking water system action level
Manganese	34	200	µg/L	NM groundwater standard
Nickel	2	200	µg/L	NM groundwater standard
Radioactivity	16			
Gross alpha	3	15	pCi/L	EPA MCL
Gross beta	1	50	pCi/L	EPA drinking water screening level
Strontium-90	3	8	pCi/L	EPA MCL
Uranium	5	30	µg/L	NM groundwater standard
Uranium-234	4	4	pCi/L	DOE 4-mrem DCG

Table 5-7 (continued)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
SVOCs	17			
Benzo(a)pyrene	2	0.2	µg/L	EPA MCL
Benzo(b)fluoranthene	1	0.29	µg/L	EPA regional screening level for tap water
Bis(2-ethylhexyl)phthalate	1	6	µg/L	EPA MCL
Dibenz(a,h)anthracene	3	0.029	µg/L	EPA regional screening level for tap water
Dioxane[1,4-]	8	6.7	µg/L	EPA regional screening level for tap water
Indeno(1,2,3-cd)pyrene	2	0.29	µg/L	EPA regional screening level for tap water
VOCs	10			
Acrolein	1	0.042	µg/L	EPA regional screening level for tap water
Dichloroethene[1,1-]	4	5	µg/L	NM groundwater standard
Tetrachloroethene	1	5	µg/L	EPA MCL
Trichloroethane[1,1,1-]	4	60	µg/L	NM groundwater standard

The total number of sample results that were above the screening levels (Tables 5-6 and 5-7) may be an overestimate for several reasons. In many cases the given screening level may not apply to a particular groundwater sample. For example, some of the screening levels (the EPA MCLs and regional screening levels for tap water) apply specifically to drinking water and not to a sample result from a non-drinking water source. Also, for a particular sampling event, multiple measurements made for an analyte may be included in the total. The multiple measurements could include both filtered and unfiltered sample results, multiple analytical laboratory analyses (e.g., made on diluted samples to improve analytical accuracy), and results from field duplicate samples. The monitoring results are described in detail in the following sections.

G. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables for this chapter present groundwater quality monitoring data for 2011 (available at <http://www.intellusnmdata.com>). Columns in the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional (regional includes water supply wells)—or indicate if the location is a spring. The depth and groundwater zone sampled for each screen appear in the table. Springs have a depth of 0 ft, and wells with unknown depths list a value of -1. Supplemental Data Table S5-1 provides definitions for sample description codes used in the data tables.

Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2011. The table also gives the total propagated one standard deviation analytical uncertainty and the analysis-specific minimum detectable activity, where available. A “<” symbol indicates that based on the analytical laboratory or secondary validation qualifiers, the result was a nondetect. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results. In 2010, LANL changed analytical laboratories for low-level tritium analyses. In August 2011, investigation revealed that some results from the new provider (American Radiation Services, Inc. [ARSL]) were subject to calculation errors. The analytical laboratory checked all results for samples submitted from 2008 through 2011 and submitted new lab reports where errors were found. Earlier incorrect results were marked in the database as rejected, and new results were added to the database.

Table S5-4 lists radionuclides detected in groundwater samples as reported by the analytical laboratory. For most radiochemical measurements, LANL reported a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (which indicates that the result is a nondetect). The analytical laboratory reports a result that is greater than the measurement-specific minimum detectable activity as detected.

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

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

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2011. The results of trace metal analyses appear in Table S5-9.

1. Organic Chemicals in Groundwater

In 2011, the Laboratory analyzed samples from selected springs and monitoring wells for organic chemicals. Table S5-10 summarizes the stations sampled and organic chemical suites for which samples were analyzed. These samples were analyzed for some or all of the following organic chemical suites: VOCs, SVOCs, PCBs, pesticides, diesel range organics, and HE. Table S5-11 shows organic chemicals detected during 2011 in groundwater and field quality control samples.

Certain organic compounds used in analytical laboratories or derived from sampling equipment are frequently detected in laboratory blanks; that is, contamination introduced by the sampling or analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993). Other compounds sporadically detected in samples as a result of cross-contamination include PCBs and polycyclic aromatic hydrocarbon (PAH) compounds (such as benzo[a]pyrene).

Bis(2-ethylhexyl)phthalate is a component of plastics, including sample bottles and tubing. It has been detected repeatedly at several wells since 2005, particularly in a few wells drilled since 2008. In some cases, the compound was found at concentrations above the 6-µg/L EPA MCL. Concentrations generally have fallen significantly during the years following initial well sampling. Based on the history of concentrations of bis(2-ethylhexyl)phthalate for these wells, it appears that the compound initially leaches from some material used during drilling or well construction.

Only three wells had bis(2-ethylhexyl)phthalate detections in 2011. One sample in Mortandad Canyon intermediate well MCOI-6 showed bis(2-ethylhexyl)phthalate at a concentration of 3.4 µg/L. MCOI-6 previously had bis(2-ethylhexyl)phthalate concentrations ranging from 2.3 µg/L to 12.4 µg/L between June 2005 and August 2007, and bis(2-ethylhexyl)phthalate was also detected at concentrations just above the method detection limit (MDL) (2 µg/L to 3 µg/L) in three other samples before 2011.

A sample from Mortandad Canyon regional aquifer well R-46 had a bis(2-ethylhexyl)phthalate concentration of 7.5 µg/L. The highest concentration at the well, just after it was constructed in 2009, was 96 µg/L; concentrations have declined steadily since 2009. Water Canyon regional aquifer well CdV-R-37-2 had 2.95 µg/L of bis(2-ethylhexyl)phthalate in a sample from the 1,200-ft screen. There was only one prior detection at this screen, in 2002, with numerous intervening samples containing no detections of bis(2-ethylhexyl)phthalate.

The detection of several other organic compounds in well samples was likely the result of analytical cross-contamination rather than their presence in groundwater. Several PAH compounds (such as benzo[a]pyrene) were found in samples from R-61, R-23, R-29, R-30, and Spring 4. In some of these cases, some compounds

were found in a primary sample or field duplicate sample but not both. The compounds have generally not been detected in other samples from the wells or spring.

2. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at elevated concentrations in springs and wells throughout the Rio Grande valley. Other radioactivity in groundwater samples comes from members of the decay chains for naturally occurring uranium-235, uranium-238 (including radium-226 and uranium-234), and thorium-232 (including radium-226). Potassium-40 is also a source of natural radioactivity.

No 2011 activity or concentration value for a radioactivity analyte in a Los Alamos County water supply well exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water. The 2011 samples from water supply wells used by the City of Santa Fe and Pueblo de San Ildefonso had uranium and gross-alpha results near or above screening levels, as described in a later section.

No 2011 radioactivity results for intermediate groundwater or regional aquifer wells within or immediately adjacent to LANL were above screening levels.

In 2008, the method for analyzing radium-228 changed from EPA:901.1 to EPA:904, with a corresponding decrease in minimum detectable activity from a range of 10 pCi/L to 30 pCi/L to a range of 0.3 pCi/L to 1 pCi/L. This change in method sensitivity corresponds to an increased number of detections. In 2010, radium-228 was detected in water supply wells O-4 and PM-5 at respective concentrations of 11.8 pCi/L and 6.58 pCi/L, above the EPA MCL of 5 pCi/L. A result from O-4 for a field duplicate sample was nondetect at < 0.412 pCi/L. Earlier results and the 2011 results from both wells for radium-228 were nondetect.

Results for strontium-90 from alluvial groundwater in Los Alamos Canyon (and past results from Mortandad Canyon, not sampled in 2011 because of drought conditions and no discharge from the Radioactive Liquid Waste Treatment Facility [RLWTF]) were near or above the 4-mrem/yr DOE DCG and EPA MCL screening levels (Table 5-8). Strontium-90 contributed most of the dose in alluvial groundwater for samples taken in 2010 and 2011; other radioactive analytes contributed little. In past years, americium-241, plutonium-238, and plutonium-239/240 results in some Mortandad Canyon alluvial wells have occasionally exceeded the 4-mrem/yr DOE DCG screening levels, mainly in unfiltered samples.

Table 5-8
Radioactivity Results above Screening Levels in Alluvial Groundwater for 2011

Chemical	Location	Result	Trends
Strontium-90	Two wells in DP and Los Alamos Canyons	14.7 pCi/L to 64.5 pCi/L, above EPA MCL screening level of 8 pCi/L and 40-pCi/L, 4-mrem/yr DOE DCG screening level	Fairly stable for 10 years because of retention on alluvium
Gross beta	Two wells in DP and Los Alamos Canyons	33 pCi/L to 241 pCi/L, above EPA drinking water screening level of 50 pCi/L	Because of strontium-90 content

3. Metals in Groundwater

The presence of some metals in groundwater at concentrations near or above screening levels may be because of natural occurrence or because of well sampling and well construction issues, rather than LANL releases.

In some LANL characterization wells, the use of fluids to assist well drilling affected the chemistry of groundwater samples. From 1998 through 2006, more than 40 new wells were drilled for hydrogeologic characterization beneath the Pajarito Plateau as part of the Laboratory's Hydrogeologic Workplan (LANL 1998) or as part of corrective measures. The potential for residual drilling fluids and additives to mask detection of certain contaminants led to concern about the reliability or representativeness of the groundwater quality data obtained from some wells, as described in the Well Screen Analysis Report, Revision 2 (LANL 2007a).

Addition of the organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, consuming available oxygen and changing chemical behavior of several constituents found in groundwater and adjacent aquifer material. With reducing conditions (absence of oxygen), the solubility of metals such as manganese and iron increases, and they are dissolved from the surface of minerals that make up the aquifer's rock framework or are possibly dissolved from well fittings. Wells drilled since 2007 have been drilled without the use of drilling fluids, other than water, in the saturated zone. There have been minor exceptions of using foam approximately 100 ft above the water table. These wells also undergo extensive well development at the outset to remove drilling fluids and reduce the turbidity of water samples.

Despite better development and construction practices, a few new wells have shown elevated iron and manganese concentrations in filtered samples. In 2011, samples from R-61 (screens at 1,125 ft and 1,220 ft), R-55i, and R-54 had unusually high iron and manganese concentrations. The performance of these wells was evaluated to determine what actions might improve their water sample quality.

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

H. GROUNDWATER SAMPLING RESULTS BY MONITORING GROUP

In the following sections, groundwater quality results for water supply well monitoring, monitoring locations in the six area-specific monitoring groups, and the General Surveillance monitoring group in the watersheds that cross Laboratory property are discussed. The tables and discussions are grouped according to groundwater mode, proceeding from the regional aquifer to the alluvial groundwater.

The accompanying tables and text mainly address contaminants found at levels near or above standards or screening levels. In the case of the regional aquifer, information regarding contaminants (such as nitrate, perchlorate, and tritium) found at lower concentrations but possibly indicating effects by LANL activities is included. The discussion addresses radioactivity, general inorganic compounds (major anions, cations, and nutrients), metals, and organic compounds for each groundwater zone. The accompanying plots and maps give a temporal and spatial context for most of the contaminants found near or above screening levels.

1. Water Supply Monitoring

a. Los Alamos County

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

With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. In well O-1 in Pueblo Canyon, 2011 perchlorate concentrations were up to 24% of the 4- $\mu\text{g/L}$ Consent Order screening level, or 6% of the EPA's interim health advisory of 15 $\mu\text{g/L}$ (Figure 5-8). Even though the perchlorate levels are below regulatory limits, this well is not used by Los Alamos County for water supply. The levels of tritium and perchlorate at supply well O-1, though below standards or screening levels, indicate the presence of past effluent and surface water recharge in the regional aquifer (Table 5-9). Well O-4, the second well in the Otowi well field, showed no evidence of Laboratory impact in 2011.

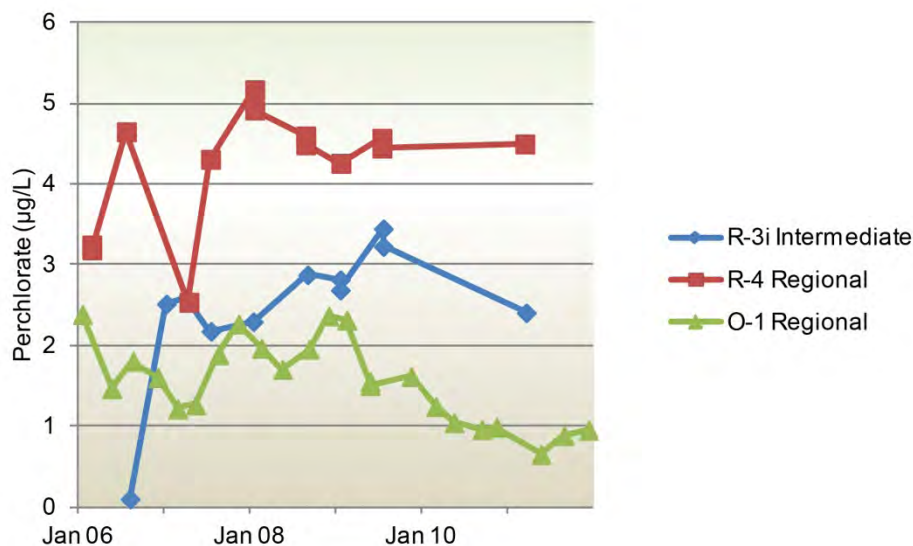


Figure 5-8 Perchlorate at general surveillance and water supply (well O-1) monitoring locations in Pueblo Canyon intermediate and regional aquifer groundwater. The Consent Order screening level is 4 µg/L.

Table 5-9
Groundwater Quality in Los Alamos Water Supply Wells

Chemical	Location	Result	Trends
Arsenic	Water supply well G-2A	6.97 µg/L, below EPA MCL of 10 µg/L; NM groundwater standard is 100 µg/L	Sporadic values above EPA MCL for many years in this well field
Total lead	Water supply well G-5A	11.2 µg/L, below EPA drinking water system action level of 15 µg/L	1 µg/L to 2.3 µg/L since 2004
Tritium	Water supply well O-1	5.5 pCi/L, below EPA MCL of 20,000 pCi/L	Results are variable between 3.5 pCi/L and 58 pCi/L since 2000 and have declined since 2004.
Perchlorate	Water supply well O-1	0.66 µg/L to 0.96 µg/L, below Consent Order screening level of 4 µg/L	Results are variable between 1.2 µg/L and 3 µg/L since 2001 and have declined since 2008.

The Guaje well field, located northeast of the Laboratory, contains five water supply wells. Naturally occurring arsenic has generally been found in this well field at levels above the EPA MCL of 10 µg/L since the field was developed in the early 1950s. In 2011, arsenic was detected only in G-2A (Table 5-9); the result was above the 5-µg/L practical quantitation limit (PQL).

A sample from G-5A had a total lead concentration above the 15-µg/L EPA drinking water action level. Eight prior sample results since the first in 2004 have a maximum concentration of 2.3 µg/L. Lead is not mobile in groundwater, so the lead may be derived from materials within the well.

Five wells (PM-1 through PM-5), located in Sandia Canyon, Cañada del Buey, and Pajarito Canyon, make up the Pajarito Mesa field. These wells showed no evidence of contaminants in 2011.

b. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near the Rio Grande (Table 5-10). Except for LA-5, part of the former Los Alamos well field, these wells lie north of LANL along the Rio Grande; some are east of the river. As a result, the wells do not lie along groundwater flow paths emanating from LANL. Other Pueblo de San Ildefonso wells and springs are covered in later sections.

Table 5-10
Groundwater Quality in San Ildefonso Water Supply Wells

Chemical	Location	Result	Trends
Uranium	J. Martinez House Well and Pajarito Well (Pump 1)	Up to 15.9 µg/L in J. Martinez House Well, below NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	J. Martinez House Well, J. Martinez House Well and Pajarito Well (Pump 1)	Up to 13.6 pCi/L in J. Martinez House Well, below EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; these values were not corrected for this)	Naturally occurring, because of uranium
Fluoride	Pajarito Well (Pump 1)	Up to 0.93 mg/L, below NM groundwater standard of 1.6 mg/L	Naturally occurring
Boron	Pajarito Well (Pump 1)	657 µg/L, below NM groundwater standard (for irrigation) of 750 µg/L	Naturally occurring
Arsenic	J. Martinez House Well and Pajarito Well (Pump 1)	6 µg/L to 17 µg/L, above EPA MCL of 10 µg/L	Naturally occurring

The groundwater quality data for these wells and springs indicate the widespread presence of naturally occurring uranium at levels below the NM groundwater standard of 30 µg/L (Table 5-10). These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in well water throughout the Pojoaque area and Pueblo de San Ildefonso lands. Elevated gross-alpha values for these wells reflect the presence of uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; these gross-alpha results were not corrected for uranium. The wells also have elevated natural concentrations of boron, fluoride, and arsenic.

c. City of Santa Fe

In 2011, the Laboratory sampled three wells in the City of Santa Fe's Buckman well field (Table 5-11). As in past samples, these wells contain natural uranium near or above the NM groundwater standard of 30 µg/L. The elevated gross-alpha values for these wells also reflect the presence of uranium. The 15-pCi/L gross-alpha EPA MCL excludes the gross-alpha contribution from uranium; these gross-alpha results were not corrected for uranium. Naturally occurring arsenic is also elevated in some wells. Samples were also collected from four piezometers in the well field; those results are reported in a separate publication (LANL 2012b).

Table 5-11
Groundwater Quality in Buckman Well Field Supply Wells

Chemical	Location	Result	Trends
Uranium	Buckman Well No. 1	16 µg/L to 31 µg/L, above NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Buckman Wells No. 1 and No. 8	11 pCi/L to 22.7 pCi/L, above EPA MCL of 15 pCi/L (not applicable to gross alpha from uranium; these values were not corrected for this)	Naturally occurring, because of uranium
Arsenic	Buckman Wells No. 1 and No. 8	7.1 µg/L to 11 µg/L, above EPA MCL of 10 µg/L	Naturally occurring

2. Guaje Canyon (including Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that lies north of Laboratory land and heads in the Sierra de los Valles. The canyon has not received any effluents from LANL activities (Table 5-12). The Guaje well field, located northeast of the Laboratory, contains five water supply wells. Naturally occurring arsenic has generally been found in this well field at levels above the EPA MCL of 10 µg/L since the field was developed in the early 1950s (Table 5-9).

Table 5-12
Summary of Groundwater Contamination in
Guaje Canyon (includes Rendija and Barrancas Canyons)

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

The tributary Rendija and Barrancas Canyons have seen, respectively, little and no past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

3. TA-21 Monitoring Group (Los Alamos and DP Canyons) and Pueblo Canyon

The TA-21 monitoring group is located in and around TA-21 and is primarily located in upper Los Alamos Canyon (Table 5-13). The group includes monitoring wells completed in the perched intermediate groundwater and in the regional aquifer. TA-21 is located on the mesa north of Los Alamos Canyon. DP Canyon borders the north side of the mesa and joins Los Alamos Canyon east of TA-21. TA-21 consists of two past operational areas, DP West and DP East, both of which produced liquid and solid radioactive wastes. The operations at DP West included plutonium processing, while the operations at DP East included the production of weapons initiators and tritium research.

Table 5-13
Summary of Groundwater Contamination in Los Alamos Canyon
and the TA-21 Monitoring Group (includes Bayo, Acid, Pueblo, and DP Canyons)

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Bayo Canyon	Past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Past effluent discharges, current sanitary effluent	None	Perchlorate at 60% of Consent Order screening level, fluoride at 64% and nitrate (as nitrogen) at 51% of NM groundwater standards	Perchlorate above Consent Order screening level, trace perchlorate, tritium, and nitrate
Los Alamos and DP Canyons	Past effluent discharges	Strontium-90 above EPA MCL screening level, gross beta above EPA drinking water screening level, chloride above, total dissolved solids (TDS) at 80% and fluoride at 60% of NM groundwater standards	No monitoring locations	No monitoring locations
TA-21 monitoring group	Past effluent discharges	No monitoring locations	Perchlorate above Consent Order screening level, tritium up to 13% of EPA MCL screening level, 1,4-dioxane at 52% of EPA tap water screening level	None
Lower Los Alamos Canyon	Past effluent discharges	None	Perchlorate above Consent Order screening level, fluoride at 52% of NM groundwater standard	None

From 1952 to 1986, a liquid-waste treatment plant discharged effluent containing radionuclides from the former plutonium-processing facility at TA-21 into DP Canyon. Primary potential sources of contaminants in the vicinity of the TA-21 monitoring group include the effluent outfall [Solid Waste Management Unit [SWMU] 21-011(k)], the adsorption beds and disposal shafts at MDA T, DP West, and waste lines and sumps. Other potential sources include DP East and a diesel spill. The monitoring objectives for the TA-21

monitoring group are based in part on the results and conclusions presented in the Los Alamos and Pueblo Canyons Investigation Report (LANL 2004) as well as on the NMED-approved Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1 (LANL 2008a).

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at TA-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically in recent decades.

Bayo Canyon, a tributary of Los Alamos Canyon, contained a now-decommissioned firing site. The canyon has only ephemeral surface water and no known alluvial or intermediate groundwater.

Pueblo Canyon receives effluent from the new Los Alamos County Wastewater Treatment Plant (completed in 2007). Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Compared with past decades, little radioactivity is found in current groundwater samples. Perchlorate concentrations from one regional aquifer monitoring well in Pueblo Canyon are above the Consent Order screening level, and tritium, nitrate, and fluoride concentrations in some wells are elevated but are below standards. These findings may indicate a lingering influence on the regional aquifer from past discharges of radioactive wastewater in Acid Canyon.

a. Pueblo Canyon General Surveillance Monitoring

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, has perchlorate values above the Consent Order screening level of 4 µg/L (Figures 5-8 and 5-9, Table 5-14).

Table 5-14
Groundwater Quality in Pueblo Canyon (includes Acid Canyon)

Chemical	Location	Result	Trends
Perchlorate	Regional aquifer well R-4	4.5 µg/L, above Consent Order screening level of 4 µg/L	Concentrations fairly steady since 2006
Perchlorate	Intermediate well R-3i	2.4 µg/L, below Consent Order screening level of 4 µg/L	Concentrations fairly steady since 2006
Nitrate (as N)	Intermediate well R-3i	5.1 mg/L, below NM groundwater standard of 10 mg/L	Concentrations fairly steady since 2006, nearby intermediate wells have slightly lower concentrations
Uranium	Intermediate well R-3i	9.7 µg/L, below NM groundwater standard of 30 µg/L	May be leached from bedrock by percolation of sanitary effluent, steady since 2006
Fluoride	Intermediate well R-5	1 mg/L, below NM groundwater standard of 1.6 µg/L	Concentrations fairly steady since 2004

Intermediate groundwater samples have also shown concentrations near standards of perchlorate, fluoride, and nitrate (Figure 5-10, Table 5-14). An intermediate screen in regional aquifer well R-5 shows fluoride values higher than those in nearby wells, but the results are below the NM groundwater standard. The 2011 uranium concentrations in samples from Pueblo Canyon intermediate well R-3i ranged from 9.2 µg/L to 9.7 µg/L, above levels in nearby wells but below the standard. The higher uranium concentrations may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

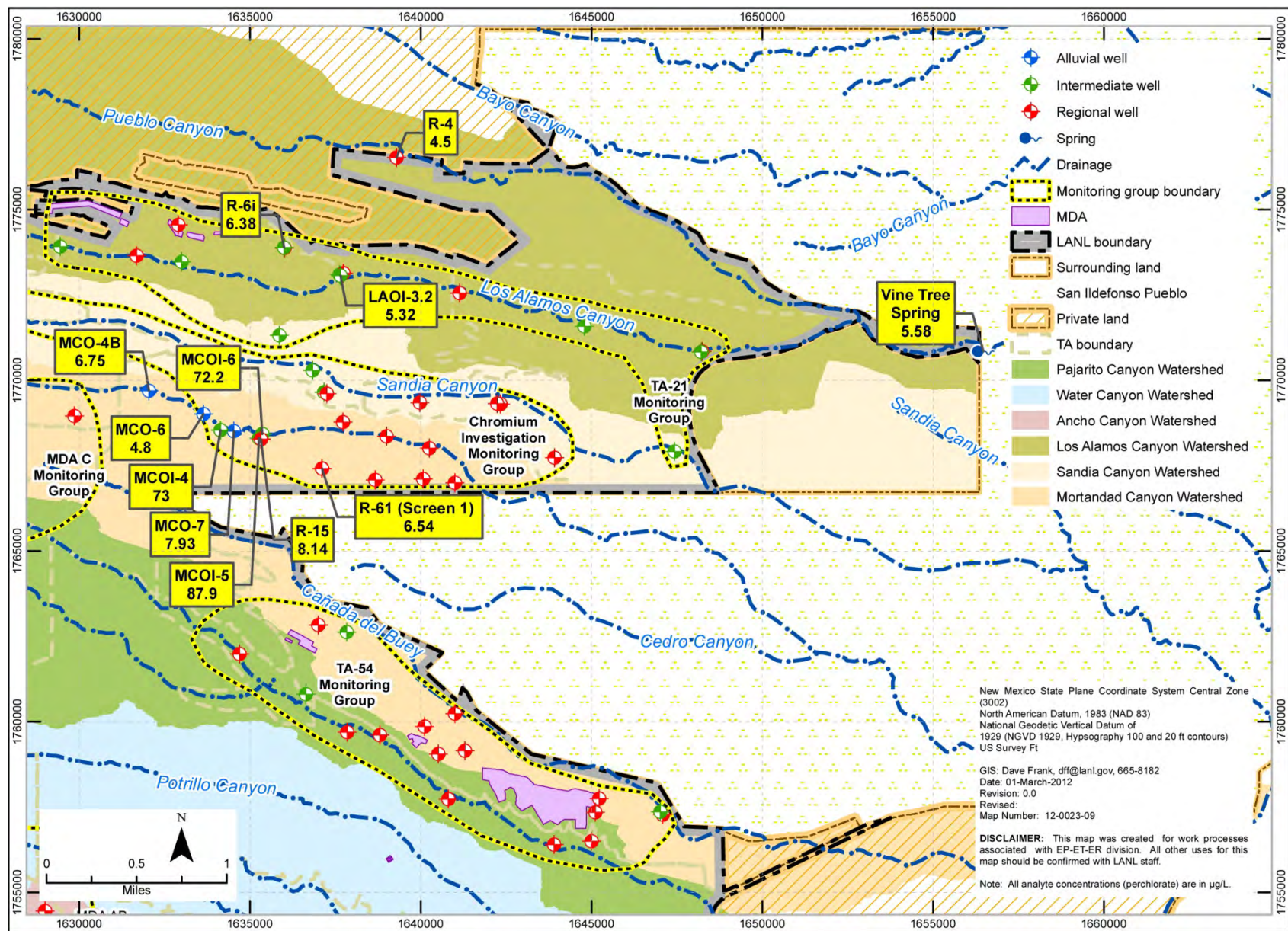


Figure 5-9 Wells with 2011 perchlorate concentrations above the 4-µg/L NM Consent Order screening level. The maximum concentration for the year is shown in µg/L.

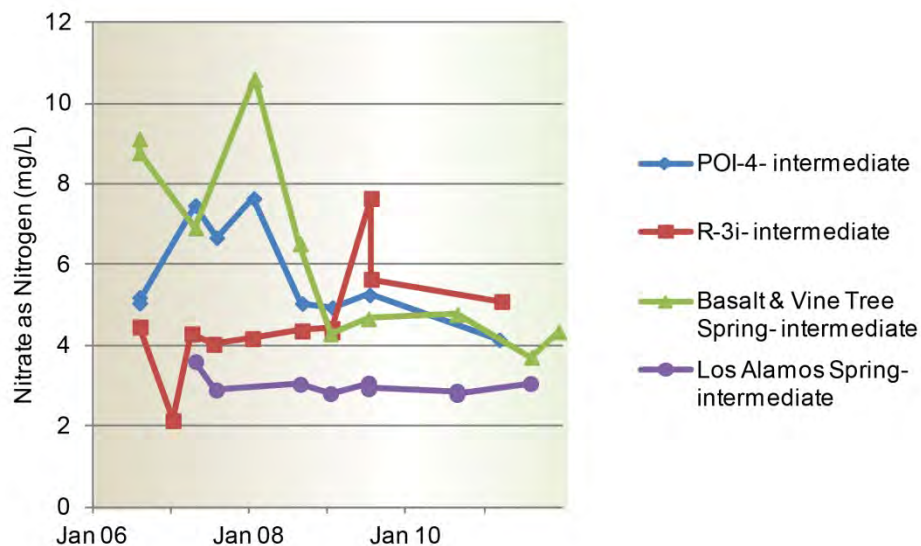


Figure 5-10 Nitrate (as nitrogen) at general surveillance monitoring locations in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater. The NM groundwater standard is 10 mg/L.

b. TA-21 Monitoring Group (Los Alamos and Sandia Canyons)

TA-21 is located on the mesa north of Los Alamos Canyon. The TA-21 monitoring group is primarily located in upper Los Alamos Canyon.

Several intermediate wells have elevated activities of tritium and high concentrations of perchlorate and 1,4-dioxane (Table 5-15, Figures 5-11 through 5-13). Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 2,540 pCi/L of tritium. For comparison, the EPA MCL (which applies to drinking water) is 20,000 pCi/L.

**Table 5-15
Groundwater Quality in TA-21 Monitoring Group**

Chemical	Location	Result	Trends
Tritium	Intermediate wells R-6i, LAOI-3.2, and LAOI-3.2a	1,210 pCi/L to 2,540 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i, decreasing in LAOI-3.2 and LAOI-3.2a
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and R-9i	2.3 µg/L to 6.4 µg/L, above Consent Order screening level of 4 µg/L	Highest in R-6i, lowest but steady for two years in R-9i
Dioxane[1,4-]	Intermediate well R-6i	3.5 µg/L, below EPA regional screening level for tap water of 6.7 µg/L	Detected in nearly every sampling event since 2006, all values just above 2-µg/L MDL and estimated

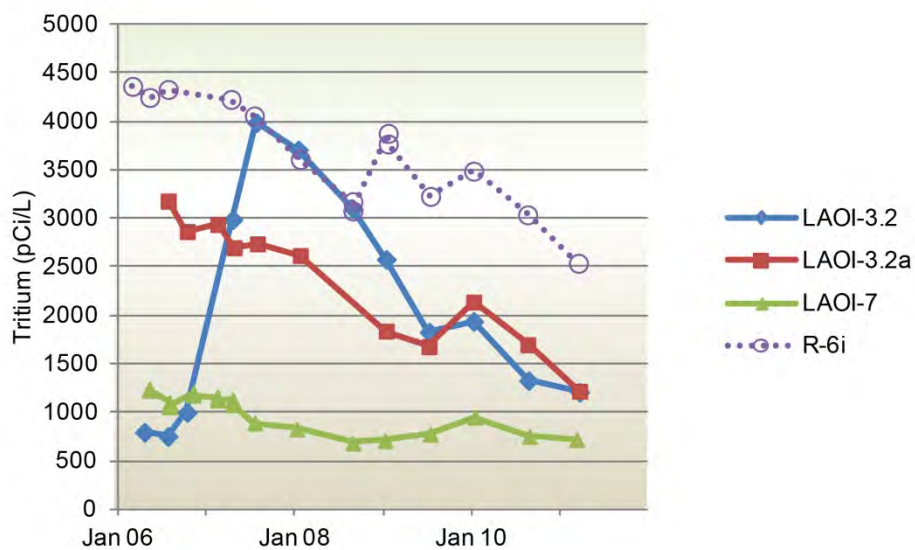


Figure 5-11 Tritium in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL (which does not apply to these samples) is 20,000 pCi/L.

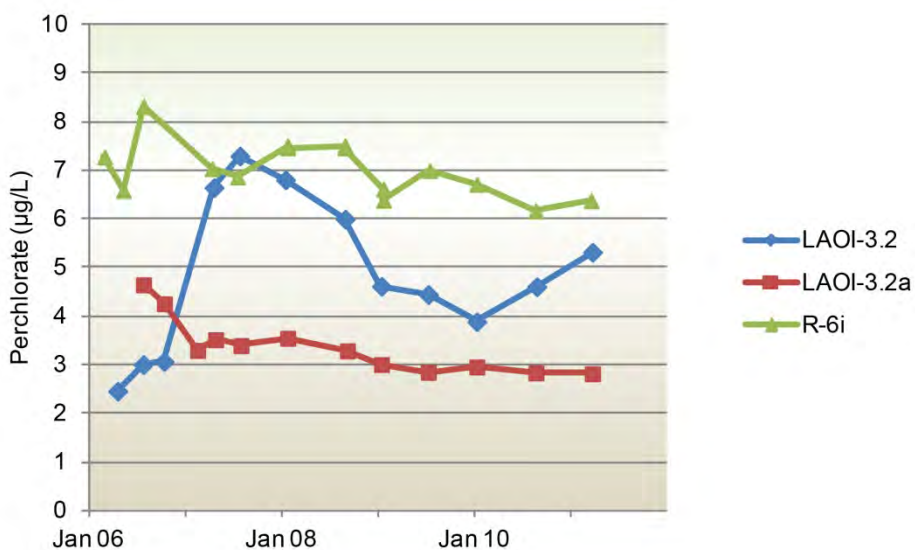


Figure 5-12 Perchlorate in the TA-21 monitoring group in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

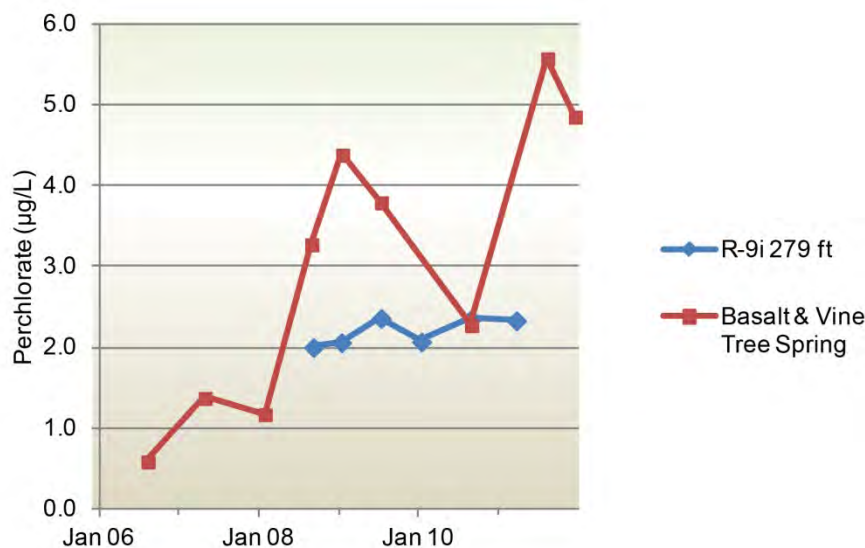


Figure 5-13 Perchlorate in the TA-21 monitoring group at R-9i and at general surveillance monitoring locations in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

The 2011 nitrate (as nitrogen) concentrations in R-6i, LAOI-3.2, and LAOI-3.2a ranged from 2.1 mg/L to 3.75 mg/L. The nitrate (as nitrogen) concentrations in these wells have fluctuated over their period of sampling but are below the 10-mg/L NM groundwater standard. The perchlorate concentrations in these wells ranged up to 6.4 µg/L, above the Consent Order screening level of 4 µg/L. The perchlorate concentration in the deeper intermediate screen at R-9i since late 2008 has been between 2.0 µg/L and 2.4 µg/L (Figure 5-13).

In 2006, LANL measured and detected 1,4-dioxane for the first time in intermediate well R-6i. The compound has been detected in nearly every sampling event. The 1,4-dioxane EPA regional screening level for tap water is 6.7 µg/L.

c. Los Alamos Canyon General Surveillance Monitoring

Alluvial wells in DP and Los Alamos Canyons continue to show elevated activities of strontium-90; the values range up to and above the 8-pCi/L EPA MCL screening level (Figure 5-14, Table 5-16). Results from filtered and unfiltered samples from the same date are usually similar, so both are shown in Figure 5-14. Strontium-90 continues to be found in groundwater samples because it has been retained on the alluvium by cation exchange. Fluoride is also present in samples but at concentrations below the NM groundwater standard of 1.6 mg/L. In 2011, the fluoride concentration in Los Alamos Canyon alluvial well LAO-3a was 0.96 mg/L.

The chloride concentration of 341 mg/L in a sample at DP Canyon alluvial well LAUZ-1 was above the 250-mg/L NM groundwater standard (Figure 5-15). Chloride concentrations at the well have been elevated for 14 years of monitoring and above the standard in three samples. In other drainages surface water and alluvial groundwater chloride concentrations show seasonal variation. Concentrations are highest in winter when snowmelt runoff carries road salt into the canyons. The seasonal variability in DP Canyon is not as clear. Two other alluvial wells, LAO-0.3 and LAO-0.6, located in Los Alamos Canyon above the confluence with DP Canyon, had their highest chloride concentrations in six years of monitoring. The concentrations at these wells were 50% and 72%, respectively, of the NM groundwater standard.

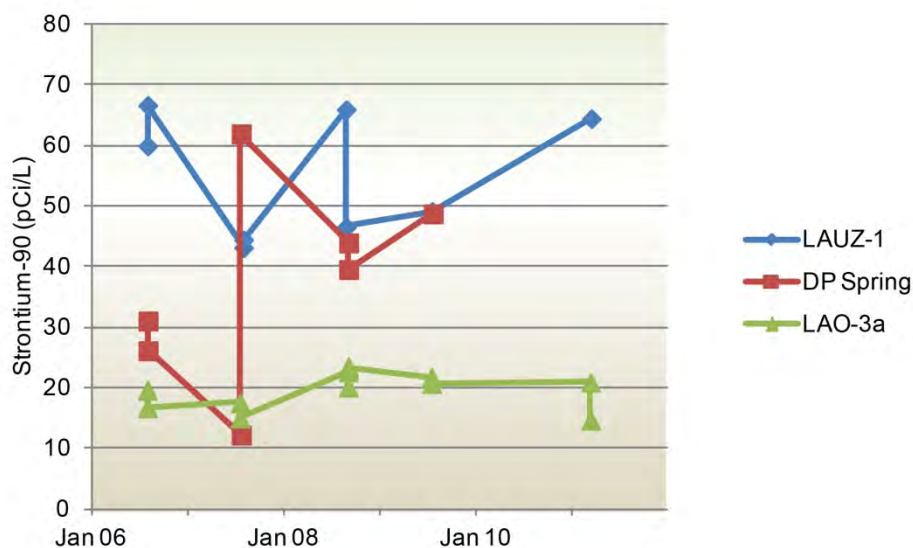


Figure 5-14 Strontium-90 at general surveillance monitoring locations in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results. For comparison purposes, the EPA MCL (which does not apply to these samples) is 8 pCi/L.

Table 5-16
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Strontium-90	Alluvial wells LAUZ-1 and LAO-3a	14.7 pCi/L to 64 pCi/L, above 8-pCi/L EPA MCL screening level and 40-pCi/L, 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, remains elevated because of retention on alluvium
Gross beta	Alluvial wells LAUZ-1 and LAO-3a	33 pCi/L to 241 pCi/L, above EPA drinking water system screening level of 50 pCi/L	Because of strontium-90; decreased since cessation of discharges in 1986, remains elevated because of retention on alluvium
Chloride	Alluvial wells LAUZ-1, LAO-0.3, and LAO-0.6	126 mg/L to 341 mg/L, above NM groundwater standard of 250 mg/L	Similar but variable results at LAUZ-1, over 14 years of monitoring, above standard three times; seasonal variation not clear; highest of six years at the other two wells
TDS	Alluvial well LAUZ-1	798 mg/L, below NM groundwater standard of 1,000 mg/L	Similar but variable results over seven years of samples
Fluoride	Alluvial well LAO-3a	0.96 mg/L, below NM groundwater standard of 1.6 mg/L	Similar levels since 2000

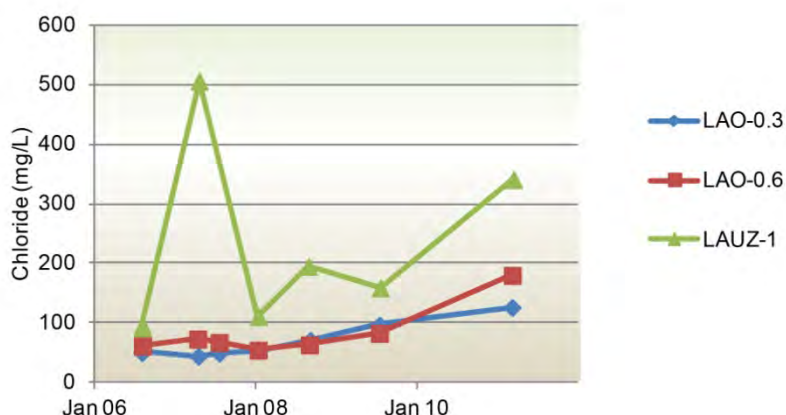


Figure 5-15 Chloride at general surveillance monitoring locations in in Los Alamos and DP Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

d. Lower Los Alamos Canyon General Surveillance Monitoring

Los Alamos Spring and Vine Tree Spring on Pueblo de San Ildefonso land are both fed by intermediate groundwater. Basalt Spring is a spring a few feet from Vine Tree Spring that has been monitored since the 1950s; it apparently dried up, and discharge moved to Vine Tree Spring where the 2011 samples were collected. The 2011 nitrate (as nitrogen) results in Los Alamos and Vine Tree Springs ranged from 3.1 mg/L to 4.4 mg/L, below the NM groundwater standard of 10 mg/L. Earlier nitrate (as nitrogen) results from Basalt Spring were above the standard.

At Vine Tree Spring and Basalt Spring, the perchlorate concentrations since late 2008 have been near or above the Consent Order screening level of 4 µg/L (Table 5-17, Figure 5-13). The 2011 fluoride concentration at Los Alamos Spring was 52% of the 1.6-mg/L NM groundwater standard. Similar concentrations have been found in samples from the spring since the 1960s.

**Table 5-17
Groundwater Quality in Lower Los Alamos Canyon**

Chemical	Location	Result	Trends
Perchlorate	Vine Tree Spring (intermediate)	4.9 µg/L to 5.6 µg/L, above Consent Order screening level of 4 µg/L	Combined with results from nearby Basalt Spring, increasing since 2006
Fluoride	Los Alamos Spring (intermediate)	0.82 mg/L, below NM groundwater standard of 1.6 mg/L	Similar levels since 1960s

4. Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Monitoring focuses on the characterization and fate and transport of chromium contamination in intermediate perched groundwater and within the regional aquifer. The distribution of wells in the monitoring group also addresses past releases from NPDES Outfall 051, which discharged from the RLWTF in the Mortandad Canyon watershed.

The RLWTF discharged effluent containing radioactivity into Mortandad Canyon from 1963 through 2010 (Emelity 1996, Del Signore 2012). RLWTF effluent volumes were considerably reduced in 2010 and eliminated in 2011 because of process changes at the RLWTF (Del Signore 2011, 2012). All 2011 treated water went to a new effluent evaporator (Del Signore 2012).

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives sanitary effluent, releases from the steam plant, and cooling tower discharges from computing facilities and the TA-3 power plant (Table 5-18). Treated sanitary effluent from the TA-46 SWWS Plant has been routed to Sandia Canyon since 1992. Until 1972, chromate was used to treat cooling water at the power plant (LANL 1973). These earlier discharges are associated with the hexavalent chromium concentrations in intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons (Figure 5-16). Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been diverted to the south by southwesterly dipping strata prior to reaching the regional aquifer (LANL 2006a, 2008b).

Table 5-18
Summary of Groundwater Contamination in Sandia and
Mortandad Canyons and the Chromium Investigation Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Current and past effluent discharges	No monitoring locations	No monitoring locations	None
Chromium Investigation monitoring group (Sandia Canyon)	Current and past effluent discharges	None	Chromium above NM groundwater standard	Chromium at 74% and nitrate at 60% of NM groundwater standards
Chromium Investigation monitoring group (Mortandad Canyon)	Past effluent discharges	No monitoring locations	Bis(2-ethylhexyl)phthalate at 57% and tritium at 21% of EPA MCL screening levels, perchlorate above Consent Order screening level, chromium above and nitrate up to 94% of NM groundwater standards, 1,4-dioxane above EPA regional screening level for tap water	Chromium above and nitrate at 66% of NM groundwater standards, total lead at 76% EPA drinking water system action level, perchlorate above Consent Order screening level
Mortandad and Ten Site Canyons	Past effluent discharges	Fluoride at 58% of NM groundwater standard, perchlorate above Consent Order screening level	No monitoring locations	None
Cañada del Buey	Dry and liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Mortandad Canyon also has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of NPDES outfalls, including one from the RLWTF at TA-50 (Table 5-18). Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35. Some Mortandad Canyon wells are part of the TA-54 and MDA C monitoring groups and are discussed in a later section.

The 2011 chromium concentrations exceeded the NM groundwater standard in Mortandad Canyon regional aquifer wells R-28, R-42, and R-50 (Figure 5-16). Other constituents detected at elevated concentrations or activities in wells in the monitoring group include nitrate, perchlorate, and tritium. A conceptual model for the sources and distribution of these contaminants is presented in the Investigation Report for Sandia Canyon (LANL 2009a).

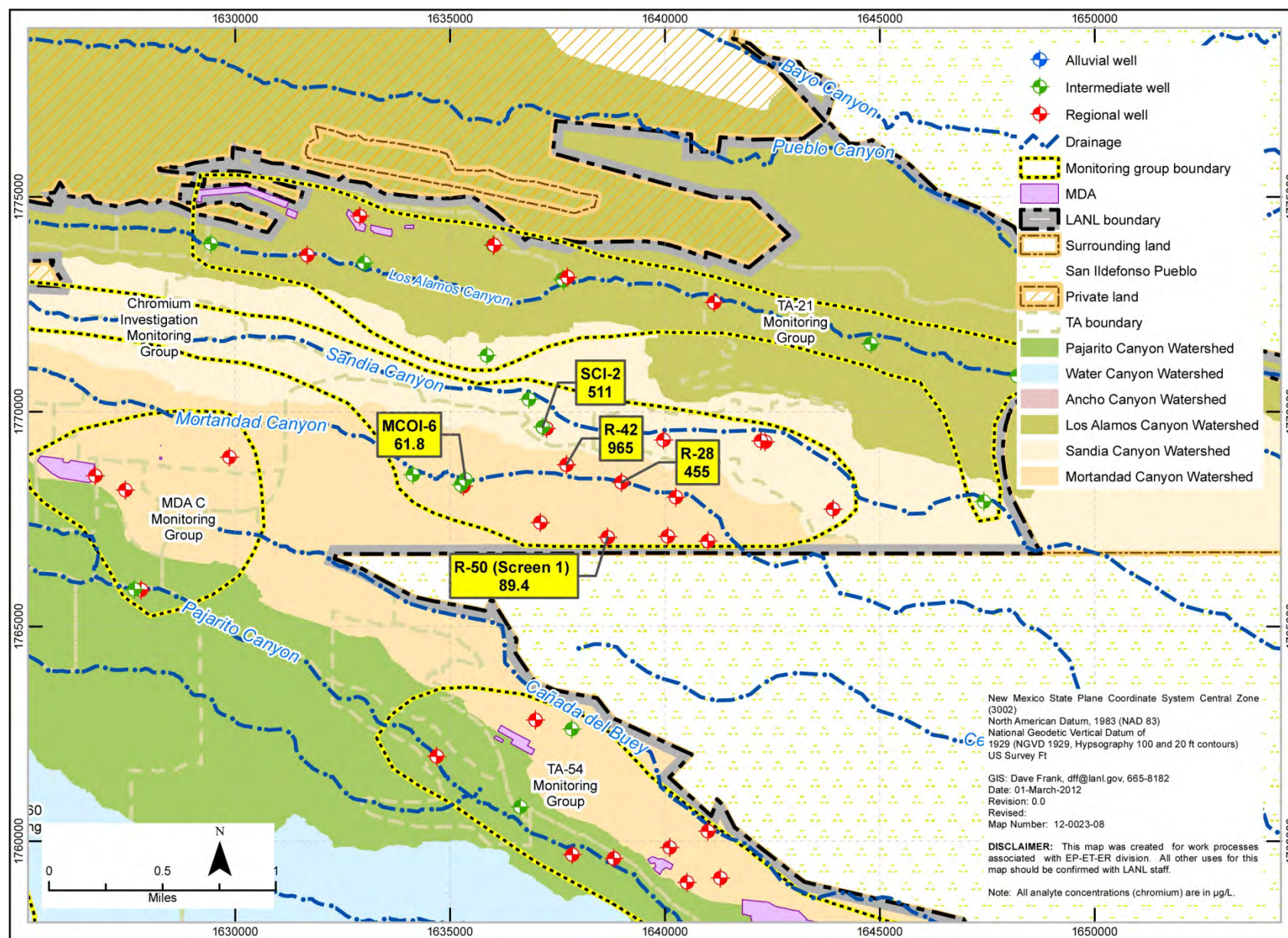


Figure 5-16 Wells with 2011 dissolved or hexavalent chromium concentrations above the 50-µg/L NM groundwater standard. The maximum concentration for the year is shown in µg/L.

The conceptual model hypothesizes that chromium originated from releases into Sandia Canyon and may have migrated along lateral pathways to locations beneath Mortandad Canyon. For this reason, intermediate perched and regional wells beneath Mortandad Canyon are included in the Chromium Investigation monitoring group. Other areas of contamination beneath Sandia and Mortandad Canyons may be associated with Mortandad Canyon sources. These sources and the migration pathways are described in the Investigation Report for Sandia Canyon (LANL 2009a).

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two wells have ever contained water. Because treated effluent from the Laboratory's SWWS Plant may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture monitoring holes was installed during 1992 within the upper and middle reaches of the drainage.

a. Sandia Canyon General Surveillance Monitoring

The only wells located in Sandia Canyon that are not part of the Chromium Investigation monitoring group are R-10 and R-10a on Pueblo de San Ildefonso land. No constituents were measured near or above standards in these wells during 2011.

b. Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. For regional aquifer wells, filtered chromium concentrations ranged from 37 µg/L in Sandia Canyon well R-43 to 965 µg/L in Mortandad Canyon well R-42 (Table 5-19, Figures 5-16 through 5-18). The NM groundwater standard is 50 µg/L.

Table 5-19
Groundwater Quality in the Chromium Investigation Monitoring Group (Sandia and Mortandad Canyons)

Chemical	Location	Result	Trends
Chromium	Sandia Canyon regional aquifer well R-43 (upper screen)	16 µg/L to 37 µg/L, below NM groundwater standard of 50 µg/L	Below 5 µg/L through 2009, now increasing
Chromium	Mortandad Canyon regional aquifer wells R-28, R-42, and R-50 (upper screen)	Average of 396 µg/L at R-28, 930 µg/L at R-42, and 78 µg/L at R-50, above NM groundwater standard of 50 µg/L	Results at R-42 and R-28 in this range for several years of sampling, increasing at R-50
Nitrate (as N)	Sandia Canyon regional aquifer wells R-11 and R-43 (upper screen)	Usually above 5 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over four years of sampling, recent range is 4 mg/L to 6 mg/L
Nitrate (as N)	Mortandad Canyon regional aquifer wells R-42, R-28, R-45 (upper screen) and R-15	1.5 mg/L to 6.5 mg/L, below NM groundwater standard of 10 mg/L	Higher values in R-42 and lowest in R-15 and R-45, results in this range for several years of sampling except for sampling-related fluctuations
Perchlorate	Mortandad Canyon regional aquifer wells R-15 and R-61 (upper screen)	Average of 7.8 µg/L in R-15, up to 6.5 µg/L in R-61, above Consent Order screening level of 4 µg/L	Concentrations rising in R-15 over several years, R-61 first sampled in 2011
Total lead	Mortandad Canyon regional aquifer well R-15	1.1 µg/L to 11.4 µg/L, below EPA drinking water system action level of 15 µg/L; filtered lead < 2 µg/L	Up to 39 µg/L in 2010 µg/L, earlier results were nondetects or were below 2 µg/L
Tritium	Mortandad Canyon intermediate wells MCOI-4, MCOI-5, and MCOI-6	2,320 pCi/L to 4,280 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing since 2008, wells sample separate isolated perched zones
Chromium	Sandia Canyon intermediate well SCI-2	Average of 488 µg/L, above NM groundwater standard of 50 µg/L	Results in this range for several years
Chromium	Mortandad Canyon intermediate well MCOI-6	Average of 56 µg/L, above NM groundwater standard of 50 µg/L	Increasing since 2007
Nitrate (as N)	Sandia Canyon intermediate well SCI-2	Average of 4.3 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over four years of sampling, recent range is 4 mg/L to 5 mg/L

Table 5-19 (continued)

Chemical	Location	Result	Trends
Nitrate (as N)	Mortandad Canyon intermediate wells MCOI-4, MCOI-5, and MCOI-6	3.9 mg/L to 9.4 mg/L, below NM groundwater standard of 10 mg/L	Results decreasing in MCOI-6 and MCOI-4 for several years, wells sample separate isolated perched zones
Perchlorate	Mortandad Canyon intermediate wells MCOI-4, MCOI-5, and MCOI-6	63 µg/L to 88 µg/L, above Consent Order screening level of 4 µg/L	Results in MCOI-4 and MCOI-6 decreased substantially through 2009, less change in MCOI-5
Bis(2-ethylhexyl)phthalate	Mortandad Canyon intermediate well MCOI-6	3.4 µg/L, below EPA MCL screening level of 6 µg/L	Frequent detects up to 12 µg/L before 2008, few since, possibly related to drilling or sampling materials
Dioxane[1,4-]	Mortandad Canyon intermediate wells MCOI-4, MCOI-5, and MCOI-6	4.7 µg/L to 12.1 µg/L in MCOI-6, above EPA regional screening level for tap water of 6.7 µg/L	Highest in MCOI-4 (not sampled for SVOCs in 2011 because of lack of water), lowest and fairly steady in MCOI-5, > 50% decline at MCOI-6 since 2009

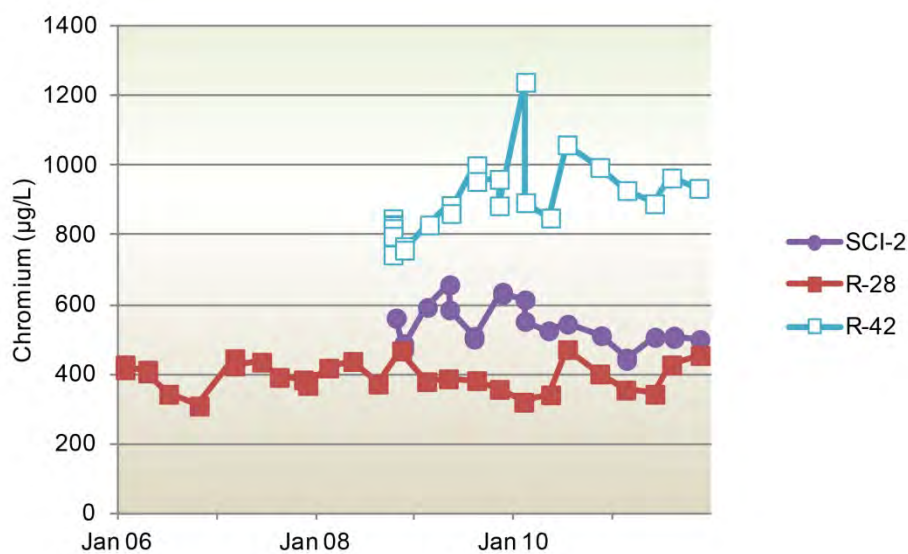


Figure 5-17 Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

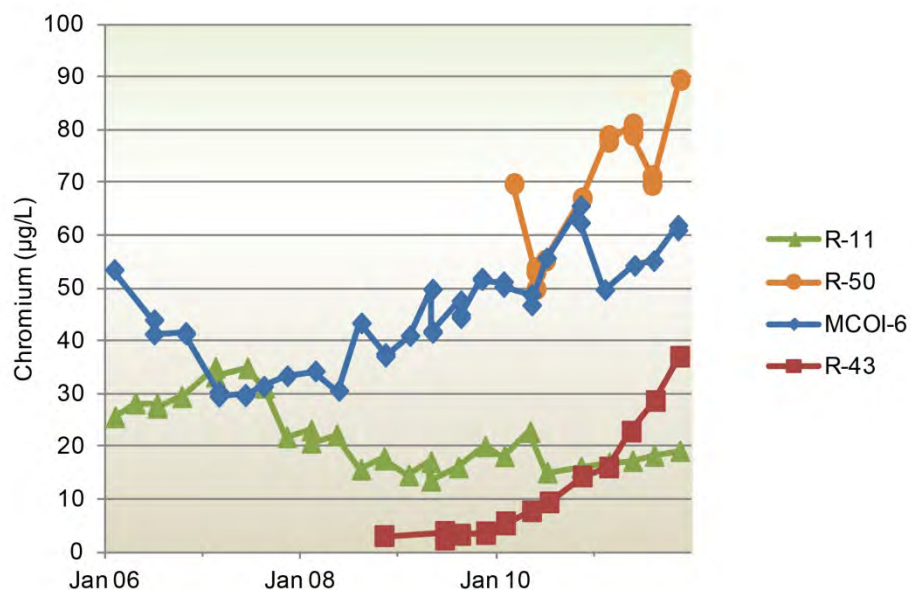


Figure 5-18 Filtered chromium in the Chromium Investigation monitoring group in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

Regional aquifer wells R-43 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon had 2011 nitrate (as nitrogen) concentrations up to 65% of the 10-mg/L NM groundwater standard (Figures 5-19 and 5-20). R-36 had one unusually elevated result on November 16, 2011, and R-11 had a corresponding low result, suggesting samples may have been switched. Nitrate (as nitrogen) concentrations were also elevated (that is, above 2 mg/L) in samples from regional aquifer wells R-36 in Sandia Canyon and R-15, R-28, and R-45 in Mortandad Canyon.

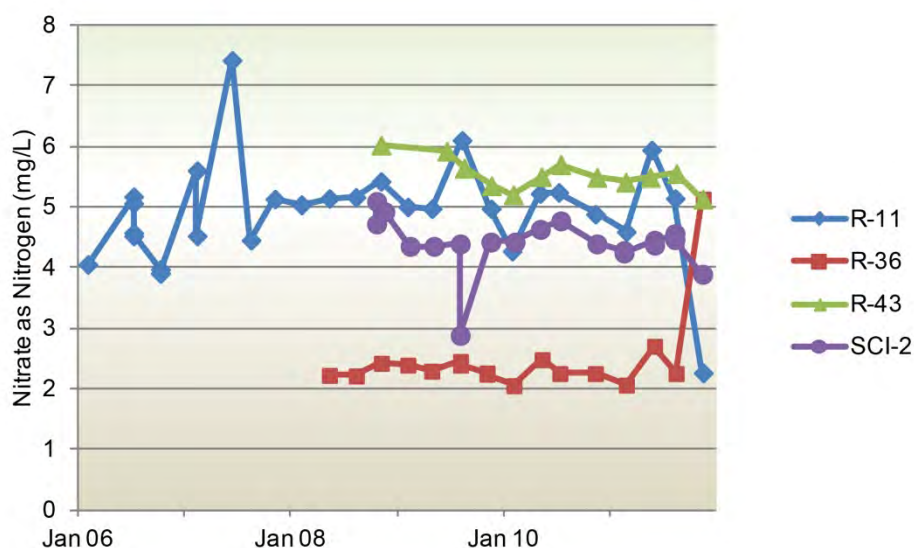


Figure 5-19 Nitrate (as nitrogen) in the Chromium Investigation monitoring group in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Many of the results in 2007 and 2008 are estimated because of analytical quality issues.

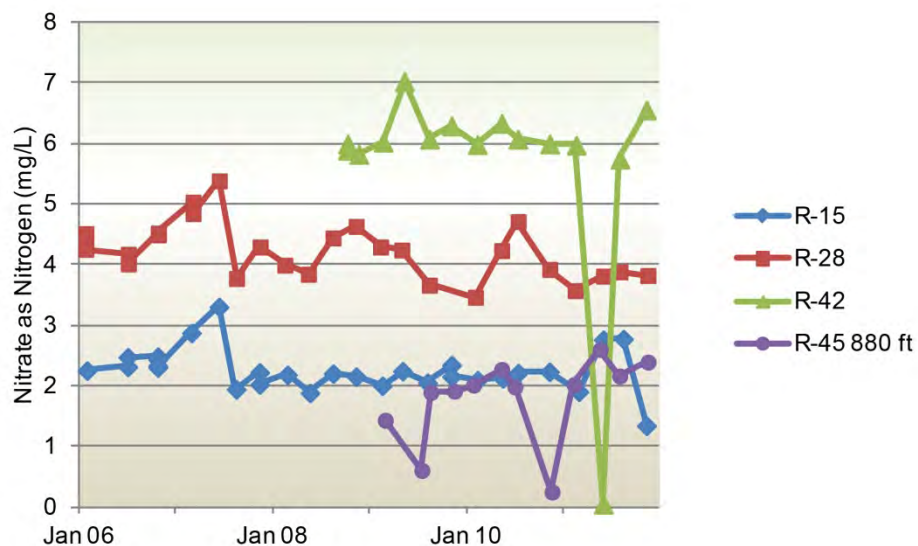


Figure 5-20 Nitrate (as nitrogen) in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Most of the 2007 and some 2009 results are estimated because of analytical quality issues.

The perchlorate concentration in R-15 was above the Consent Order screening level of 4 $\mu\text{g/L}$ (Figures 5-9 and 5-21). Samples taken from the upper screen of R-61 were also above the screening level.

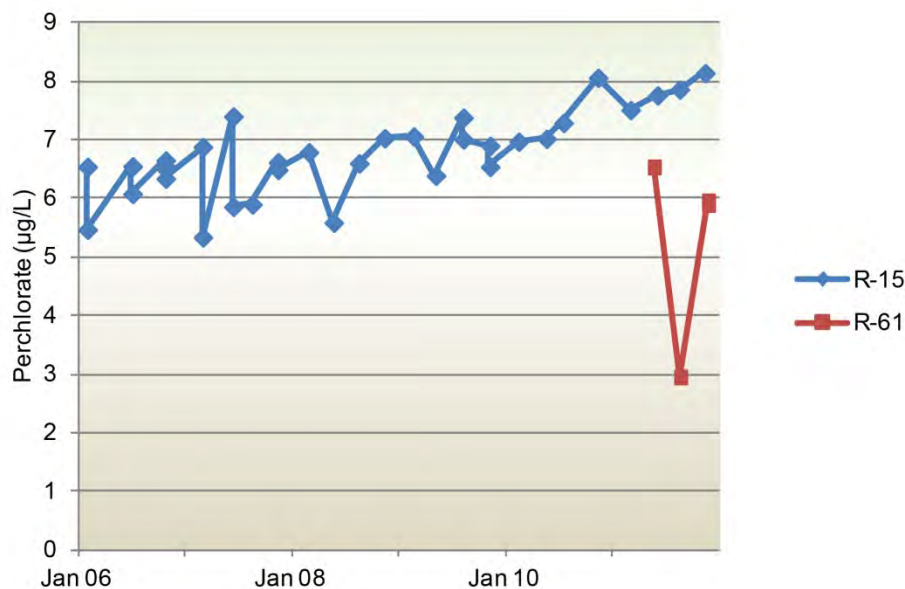


Figure 5-21 Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon regional aquifer wells R-15 and R-61 (1,125-ft screen). The Consent Order screening level is 4 $\mu\text{g/L}$.

A sample from R-15 also had a total lead concentration of 11.4 $\mu\text{g/L}$, at 76% of the 15- $\mu\text{g/L}$ EPA drinking water action level. Two other 2011 results were 3.6 $\mu\text{g/L}$ and 5.7 $\mu\text{g/L}$, and two 2010 results from the well were 9.1 $\mu\text{g/L}$ and 39.5 $\mu\text{g/L}$; most of the earlier results were below the 1- $\mu\text{g/L}$ MDL. The presence of lead in samples is likely from well construction or sampling materials.

SCI-2, an intermediate groundwater monitoring well in Sandia Canyon, had filtered chromium concentrations up to 511 $\mu\text{g/L}$ during 2011 (Table 5-19, Figures 5-16 and 5-17). In Mortandad Canyon,

MCOI-6 had filtered chromium concentrations up to 61.8 $\mu\text{g/L}$ (Figures 5-16 and 5-18). The nitrate (as nitrogen) concentration in SCI-2 was up to 4.6 mg/L (Figure 5-19) and in MCOI-6 was 9.4 mg/L (Figure 5-22), both below the 10-mg/L NM groundwater standard.

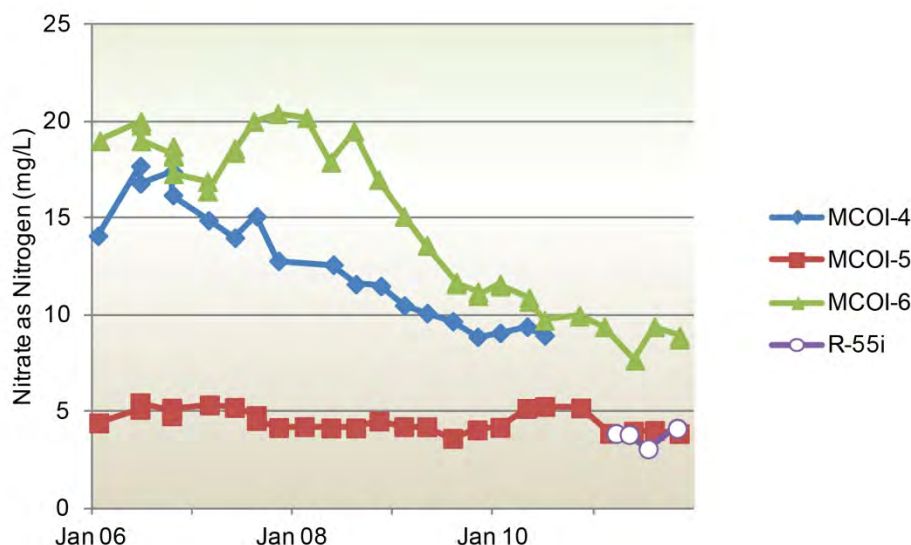


Figure 5-22 Nitrate (as nitrogen) in the Chromium Investigation monitoring group and in the TA-54 monitoring group (R-55i) in Mortandad Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L. Many of the results, particularly in 2006, are estimated because of analytical laboratory quality issues.

The chemical 1,4-dioxane has been detected since 2006 in MCOI-4, MCOI-5, and MCOI-6 (Figure 5-23). The 1,4-dioxane EPA regional screening level for tap water is 6.7 $\mu\text{g/L}$. MCOI-4, which has had the highest concentrations, was only partially sampled in 2011 because of lack of water. Perchlorate in these wells is above the 4- $\mu\text{g/L}$ Consent Order screening level (Figures 5-9 and 5-24).

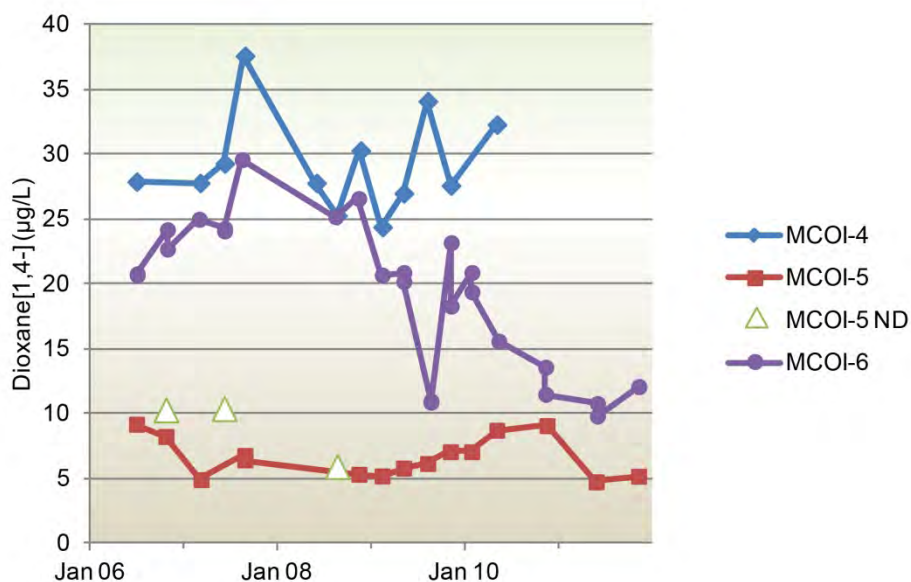


Figure 5-23 Concentrations of 1,4-dioxane in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The EPA regional screening level for tap water is 6.7 $\mu\text{g/L}$. About half the results are estimated; nondetects (NDs) are reported at the PQL for MCOI-5.

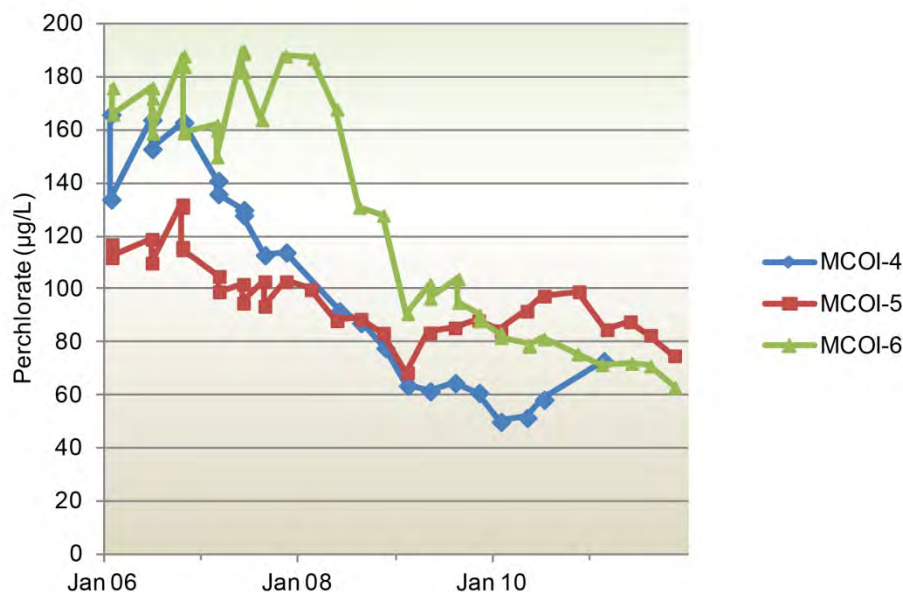


Figure 5-24 Perchlorate in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.

Bis(2-ethylhexyl)phthalate was detected in MCOI-6 at 57% of the 6-µg/L EPA MCL screening level. The compound was found in this well at concentrations up to 12 µg/L in 2006 and 2007. It has been detected in four sampling events since then, at concentrations just above the 2-µg/L to 3-µg/L MDL. LANL believes that the presence of this compound in samples is related to drilling or sampling materials rather than being a groundwater contaminant.

Intermediate wells MCOI-5 and MCOI-6 had tritium activities that ranged from 12% to 21% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-25). Tritium activities in these wells and MCOI-4 have decreased significantly since 2007.

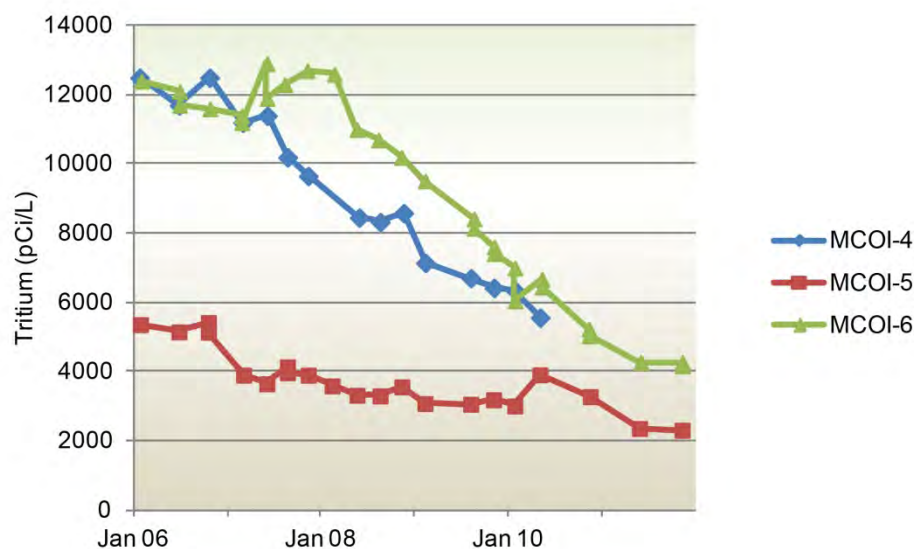


Figure 5-25 Tritium in the Chromium Investigation monitoring group in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 20,000 pCi/L.

c. Mortandad Canyon General Surveillance Monitoring

Several regional aquifer wells in Mortandad Canyon are part of the general surveillance monitoring group. No constituents were measured near or above standards in these wells during 2011.

Because of dry conditions during 2011, alluvial wells in Mortandad Canyon were often dry and none were sampled for radionuclides. Prior to effluent quality improvements in 1999, radionuclide levels in Mortandad Canyon alluvial groundwater were, in general, highest just below the TA-50 RLWTF outfall at wells MCO-3 or MCO-4B and decreased down the canyon. Most radionuclides adsorb to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. Since the early 1990s, radionuclide levels in alluvial groundwater samples have not exceeded the 100-mrem/yr public dose DOE DCG screening levels (applicable to effluent discharges).

The strontium-90 activity in the RLWTF effluent has been below detection since 2003. The inventory of strontium-90 in the alluvium is gradually declining because discharge amounts have decreased and the half-life of strontium-90 is 28.8 years. Strontium-90 continues to be found in groundwater samples because it has been retained by cation exchange on sediment within the upstream portion of the alluvium (Table 5-20).

Table 5-20
Groundwater Quality in Mortandad Canyon Alluvial Groundwater

Chemical	Location	Result	Trends
Strontium-90	Alluvial wells MCO-3, MCO-4B, MCO-5, and MCO-6	For 2010, 29 pCi/L to 62 pCi/L, above EPA MCL screening level of 8 pCi/L and 40-pCi/L, 4-mrem/yr DOE DCG screening level	Not sampled for radioactivity in 2011 because of dry conditions. Fairly stable between 30 pCi/L to 80 pCi/L for 10 years because of retention on alluvium
Fluoride	Alluvial wells MCO-6 and MCO-7	0.81 mg/L to 0.93 mg/L, below NM groundwater standard of 1.6 mg/L	Results decreasing below RLWTF outfall and generally below standard since 1999 effluent treatment upgrades
Perchlorate	Alluvial wells MCO-4B, MCO-6 and MCO-7	4.3 µg/L to 7.9 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades

In 2010, total LANL-derived radioactivity exceeded the 4-mrem/yr DOE DCG screening level in Mortandad Canyon alluvial groundwater samples from wells MCO-4B and MCO-5, was 99% of the screening level in MCO-3, and was 95% of the screening level in MCO-6 (Figure 5-26). Strontium-90 was the dominant contributor to dose in these samples. The 2010 results for strontium-90 were close to or exceeded the 4-mrem/yr DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (8 pCi/L) in all four wells.

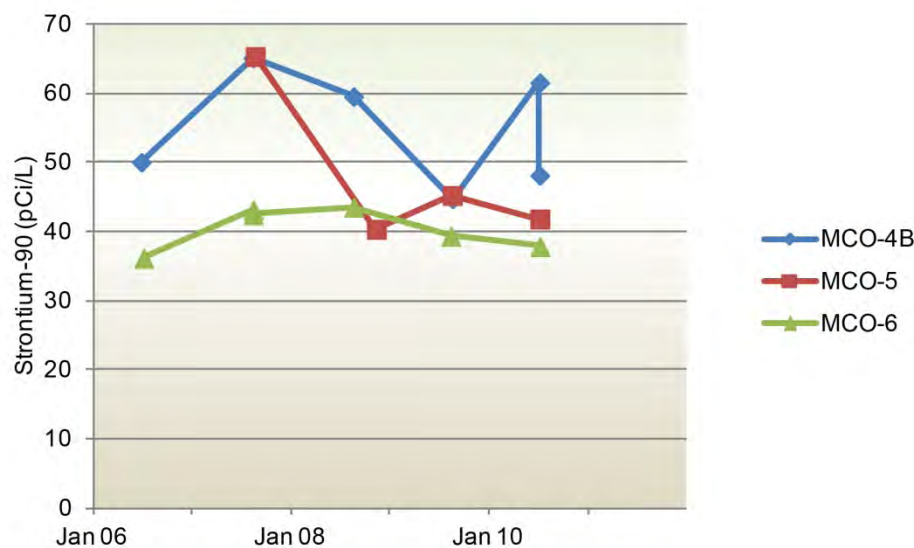


Figure 5-26 Total (unfiltered) strontium-90 at general surveillance monitoring locations in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 8 pCi/L.

Because of dry conditions during 2011, there was little runoff. As a result, alluvial wells in Mortandad Canyon were often dry. Between 2006 and 2010, the chloride concentration in surface water and alluvial wells and samples in Mortandad Canyon approached or exceeded the 250-mg/L NM groundwater standard. These locations showed peaks in chloride concentrations mainly in early winter, evidently the result of runoff affected by road salting. Similar trends occur in sodium concentrations and TDS. The concentration peaks at monitoring locations farther downstream occurred later in the year.

At alluvial well MCO-3, chloride values in 2008 through 2010 were highest each year during February through May, up to 144 mg/L. MCO-3 has been sampled since 1963. With the exception of a few chloride results in about 1971 and 1990, the chloride concentrations since 2006 at MCO-3 are the highest measured at the well over its monitoring history.

The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and since 2006 are higher than most previous values (Figure 5-27). As RLWTF effluent discharge and total chloride mass discharged decreased after 1990 and ended in 2010, the average annual effluent chloride concentration also decreased. Accordingly, RLWTF effluent is not believed to be the cause of the increasing chloride concentration in recent downstream alluvial groundwater samples. These results suggest that increased application of road salt during the past few years has a greater impact on recent groundwater chloride concentrations than the past RLWTF effluent discharges.

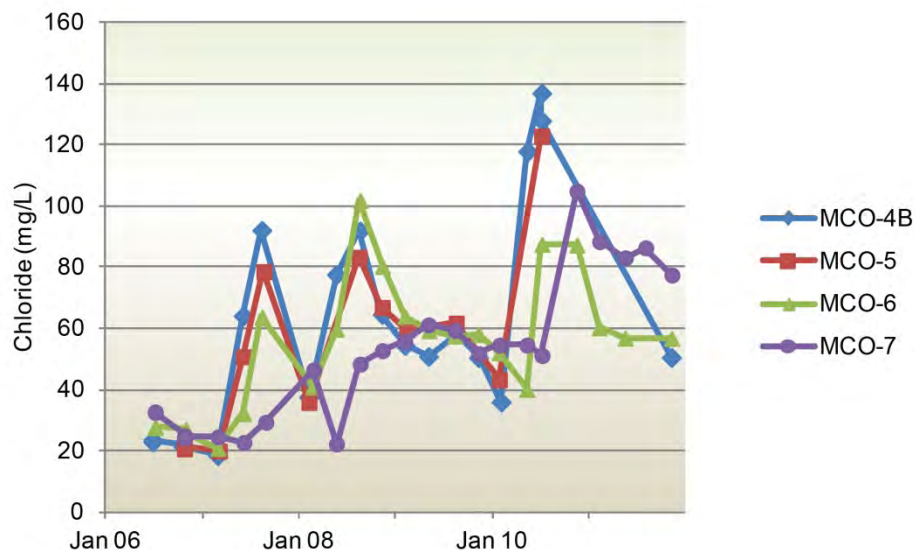


Figure 5-27 Chloride histories for general surveillance monitoring locations in Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

Under the groundwater discharge plan application for the RLWTF, the Laboratory has collected additional quarterly samples since 1999 for nitrate, fluoride, perchlorate, and TDS from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-3, MCO-4B, MCO-6, and MCO-7.

The 2011 nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L; the maximum was 1.24 mg/L in MCO-6. The fluoride concentrations were below the NM groundwater standard of 1.6 mg/L, though many were above 50% of the standard. The highest 2011 groundwater fluoride concentration downstream of the RLWTF outfall was 0.933 mg/L in MCO-7.

Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had elevated perchlorate concentrations (Figures 5-9 and 5-28). The 2011 concentrations at three alluvial wells were above the Consent Order screening level of 4 µg/L. In 2000, the perchlorate concentrations in these wells were above 200 µg/L; they declined substantially following the removal of perchlorate from RLWTF effluent in March 2002.

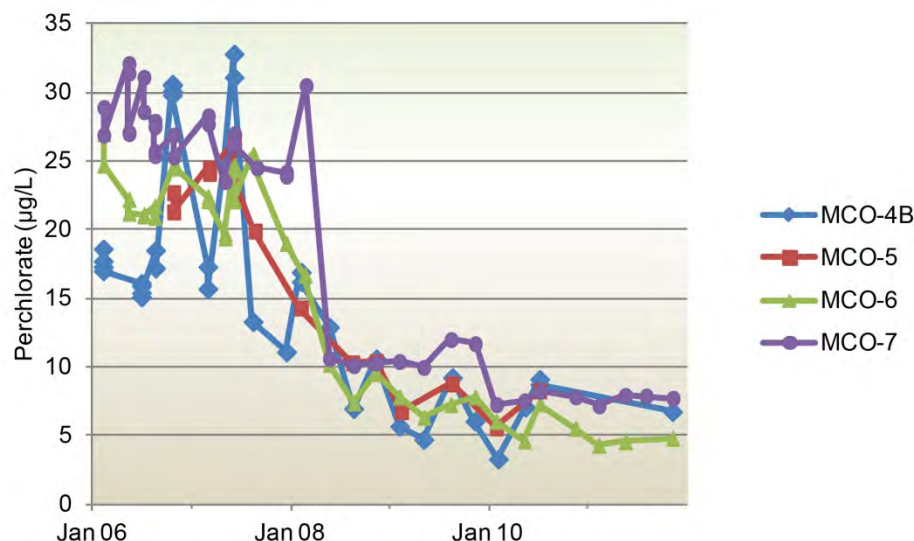


Figure 5-28 Perchlorate at general surveillance monitoring locations in Mortandad Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.

d. Cañada del Buey General Surveillance Monitoring

Alluvial well CDBO-6 in Cañada del Buey was sampled twice in 2011. No results were measured near or above regulatory standards or screening levels. All other alluvial wells in Cañada del Buey were dry.

5. MDA C and TA-54 Monitoring Groups (Mortandad, Pajarito, Twomile, and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. Saturated alluvium occurs in lower Pajarito Canyon near the eastern Laboratory boundary but does not extend beyond the boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9 (Table 5-21). Some firing sites border portions of tributaries Twomile and Threemile Canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas at TA-54, used for disposal of organic chemicals and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated area of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-3. The main groundwater impacts are from organic chemicals and from HE (Tables 5-22 and 5-23).

Table 5-21

Summary of Groundwater Contamination in Pajarito Canyon and the MDA C and TA-54 Monitoring Groups

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
MDA C monitoring group (Mortandad Canyon)	Non-effluent sources	No monitoring locations	None	Bis(2-ethylhexyl)phthalate above and antimony at 71% of EPA MCL screening levels
TA-54 monitoring group (Mortandad and Pajarito Canyons)	Non-effluent sources	No monitoring locations	1,4-Dioxane at 70% of EPA regional screening level for tap water, nitrate (as N) up to 41% of NM groundwater standard	Trichloroethene at 12% of EPA MCL screening level
Pajarito, Twomile, and Threemile Canyons	Non-effluent sources, liquid sources major in past but minor currently	None	1,1-Dichloroethene and 1,1,1-trichloroethane above NM groundwater standards, trichloroethene at 51% of EPA MCL screening levels, 1,4-dioxane above and RDX at 80% of EPA regional screening level for tap water	None

Table 5-22
Groundwater Quality in MDA C and TA-54 Monitoring Groups

Chemical	Location	Result	Trends
Total antimony	Regional aquifer well R-46	3.1 µg/L to 4.25 µg/L, below EPA MCL screening level of 6 µg/L	Results in this range since first samples in 2009
Bis(2-ethylhexyl) phthalate	Regional aquifer well R-46	7.48 µg/L in R-46, above EPA MCL screening level of 6 µg/L	More than 10-fold decline since 2009
Trichloroethene	Regional aquifer well R-20 (screen 2)	0.3 µg/L to 0.59 µg/L, below EPA MCL screening level of 5 µg/L	Found in every sampling event since December 2008, concentrations decreasing since December 2009
Dioxane[1,4-]	929-ft intermediate screen 1 at R-37	3.1 µg/L to 4.7 µg/L, below EPA regional screening level for tap water of 6.7 µg/L	Detected in nearly every sampling event since 2009, all detections just above the 2-µg/L MDL and estimated
Nitrate (as N)	Intermediate well R-55i	3.1 mg/L to 4.2 mg/L, below NM groundwater standard of 10 mg/L	First sampled in 2011
Trichloroethene	Intermediate well R-40	0.27 µg/L to 0.43 µg/L, below EPA MCL screening level of 5 µg/L	Found in some sampling events in 2010 and 2011, not found in 2009, screen pumps dry on sampling

Table 5-23
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
Dichloroethene [1,1-]	Intermediate well 03-B-13	2.3 µg/L to 10.8 µg/L, above NM groundwater standard of 5 µg/L	Detected in every sample since 2006, seasonally variable with highest concentrations in 2008
Trichloroethane [1,1,1-]	Intermediate well 03-B-13	99 µg/L to 210 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample since 2006, seasonally variable
Trichloroethene	Intermediate well 03-B-13	1.18 µg/L to 2.25 µg/L, below EPA MCL screening level of 5 µg/L	Detected in every sample since 2006, seasonally variable
Dioxane[1,4-]	Intermediate well 03-B-13	185 µg/L to 912 µg/L, above EPA regional screening level for tap water of 6.7 µg/L	Detected since 2006, seasonally variable
RDX	Intermediate Bulldog and Kieling Springs	3.9 µg/L to 4.9 µg/L, below EPA regional screening level for tap water of 6.1 µg/L	Found in every sample at Bulldog Spring and at low values in Kieling Spring, sampled since 2004, values fluctuate

MDA C is located on Mesita del Buey in TA-50, at the head of Ten Site Canyon. The MDA C monitoring group includes nearby regional monitoring wells on the mesa top and in Mortandad Canyon. TA-50 is bounded on the north by Effluent and Mortandad Canyons, on the east by the upper reaches of Ten Site Canyon, on the south by Twomile Canyon, and on the west by TA-55.

MDA C is an inactive landfill where solid low-level radioactive wastes and chemical wastes were disposed of between 1948 and 1974. Vapor-phase VOCs and tritium are present in the upper 500 ft of the unsaturated zone beneath MDA C (LANL 2011c). The primary vapor-phase contaminants beneath MDA C are trichloroethene, tetrachloroethene, and tritium. There is no evidence of groundwater contamination in the regional aquifer. MDA C is located on a mesa top above thick, unsaturated units of the Bandelier Tuff, and therefore, present-day aqueous-phase transport is generally believed to be minimal.

TA-54 is situated in the east-central portion of the Laboratory on Mesita del Buey. TA-54 includes four MDAs designated as G, H, J, and L; a waste characterization, container storage, and transfer facility (TA-54 West); active radioactive waste storage and disposal operations at Area G; hazardous and mixed-waste storage operations at Area L; and administrative and support areas. The transfer facility is located at the western end of TA-54.

At TA-54, groundwater monitoring is conducted to support both (1) the corrective measures process for SWMUs and areas of concern (AOCs) (particularly MDAs G, H, and L) under the Consent Order and (2) the Resource Conservation Recovery Act permit. The TA-54 monitoring group was established to address the monitoring requirements for all portions and aspects of TA-54. The TA-54 monitoring group includes both intermediate perched and regional wells in the near vicinity. Other downgradient wells have general relevance to TA-54 and other potential upgradient sources but are not considered part of the TA-54 monitoring network and are not included in the monitoring group.

Pore-gas monitoring data show vapor-phase organic compounds are present in the upper portion of the unsaturated zone beneath MDAs G and L. The primary contaminants in the vapor phase at TA-54 are 1,1,1-trichloroethane; trichloroethene; Freon-113; and tritium (LANL 2005b, 2006b, 2007b).

Data from the groundwater monitoring network around TA-54 show sporadic detections of a variety of contaminants, including several VOCs. The temporal and spatial nature of the occurrences does not, however, clearly indicate the presence of a release from potential sources at TA-54 (LANL 2009b). Further evaluations of existing groundwater data near TA-54 and detailed descriptions of organic and inorganic contaminants detected in intermediate perched and regional groundwater at TA-54 are presented in the corrective measures evaluation reports for MDAs G, H, and L (LANL 2011d, 2011e, 2011f).

a. MDA C Monitoring Group

The total and filtered antimony concentrations at regional aquifer well R-46 ranged from 3.06 µg/L to 4.25 µg/L, below the EPA MCL screening level of 6 µg/L. Results for antimony have been in this range since the first samples were collected from the well in 2009. The source of antimony is uncertain; it may be from well drilling or construction materials.

The bis(2-ethylhexyl)phthalate concentration of 7.48 µg/L from regional aquifer well R-46 was above the 6-µg/L EPA MCL screening level. The concentration of this compound was 96 µg/L in samples taken after well construction in 2009 and has declined with time. The presence of bis(2-ethylhexyl)phthalate is apparently caused by drilling or construction materials.

b. TA-54 Monitoring Group

Rehabilitation activities were conducted at regional aquifer well R-20 through December 2007 to improve sample quality (LANL 2008c). Beginning with a December 18, 2008, sample, trichloroethene has been detected at the 1,147-ft regional aquifer screen in every sampling event (Figure 5-29). Results from the first sampling events were near the detection limit of 0.25 µg/L and were estimated. Results from the following sampling events reached 3.04 µg/L in December 2009. Sample concentrations declined through 2011. The EPA MCL (which does not apply to these samples) for trichloroethene is 5 µg/L. The NM groundwater standard is 100 µg/L. Trichloroethene has not been detected at the shallower 904-ft regional screen and was not detected at R-20 prior to rehabilitation. A source for trichloroethene has not been determined at this time, and additional wells are planned to investigate water quality in the area.

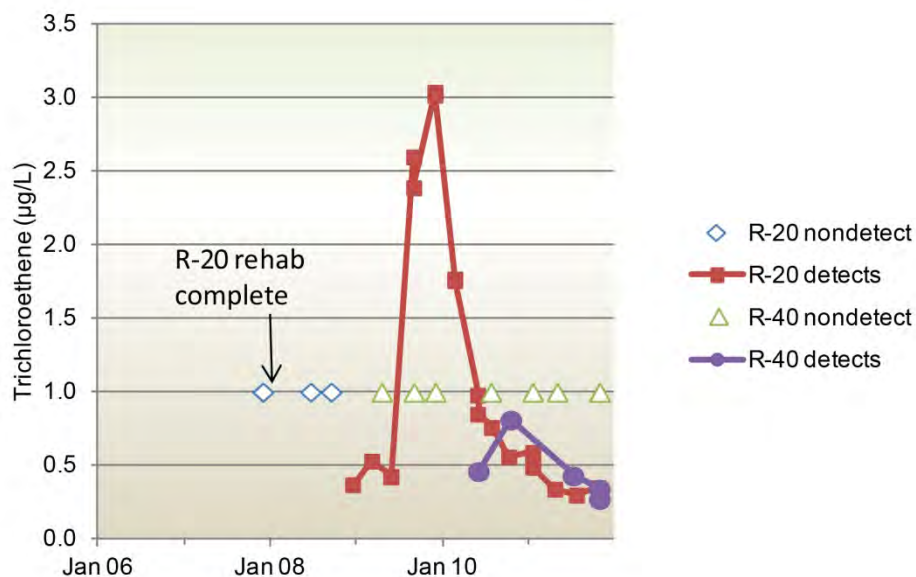


Figure 5-29 Trichloroethene in the TA-54 monitoring group at Pajarito Canyon regional aquifer well R-20 at 1,147 ft and intermediate well R-40 at 752 ft. The EPA MCL (which does not apply to these samples) is 5 µg/L. The NM groundwater standard is 100 µg/L. Nondetects are reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L. R-20 underwent rehabilitation in 2007.

Trichloroethene was also detected in two of the four annual sampling events during both 2010 and 2011 at the 751-ft intermediate screen in R-40 (Figure 5-29). This well is about 0.25 mi up Pajarito Canyon from R-20. The estimated concentrations were between 0.27 µg/L and 0.81 µg/L. Trichloroethene was not detected in 2009 at this screen or at all in the other intermediate screen (at 649 ft) or the regional screen (at 849 ft) of R-40. This screen is difficult to sample because the perched zone has little water and the screen is quickly pumped dry.

The chemical 1,4-dioxane was detected at the 929-ft intermediate upper screen of R-37, located near the upper part of Cañada del Buey (Figure 5-30). The highest value was 70% of the EPA regional screening level for tap water. All of the results were estimated because they were near the MDL of about 2.1 µg/L. Concentrations of 1,4-dioxane have been found in nearly every sampling event at this screen since the well was constructed in 2009.

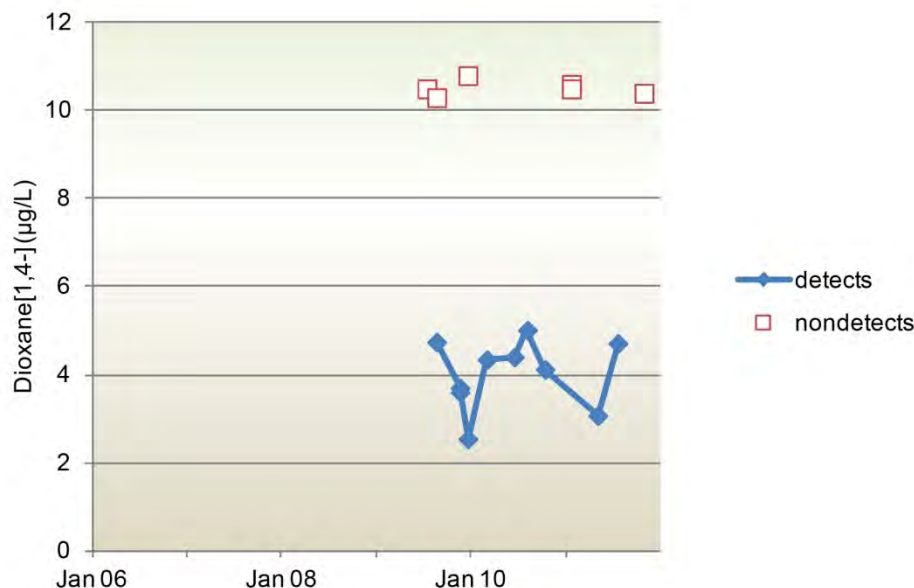


Figure 5-30 Concentrations of 1,4-dioxane in the TA-54 monitoring group in Mortandad Canyon intermediate groundwater at 929 ft in R-37. The EPA regional screening level for tap water is 6.7 µg/L. All of the detected results are estimated; nondetects are reported at the PQL.

The nitrate (as nitrogen) concentration in samples from intermediate well R-55i ranged from 3.09 mg/L to 4.16 mg/L, below the 10 mg/L NM groundwater standard (Figure 5-22). The well was first sampled in 2011. The nitrate concentrations are unusually elevated and unlike any nearby wells.

c. Pajarito Canyon General Surveillance Monitoring

Samples from two intermediate groundwater springs in upper Pajarito Canyon contained RDX, HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and other HE compounds as in prior years. One RDX result from Bulldog Spring was 80% of the EPA regional screening level for tap water (Figure 5-31). The result of 3.9 µg/L at Kielling Spring is the highest measured since sampling began in 2004; concentrations are usually nondetect or less than 0.2 µg/L.

SWMU 03-010(a) is the outfall area from a former vacuum repair shop and is currently under investigation (DOE 2005). The outfall area is located on a steep slope on the rim of Twomile Canyon about 30 ft west of a general warehouse (Building 03-30). A small zone of shallow intermediate perched groundwater is apparently recharged by runoff from the parking lot and building roofs; the groundwater becomes contaminated through contact with the soil.

This perched groundwater is tapped at a depth of 21 ft by well 03-B-13. Two other wells, 03-B-09 and 03-B-10, were plugged and abandoned in 2009 (LANL 2009c). Samples from 03-B-13 in past years had chloride (Figure 5-32) and TDS results that were elevated, with chloride sometimes above the groundwater standard. The seasonal pattern of sodium and chloride concentrations, with elevated values in winter, suggest that road salting is the source of this variation. Samples from these wells also contained several organic chemicals, including four chlorinated solvents (Table 5-23). The concentrations of several organic chemicals have exceeded NM groundwater standards or other screening levels. Compounds found in well samples included 1,1-dichloroethane; 1,1-dichloroethene; trichloroethene; 1,1,1-trichloroethane; and 1,4-dioxane.

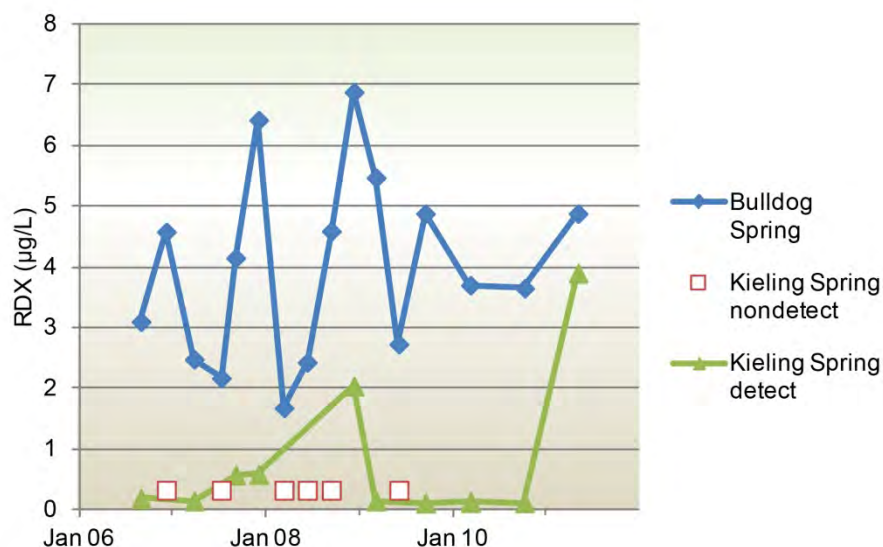


Figure 5-31 RDX at general surveillance monitoring locations in Pajarito Canyon intermediate groundwater at Bulldog and Kieling Springs. The EPA tap water screening level is 6.1 µg/L. Nondetects are reported at the PQL.

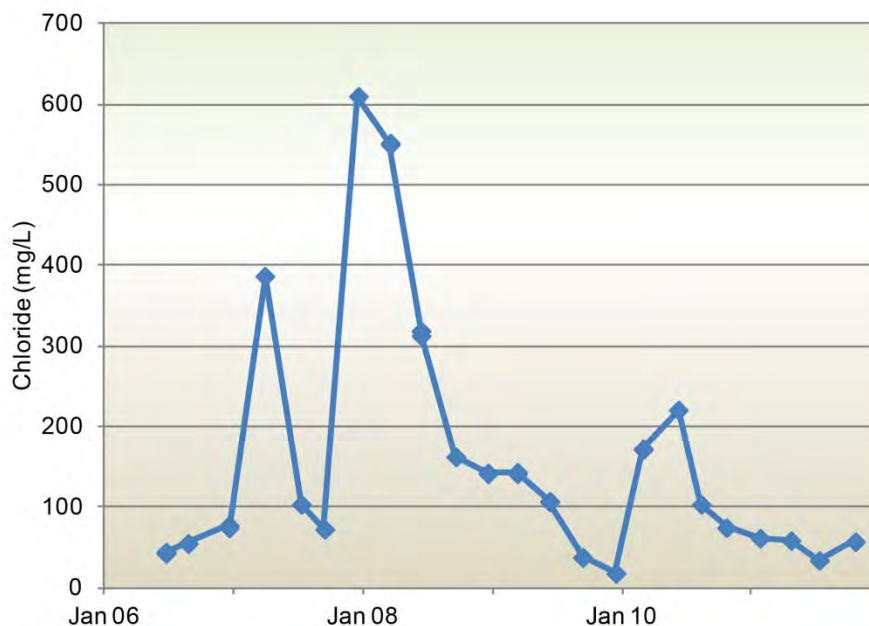


Figure 5-32 Chloride history in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 250 mg/L.

Seasonal variation is shown by several other field parameters and concentrations of other chemical compounds measured in water samples from wells 03-B-10 and 03-B-13 (LANL 2009c). Variation in oxidation-reduction potential and total organic carbon indicate changes in reducing conditions. Oxidation-reduction potential changes, for example, with a change in the amount of oxygen dissolved in the water. Changes in oxidation-reduction potential lead to observed seasonal changes in turbidity and concentrations of dissolved iron and manganese; under more reducing conditions (e.g., less oxygen), iron and manganese are more soluble.

Figures 5-33 through 5-35 show 1,1-dichloroethene; 1,1,1-trichloroethane; and 1,4-dioxane histories for 03-B-13. For some solvents, their retention on solid surfaces is lower in higher ionic strength solutions. Thus, increases in concentration of 1,1-dichloroethene and 1,1,1-trichloroethane could result from increasing concentrations of sodium and chloride (because of infiltration of snowmelt bearing salt), which releases these compounds from the aquifer matrix. For example, the elevated chloride (Figure 5-32) and TDS observed in the groundwater in December 2007 might cause release of 1,1,1-trichloroethane during the following months (Figure 5-34).

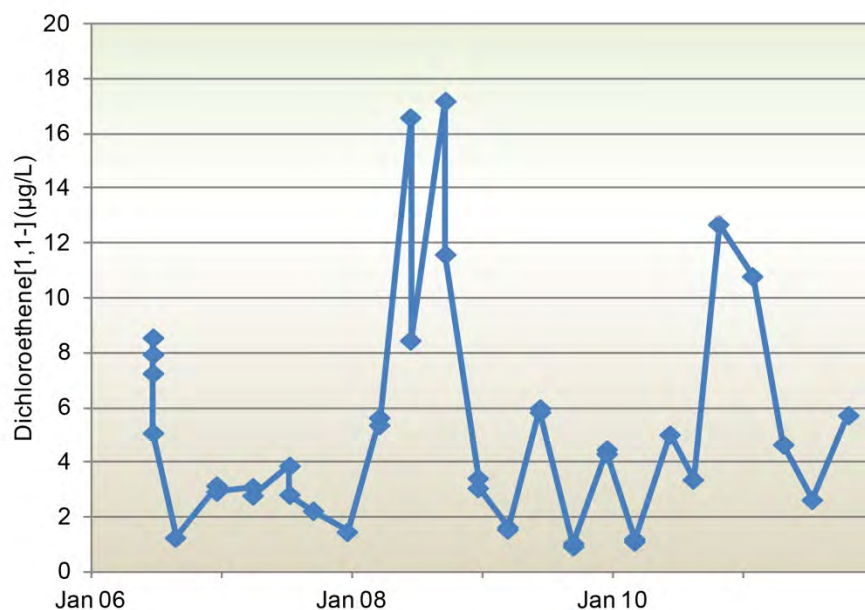


Figure 5-33 History of 1,1-dichloroethene in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 5 µg/L.

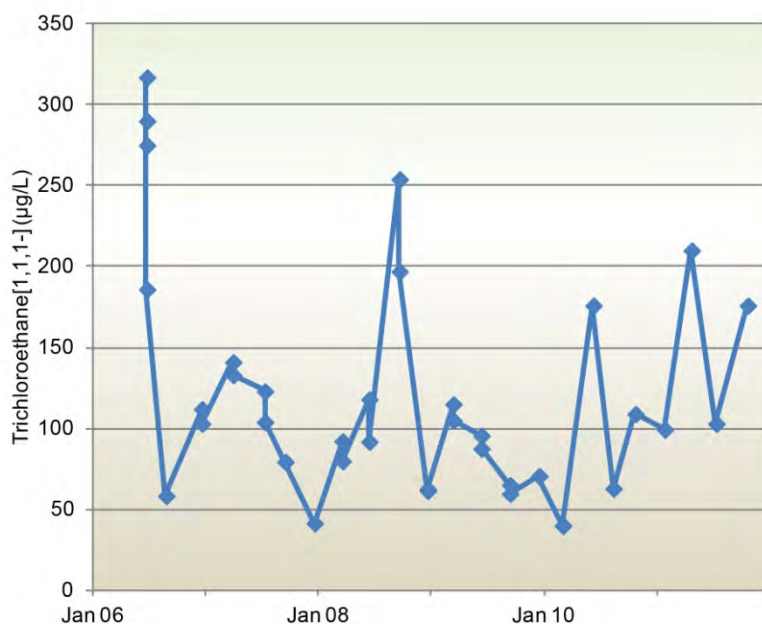


Figure 5-34 History of 1,1,1-trichloroethane in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. The NM groundwater standard is 60 µg/L.

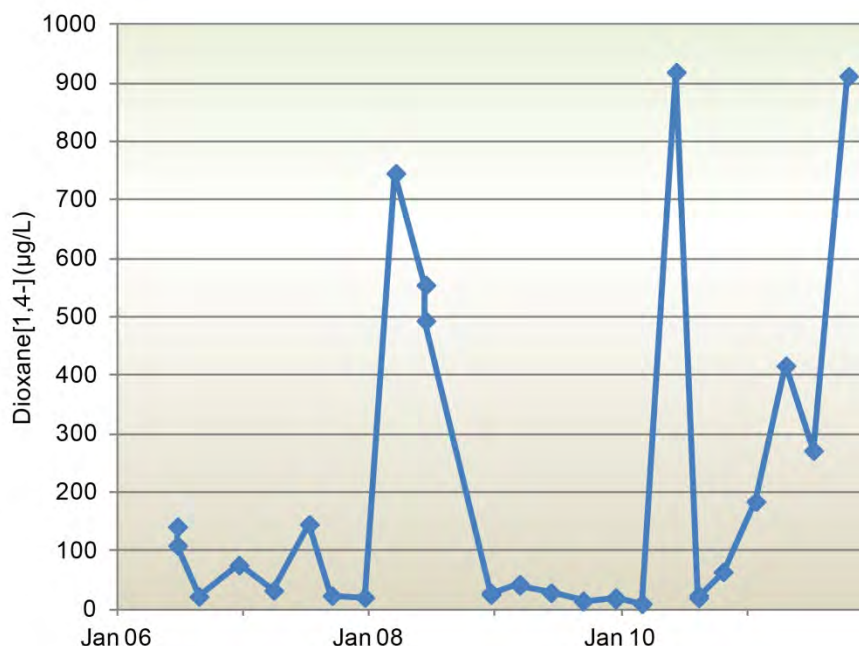


Figure 5-35 History of 1,4-dioxane history in Pajarito Canyon intermediate groundwater at general surveillance monitoring well 03-B-13. For comparison purposes, the EPA regional screening level for tap water is 6.7 µg/L.

6. TA-16 260 Monitoring Group (Pajarito Canyon, Water Canyon, and Cañon de Valle)

Water Canyon and Cañon de Valle (a tributary) traverse the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE processing sites in TA-16 and TA-9 (Table 5-24). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. This outfall discharges a much smaller amount of water than the previous outfalls and generally meets NPDES permit requirements.

Table 5-24
Summary of Groundwater Contamination in Water
and Pajarito Canyons and the TA-16 260 Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
TA-16 260 monitoring group (Cañon de Valle and Pajarito Canyon)	Dry and past effluent sources	Barium above NM groundwater standard	Nickel above NM groundwater standard; total chromium at 69%, total beryllium at 62%, tetrachloroethene above and trichloroethene at 83% of EPA MCL screening levels; total lead above EPA drinking water system action level; RDX above EPA regional screening level for tap water	Tetrachloroethene at 7% of EPA MCL screening levels, RDX at 23% of EPA regional screening level for tap water
Cañon de Valle	Dry and past effluent sources	Barium and boron above NM groundwater standards; tetrachloroethene at 33%, and trichloroethene at 12% of EPA MCL screening levels; and RDX above EPA regional screening level for tap water	Boron above NM groundwater standard, tetrachloroethene at 42% and trichloroethene at 39% of EPA MCL screening levels, RDX above EPA regional screening level for tap water	No monitoring locations

Table 5-24 (continued)

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Water Canyon	Dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor non-effluent sources	No alluvial groundwater	No intermediate groundwater	None

The Potrillo, Fence, and Indio Canyon watersheds contain several open-burning/open-detonation and firing sites used for testing of weapons system components. These three small canyons have surface water only in response to precipitation events and no known alluvial or intermediate groundwater.

The TA-16 260 monitoring group was established for the upper Water Canyon/Cañon de Valle watershed to monitor contaminants released from Consolidated Unit 16 021(c)-99, the TA-16 260 Outfall (hereafter, the 260 Outfall), and other sites at TA-16. The 260 Outfall is a former HE-machining outfall that discharged HE-bearing water to Cañon de Valle for almost 50 years.

Results of the 260 Outfall corrective measures evaluation (LANL 2007c) show the drainage channel below the outfall and the canyon bottom as well as surface water, alluvial groundwater, and intermediate perched groundwater contain explosive compounds, including RDX, HMX, TNT (2,4,6 trinitrotoluene), and barium. In addition, the VOCs tetrachloroethene and trichloroethene have been detected in springs, alluvial groundwater, and intermediate perched groundwater.

a. TA-16 260 Monitoring Group

RDX was detected at Pajarito Canyon regional well R-18 at a concentration that is 19% of the 6.1- $\mu\text{g/L}$ EPA regional screening level for tap water. RDX has been detected at this well since August 2006 in every sample at increasing concentrations.

Regional well R-63 was first sampled in 2011. RDX concentrations ranged from 1.25 $\mu\text{g/L}$ to 1.43 $\mu\text{g/L}$, below the 6.1- $\mu\text{g/L}$ EPA regional screening level for tap water. The shallowest two regional aquifer screens at well R-25 had 2011 RDX concentrations of 0.26 $\mu\text{g/L}$ to 0.47 $\mu\text{g/L}$, also below the 6.1- $\mu\text{g/L}$ EPA regional screening level for tap water. RDX has been found at R-25 since the well was first sampled in 2000. Initial concentrations were higher, possibly because of a delay in installing the sampling system that allowed water from shallower screens to enter the regional aquifer screens.

The shallowest regional aquifer screen of R-25 also contained tetrachloroethene at a concentration of 0.33 $\mu\text{g/L}$, just above the 0.3- $\mu\text{g/L}$ MDL and below the EPA MCL screening level of 5 $\mu\text{g/L}$. Tetrachloroethene has been detected near this concentration in many sampling events at this screen since 2007.

The shallowest two screens at well R-25 (which sample intermediate groundwater) have shown elevated concentrations of metals such as nickel and chromium for several years. The elevated concentrations were caused by damage to the screens during well construction. In 2008, new wells were drilled to replace some of the upper R-25 screens.

Total beryllium and lead concentrations in samples from intermediate piezometer R-26 PZ-2 were elevated. This piezometer is sampled with a bailer, and the samples have elevated turbidity that sometimes exceeds the upper limit of the instrument (1,000 nephelometric turbidity units). The elevated total metals concentrations may reflect composition of sediment, drilling materials, or abraded well components in the piezometer.

Samples from nine intermediate perched zone wells or well screens contained several HE compounds. Of these compounds, RDX was present at the highest concentrations relative to the screening levels, above the 6.1- $\mu\text{g/L}$ EPA regional screening level for tap water (Figures 5-36 through 5-39). As seen in Figure 5-39, samples from the shallowest two screens at well R-25, which sample intermediate groundwater, show variability that may be because of switching of samples or drilling of new nearby wells (LANL 2009d).

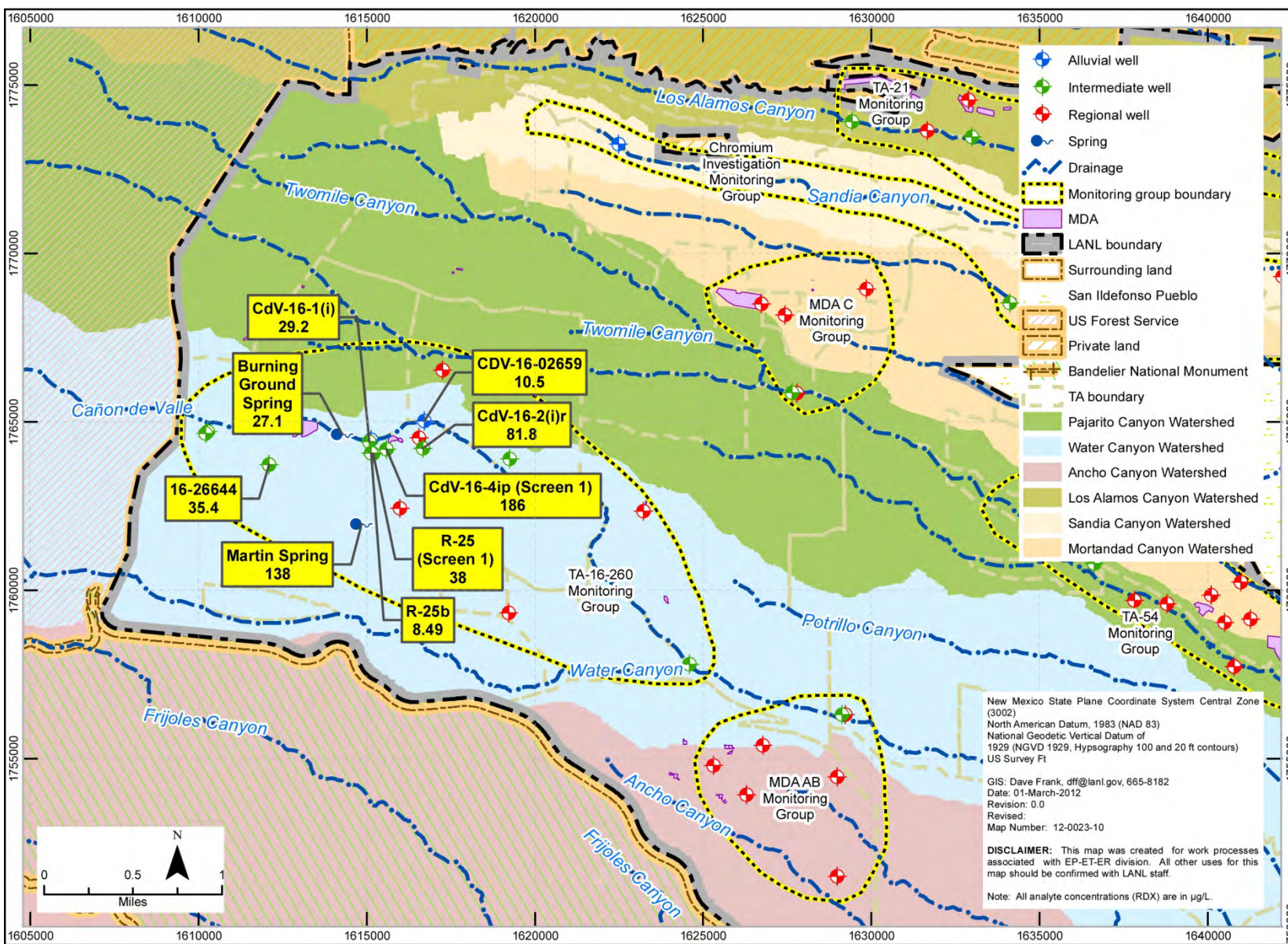


Figure 5-36 Wells with 2011 RDX concentrations above the 6.1-µg/L EPA tap water screening level. The maximum concentration for the year is shown in µg/L. Only the upper screen (which has the highest concentration) is represented for wells R-25 and CdV-16-4ip. Two deeper screens in R-25 and one in CdV-16-4ip also have RDX concentrations above the screening level.

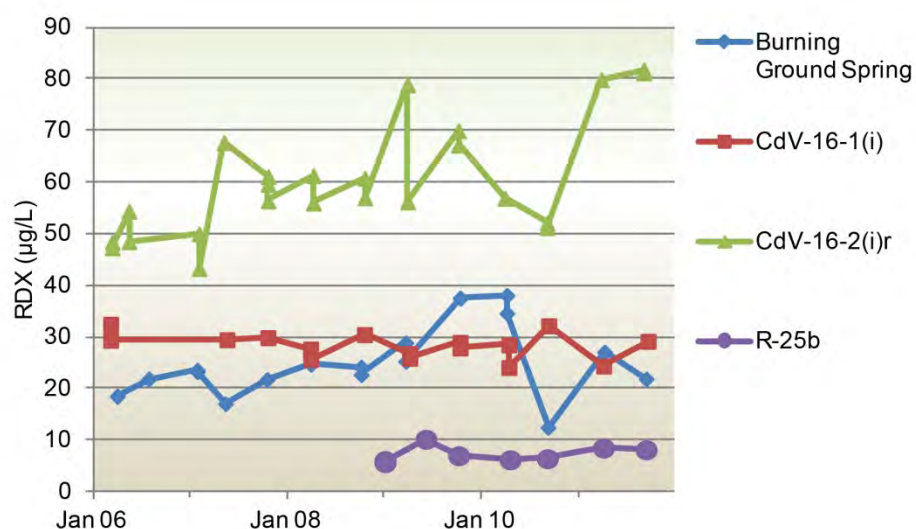


Figure 5-37 RDX in the TA-16 260 monitoring group and at general surveillance monitoring location Burning Ground Spring in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.

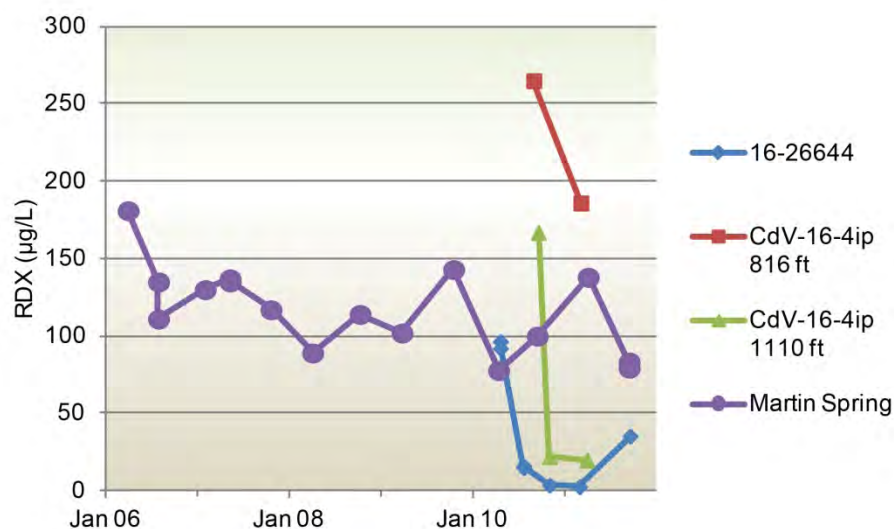


Figure 5-38 RDX in the TA-16 260 monitoring group and at general surveillance monitoring location Martin Spring in Cañon de Valle intermediate groundwater. The EPA tap water screening level is 6.1 µg/L.

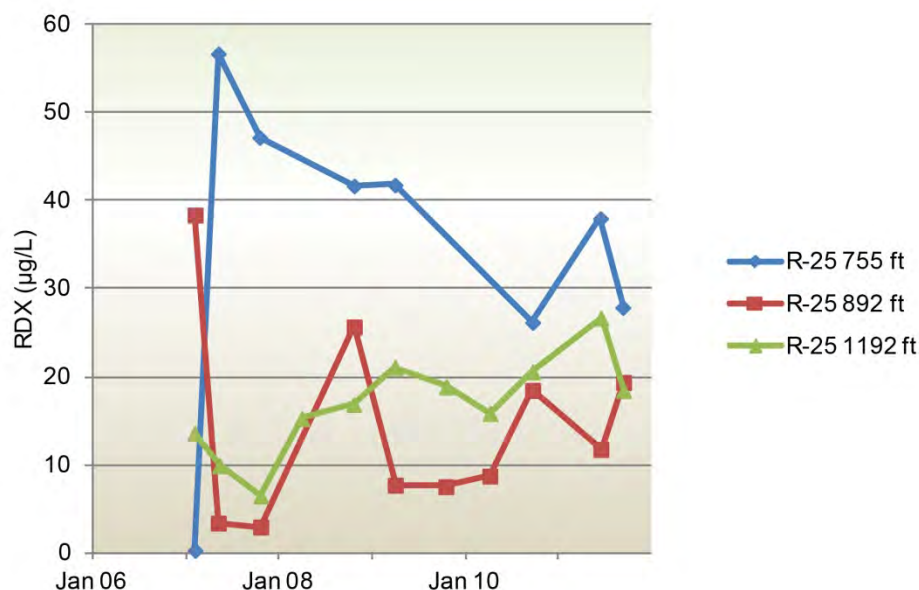


Figure 5-39 RDX in the TA-16 260 monitoring group in Cañon de Valle intermediate groundwater. The EPA Regional screening level for tap water is 6.1 µg/L.

The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in several intermediate wells and springs (Table 5-25).

**Table 5-25
Groundwater Quality in the TA-16 260 Monitoring Group**

Chemical	Location	Result	Trends
RDX	Pajarito Canyon regional aquifer well R-18	1.18 µg/L, below EPA regional screening level for tap water of 6.1 µg/L	Found in all sampling events since August 2006, values increasing
RDX	Cañon de Valle regional aquifer wells R-25 and R-63	0.47 µg/L in R-25 and 1.43 µg/L in R-63, below EPA regional screening level for tap water of 6.1 µg/L	At R-25 found in most sampling events at these concentrations, R-63 first sampled in 2011
Tetrachloroethene	Regional aquifer well R-25	0.33 µg/L, below EPA MCL screening level of 5 µg/L	Present in many samples since 2007 at shallowest regional screen
Nickel	Intermediate well R-25	623 µg/L, above NM groundwater standard of 200 µg/L	Similar results in shallowest screen since 2001 because of construction damage
Total chromium	Intermediate well R-25	68.6 µg/L, below EPA MCL screening level of 100 µg/L	Elevated total results in shallowest screen because of construction damage, declining from 153 µg/L since 2005
Total beryllium	Intermediate piezometer R-26 PZ-2	2.47 µg/L, below EPA MCL screening level of 4 µg/L	Piezometer sampled with bailer, turbidity often off scale
Total lead	Intermediate piezometer R-26 PZ-2	16.7 µg/L, above EPA drinking water system action level of 15 µg/L	Piezometer sampled with bailer, turbidity often off scale
RDX	Nine intermediate wells or well screens	Up to 186 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Present during several years of sampling of wells
Tetrachloroethene	Nine intermediate wells or well screens	0.32 µg/L to 5.03 µg/L, above EPA MCL screening level of 5 µg/L	Present during several years of sampling of wells
Trichloroethene	Six intermediate wells or well screens	0.25 µg/L to 4.14 µg/L, below EPA MCL screening level of 5 µg/L	Present during several years of sampling of wells
Barium	Alluvial well CDV-16-611923 in Cañon de Valle	10,600 µg/L to 49,400 µg/L, above NM groundwater standard of 1,000 µg/L	Three years of sampling

b. Water Canyon General Surveillance Monitoring

Boron was found in samples from intermediate groundwater at Martin Spring at concentrations above the NM groundwater standard for irrigation use (Figure 5-40); however, this spring is not used for irrigation. Boron is also present at elevated levels in downstream alluvial wells.

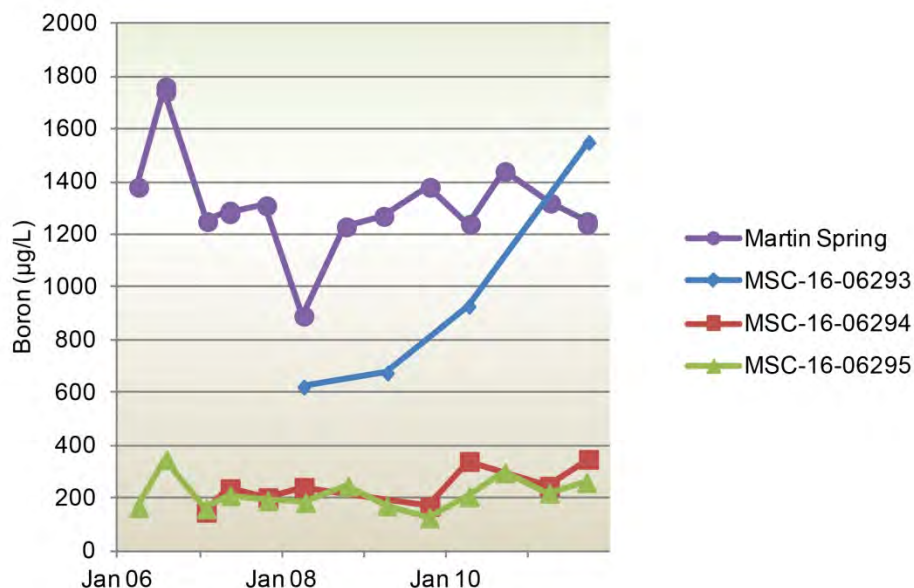


Figure 5-40 Boron at general surveillance monitoring locations in Martin Spring Canyon (a Cañon de Valle tributary) intermediate groundwater at Martin Spring and in alluvial groundwater. The NM groundwater standard for irrigation use is 750 µg/L.

Samples from intermediate groundwater at Martin Spring and Burning Ground Spring contained several HE compounds. RDX was present at the highest concentrations relative to the screening levels, above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-36 through 5-38). The RDX levels have been fairly steady at both of these monitoring sites. The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in these springs at concentrations below the EPA MCL screening levels (Table 5-26).

Barium exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-41 and 5-42). Barium has also been found at elevated concentrations in Fish Ladder Canyon, in intermediate Fish Ladder Spring, and in three alluvial wells (Figure 5-43).

These alluvial well samples also contained several HE compounds. As with intermediate perched groundwater, RDX was the HE compound present in alluvial groundwater at the highest concentrations relative to the screening levels, with some sample results above the 6.1-µg/L EPA regional screening level for tap water (Figures 5-36 and 5-44).

Samples from Cañon de Valle alluvial well CDV-16-02655 had tetrachloroethene and trichloroethene at concentrations below the EPA MCL screening levels (Table 5-26). Only alluvial well FLC-16-25278 in Fish Ladder Canyon was sampled in 2011. The tetrachloroethene concentration in alluvial well FLC-16-25280 was above the 5-µg/L EPA MCL from 2008 through 2010, but the well was not sampled in 2011.

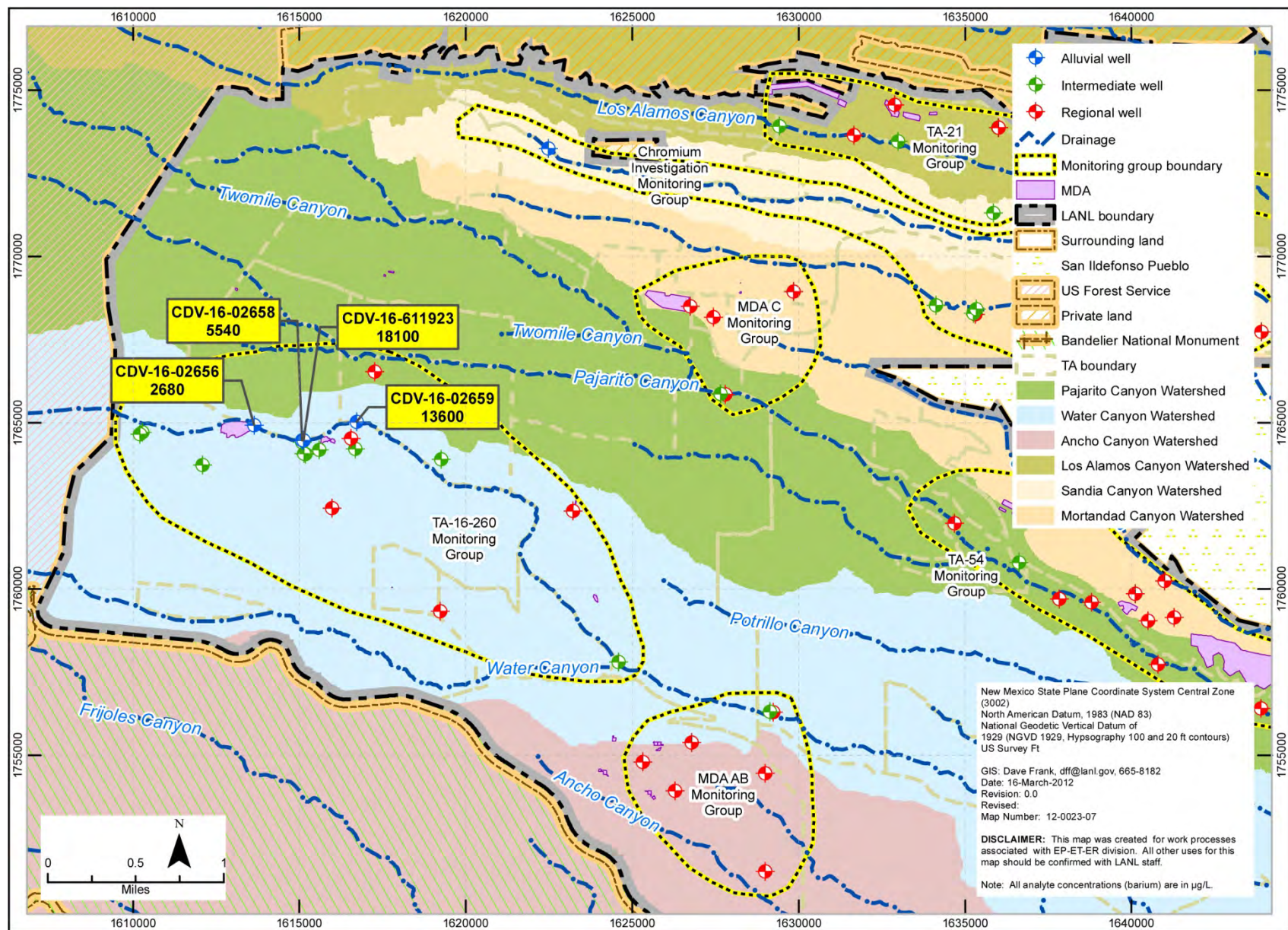


Figure 5-41 Wells with 2011 barium concentrations above the 1,000-µg/L NM groundwater standard. The maximum concentration for the year is shown in µg/L.

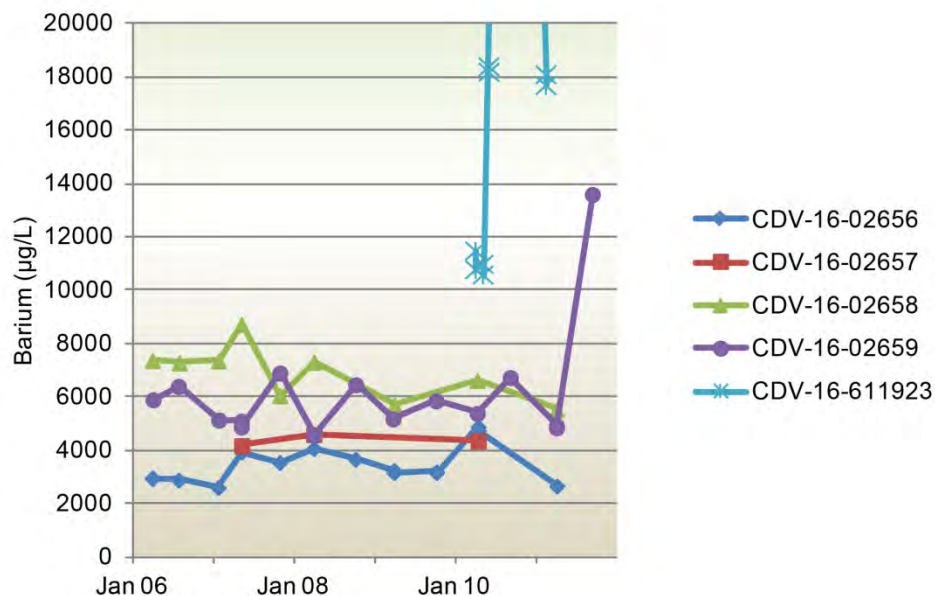


Figure 5-42 Barium in the TA-16 260 monitoring group (CDV-16-611923) and at general surveillance monitoring locations in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1,000 µg/L. The highest values in CDV-16-611923 were 35,000 µg/L and 50,000 µg/L.

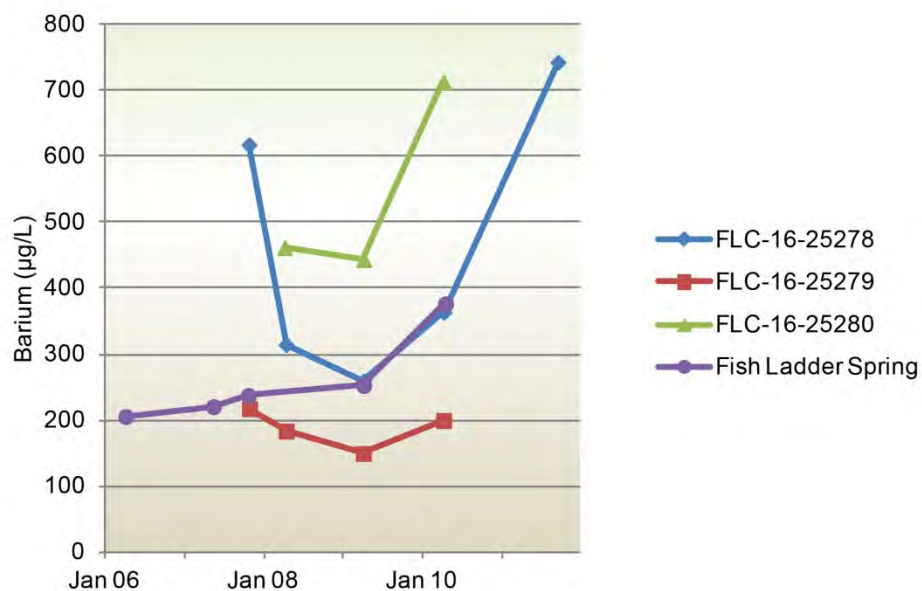


Figure 5-43 Barium at general surveillance monitoring locations in Fishladder Canyon intermediate groundwater at Fish Ladder Spring and in alluvial groundwater. The NM groundwater standard is 1000 µg/L.

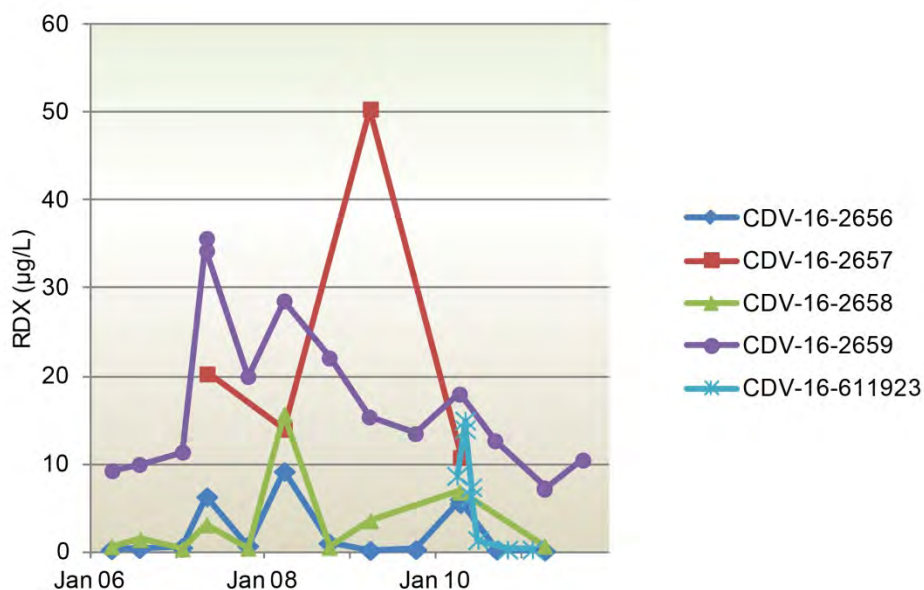


Figure 5-44 RDX in the TA-16 260 monitoring group (CDV-16-611923) and at general surveillance monitoring locations in Cañon de Valle alluvial groundwater. The EPA tap water screening level is 6.1 µg/L.

Table 5-26

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

Chemical	Location	Result	Trends
Boron	Intermediate Martin Spring	1,240 µg/L to 1,320 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected since 1995, approximate 40% decrease since 2003
RDX	Intermediate Martin and Burning Ground Springs	22 µg/L to 138 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Higher in Martin Spring; present at these levels since 1996
Tetrachloroethene	Intermediate Martin and Burning Ground Springs	0.41 µg/L to 2.1 µg/L, below EPA MCL screening level of 5 µg/L	Higher in Burning Ground Spring, present at these levels since 1996
Trichloroethene	Intermediate Martin and Burning Ground Springs	0.26 µg/L to 1.94 µg/L, below EPA MCL screening level of 5 µg/L	Higher in Burning Ground Spring, present at these levels since 1996
Boron	One alluvial well in Martin Spring Canyon	1,550 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected since 2001
Barium	Three alluvial wells in Cañon de Valle, one in Fish Ladder Canyon	743 µg/L to 13,600 µg/L, above NM groundwater standard of 1,000 µg/L	Present at these levels for 14 years of sampling in Cañon de Valle, four years in Fish Ladder Canyon
RDX	Three alluvial wells in Cañon de Valle, two in Martin Spring Canyon	0.15 µg/L to 10.5 µg/L, above EPA regional screening level for tap water of 6.1 µg/L	Highest in Cañon de Valle, present at these levels since 1997, present since 2000 in Martin Spring Canyon
Tetrachloroethene	Cañon de Valle alluvial well CDV-16-02655	1.67 µg/L, below EPA MCL screening level of 5 µg/L	Detected since 2005, concentrations higher in 2010 and 2011
Trichloroethene	Cañon de Valle alluvial well CDV-16-02655	0.59 µg/L, below EPA MCL screening level of 5 µg/L	Detected in 2010 and 2011

7. MDA AB Monitoring Group (Ancho and Water Canyons)

The MDA AB monitoring group is located in TA-49. TA-49, also known as the Frijoles Mesa Site, is located on a mesa in the upper part of the Ancho Canyon drainage, and part of the MDA drains into Water

Canyon. The canyons in the Ancho watershed are mainly dry with little alluvial and no known intermediate groundwater.

Area AB was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing produced large inventories of radioactive and hazardous materials: isotopes of uranium and plutonium, lead, and beryllium; explosives such as TNT, RDX, and HMX; and barium nitrate. Some of this material remains in shafts on the mesa top. Further information about activities, SWMUs, and AOCs at TA-49 can be found in recent Laboratory reports (LANL 2010b, 2010c).

No contaminants were found in MDA AB wells at concentrations near or above standards (Table 5-27). Some PAH compounds (such as benzo[k]fluoranthene) were found at concentrations near their detection limits in samples collected during June 2011 at R-29 and R-30. The wells were sampled two (R-30) or three (R-29) other times during 2011, and none of the compounds were detected. PAH compounds appear sporadically in samples at other locations, sometimes in only one of a pair of duplicate samples, and are not repeatable. At concentrations near the detection limit, their presence can be attributed to cross-contamination during sampling or analysis.

Table 5-27

Summary of Groundwater Contamination in Ancho Canyon and the MDA AB Monitoring Group

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
MDA AB monitoring group (Water and Ancho Canyons)	Non-effluent sources and past effluent sources	Little or no alluvial groundwater	No intermediate groundwater	None

In 1960, the USGS drilled three deep wells at TA-49 (Test Wells DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. As with other wells installed during that period, samples from these three test wells have shown elevated metals concentrations related to corrosion or flaking of well components. In 2010, the total lead concentration in a sample from Test Well DT-9 of 20.1 µg/L was above the EPA drinking water system action level of 15 µg/L. Another sample collected during the year had a total lead result of < 2 µg/L. The 2011 total lead results in DT-5A and DT-9 were 0.87 µg/L and 1.3 µg/L, respectively. Some results during the 1990s were above 50 µg/L.

8. White Rock Canyon General Surveillance Monitoring

The springs that issue along the Rio Grande in White Rock Canyon represent a principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al. 1980). The White Rock Canyon springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Table 5-28). A few springs such as Spring 2B (near Spring 2 in Figure 5-7) appear to represent discharge of intermediate perched groundwater; that spring is supplied by percolation of municipal sanitary effluent discharge or irrigation with effluent from athletic fields near White Rock. It has only been sampled in 2003 and 2005 because of lack of flow. The water discharging at other springs may be a mixture of regional aquifer groundwater, intermediate perched groundwater, and percolation of recent precipitation (Longmire et al. 2007).

Table 5-28

Summary of Groundwater Contamination in White Rock Canyon Springs

Location	Potential Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, uranium

For 2011, tritium was not detected in most of the White Rock Canyon springs. In previous years, the highest tritium results have been found at the Spring 4 group of springs. Tritium activities in samples from these springs in 2009 were about 8 pCi/L at Spring 4 and Spring 4C and 23 pCi/L at Spring 4B. In 2011, the tritium activity at Spring 4 was 4.38 pCi/L and at Spring 4B was 14.57 pCi/L. These springs discharge within a hundred yards of each other near the Rio Grande.

Other than tritium, the only radioactivity detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-29). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs.

Table 5-29
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	11.4 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Total arsenic	Regional aquifer Spring 2 (Pueblo de San Ildefonso)	Up to 10.1 µg/L, above EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Results for White Rock Canyon spring perchlorate samples collected in 2011 are consistent with prior data; concentrations are below background levels observed in sampling of NM groundwater by Plummer et al. (2006). The highest perchlorate value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land at a concentration of 0.824 µg/L. This spring also shows elevated nitrate (2.18 mg/L, below the 10-mg/L NM groundwater standard) and uranium (11.4 µg/L, below the 30-µg/L NM groundwater standard) values; it is not located near any apparent sources of contamination. Springs in the Spring 4 series had perchlorate values of 0.53 to 0.63 µg/L.

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To Read About**Turn to Page**

<i>Introduction</i>	6-1
<i>Hydrologic Setting</i>	6-2
<i>Surface Water and Sediment Standards and Screening Levels</i>	6-6
<i>Sampling Locations and Methods</i>	6-10
<i>Sampling Results by Constituents</i>	6-15
<i>Conclusions</i>	6-52
<i>References</i>	6-53

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) monitors the quality of surface water, including storm water, and canyon-bottom sediment to evaluate effects associated with transport of legacy contaminants and ongoing Laboratory operations. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. In this chapter, spatial and temporal aspects of storm water and sediment data are evaluated. The sampling results are compared with various screening criteria to protect human health and the aquatic environment.

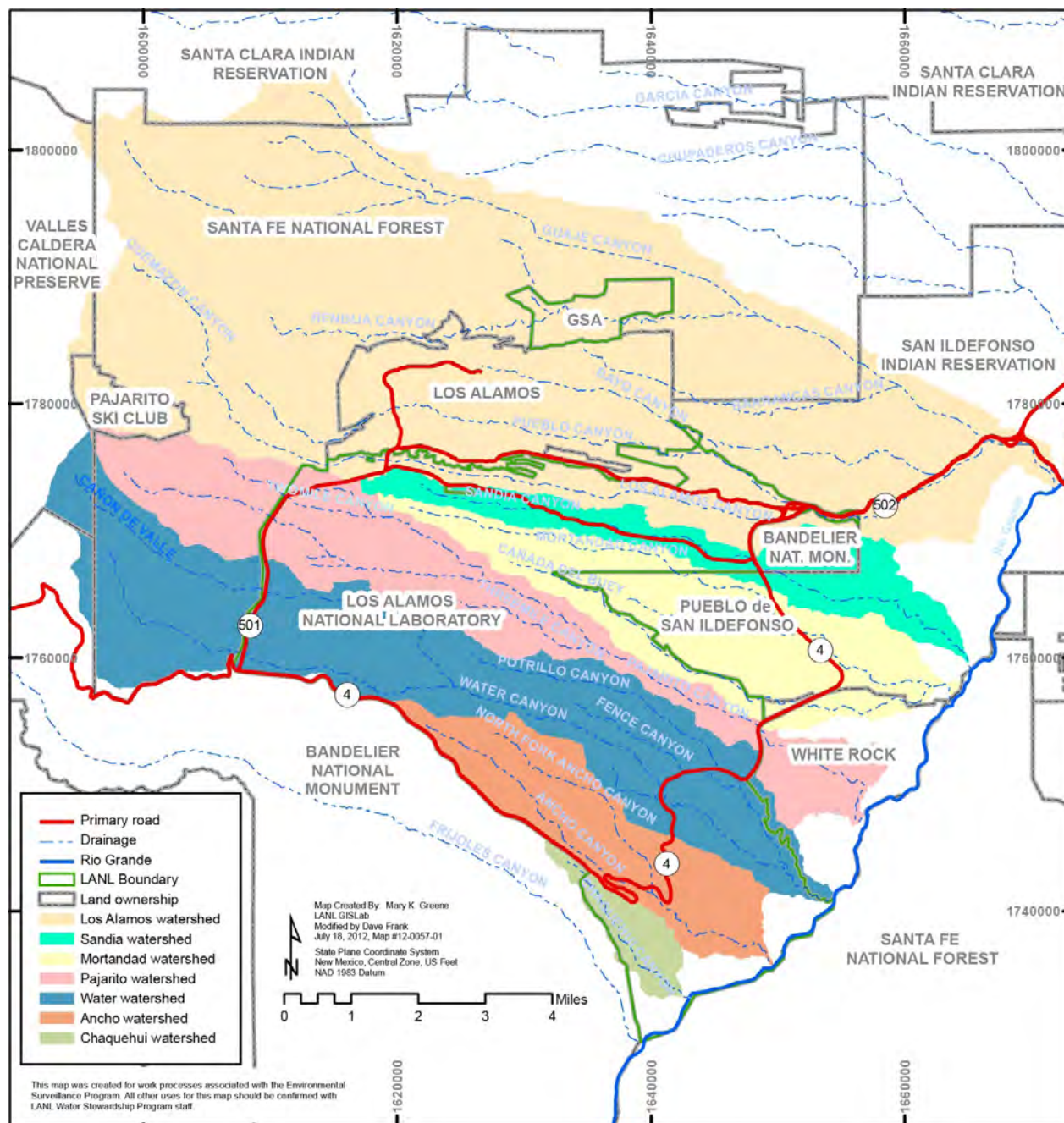
Annual monitoring of sediment sampled from selected locations at and near LANL has occurred since 1969, as part of the US Department of Energy (DOE) Environmental Protection Program (DOE 2008). This currently includes sampling of active channels, overbank-flow sediment deposition on floodplains, and other settings and is intended to evaluate changes in substance concentrations at specific locations over time and potential changes in risk estimates for locations receiving flooding. Detailed evaluations of constituents in sediment across LANL have indicated that concentrations are within regulatory acceptable risks and dose limits (e.g., the Canyons Investigation Reports (IRs): LANL 2004, 2005a, 2006a, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b). Ongoing monitoring is designed to confirm that constituent concentrations are not increasing because of changing conditions in the watersheds or, alternatively, to identify such changes if they occur. An additional objective of this monitoring is to evaluate the effects of sediment transport mitigation activities that have been undertaken in the Los Alamos Canyon watershed (LANL 2008a, 2008b).

Sediment and surface water monitoring and assessments at the Laboratory in 2011 occurred under several tasks. Sediment monitoring in 2011 occurred following the annual summer monsoon season, and this work is described in a sampling and analysis plan (LANL 2011c). Extensive sampling of storm water occurred in Los Alamos and Pueblo Canyons under a plan to monitor the effectiveness of sediment transport mitigation activities (LANL 2011d). Control and monitoring of storm water discharges associated with solid waste management units (SWMUs) and areas of concern (AOCs) occurred under the Individual Permit (IP) with the US Environmental Protection Agency (EPA). Sampling of storm water at gauge stations occurred as part of the Laboratory's environmental surveillance activities. These data are presented in this chapter.

Not included in this chapter are data from the following programs for the following reasons: the Storm Water General Permit for Construction Activities is used to control storm water discharges from areas of one acre or greater that are cleared, graded, or excavated; storm water sampling at other locations to monitor industrial activities occurred under the Multi-Sector General Permit (MSGP) with the EPA; and the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2009e, 2010) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels for an extensive list of constituents. In 2011, sampling of base flow and storm water at two locations along the Rio Grande occurred under an agreement with the City and County of Santa Fe and the Buckman Direct Diversion Project, and results were included in a report evaluating background and baseline concentrations of polychlorinated biphenyls (PCBs) in and near the Laboratory (LANL 2012).

B. HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven primary watersheds that drain directly into the Rio Grande, each defined by a master canyon (Figure 6-1). Listed from north to south, the master canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui Canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water Canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains (the Sierra de los Valles), mostly within the Santa Fe National Forest in areas burned in the Las Conchas Fire. The remainder of the primary watersheds head on the Pajarito Plateau, in areas not burned by the Las Conchas Fire. Only the Ancho Canyon watershed is entirely located on Laboratory land.



GSA = General Services Administration.

Figure 6-1 Primary watersheds at LANL

In 2011, snowmelt runoff only crossed the eastern Laboratory boundary in Pueblo Canyon, estimated at 62 acre-feet (ac-ft); however, 29 ac-ft of the runoff was effluent from the Los Alamos County Waste Water Treatment Plant (WWTP). Continuous runoff was present at that location for 65 days. Total storm water runoff at downstream gauges in the canyons leaving the Laboratory is estimated at 154 ac-ft, approximately 87% of this occurring in Los Alamos and Pueblo Canyons and the remaining 13% in Pajarito, Potrillo, Water, and Ancho Canyons above White Rock.

Figure 6-2 shows the estimated storm water runoff volume at LANL from June through October since 2010 and the seasonal precipitation since 1995, indicating that the total storm water runoff of the four-month period in 2011 (91 ac-ft) was three times that in 2010, although the 2011 precipitation was slightly less than in 2010. This is because of Las Conchas Fire effects, including increased runoff volumes and times to peak. Figure 6-3 shows the 2002 to 2010 mean monthly total precipitation (snow water equivalent and monsoonal precipitation) across the Pajarito Plateau throughout the year and the 2011 mean monthly total precipitation. Aside from a spring snowstorm in April, January to June of 2011 was drier than normal. During the monsoonal period, July through September, the precipitation fluctuated from below normal in July to normal in August, above normal in September, and normal in October. The following winter, the snow in November was below normal and in December was above normal. Figure 6-4 shows the 2002 to 2010 monthly mean of the daily maximum and minimum temperatures across the Pajarito Plateau throughout the year and the monthly mean of the daily maximum and minimum temperatures during 2011. The 2011 temperatures were normal with the following exceptions: the minimum nighttime temperatures for January and February were below normal, the maximum daytime temperature for March was above normal, June and August daytime maximum and nighttime minimum temperatures were above normal, and the nighttime temperature for December was below normal. In general, the summer temperatures were warmer, and the winter temperatures were colder.

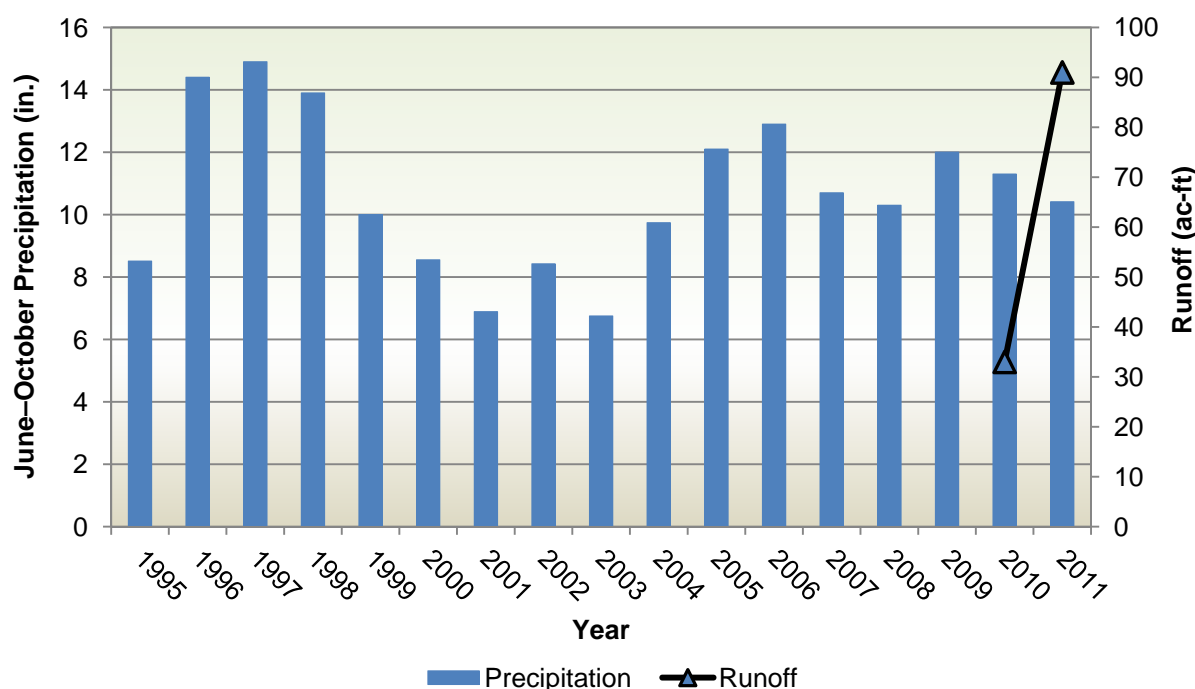


Figure 6-2 Estimated storm water runoff volume in LANL canyons (Pueblo Canyon to Ancho Canyon) from 2010 to 2011 and precipitation at Technical Area 6 (TA-6) during the months of June through October from 1995 to 2011

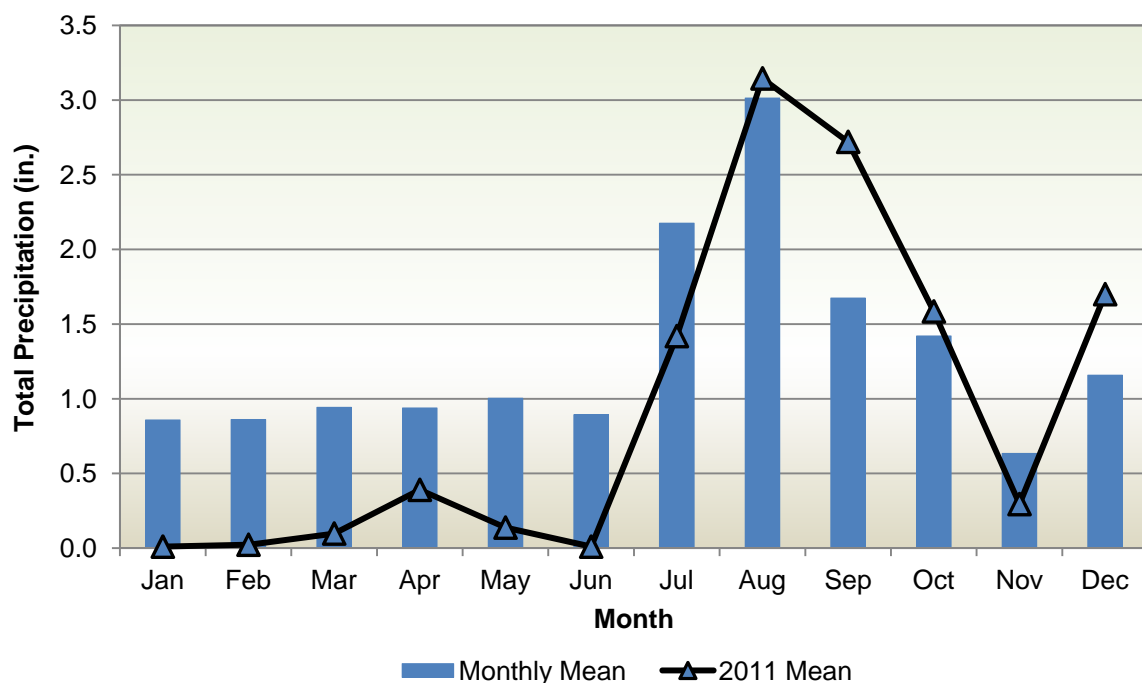


Figure 6-3 Mean of the monthly total precipitation from LANL's meteorological tower network (TA-6, TA-49, TA-53, TA-54, and northern community) over the period of record 2002 to 2010 and the mean of the monthly total precipitation over 2011

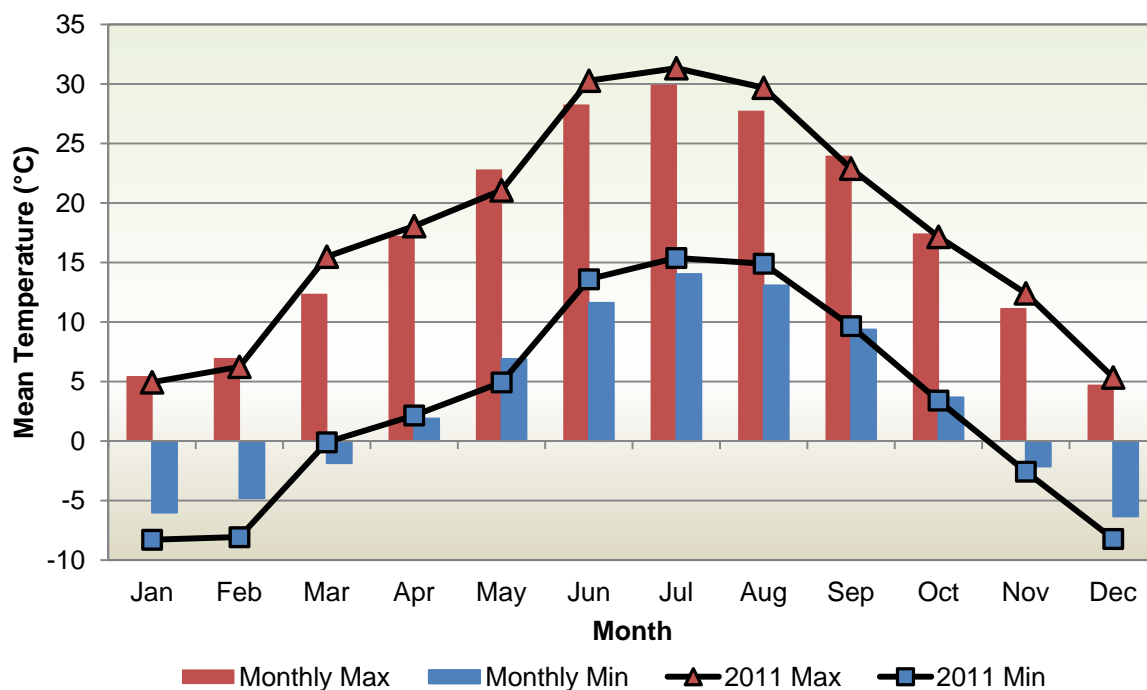


Figure 6-4 Monthly mean of the daily maximum and minimum temperatures averaged from LANL's meteorological tower network (TA-6, TA-49, TA-53, TA-54, and northern community) over the period of record 2002 to 2010 and the monthly mean of the daily maximum and minimum temperatures during 2011

The Laboratory has installed various sediment-control structures to minimize the erosive nature of storm water runoff and to enhance deposition of sediment (Figure 6-5). In Pueblo Canyon, the central focus of the mitigations is to maintain a physically, hydrologically, and biologically functioning wetland that can reduce peak discharge and trap suspended sediment; thus, a grade-control structure was installed to prevent headcutting at the terminus of the wetland, a wing ditch was installed to reduce flood peaks and enhance channel/floodplain interaction before floods reach the wetland, and willows were planted to potentially promote the establishment of additional riparian or wetland vegetation that will also dampen flood peaks and slow floods resulting in sediment deposition. In DP Canyon, a grade-control structure was installed to stabilize and potentially bury the channel and adjacent floodplains where LANL-derived substances are entrained in floods originating from a portion of the Los Alamos town site. In Los Alamos Canyon, a detention basin (DB)/low-head weir was built after the Cerro Grande Fire to trap ash, sediment, and debris in floods and has performed in the same manner after the Las Conchas Fire. Two DBs were constructed below the SWMU 01-001(f) drainage to capture PCB-contaminated sediment in runoff into the canyon. In Mortandad Canyon, three sediment traps were constructed in 1976/1980 to trap sediment suspended in storm water. In Pajarito Canyon, a large flood-control structure was built after the Cerro Grande Fire to reduce the potential for large flood peaks impacting down-canyon facilities and has functioned in the same manner after the Las Conchas Fire. In lower Pajarito Canyon, the wetland reduces peak discharge and traps suspended sediment.

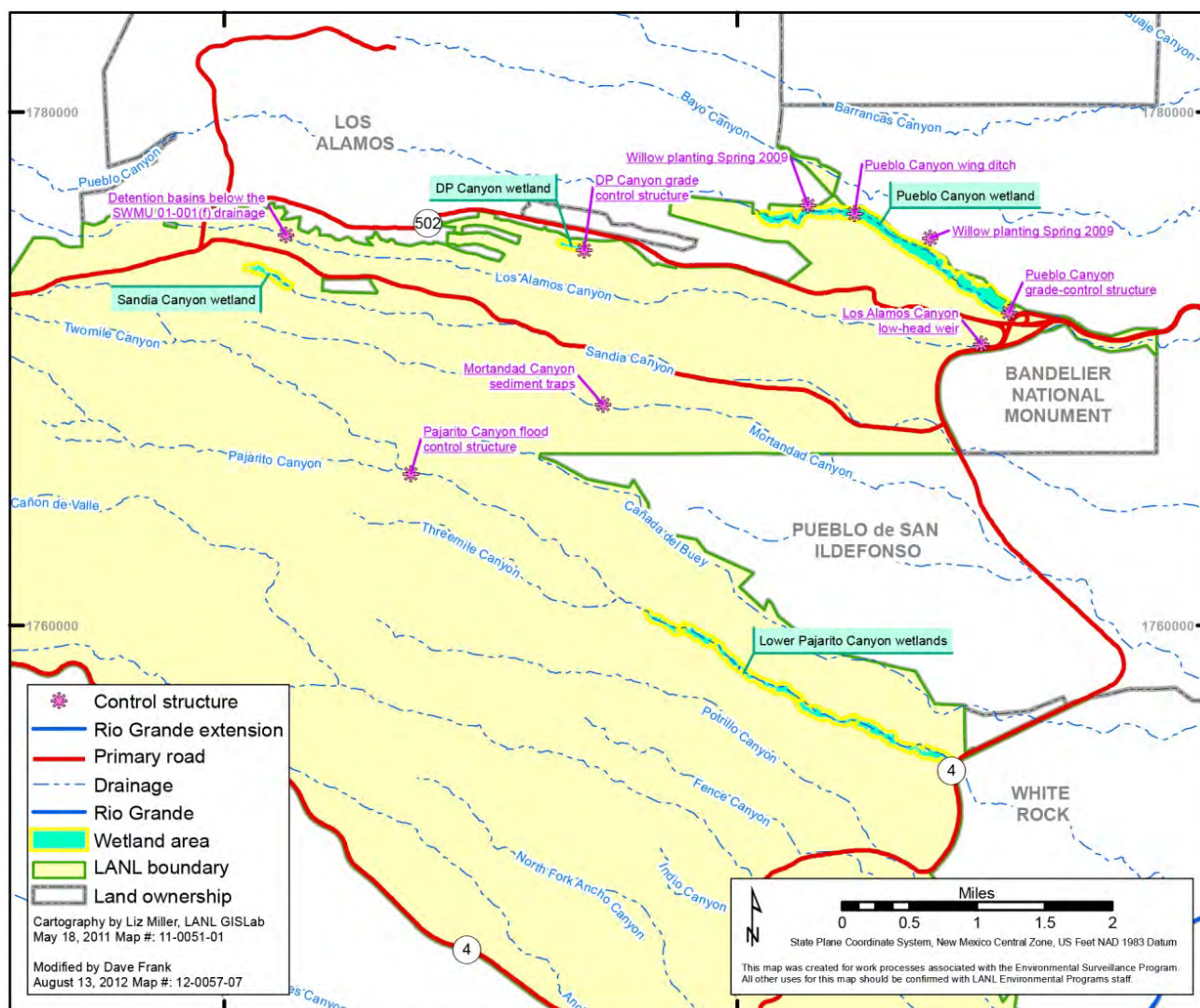


Figure 6-5 Sediment-control structures installed by LANL

C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS

The effects of disturbances, including drought, construction, fire, fire suppression, global atmospheric fallout and Laboratory operations, on watersheds are monitored using results of surface water and sediment sampling. Monitoring results are compared with published standards and screening levels applicable to LANL. These standards and screening levels are summarized in Table 6-1.

1. Surface Water

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for New Mexico in its Standards for Interstate and Intrastate Surface Waters, presented in 20.6.4.1 through 20.6.4.901 of the New Mexico Administrative Code (NMAC) (Figure 6-6, Table 6-2, and NMWQCC 2011). The current standards were approved by EPA on January 14, 2011, and can be found on the New Mexico Environment Department's (NMED's) Web site at <http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.htm>. New Mexico water quality standards do not apply to surface waters on Native American lands, and in this report standards are used as screening levels for comparison with surface water data from Pueblo de San Ildefonso land. Surface water within the Laboratory is not a source of drinking, municipal, industrial, or irrigation water. As described below, under the NMWQCC standards, surface waters within the Laboratory are not considered a drinking water source for humans. However, wildlife may use surface waters within the Laboratory, and standards are set at levels to protect wildlife habitat. Stream flow may also extend beyond the LANL boundary (i.e., onto Pueblo de San Ildefonso land).

Under the NMWQCC standards, all surface waters within LANL boundaries are assigned specified designated uses, ranging from coldwater aquatic life to livestock watering, wildlife habitat, limited aquatic life, and secondary contact. Perennial surface waters within LANL boundaries are assigned the designated uses under 20.6.4.126 NMAC. Intermittent and ephemeral portions of channels managed by DOE are assigned the designated uses under 20.6.4.128 NMAC. Portions of watersheds scheduled for land transfer from LANL to Los Alamos County and portions of streams off of LANL property are assigned designated uses under 20.6.4.97 NMAC and 20.6.4.98 NMAC.

In this document organic and inorganic analytical results from sediment are compared with NMED's risk-based residential soil screening levels (SSLs), and radionuclide analytical results from sediment are compared with LANL's risk-based residential screening action levels (SALs). Exceedance of these screening levels and standards identifies analytes for additional evaluation. Storm water flowing over SWMUs and AOCs are compared with target action levels (TALs) to assess the effectiveness of storm water controls under the IP (NM0030759). Storm water samples from gauge stations are compared with NMWQCC standards, and sampling was performed under the Laboratory's Environmental Surveillance Program. These comparisons, however, are for informational purposes only and are not indicative of regulatory compliance. Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 30 milligrams calcium carbonate per liter (mg CaCO₃/L) (EPA 2006). For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life in perennial stream segments, the Laboratory uses the protocol employed by NMED for assessing standards attainment in New Mexico (NMED 2011).

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

Media and Analyte Type	Standard	Screening Level	Reference	Notes
Surface water, radionuclides, and radioactivity	New Mexico gross alpha, radium-226 + radium-228, and tritium water quality standard for surface water		NMWQCC (2011)	Based on the protection of livestock watering for radium-226, radium-228, tritium, and gross-alpha radiation. NMWQCC standards are not specific about exposure frequency or duration, and single sample results are compared with numeric criteria. The gross-alpha standard excludes alpha radiation from source, special nuclear, and byproduct material regulated by the Atomic Energy Act. NMWQCC standards do not apply on pueblo land or lands slated for land transfer from DOE. For samples from those locations, the standards are applied as screening levels in this report.
Surface water, radionuclides, and radioactivity		Biota Concentration Guides (BCGs)	DOE (2002, 2004)	Surface water is generally present sporadically or is not available for long-term access and does not provide persistent drinking water. The actual exposure pathway is to plants and animals and not to humans. Perennial water BCGs are used for samples collected from designated perennial stream segments, and terrestrial water BCGs are applied to all other locations. BCGs are obtained from RESRAD-BIOTA 1.5 and are based on 1 rad/day (10 milligray per day [mGy/day]) exposure limit for aquatic animals and 0.1 rad/day (1 mGy/day) for riparian or terrestrial animals.
Surface water, non-radionuclides	New Mexico water quality standards for surface water		NMWQCC (2011)	Single sample results are compared with applicable segment-specific water quality standards. Standards for livestock watering, wildlife habitat, and acute and chronic aquatic life criteria apply to all stream segments, excluding samples from pueblo land or lands slated for land transfer from DOE. At those locations, the standards are applied as screening levels in this report. Standards for human health criteria, including PCBs, apply to all stream segments.
Sediment, radionuclides	None	BCGs	DOE (2002, 2004)	Dose limit to biota is the same as for surface water. Individual results are compared with BCGs obtained from RESRAD-BIOTA 1.5.
Sediment, radionuclides		Background	Ryti et al. (1998) or McLin and Lyons (2002)	Results from samples from the Pajarito Plateau are compared with plateau-specific background levels to identify potential contaminants. Results from samples along the Rio Grande and from Cochiti Reservoir are compared with background levels specific to major rivers and reservoirs within the Rio Grande drainage system.
Sediment, non-radionuclides	None	Background	Ryti et al. (1998)	Results for inorganic chemicals from Pajarito Plateau stations are compared with plateau-specific background levels. There are no established background levels for organic chemicals on or off the Pajarito Plateau, and all detected organic chemicals are considered as contaminants.

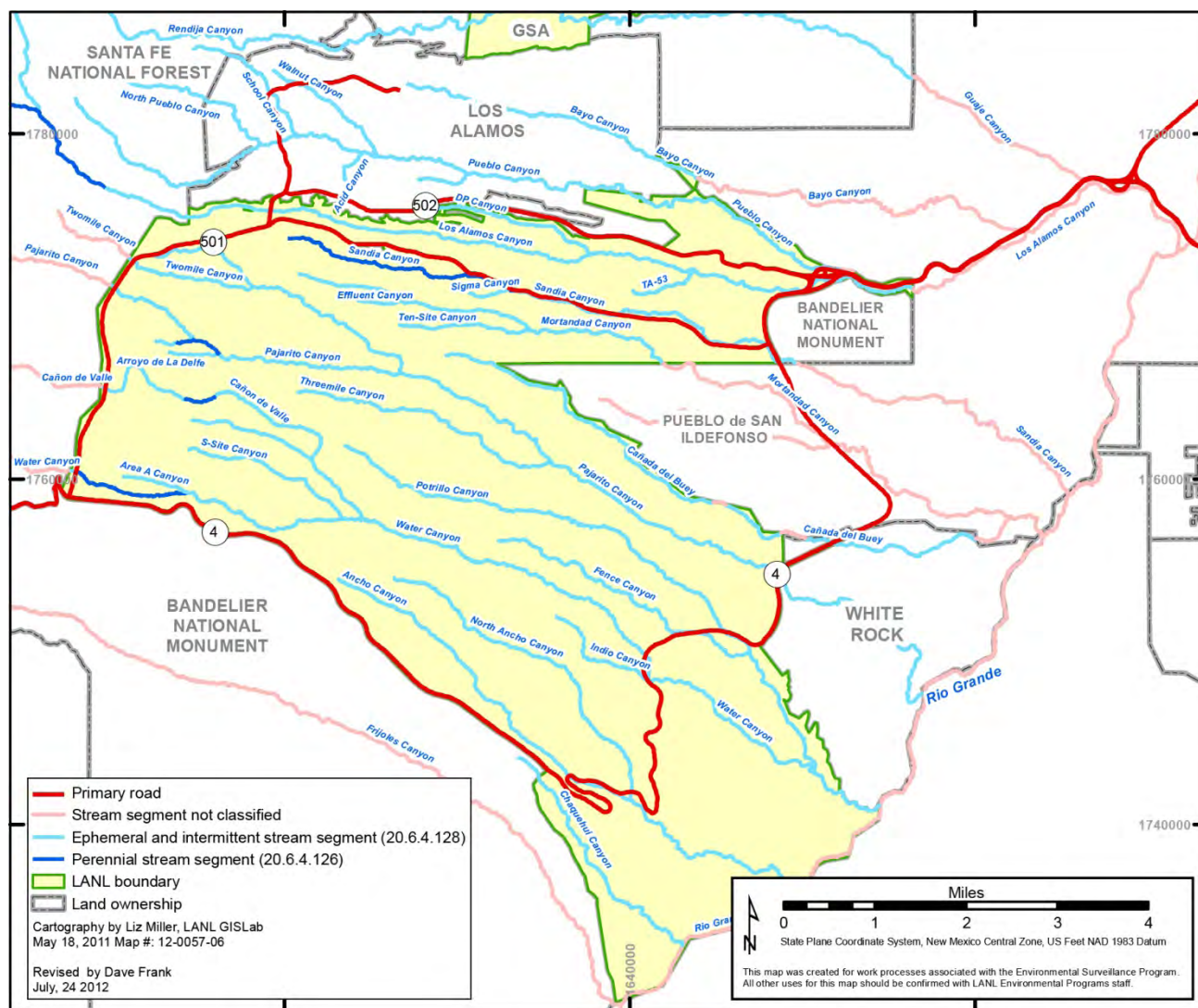


Figure 6-6 Major drainages within Laboratory land, showing designated stream segments

Table 6-2
NMWQCC Designated Uses for LANL Surface Waters

Stream Segment	Designated Uses	Description of Associated Users
Designated perennial segments on LANL property, including parts of Cañon de Valle, Pajarito Canyon, Water Canyon, and Sandia Canyon. See NMWQCC 2011 20.6.4.126 NMAC	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact
	Coldwater aquatic life	Fish, aquatic invertebrates, etc.
Ephemeral and intermittent segments on LANL property and all of Pueblo Canyon 20.6.4.97 and 20.6.4.128 NMAC	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Limited aquatic life	Aquatic invertebrates, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact
Intermittent segments not on LANL property 20.6.4.98 NMAC	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Marginal warmwater aquatic life	Limited ability for stream to sustain a natural aquatic life population on a continuous annual basis
	Primary contact	Recreational or other water use in which there is prolonged and intimate human contact with the water, such as swimming and water skiing, involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard. Primary contact also means any use of surface waters of the state for cultural, religious, or ceremonial purposes in which there is intimate human contact with the water, including but not limited to ingestion or immersion, that could pose a significant health hazard

2. Radionuclides in Surface Water

DOE Order 5400.5 prescribes total dose limits associated with exposure to radionuclides in environmental media. Because of the limited extent of stream flow, there are no drinking water systems on the Pajarito Plateau that rely on surface water supplies. The emphasis of the radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms. For protection of biota, concentrations of radionuclides in surface water are compared with the DOE BCGs (DOE 2002, 2004), with site-specific modifications by McNaughton et al. (2008). For screening purposes, single sample results are first compared with BCGs to identify if radionuclides at a location pose a potential risk to biota. Following DOE guidance (DOE 2003), final evaluations of potential risk at these locations use annual time-weighted radionuclide content of the water rather than individual sample results. For water samples from in or near designated perennial stream segments, BCGs for aquatic or riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, BCGs for terrestrial animals are used.

Surface water analytical results for gross-alpha radiation, radium isotopes, and tritium are also compared with the NMWQCC standards for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary. (Note: There are no livestock at the Laboratory except for a small number of trespass cows grazing at low elevations near the west bank of the Rio Grande.) NMWQCC standards are not specific about exposure frequency or duration. Therefore, for screening purposes, single sample results are compared with numeric criteria for these analytes. It should be noted that the gross-alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act, and

the gross-alpha radiation data discussed in this chapter were not adjusted to remove these sources of radioactivity.

3. Sediment

There are no standards for sediment. Sediment data from the Pajarito Plateau are instead compared with established plateau-specific background concentrations of inorganic chemicals or radionuclides that are naturally occurring or result from global atmospheric fallout (Ryti et al. 1998, McDonald et al. 2003). Radionuclide data from regional sediment stations are compared with background levels established for major drainages of the area: the Rio Grande, the Rio Chama, and the Jemez River (McLin and Lyons 2002, McLin 2004). Background concentrations have been established for PCBs in precipitation and storm water within the upper Rio Grande watershed (LANL 2012). There are no established background levels for other organic chemicals.

SSLs for inorganic and organic chemicals and SALs for radionuclides are media-specific concentrations derived for residential exposures. If environmental concentrations of contaminants are below SALs or SSLs, then the potential for adverse human health effects is considered highly unlikely. Human health risk screening assessments for chemicals of potential concern are conducted using SSLs for residential scenarios obtained from NMED guidance (NMED 2006). Residential SALs are calculated using both adult and child receptors as described in LANL's Derivation and Use of Radionuclide Screening Action Levels, Revision 1 (LANL 2005b).

D. SAMPLING LOCATIONS AND METHODS

Surface water and sediment are sampled in all major canyons that cross current or former Laboratory lands and are also sampled along some short tributary drainages. Canyon bottom channel sediment is sampled to evaluate the accumulation of LANL-derived substances (DOE 1991), to evaluate trends over time, and to monitor effects on the canyon systems from disturbances such as construction and the Las Conchas Fire. LANL collects surface water samples across the Pajarito Plateau within and near the Laboratory as part of several programs and to meet different regulatory requirements. This includes an emphasis on monitoring close to and downstream of potential sources of Laboratory-derived substances, such as at the downstream Laboratory boundary or NM 4. These samples include base-flow samples from locations where effluent discharges maintain stream flow and storm water samples collected using automated samplers.

Figure 6-7 shows surface water locations sampled in 2011 as part of the Environmental Surveillance Program and as part of a task to monitor the effectiveness of sediment transport mitigation measures in the Los Alamos/Pueblo Canyon watershed. These locations are mostly at stream gauges and also include grab samples at a sediment DB in upper Los Alamos Canyon and locations at a tributary to Pueblo Canyon in Graduation Canyon. Figure 6-8 shows locations sampled in 2011 under the IP at SWMUs and AOCs at site monitoring areas (SMAs). Figure 6-9 shows locations sampled in 2011 under the MSGP using automated storm water samplers located close to LANL facilities.

Figure 6-10 shows sediment locations sampled in 2011 as part of the Environmental Surveillance Program. The Laboratory collected sediment samples from stream beds and adjacent flood plains on the Pajarito Plateau to a depth of 3 to 71 cm, depending on the thickness of the uppermost sediment layer. For flowing streams, samples were collected from near the edge of the main channel. Locations outside the main channel were also sampled to variable depths in hand-dug holes.

The procedures for surface water sampling depend on the type of stream flow and location. Grab samples of base flow and snowmelt runoff are collected from free-flowing streams near the bank. The grab samples are either filtered or left unfiltered and preserved in the field. Stream gauges, located mostly in canyon bottoms, are equipped with automated ISCO samplers that are activated at the start of storm water runoff events. All automated samplers collect water from the peak of the runoff event to sample water near the leading edge of floods, also called the "first flush." The year 2011 was the eighth year that the first flush of storm water was sampled at many stations, and it is a significant change from previous years (2003 and earlier), when samples were collected continuously over a two-hour period. Higher suspended sediment concentrations (SSCs) tend

to occur in the first flush compared with the average concentration over a flow event because the SSC is generally highest near the leading edge of the flood (Malmon et al. 2004, 2007). As a result, these post-2003 storm water data are not directly comparable with data from previous years. Beginning in 2010, LANL also collected multiple storm water samples throughout individual runoff events to evaluate variations in suspended sediment and contaminant concentrations within the hydrograph. All storm water samples are filtered and preserved in LANL's storm water processing facility. These samples are then shipped to commercial analytical laboratories without compositing or splitting.

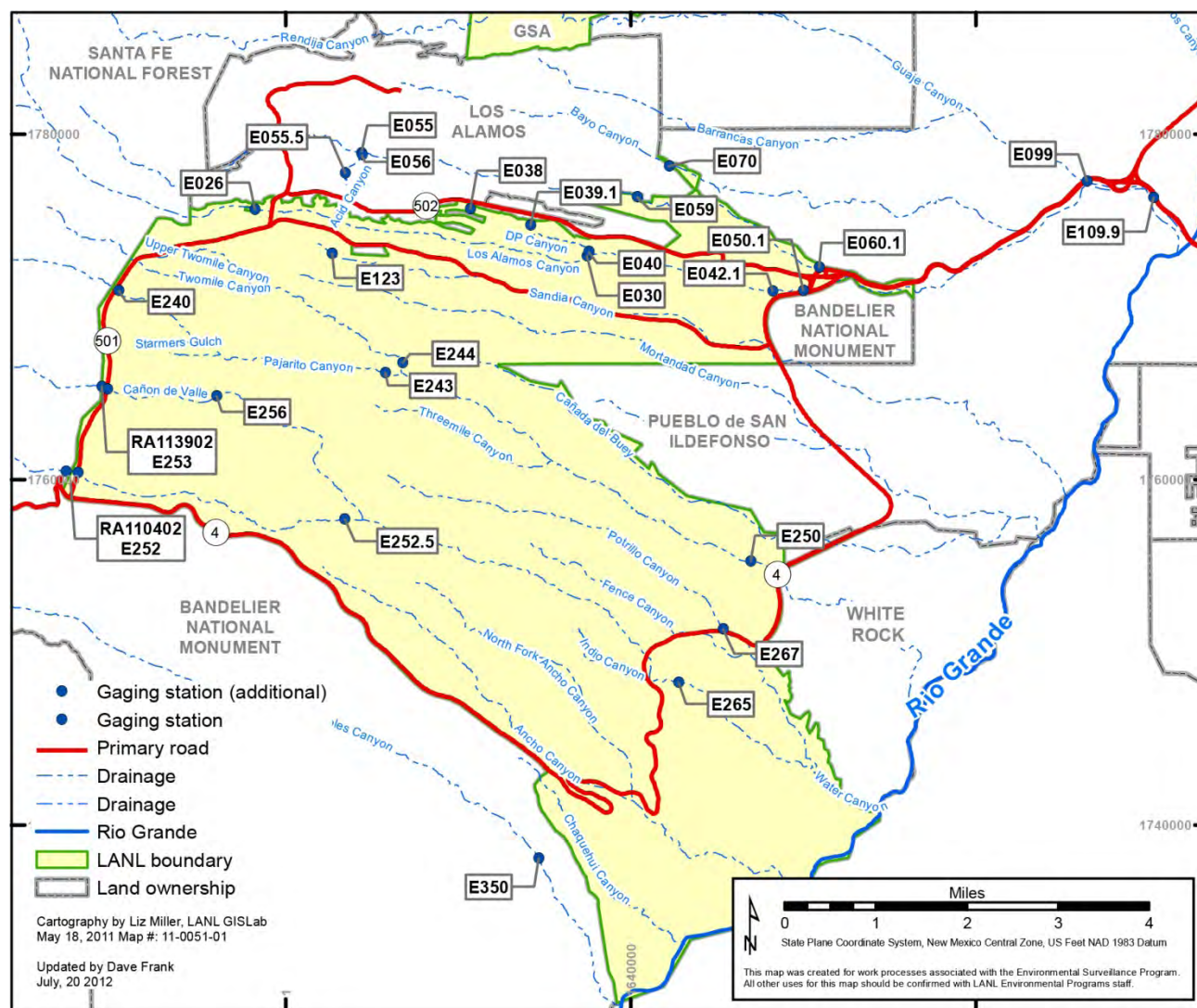


Figure 6-7 Surface water locations sampled in 2011 as part of the Environmental Surveillance Program and the Los Alamos and Pueblo Canyons monitoring plan

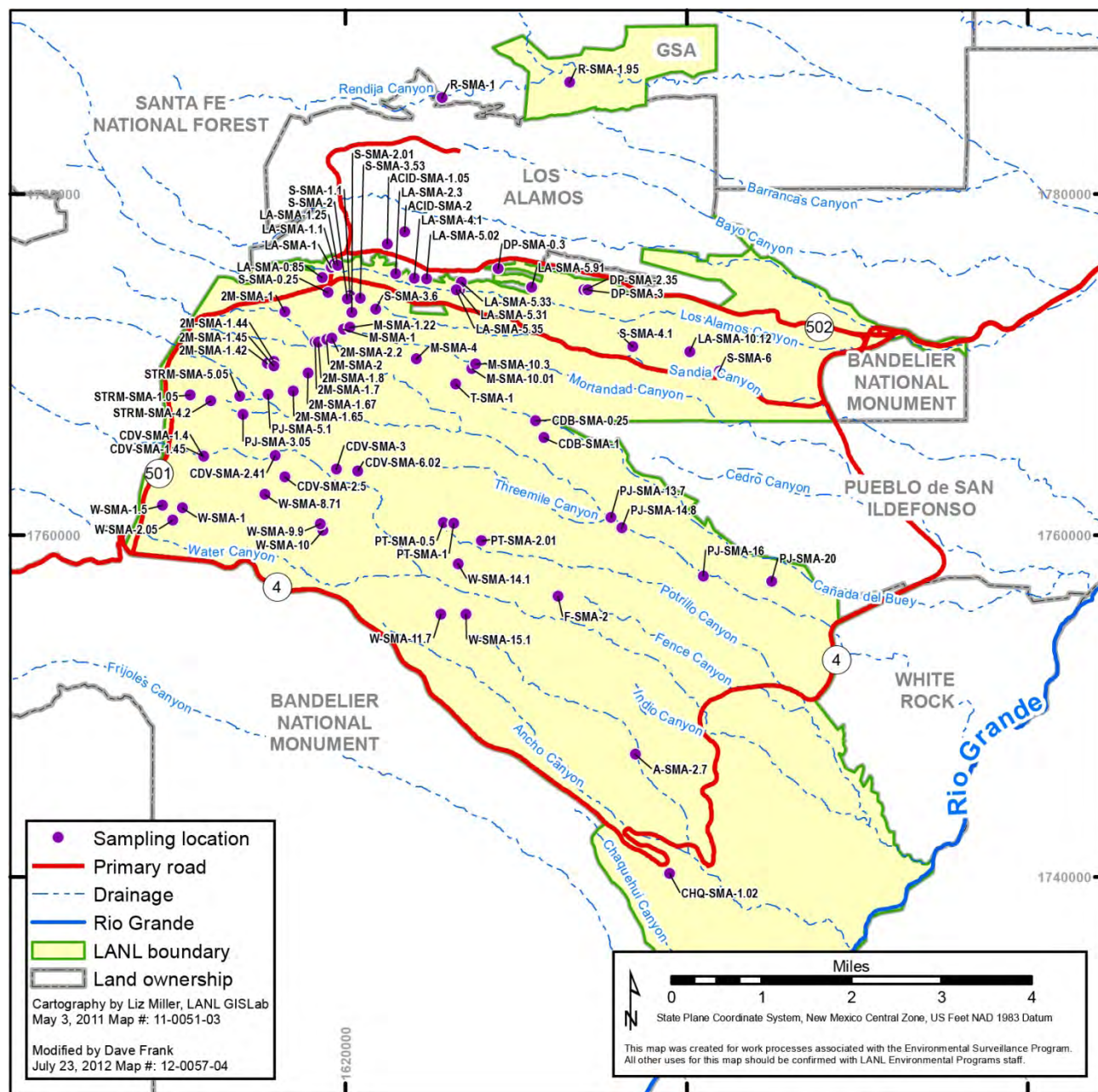
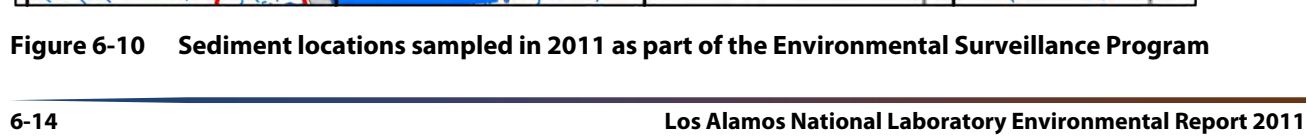


Figure 6-8 Surface water locations sampled in 2011 at IP SMAs



E. SAMPLING RESULTS BY CONSTITUENTS

LANL releases to Pajarito Plateau watersheds were initiated in the first years of LANL operations when effluents containing radionuclides, metals, and organic chemicals were discharged to canyons. Treatment of effluents prior to discharge began in the 1950s and has continued to increase in intensity since that time. Effluent discharges at LANL have been permitted since 1978. Permitted outfalls have been reduced from over 100 in 2000 to 15 permitted outfalls in 2011. LANL's outfall reduction efforts are still underway. Storm water runoff from potential release sites is managed under the IP. Storm water discharges from construction sites are managed under the construction general permit. Larger watershed-scale and smaller drainage-scale approaches to control sediment are being implemented to reduce sediment transport.

During 2011, discharge overtopped stream banks in Los Alamos, Pajarito, and Water Canyons, resulting in new sediment deposits onto floodplains that were sampled. Stream flows in Ancho, Chaquehui, Mortandad, and Sandia Canyon watersheds stayed within existing channels and therefore did not deposit sediment on adjacent floodplains. Table 6-3 presents a summary of results for radionuclides and inorganic chemicals in Pajarito Plateau sediment samples from 2011 that exceeded background values, inorganic SSLs, and radionuclide SALs.

Table 6-4 presents a summary of results for radionuclides in Pajarito Plateau storm water samples from 2011 that exceeded NMWQCC standards. Table 6-5 presents a summary of results for inorganic and organic chemicals in Pajarito Plateau storm water samples from 2011 that exceeded NMWQCC standards. All of the analytes exceeding residential SSLs in sediment collected during 2011, analytes exceeding NMWQCC standards, and analytes exceeding IP TALs are discussed further in this report. Also discussed are the radionuclides americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90, which are associated with LANL activities and global atmospheric fallout. Uranium-234 and uranium-238 are included in the discussion as associated with LANL activities and regional background. Additionally, barium and the explosive compound RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) are discussed in Water Canyon in association with LANL activities and, for barium, the regional background.

Human health and ecological assessments have been conducted as part of each of the Canyons IRs conducted under the Compliance Order on Consent (Consent Order). The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyons media are within acceptable limits for applicable exposure scenarios. Sediment data presented in this report are used to verify the conceptual model that the scale of storm water related contaminant transport observed in LANL canyons generally results in lower concentrations of contaminants in the new sediment deposits than previously existed in deposits in a given reach. The results of the comparisons of sediment data collected from flood-affected canyons in 2011 verify the conceptual model and support the premise that the risk assessments presented in the Canyons IRs represent an upper bound of potential risks in the canyons. Health effects from exposure to storm water are evaluated in Chapter 3, Dose Assessment.

Table 6-3

Summary of Results for Radionuclides and Inorganic Chemicals in Pajarito Plateau Sediment Samples from 2011

Analyte	Sediment BV ^a (pCi/g ^b for radionuclides and mg/kg for inorganic chemicals)	Percentage of Samples with Detected Results above BV	Number of Detected Results above BV	Number of Samples Analyzed	Master Watersheds with Detected Results above BV	Notes
Americium-241	0.04 (BV) 30 (SAL)	13% (BV) 0% (SAL)	15 (BV) 0 (SAL)	112	Los Alamos, Pajarito, Water	Maximum result (0.263 pCi/g) is from Los Alamos Canyon from reach LA-3E in a sample containing ash.
Cesium-137	0.9 (BV) 5.6 (SAL)	57% (BV) 0% (SAL)	35 (BV) 0 (SAL)	61	Los Alamos, Pajarito, Water, Rio Grande	Maximum result (3.58 pCi/g) is from Pajarito Canyon from reach PA-3E in a sample containing ash.
Plutonium-238	0.006 (BV) 37 (SAL)	9% (BV) 0% (SAL)	6 (BV) 0 (SAL)	66	Pajarito, Los Alamos	Maximum result (0.0498 pCi/g) is from Pajarito Canyon from reach TW-1W in a sample containing ash at the upper lab boundary.
Plutonium-239/240	0.068 (BV) 33 (SAL)	33% (BV) 0% (SAL)	22 (BV) 0 (SAL)	66	Los Alamos, Pajarito, Water	Maximum result (0.327 pCi/g) is from Los Alamos Canyon from reach LA-3E in a sample containing ash.
Strontium-90	1.04 (BV) 5.7 (SAL)	3% (BV) 2% (SAL)	2 (BV) 1 (SAL)	61	Los Alamos, Pajarito	Maximum result (6.36 pCi/g) is from Los Alamos Canyon weir basin 1 in a sample containing ash.
Uranium-234	2.59 (BV) 170 (SAL)	0% (BV) 0% (SAL)	0 (BV) 0 (SAL)	66	None	Maximum result (1.93 pCi/g) is from Water Canyon at reach CDV-0 in a sample containing ash.
Uranium-235/236	0.2 (BV) 17 (SAL)	0% (BV) 0% (SAL)	0 (BV) 0 (SAL)	66	None	Maximum result (0.149 pCi/g) is from Rio Grande above Otowi Bridge in a sample containing ash.
Uranium-238	2.29 (BV) 87 (SAL)	0% (BV) 0% (SAL)	0 (BV) 0 (SAL)	66	None	Maximum result (1.79 pCi/g) is from Los Alamos Canyon weir basin 2 in a sample containing ash.
Aluminum	15,400 (BV) 77,800 (SSL)	5% (BV) 0% (SSL)	3 (BV) 0 (SSL)	66	Pajarito, Los Alamos	Maximum result (19,200 mg/kg) is from Pajarito Canyon from reach PA-4 in a sample containing ash.
Arsenic	3.9 (SSL) 3.98 (BV)	2% (BV) 2% (SSL)	1 (BV) 1 (SSL)	66	Pajarito	Maximum result (4.07 mg/kg) is from Pajarito Canyon from reach PA-3E in a sample containing ash.
Barium	127 (BV) 15,600 (SSL)	71% (BV) 0% (SSL)	47 (BV) 0 (SAL)	66	Water, Pajarito, Los Alamos, Rio Grande	Maximum result (1,010 mg/kg) is from Water Canyon from reach CDV-2E in a sample containing ash.
Copper	11.2 (BV) 3,130 (SSL)	39% (BV) 0% (SSL)	26 (BV) 0 (SSL)	66	Pajarito, Los Alamos, Water, Rio Grande	Maximum result (32.2 mg/kg) is from Pajarito Canyon from reach PA-3E in a sample containing ash.
Cyanide	0.82 (BV) 1,220 (SSL)	71% (BV) 0% (SSL)	41 (BV) 0 (SSL)	58	Pajarito, Los Alamos, Water, Rio Grande, Frijoles	Maximum result (14.4 mg/kg) is from Pajarito Canyon from reach PA-3E in a sample containing ash.
Lead	19.7 (BV) 400 (SSL)	27% (BV) 0% (SSL)	18 (BV) 0 (SSL)	66	Pajarito, Los Alamos, Water	Maximum result (42.4 mg/kg) is from Pajarito Canyon from reach PA-3E in a sample containing ash.

Table 6-3 (continued)

Analyte	Sediment BV ^a (pCi/g ^b for radionuclides and mg/kg for inorganic chemicals)	Percentage of Samples with Detected Results above BV	Number of Detected Results above BV	Number of Samples Analyzed	Master Watersheds with Detected Results above BV	Notes
Manganese	543 (BV) 1,860 (SSL)	56% (BV) 2% (SSL)	37 (BV) 1 (SSL)	66	Pajarito, Los Alamos, Water, Rio Grande	Maximum result (2,520 mg/kg) is from Pajarito Canyon from reach PA-3E in a sample containing ash.
Mercury	0.1 (BV) 23.5 (SSL)	0% (BV) 0% (SSL)	0 (BV) 0 (SSL)	66	None	Maximum result (0.0401 mg/kg) is from Los Alamos Canyon weir basin 2 in a sample containing ash.
Selenium	0.3 (BV) 391 (SSL)	2% (BV) 0% (SSL)	1 (BV) 0 (SSL)	66	Rio Grande	Maximum result (2.39 mg/kg) is from Rio Grande below Water Canyon.
Silver	1 (BV) 391 (SSL)	20% (BV) 0% (SSL)	13 (BV) 0 (SSL)	66	Water, Pajarito, Frijoles	Maximum result (7.58 mg/kg) is from Water Canyon from reach CDV-1C in a sample containing ash.

^a BV = Background value; SAL = LANL residential screening action level; SSL = NMED residential soil screening level.

^b pCi/g = Picocuries per gram.

Table 6-4

Summary of Results for Radionuclides in Pajarito Plateau Storm Water Samples Collected at Gauge Stations from 2011

Analyte	Standard or Guide ^a (pCi/L ^b)	Percentage of Samples with Detected Results above Standard or Guide ^a	Number of Detected Results above Standard or Guide ^a	Number of Samples Analyzed	Master Watersheds with Detected Results above Standard or Guide	Notes
Gross-alpha radiation	15 (lw)	84%	56	67	Los Alamos, Sandia, Pajarito, Water, Frijoles	Ash-bearing samples contain elevated gross-alpha activity.
Americium-241	400 (db) 438 (aa) 1,460 (ra) 202,000 (ta)	0%	0	88	None	Maximum result (15.7 pCi/L) from Los Alamos Canyon above Rio Grande at E109.9 is 0.008% of terrestrial BCG from a sample containing ash.
Cesium-137	40 (db) 20,000 (sr)	7% (db) 0% (sr)	7 (db) 0 (sr)	98	None	Maximum result (257 pCi/L) from Cañon de Valle above NM 501 at E253 is 1.3% of LANL-specific BCG from a sample containing ash.

Table 6-4 (continued)

Analyte	Standard or Guide ^a (pCi/L ^b)	Percentage of Samples with Detected Results above Standard or Guide ^a	Number of Detected Results above Standard or Guide ^a	Number of Samples Analyzed	Master Watersheds with Detected Results above Standard or Guide	Notes
Plutonium-238	176 (aa) 200 (db) 551 (ra) 189,000 (ta)	0%	0	101	None	Maximum result (4.99 pCi/L) from Los Alamos Canyon above Rio Grande at E109.9 is 0.003% of terrestrial BCG from a sample containing ash.
Plutonium-239/240	187 (aa) 200 (db) 622 (ra) 201,000 (ta)	0%	0	98	None	Maximum result (98.9 pCi/L) from Los Alamos Canyon above the low-head weir at E042.1 is 0.05% of terrestrial BCG from a sample containing ash.
Radium-226 + Radium-228	30 (lw)	35%	6	17	Los Alamos	Maximum result (109 pCi/L) from Los Alamos Canyon above Rio Grande at E109.9 is from a sample containing ash. (No BCGs are available for radium-226 + radium-228.)
Strontium-90	300 (db) 30,000 (sr)	0%	0	64	None	Maximum result (48.2 pCi/L) from Los Alamos Canyon above Rio Grande at E109.9 is 0.16% of LANL-specific BCG from a sample containing ash.
Uranium-234	200 (db) 202 (aa) 684 (ra) 405,000 (ta)	6% (db) 6% (aa) 0% (ra) 0% (ta)	7 (db) 7 (aa) 0 (ra) 0 (ta)	108	Los Alamos, Water	Maximum results (398 pCi/L) from Water Canyon above NM 501 at E252 and from Los Alamos Canyon above the low-head weir at E042.1 are 0.1% of terrestrial BCG from samples containing ash.
Uranium-235/236	218 (aa) 737 (ra) 420,000 (ta)	0%	0	108	None	Maximum result (31.8 pCi/L) from Los Alamos Canyon above Rio Grande at E109.9 is 0.008% of terrestrial BCG from a sample containing ash.
Uranium-238	200 (db) 224 (aa) 757 (ra) 406,000 (ta)	7% (db) 6% (aa) 0% (ra) 0% (ta)	8 (db) 7 (aa) 0 (ra) 0 (ta)	108	Los Alamos, Water	Maximum result (412 pCi/L) at the upgradient Laboratory boundary in Water Canyon above NM 501 at E252 is 0.1% of terrestrial BCG from a sample containing ash.

^a aa = BCG for aquatic animal; lw = livestock watering standard; ra = BCG for riparian animal; sr = LANL-specific site-representative BCG; ta = BCG for terrestrial animal; db = DOE BCG.

^b pCi/L = Picocuries per liter.

Table 6-5

Summary of Results for Inorganic and Organic Chemicals in Pajarito Plateau Storm Water Samples Collected at Gauge Stations from 2011

Analyte	Sample Preparation	Standard or Guide ^a (µg/L)	Percentage of Samples with Detected Results above Standard or Guide ^a	Number of Detected Results above Standard or Guide ^a	Number of Samples Analyzed	Master Watersheds with Detected Results above Standard or Guide	Notes
Aluminum	Filtered	263 (ca) 658 (aa)	64% (ca) 27% (aa)	54 (ca) 23 (aa)	85	Los Alamos, Pajarito, Water, Sandia, Frijoles	Maximum result (6,040 µg/L) is at Water Canyon below NM 4 at E265.
Arsenic	Filtered	9 (hh)	7%	6	85	Water, Pajarito, Los Alamos	Maximum result (12.7 µg/L) is at Water Canyon below NM 4 at E265.
Barium	Filtered	Not available	n/a ^b	n/a	85	n/a	Maximum result (520 µg/L) is at Water Canyon below NM 4 at E265.
Copper	Filtered	3 (ca) 4 (aa)	38% (ca) 19% (aa)	32 (ca) 16 (aa)	85	Sandia, Los Alamos Water, Pajarito	Maximum result (17.5 µg/L) is at Sandia Canyon below the wetland at E123.
Cyanide	Unfiltered	5.2 (wh and ca) 22 (aa)	90% (wh and ca) 59% (aa)	44 (wh and ca) 29 (aa)	49	Pajarito, Water, Los Alamos, Frijoles	Maximum result (733 µg/L) is at Pajarito Canyon below NM 501 at E240.
Lead	Filtered	1 (ca) 17 (aa)	9% (ca) 0% (aa)	8 (ca) 0 (aa)	85	Water, Los Alamos	Maximum result (6.5 µg/L) is at Water Canyon below NM 4 at E265.
Manganese	Filtered	1,105 (ca) 1,999 (aa)	20% (ca) 15% (aa)	17 (ca) 13 (aa)	85	Los Alamos, Water, Pajarito	Maximum result (4,500 µg/L) is at Los Alamos Canyon above DP Canyon at E030.
Mercury	Unfiltered	0.77 (wh)	2%	2	85	Los Alamos, Water	Maximum result (2.6 µg/L) is at Los Alamos Canyon above DP Canyon at E030.
Selenium	Unfiltered	5.0 (wh and ca)	11%	9	85	Los Alamos, Pajarito	Maximum result (17.4 µg/L) is at Los Alamos Canyon above low-head weir at E042.1.
Silver	Filtered	0.4 (aa)	1%	1	85	Water	Maximum result (0.48 µg/L) is at Water Canyon below NM 4 at E265.
Total PCBs	Unfiltered	0.00064 (hh) 0.014 (ca) 2 (aa)	90% (hh) 64% (ca) 0% (aa)	87 (hh) 62 (ca) 0 (aa)	97	Los Alamos, Pajarito, Water, Sandia	Maximum result (1.72 µg/L) is at Pueblo Canyon above the WWTP at E059.
Zinc	Filtered	41 (ca) 54 (aa)	1% (ca) 0% (aa)	1 (ca) 0 (aa)	85	Los Alamos	Maximum result (46.7 µg/L) is at DP Canyon above TA-21 at E038

^a aa = Acute aquatic life standard; ca = chronic aquatic life standard; hh = human health standard; wh = wildlife habitat standard.

^b n/a = Not applicable.

1. Background-Related Constituents

Several constituents observed in storm water runoff and sediment are associated with both naturally occurring sources in soils and rock and anthropogenic sources upgradient of the Laboratory on the Pajarito Plateau.

Filtered surface water samples collected on the Pajarito Plateau in 2011 commonly contained aluminum concentrations above the NMWQCC acute aquatic life standard of 750 micrograms per liter ($\mu\text{g/L}$). However, most or all of this aluminum is likely naturally occurring (e.g., Reneau et al. 2010). For example, samples from the upgradient boundary gauge station in Cañon de Valle had aluminum concentrations of 19,900 $\mu\text{g/L}$ and 13,200 $\mu\text{g/L}$ in 2000 and 2001, respectively, after the Cerro Grande Fire. Similarly, a sample from the upgradient boundary gauge station in Pajarito Canyon had an aluminum concentration of 11,500 $\mu\text{g/L}$ in 2005. Aluminum is a natural component of soil and is not known to be derived from LANL operations in any significant quantity. The NMED Surface Water Quality Bureau has also noted that “the large number of exceedences” for aluminum on the Pajarito Plateau “may reflect natural sources associated with the geology of the region,” and that aluminum also exceeds 750 $\mu\text{g/L}$ in other parts of the Jemez area (NMED 2009). Aluminum concentrations in storm water are very similar at environmental surveillance report (ESR) gauges and IP SMAs during 2011. For sampling conducted under the IP, the highest result for filtered aluminum was 6,550 $\mu\text{g/L}$ at PT-SMA-1 in Water Canyon. The highest aluminum result determined at a gauge station in 2011 in Water Canyon was 6,040 $\mu\text{g/L}$. In 2011, aluminum concentrations in sediment did not exceed the residential SSL of 78,000 milligrams per kilogram (mg/kg). The regional background of 15,400 mg/kg was exceeded in three samples collected during 2011 containing ash from the Las Conchas burn area.

Six filtered surface water samples collected on the Pajarito Plateau in 2011 had arsenic above the NMWQCC human health standard for arsenic of 9.0 $\mu\text{g/L}$. Three of the samples with exceedances were collected at the upgradient boundary gauge station in Pajarito Canyon, with arsenic concentrations of 10.2 $\mu\text{g/L}$, 10.5 $\mu\text{g/L}$, and 11.4 $\mu\text{g/L}$. One of the samples with exceedances was collected in Los Alamos Canyon downstream of the LANL boundary but above the Rio Grande, with an arsenic concentration of 10.1 $\mu\text{g/L}$, and is associated with Guaje Canyon runoff. The absence of arsenic above the standards in the Los Alamos Canyon watershed closer to LANL sources indicates that this arsenic is most likely derived from natural sources. Arsenic concentrations in storm water at IP SMAs are less than arsenic concentrations at ESR gauges affected by the Las Conchas Fire. Arsenic did not exceed the IP TAL in samples collected in 2011. For sampling under the IP, the highest result for filtered arsenic was 5.5 $\mu\text{g/L}$. The highest filtered arsenic result detected at a gauge station in 2011 was 12.7 $\mu\text{g/L}$ in lower reaches of Water Canyon and contained ash. Arsenic was detected above the regional background value of 3.98 mg/kg and the residential SSL of 3.9 mg/kg in one 2011 sediment sample collected in Pajarito Canyon in a sample containing ash from the Las Conchas burn area.

Elevated copper concentrations have been associated with firing sites, developed areas, and forest fires. In 2011, copper concentrations in storm water exceeded the NMWQCC aquatic chronic standard for copper (3 $\mu\text{g/L}$) in Los Alamos and Water Canyons and the NMWQCC aquatic acute standard for copper (4 $\mu\text{g/L}$) in Pajarito Canyon. Prior to 2011, every watershed across the Laboratory had recorded elevated copper concentrations in storm water, including all of LANL’s upgradient boundary stations, indicating that copper most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. In addition, in 2011 every watershed had maximum TAL (MTAL) exceedances of copper concentrations in IP-related storm water samples. However, the highest copper concentrations at IP SMAs are greater than copper concentrations at ESR gauges, indicating a Laboratory contribution of copper to the canyons. For sampling under the IP, the highest result for filtered copper was 174 $\mu\text{g/L}$ at PT-SMA-1 in Water Canyon and is associated with Laboratory operations. The highest filtered copper result detected at a gauge station in 2011 was 7.9 $\mu\text{g/L}$ in Water Canyon. In 2011, no copper concentrations in sediment exceeded the residential SSL of 3,130 mg/kg .

Total cyanide was detected above the NMWQCC wildlife habitat standard of 5.2 $\mu\text{g/L}$ in all ash-bearing storm water samples collected in 2011. In 2011, cyanide was detected above the regional background value for sediment of 0.83 mg/kg in 71% of samples collected. No cyanide concentrations in sediment exceeded the residential SSL of 1,220 mg/kg . Cyanide is observed in ash from forest fires as a result of incomplete

combustion. Cyanide concentrations should decline over the next several years, as was observed following the Cerro Grande Fire in May 2000 (Gallaher and Koch 2004, 2005). Cyanide concentrations at IP SMAs are less than cyanide concentrations at ESR gauges affected by the Las Conchas Fire. For sampling under the IP, the highest result for unfiltered cyanide (weak acid dissociable) was 27.4 µg/L at PJ-SMA-3.05 in the Pajarito Canyon watershed. The highest cyanide (total) result detected at a gauge station in 2011 in Pajarito watershed was 733 µg/L.

Filtered manganese was detected above the acute aquatic life standard of 1,999 µg/L in several ash-bearing storm water samples. Manganese was detected above the residential SSL of 1,860 mg/kg in new sediment deposits in Los Alamos Canyon and above the background value of 543 mg/kg. Laboratory operations did not generate or release significant quantities of manganese. Manganese is not monitored as part of the IP. Dissolved manganese concentrations were elevated following the Cerro Grande Fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005).

Total selenium was detected above the wildlife habitat standard of 5 µg/L in many ash-bearing storm water samples. Selenium concentrations in storm water at IP SMAs are less than selenium concentrations at ESR gauges affected by the Las Conchas Fire. Unfiltered selenium did not exceed the IP TAL in samples collected in 2011. The highest unfiltered selenium result detected at a gauge station in 2011 was 17.4 µg/L. In 2011, selenium concentrations in sediment were not detected above the residential SSL of 391 mg/kg, and selenium was detected above the regional background value for sediment (0.3 mg/kg) in one of 66 samples collected. Laboratory operations did not generate or release significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande Fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005).

Elevated zinc concentrations are associated with developed areas, particularly compounds associated with tires and galvanized metals. In 2011, filtered zinc concentrations in storm water exceeded the NMWQCC standard in one sample; however, every watershed had MTAL exceedances (42 µg/L) of zinc concentrations in IP-related storm water samples. Prior to 2011, every watershed across the Laboratory, with the exception of Mortandad, had elevated zinc concentrations in storm water, including all of LANL's upgradient boundary stations, indicating that zinc most likely occurs naturally in rocks and soils in the uplands above the Pajarito Plateau. No pre-2011 or 2011 zinc concentrations in sediment exceeded the residential SSL (23,500 mg/kg).

Consistent with previous years, many surface water samples in 2011 had gross-alpha radiation levels above the NMWQCC surface water standard of 15 pCi/L for livestock watering. Of the 66 unfiltered storm water samples analyzed from the Pajarito Plateau for gross-alpha radiation, 85% exceeded 15 pCi/L, including background sample sites. For example, the highest concentrations of gross alpha in storm water, 6,200 pCi/L to 1,100 pCi/L, were measured in samples containing ash from the Las Conchas Fire. The analytical results from 2011 support earlier conclusions that the majority of the alpha radiation in surface water on the plateau is because of the decay of naturally occurring isotopes in sediment and soil from uncontaminated areas carried in storm water runoff and that Laboratory impacts are relatively small (e.g., Gallaher 2007). Naturally occurring radionuclides that are alpha emitters include isotopes of radium, thorium, and uranium.

Consistent with previous years, many surface water samples in 2011 had radium-226 and radium-228 levels above the NMWQCC surface water standard of 30 pCi/L for livestock watering. Of the 17 unfiltered storm water samples analyzed from the Pajarito Plateau at gauge stations for radium-226 and radium-228, 35% exceeded 30 pCi/L. The highest concentration of radium-226 and radium-228 in storm water, 109 pCi/L, was measured in samples containing ash from the Las Conchas Fire at Los Alamos Canyon above the Rio Grande. For sampling under the IP, the highest detected radium-226 and radium-228 concentration was 70.3 pCi/L at M-SMA-4 in Mortandad Canyon. The analytical results from 2011 support earlier conclusions that the majority of the radium-226 and radium-228 in surface water on the plateau is because of the decay of naturally occurring isotopes in sediment and soil from uncontaminated areas carried in storm water runoff and that Laboratory impacts are relatively small (e.g., Gallaher 2007).

2. LANL-Related Constituents

Several constituents were measured in storm water runoff and resultant sediment deposits that relate to historical LANL operations. The nature and extent of these constituents in sediment deposited from runoff is described in detail in the Canyons IRs referenced in the Chapter 6 Introduction. The following discussion describes the occurrences of key constituents in 2011 storm water and sediment samples and the relationship of their concentrations to pre-existing concentrations and spatial distributions.

Figures 6-11 through 6-22 illustrate the relationships between 2011 constituent concentrations in storm water and sediment to those prior to 2011. Plotted results were part of Canyons IRs or ESRs or were results from IP SMAs. Some of the sediment results that were discussed were not part of these reports so are not shown in figures. All results are plotted relative to their distance to the Rio Grande. The confluence points of each subwatershed are labeled on the upper x-axis for reference. Pre-2011 results for each subwatershed are identified using a unique color, and results obtained in 2011 are colored in green. In the storm water figures, results collected as part of the IP are identified with a triangle, and canyon gauge results are identified with an oval. In the sediment figures, results collected as part of Canyons IRs are identified with an oval, and environmental surveillance results are identified with a triangle. In some cases the highest results for a watershed are not presented but are described in the figure's footnote. Results from the DB in Los Alamos Canyon are uniquely presented.



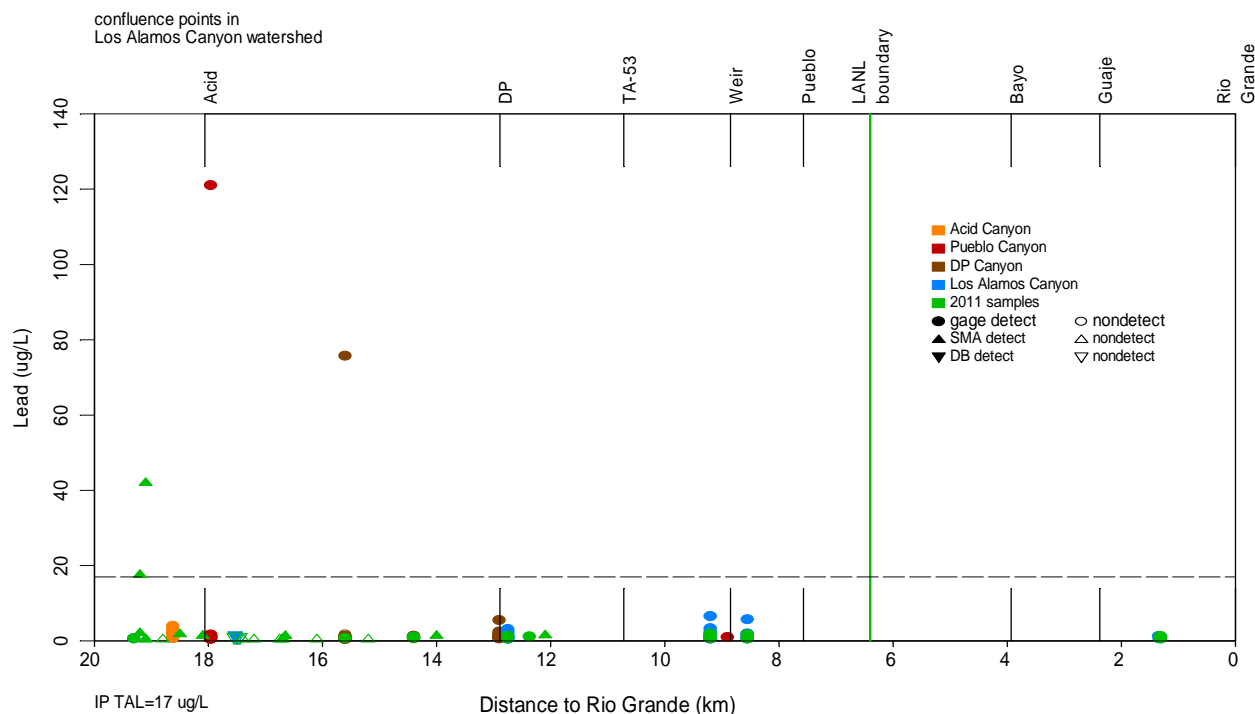


Figure 6-12a Los Alamos Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

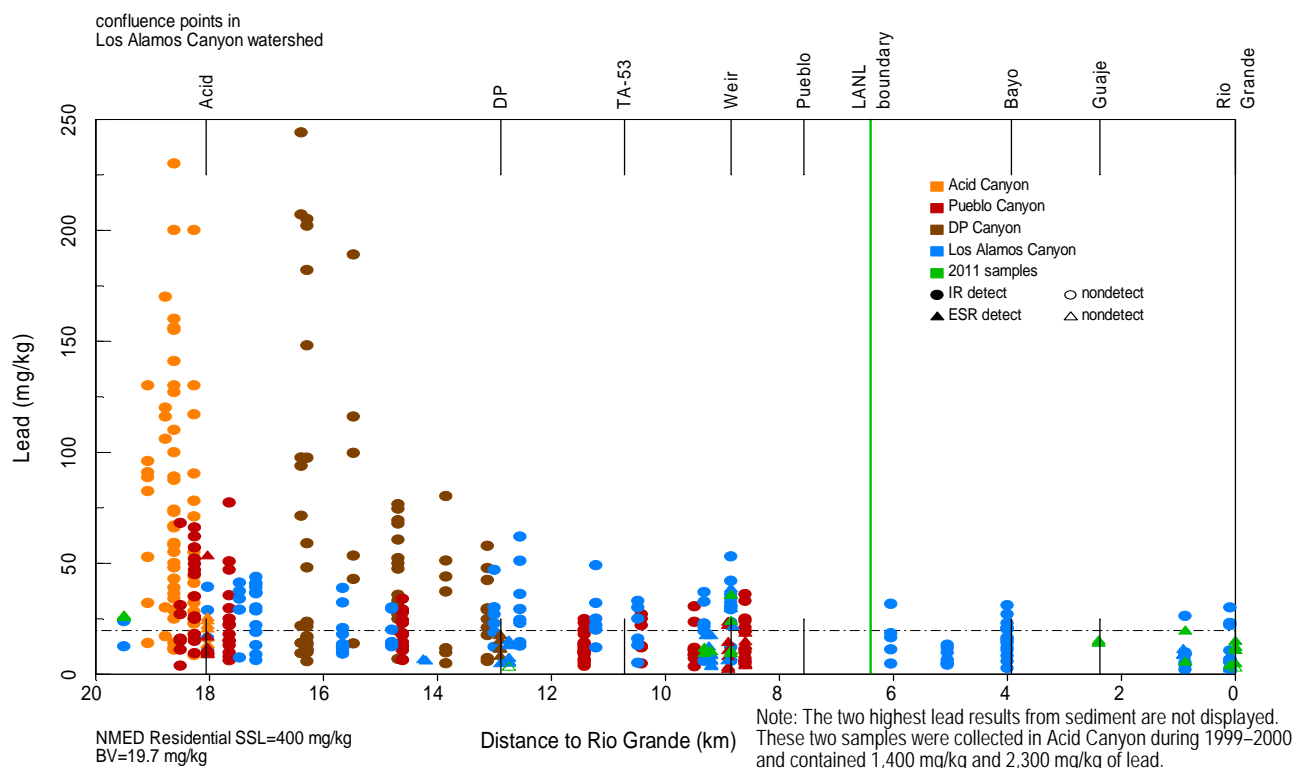


Figure 6-12b Los Alamos Canyon watershed lead concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

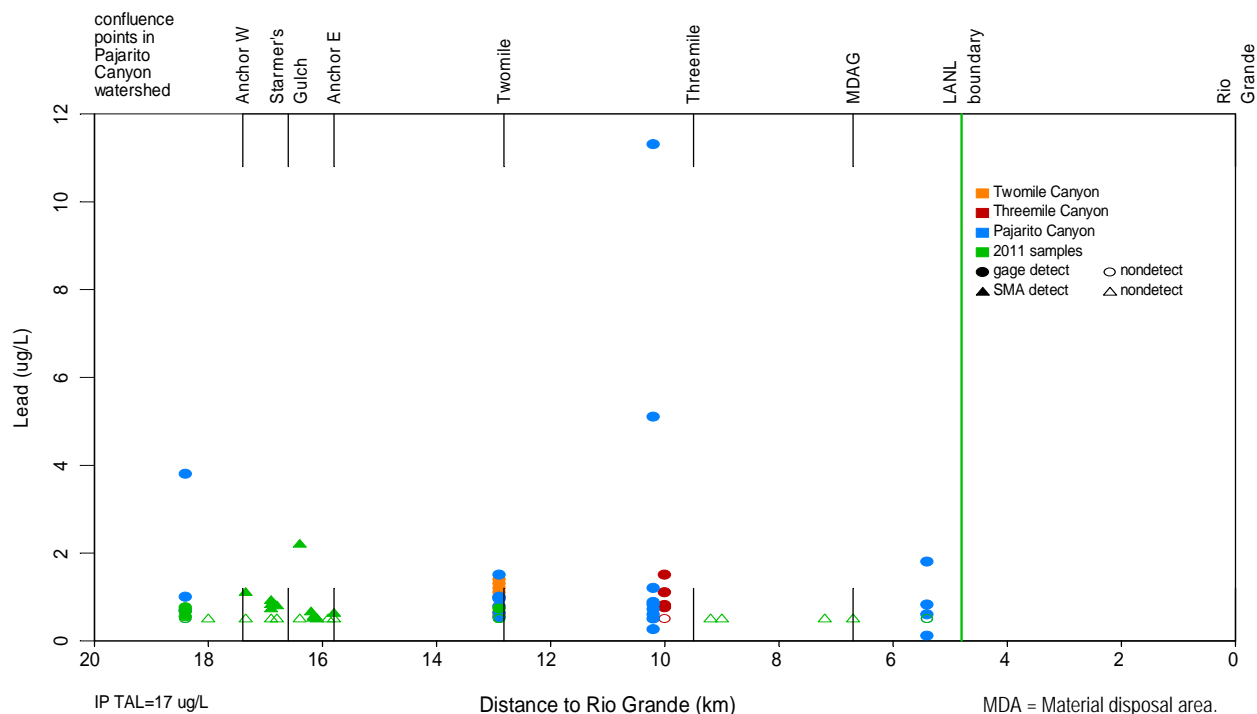


Figure 6-12c Pajarito Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

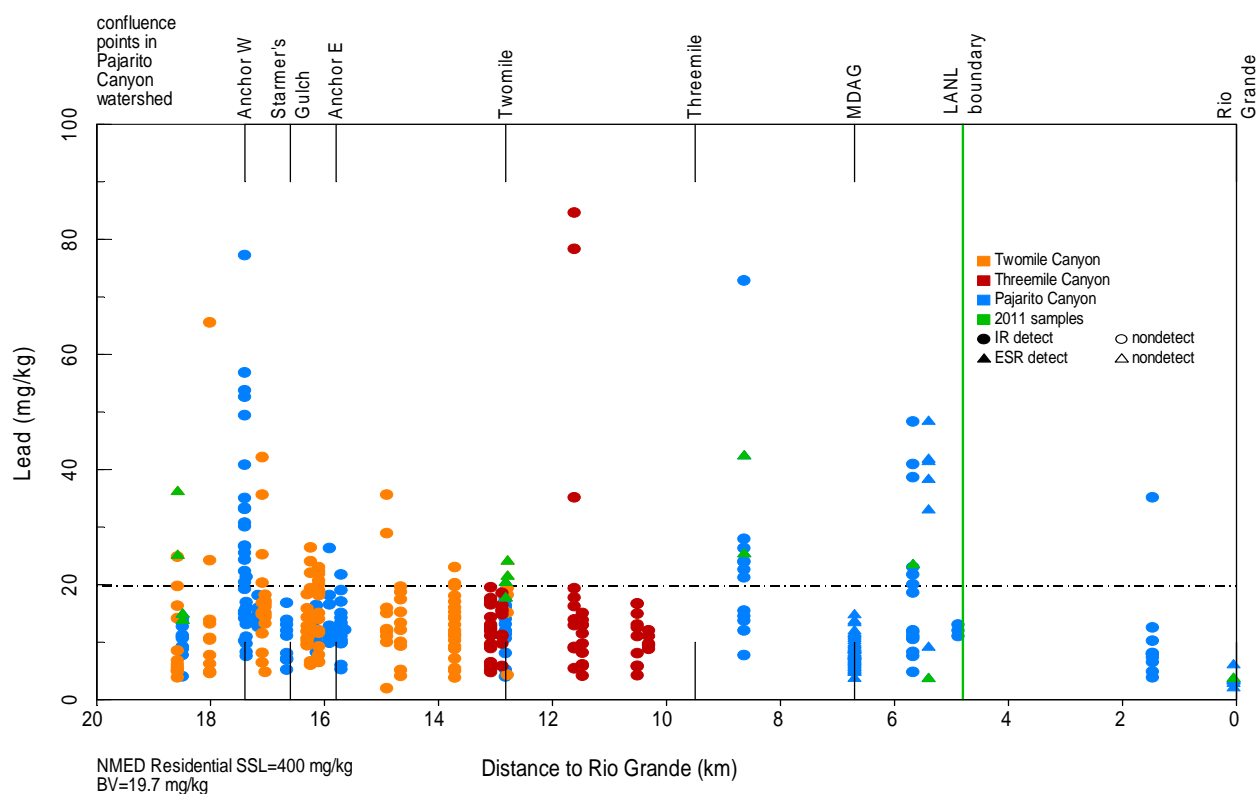


Figure 6-12d Pajarito Canyon watershed lead concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

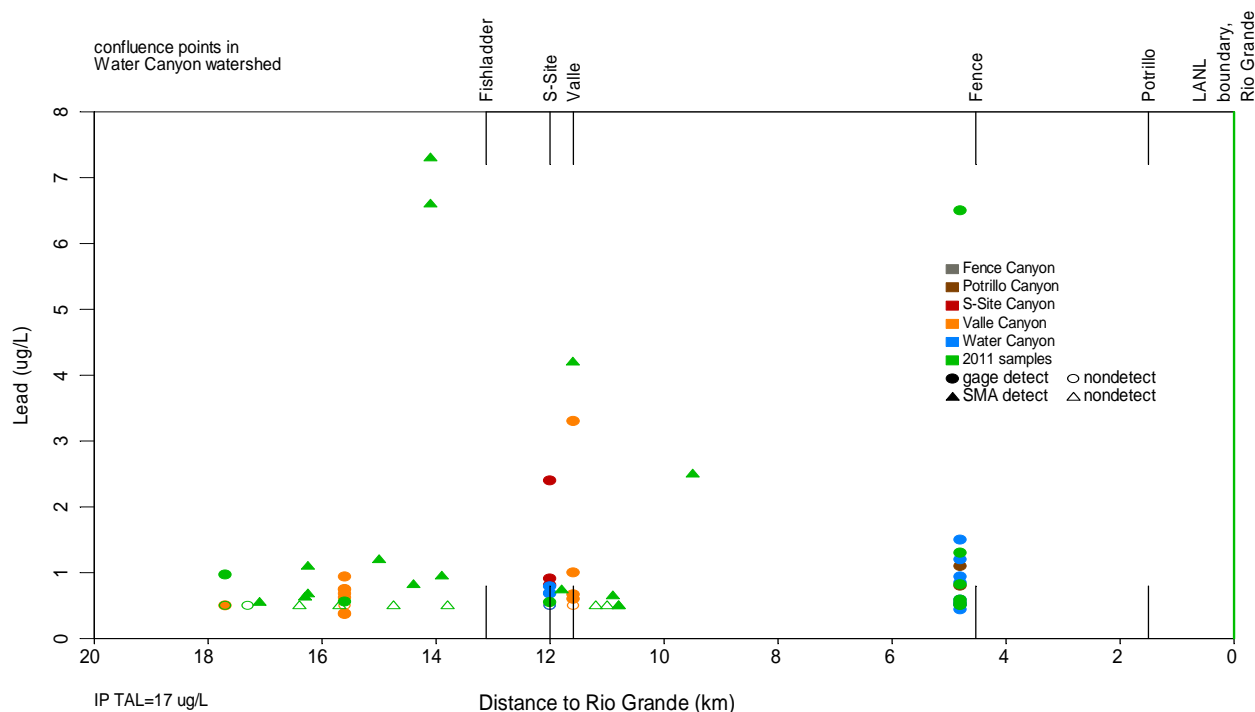


Figure 6-12e Water Canyon watershed filtered lead concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

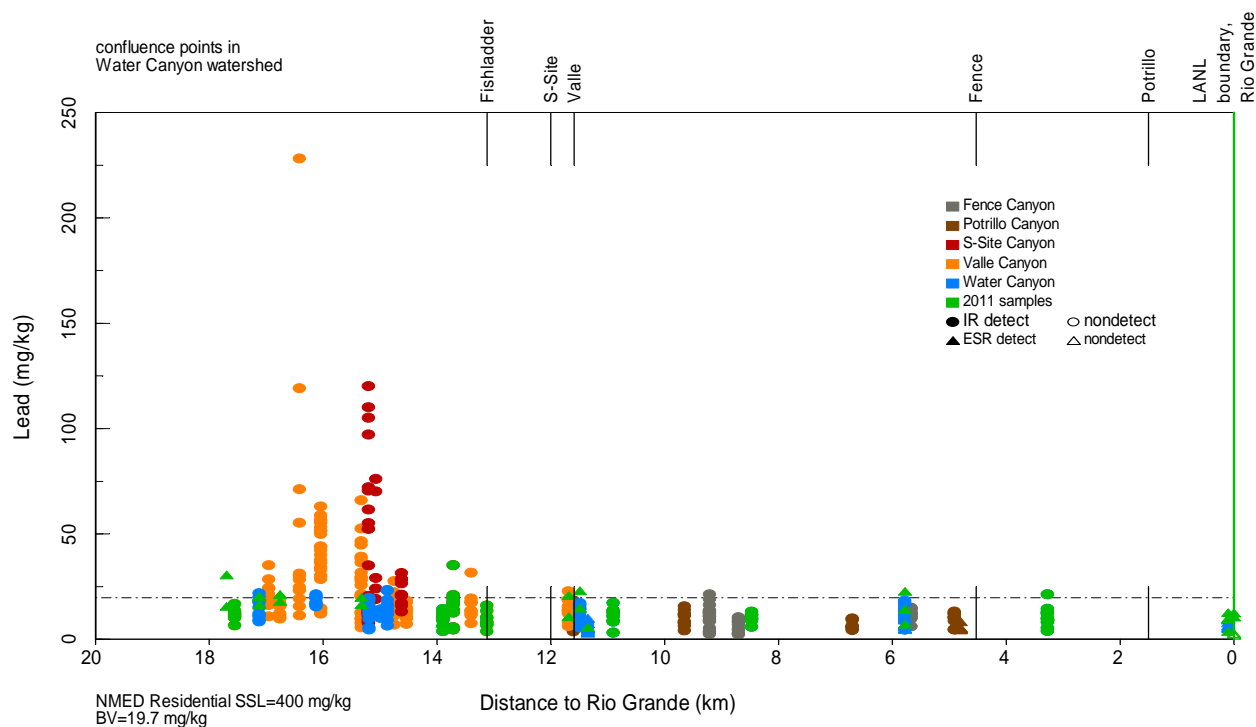


Figure 6-12f Water Canyon watershed lead concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011)

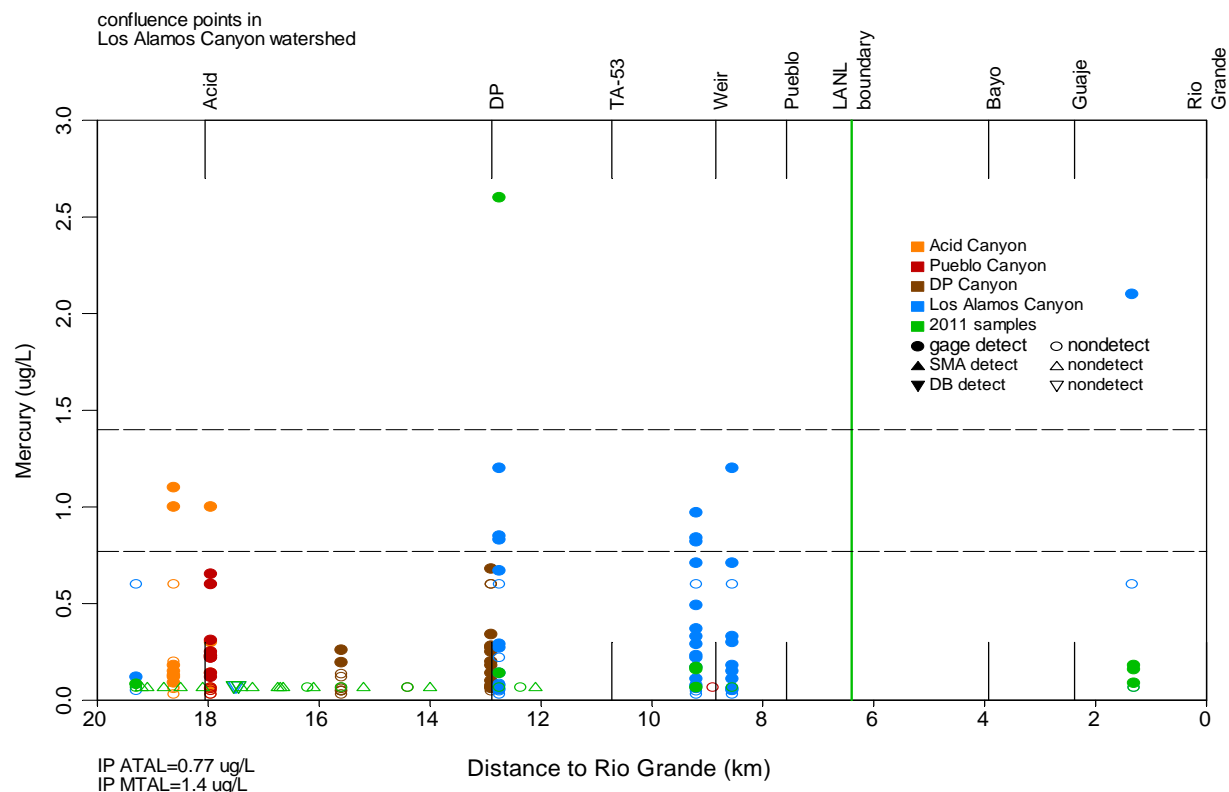


Figure 6-13a Los Alamos Canyon watershed unfiltered mercury concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

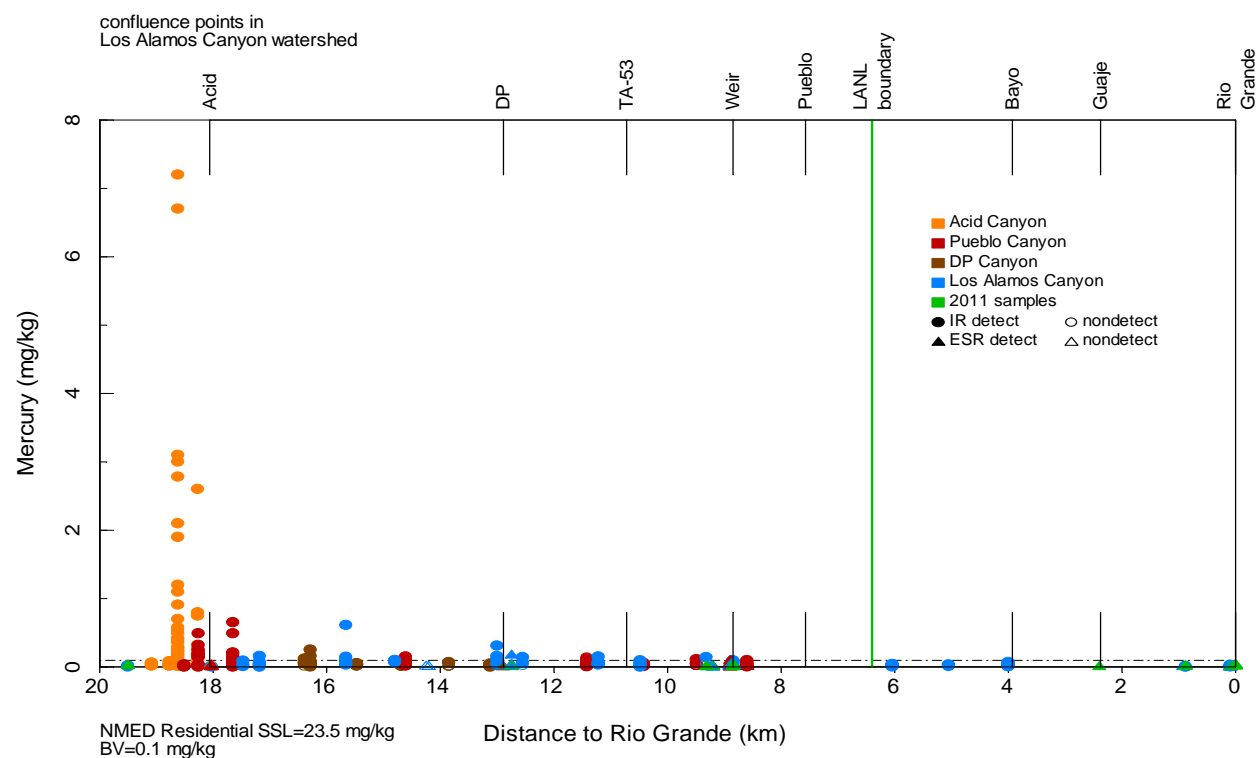


Figure 6-13b Los Alamos Canyon watershed sediment mercury concentrations from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

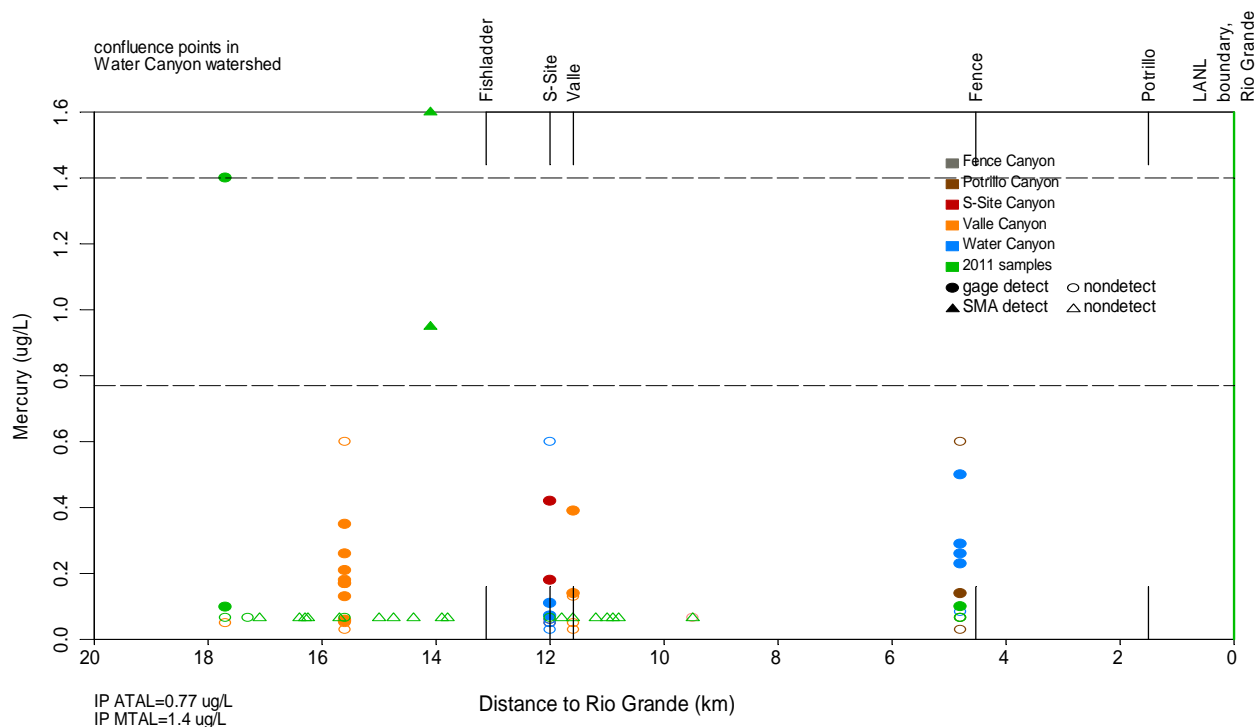


Figure 6-13c Water Canyon watershed unfiltered mercury concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

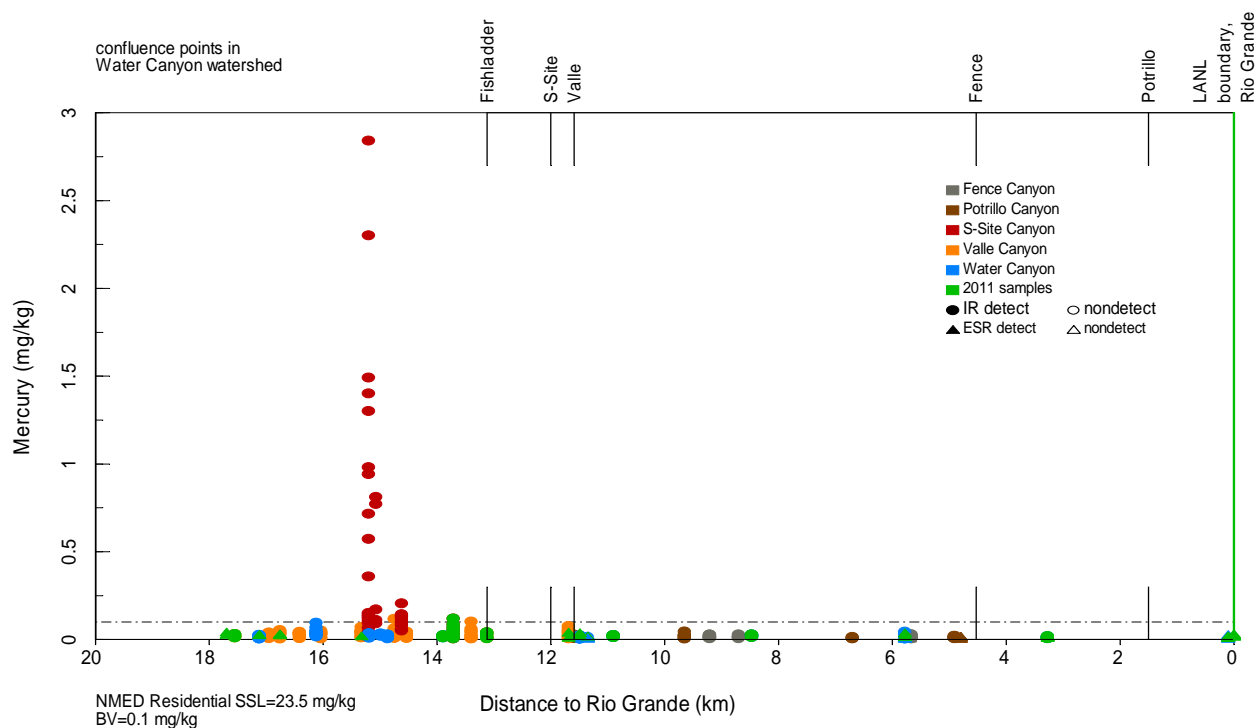


Figure 6-13d Water Canyon watershed mercury concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011)

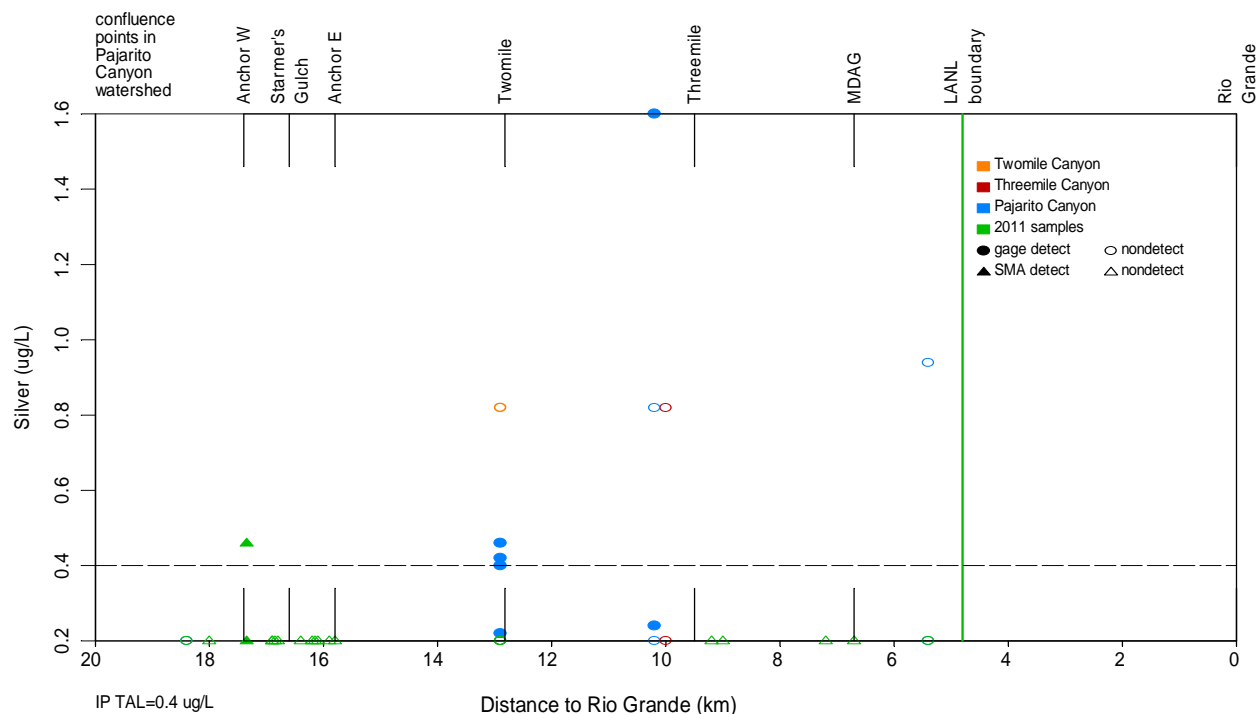


Figure 6-14a Pajarito Canyon watershed filtered silver concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

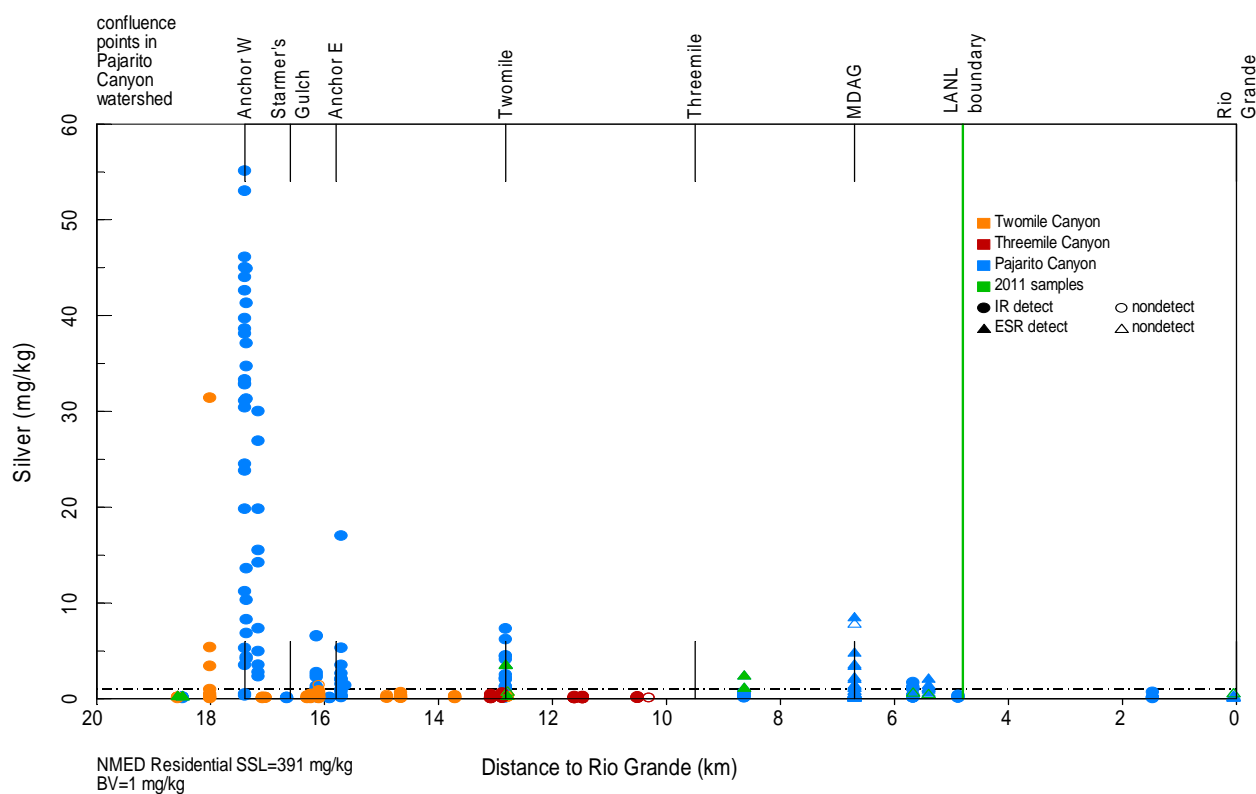


Figure 6-14b Pajarito Canyon watershed silver concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

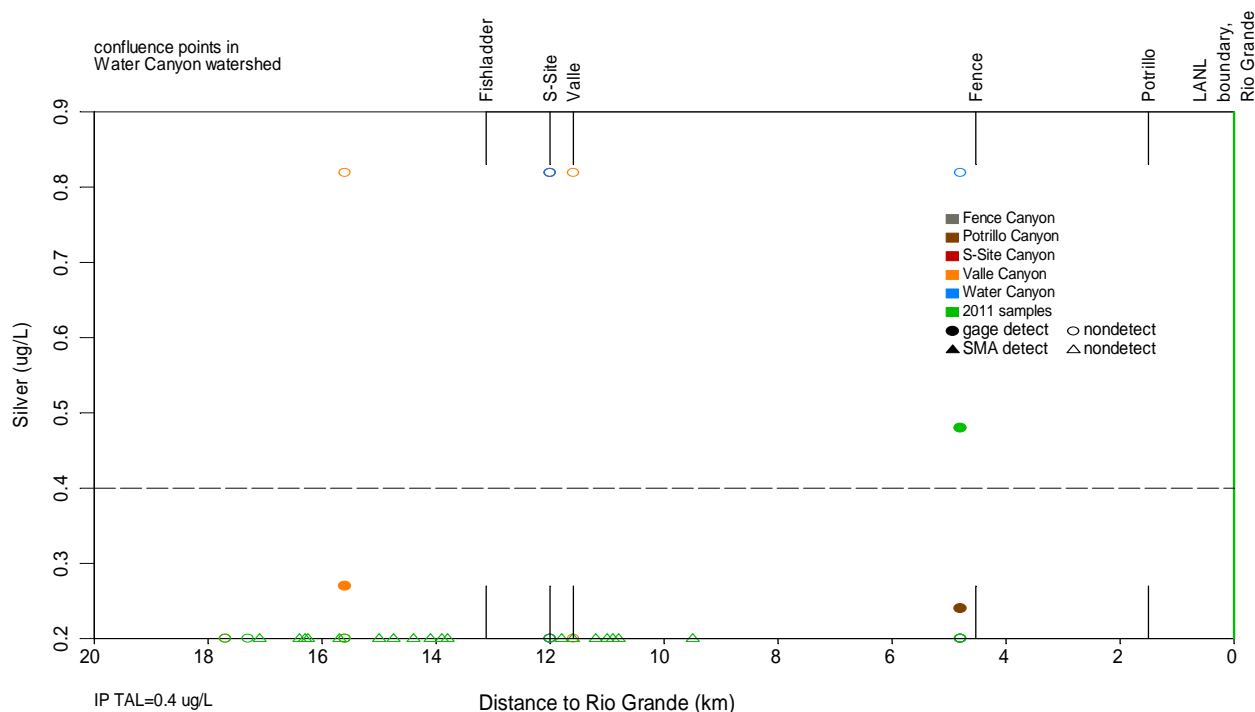


Figure 6-14c Water Canyon watershed filtered silver concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2004–2011)

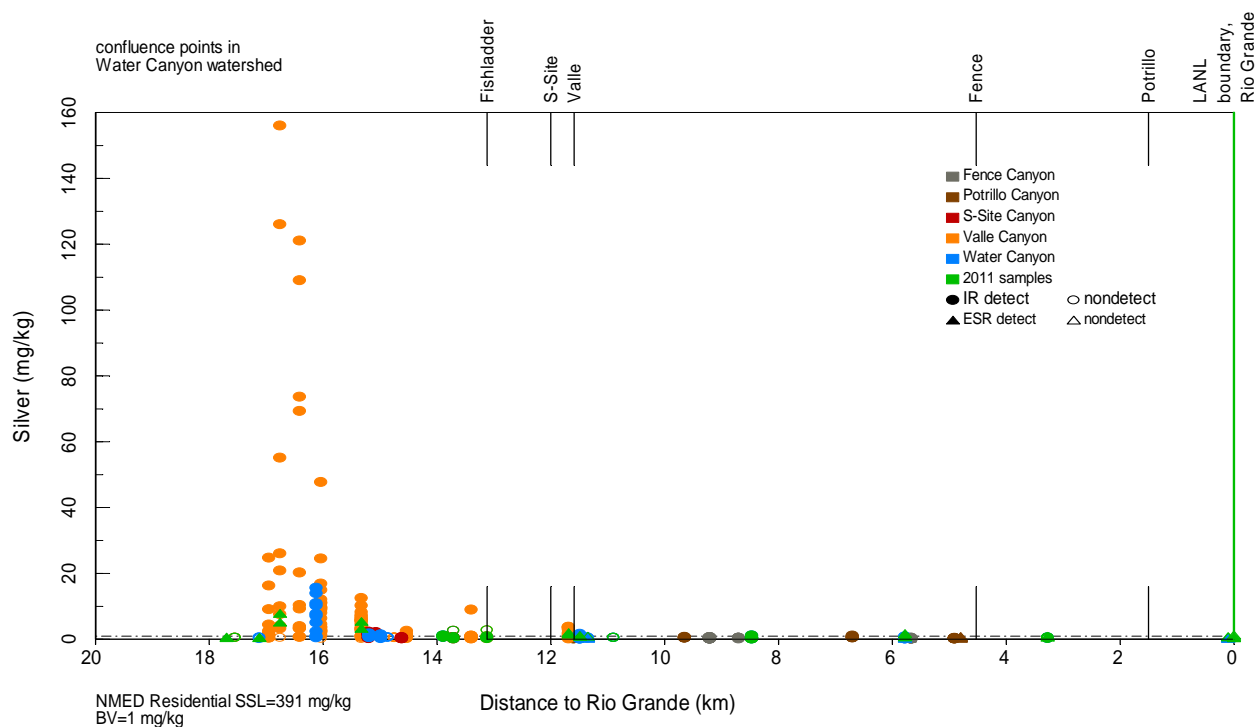


Figure 6-14d Water Canyon watershed silver concentrations in sediment from Canyons IR (data from 1999–2000, 2008–2011) and ESRs (data from 2003–2011)

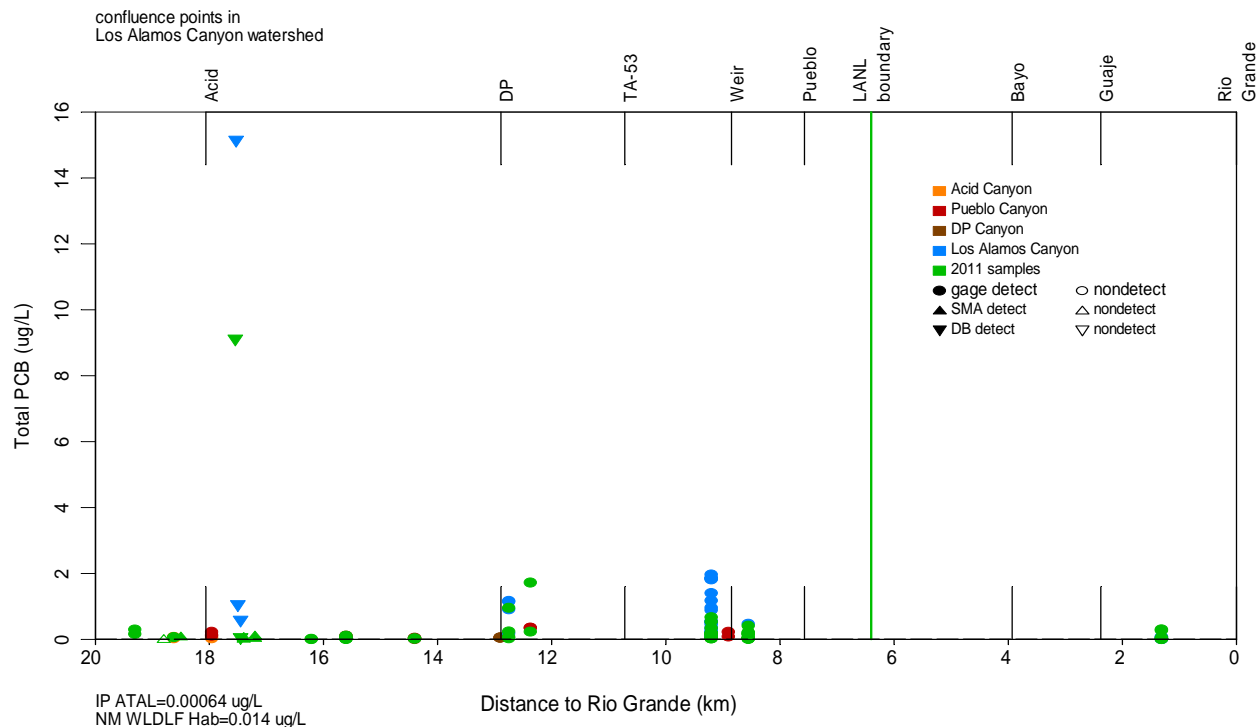


Figure 6-15a Los Alamos Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2009–2011)

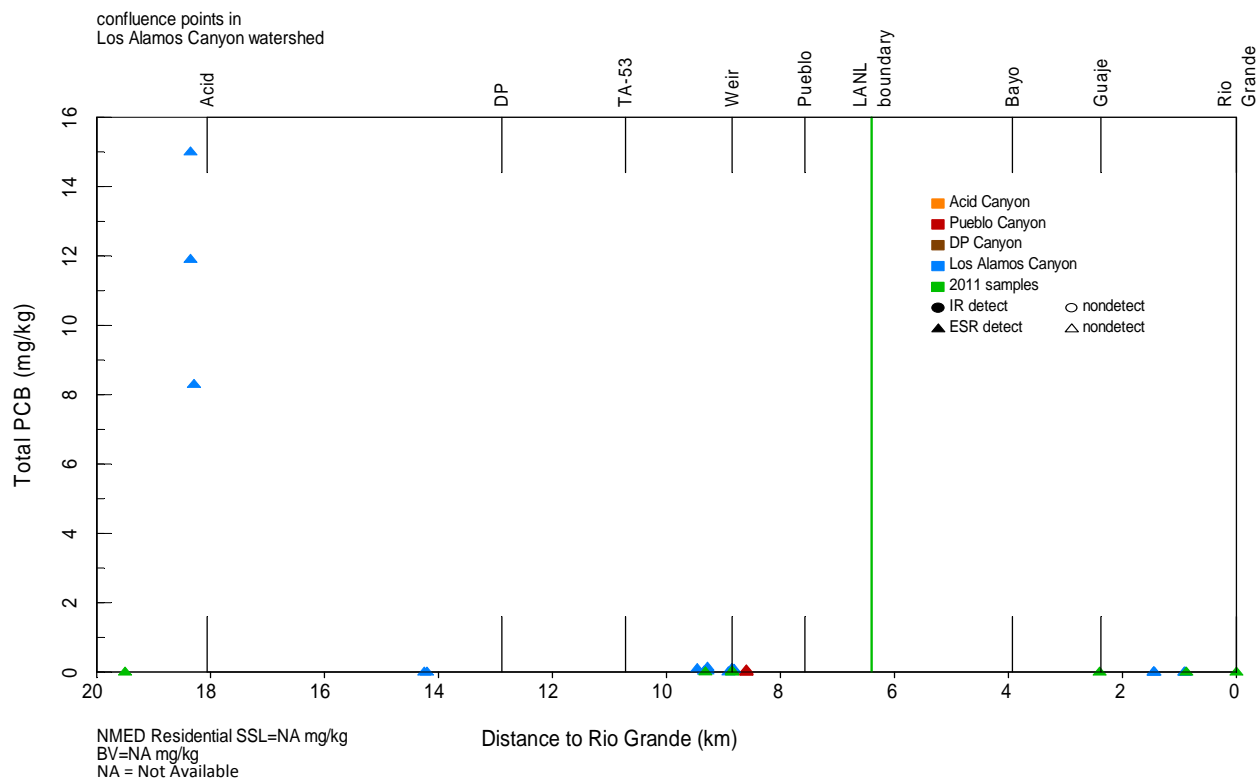


Figure 6-15b Los Alamos Canyon watershed total PCB concentrations in sediment from ESRs (data from 2009–2011)

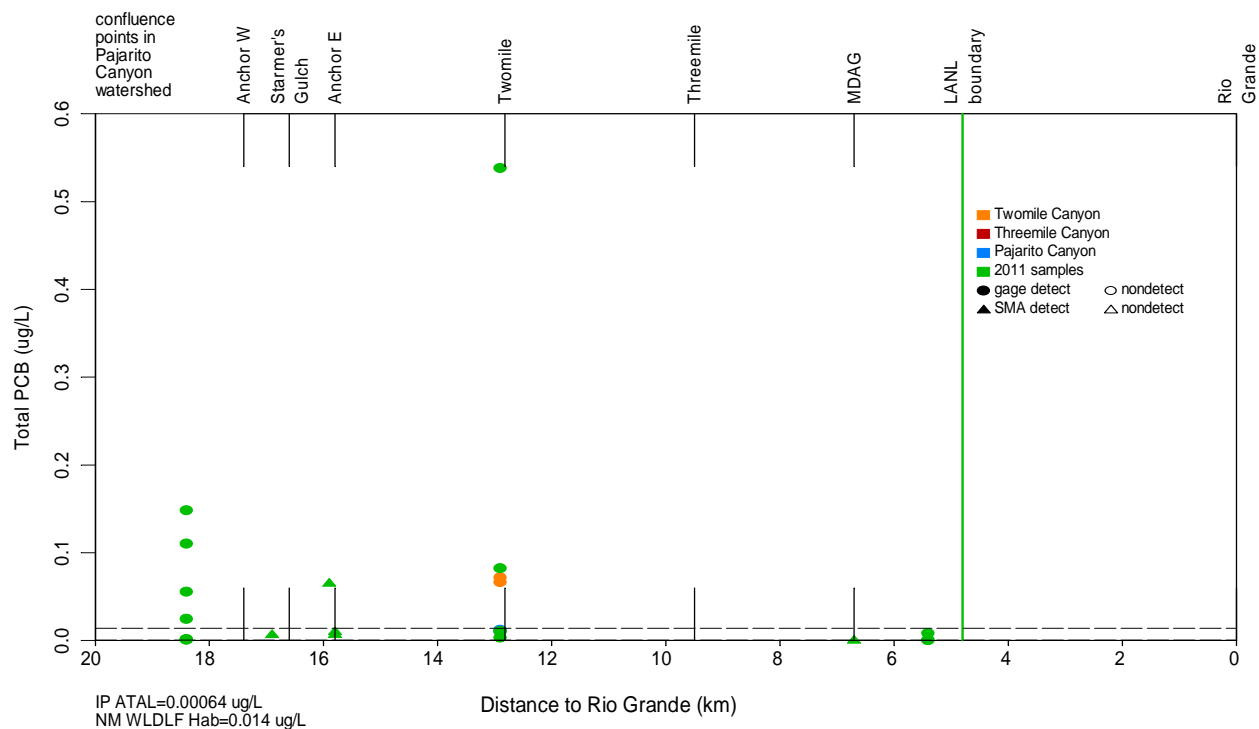


Figure 6-15c Pajarito Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2010–2011)

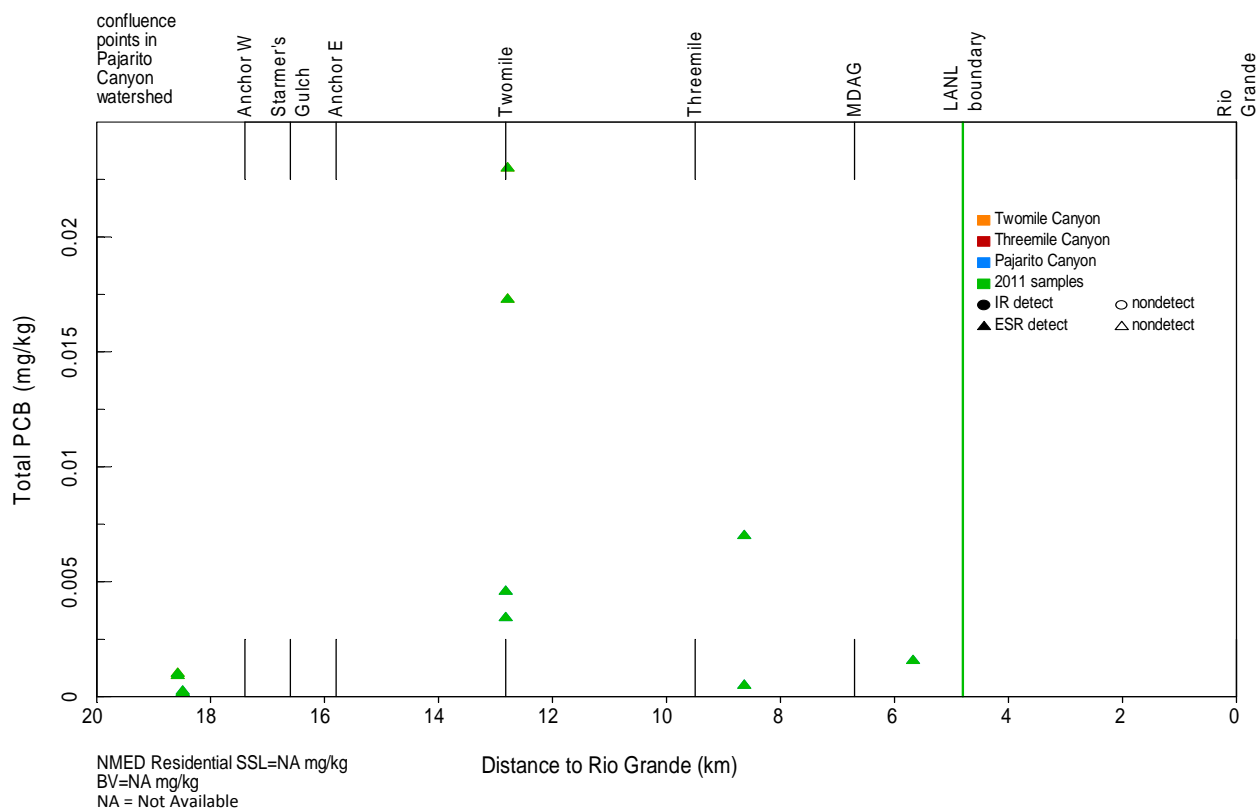


Figure 6-15d Pajarito Canyon watershed total PCB concentrations in sediment from ESR (data from 2011), congeners not analyzed in Pajarito Canyon before 2011

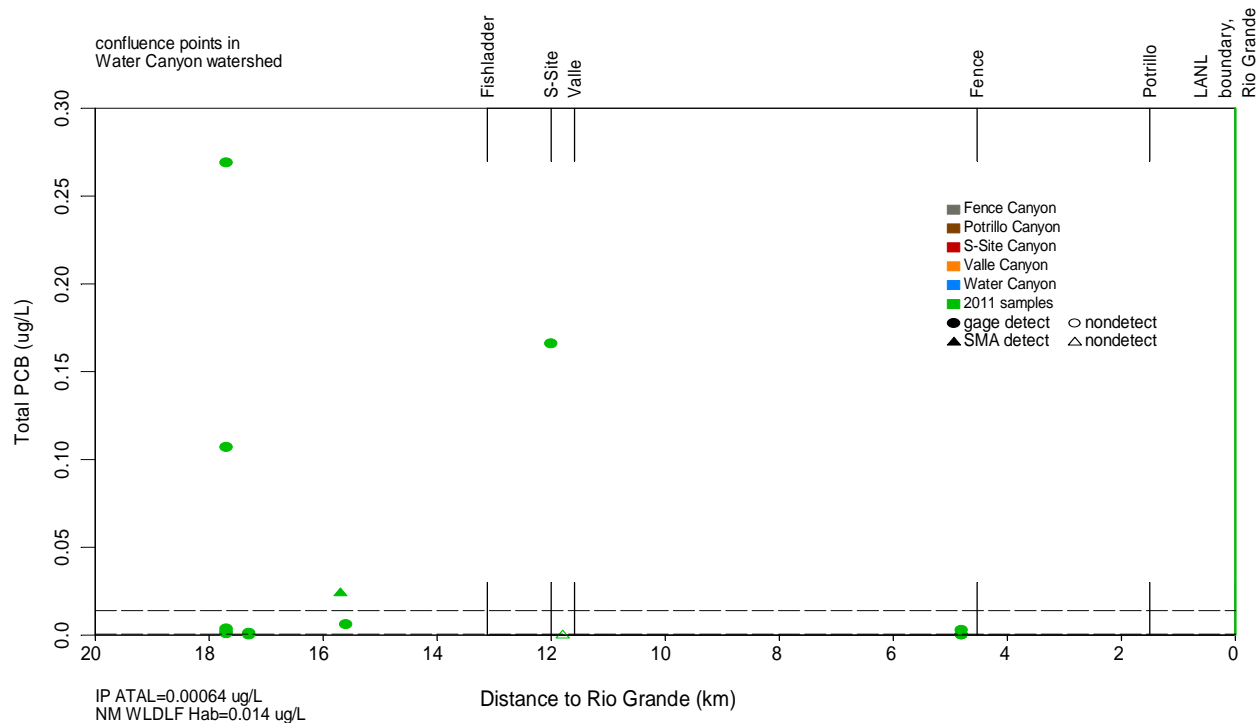


Figure 6-15e Water Canyon watershed total PCB concentrations in storm water from SMA stations (data from 2011) and gauges (data from 2010–2011)

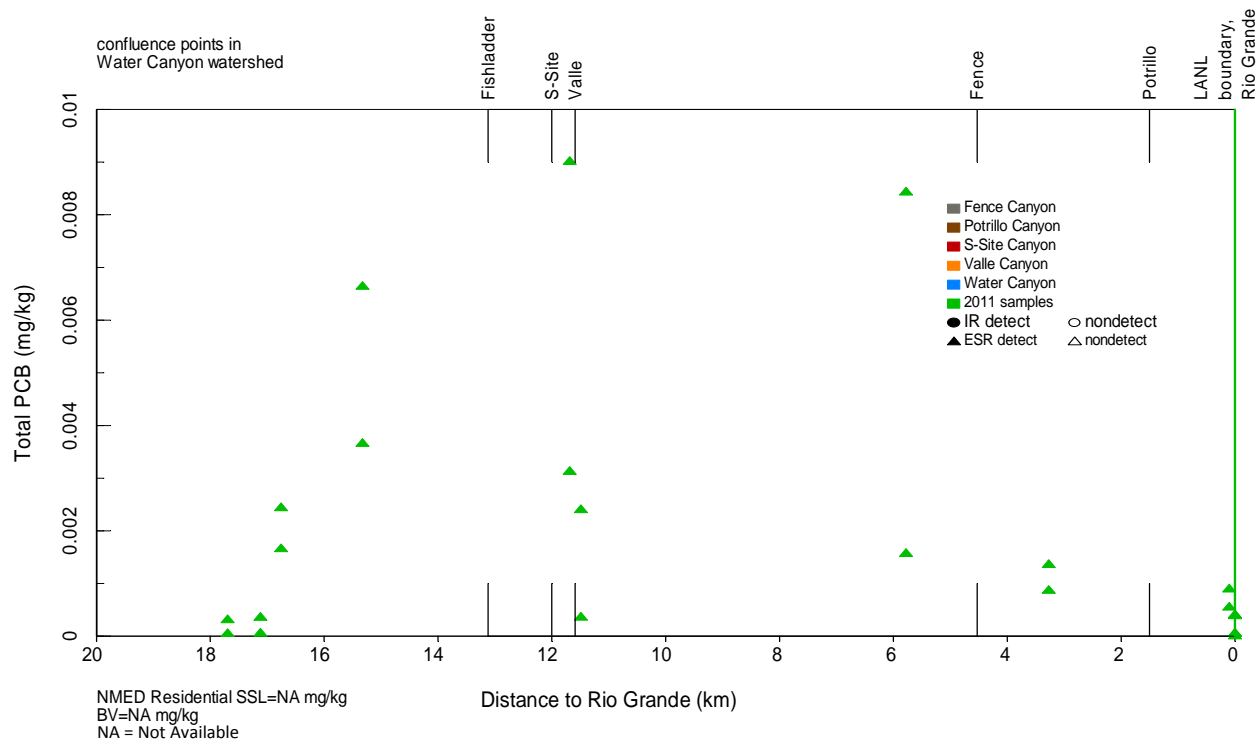


Figure 6-15f Water Canyon watershed total PCB concentrations in sediment from ESR (data from 2011), congeners not analyzed in Water Canyon before 2011

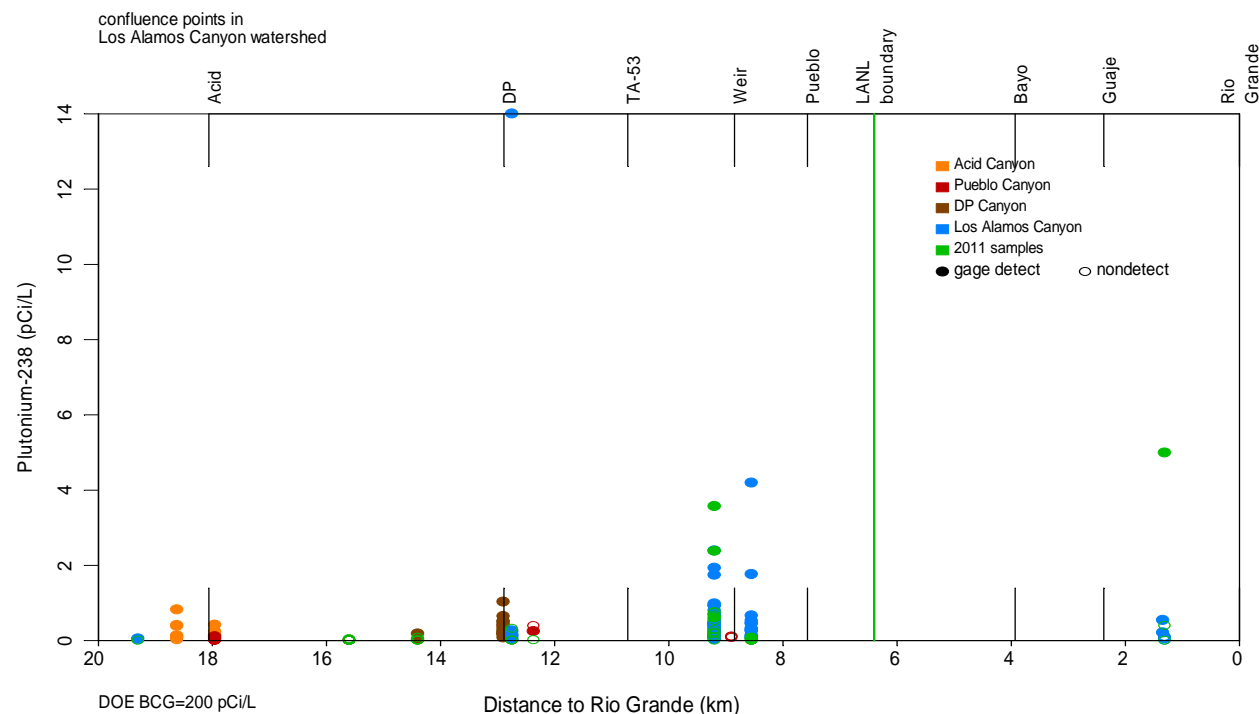


Figure 6-16a Los Alamos Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

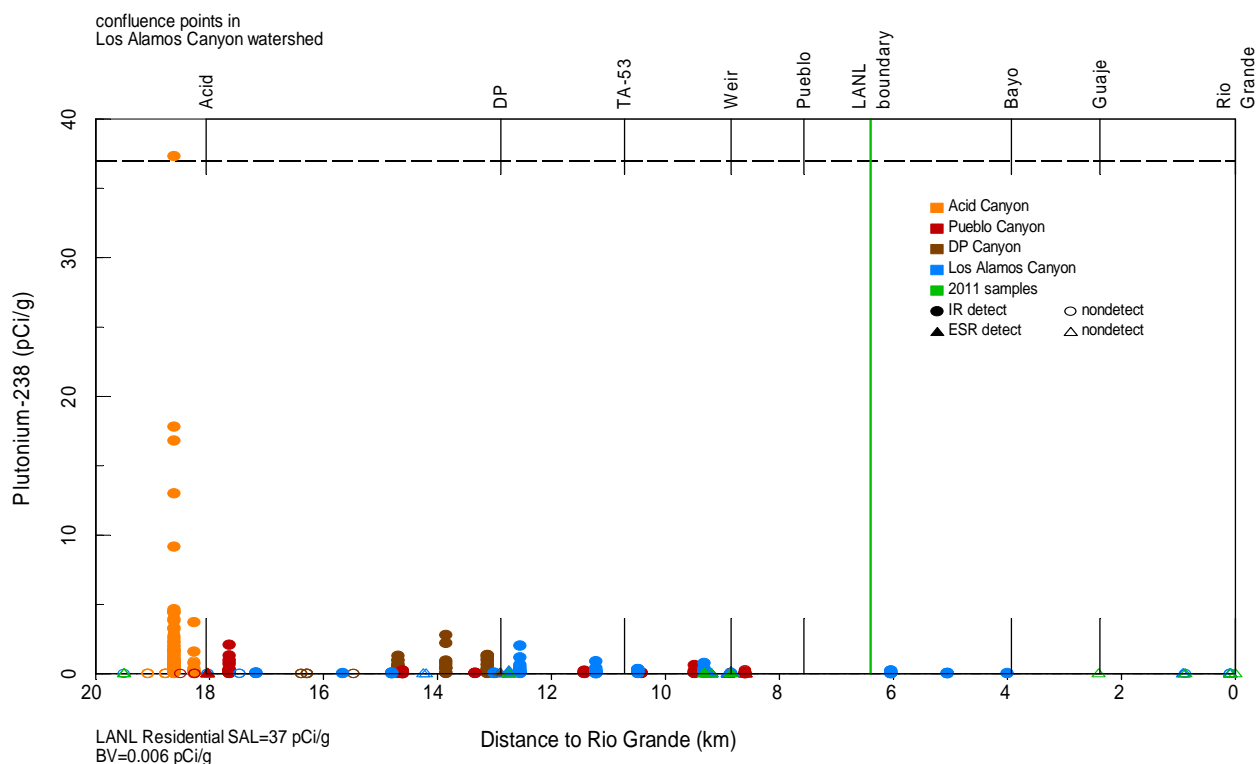


Figure 6-16b Los Alamos Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

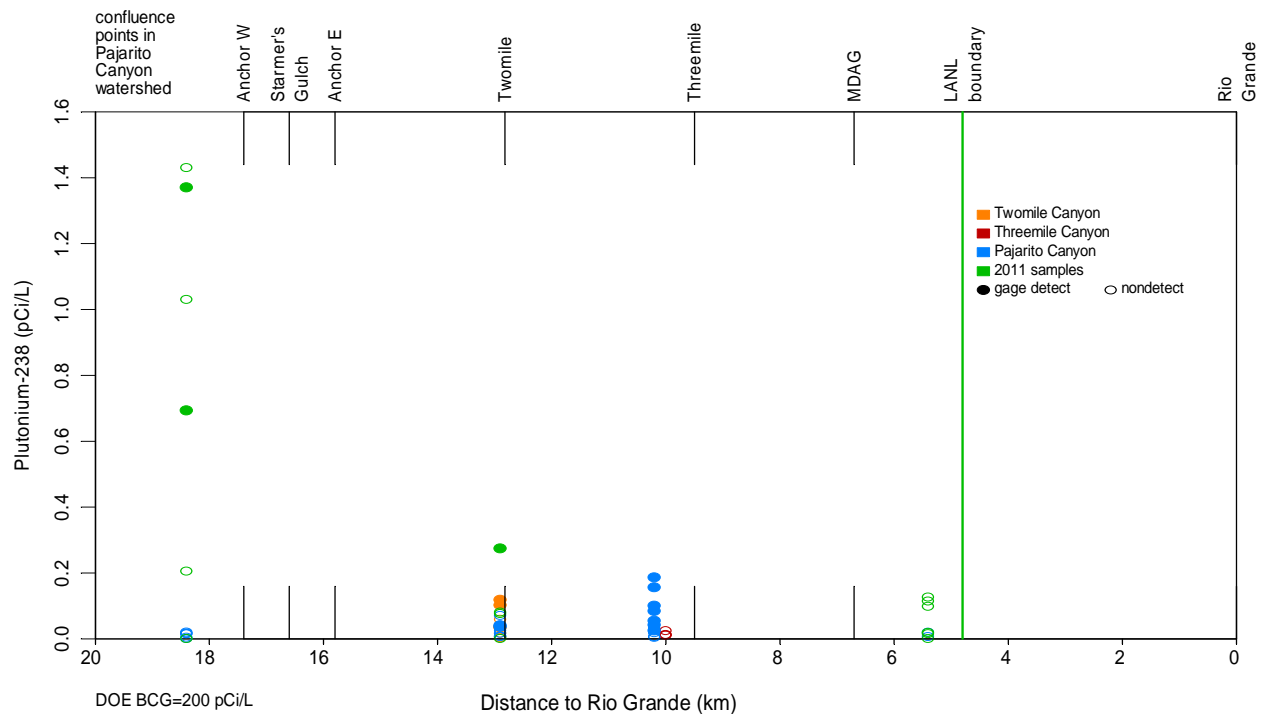


Figure 6-16c Pajarito Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

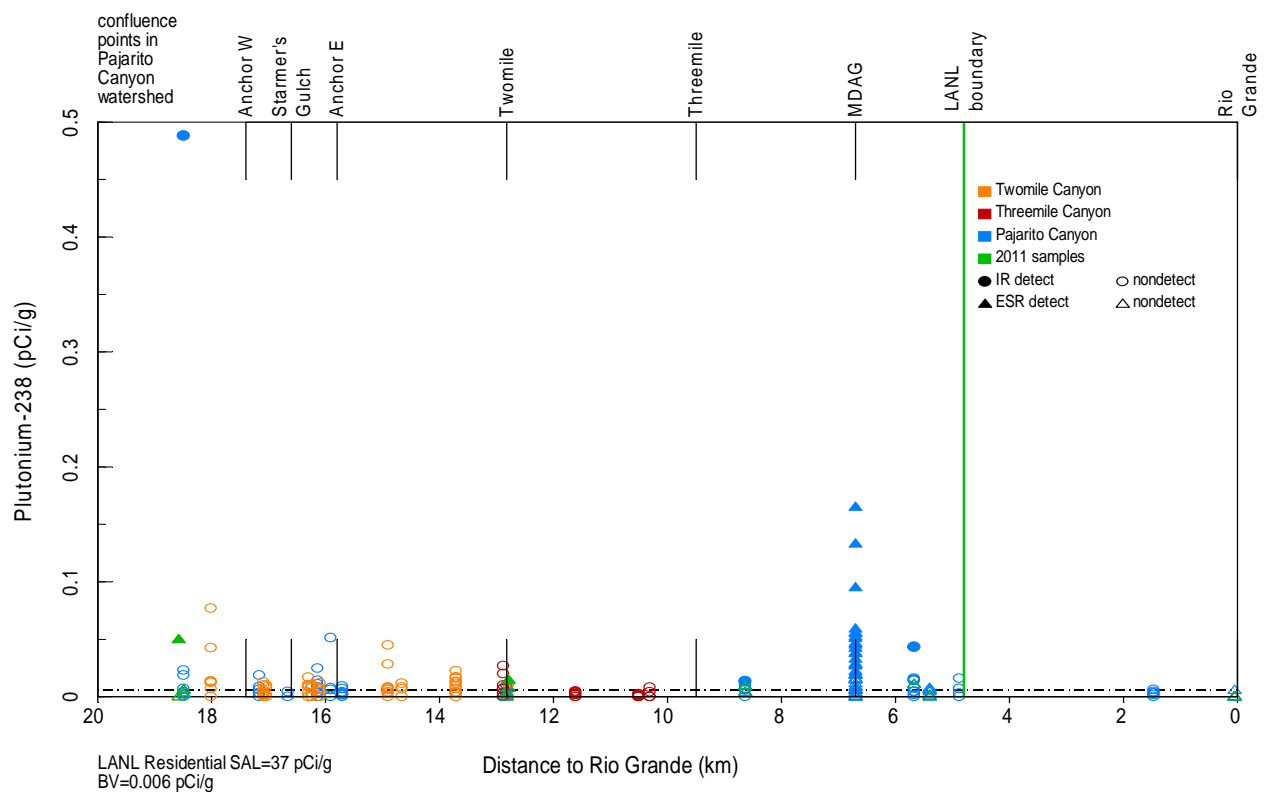


Figure 6-16d Pajarito Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

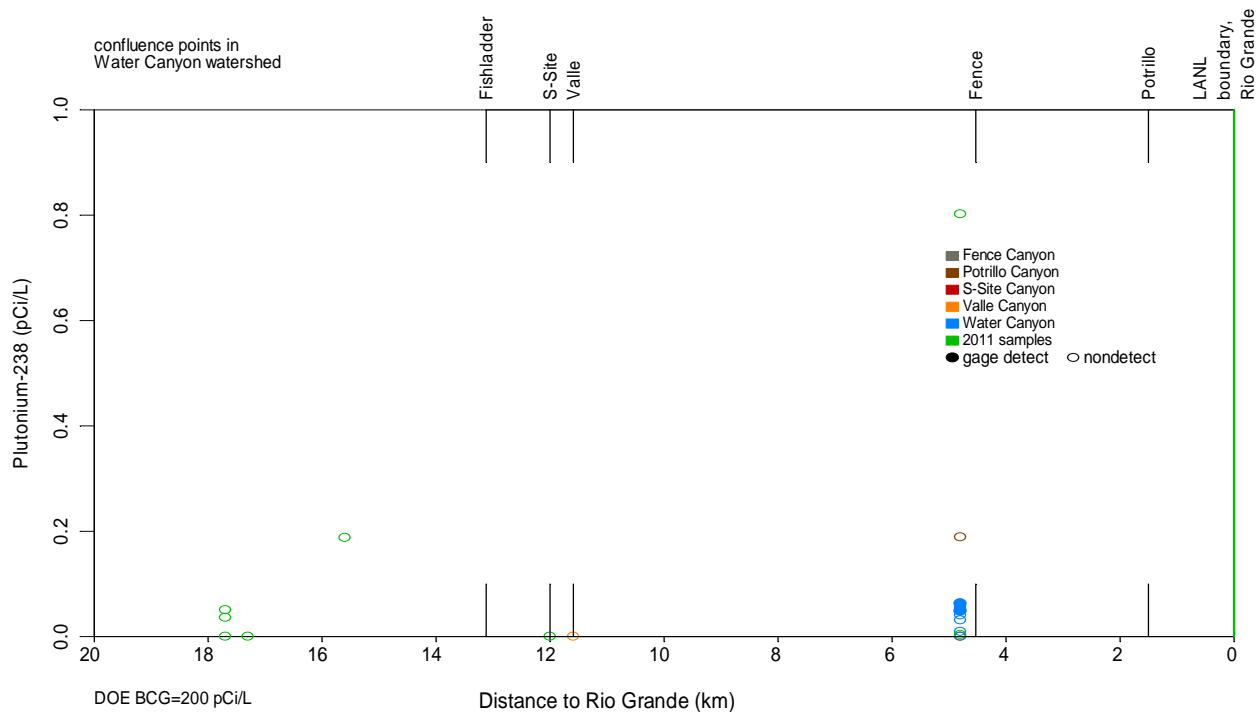


Figure 6-16e Water Canyon watershed plutonium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

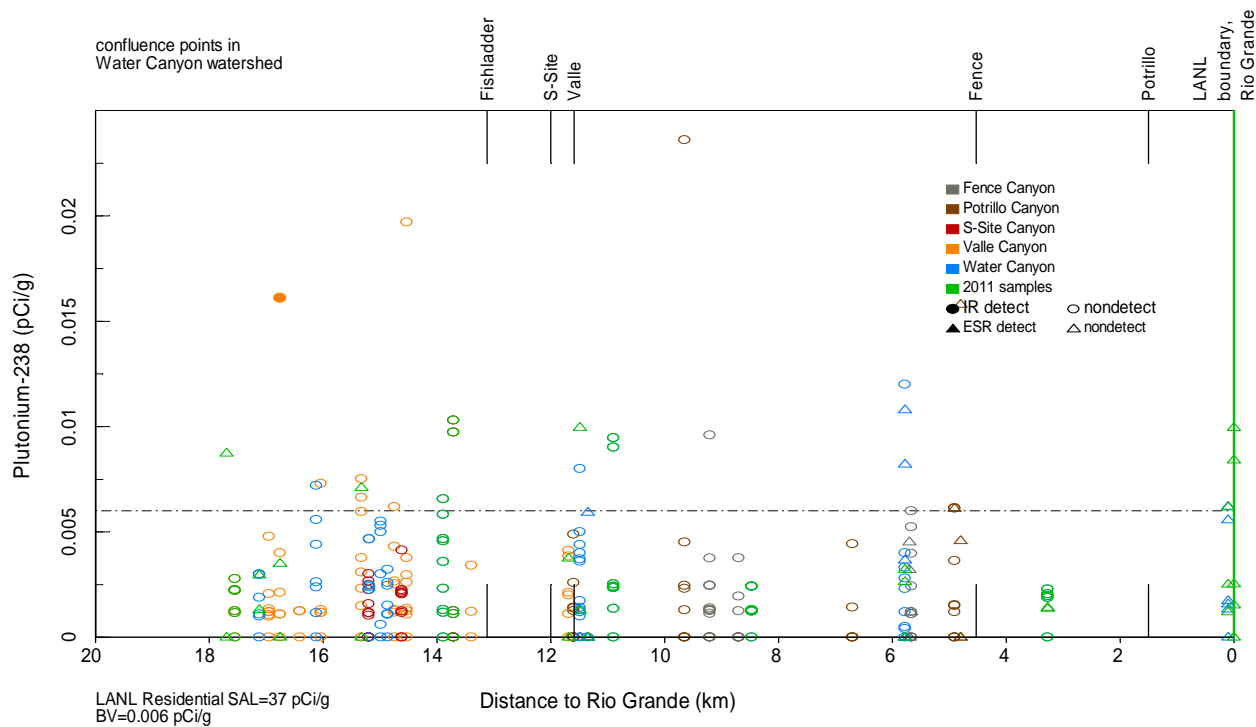


Figure 6-16f Water Canyon watershed plutonium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

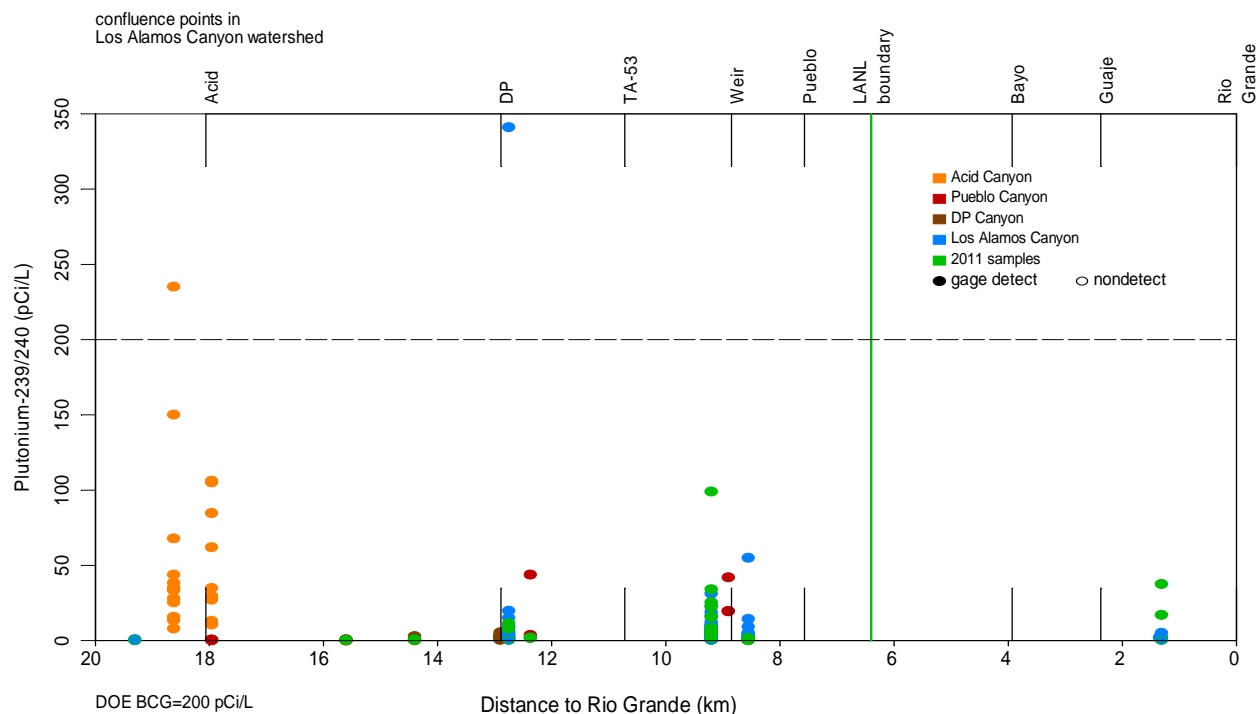


Figure 6-17a Los Alamos Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

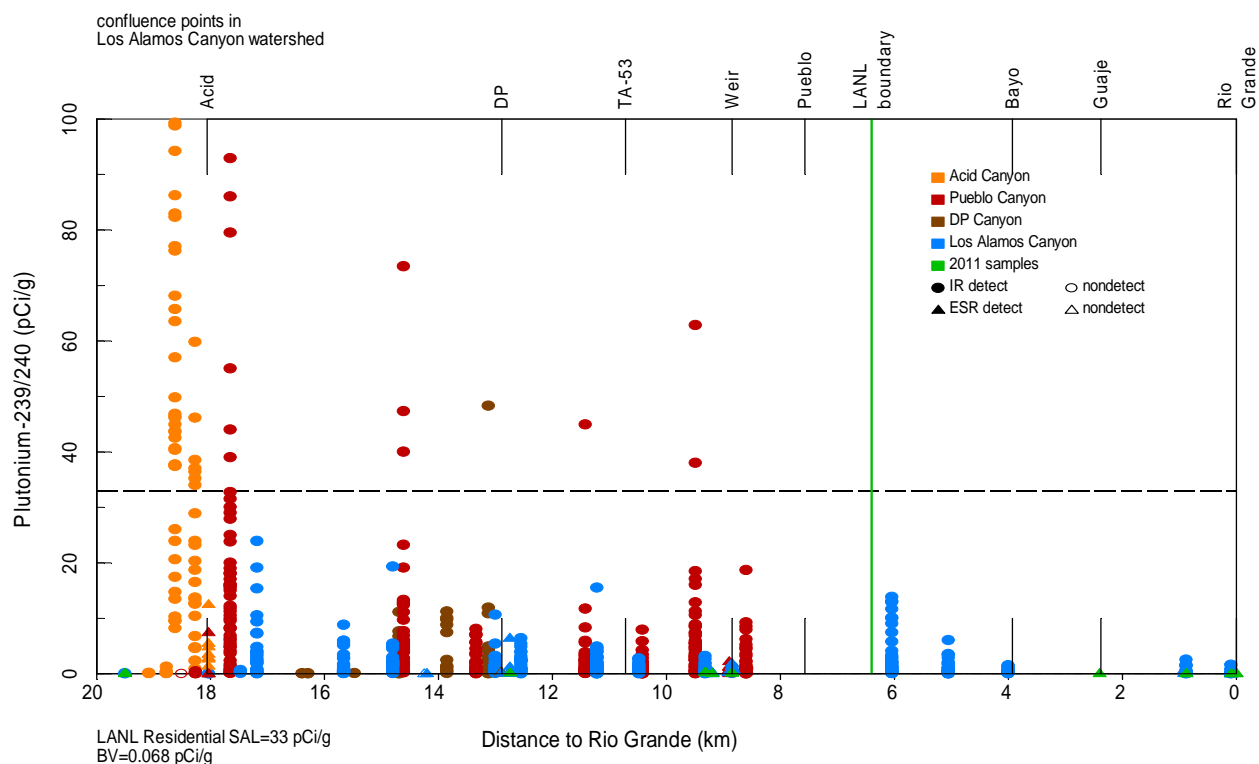


Figure 6-17b Los Alamos Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

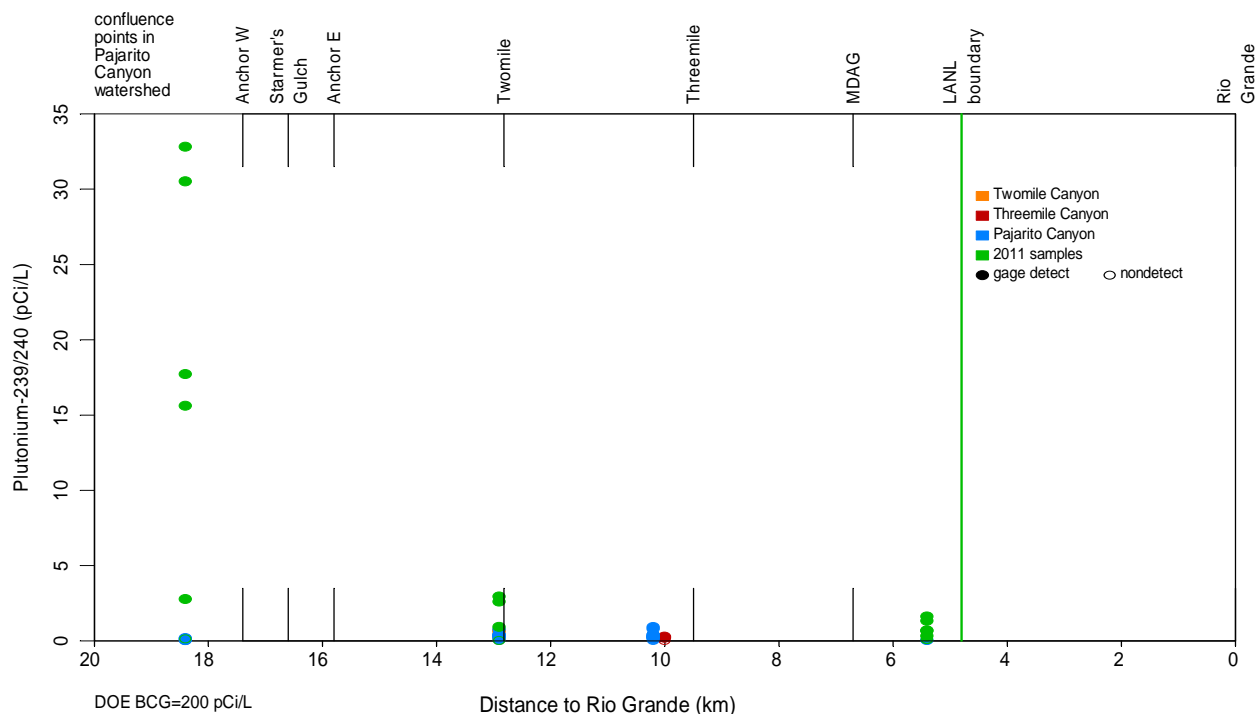


Figure 6-17c Pajarito Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

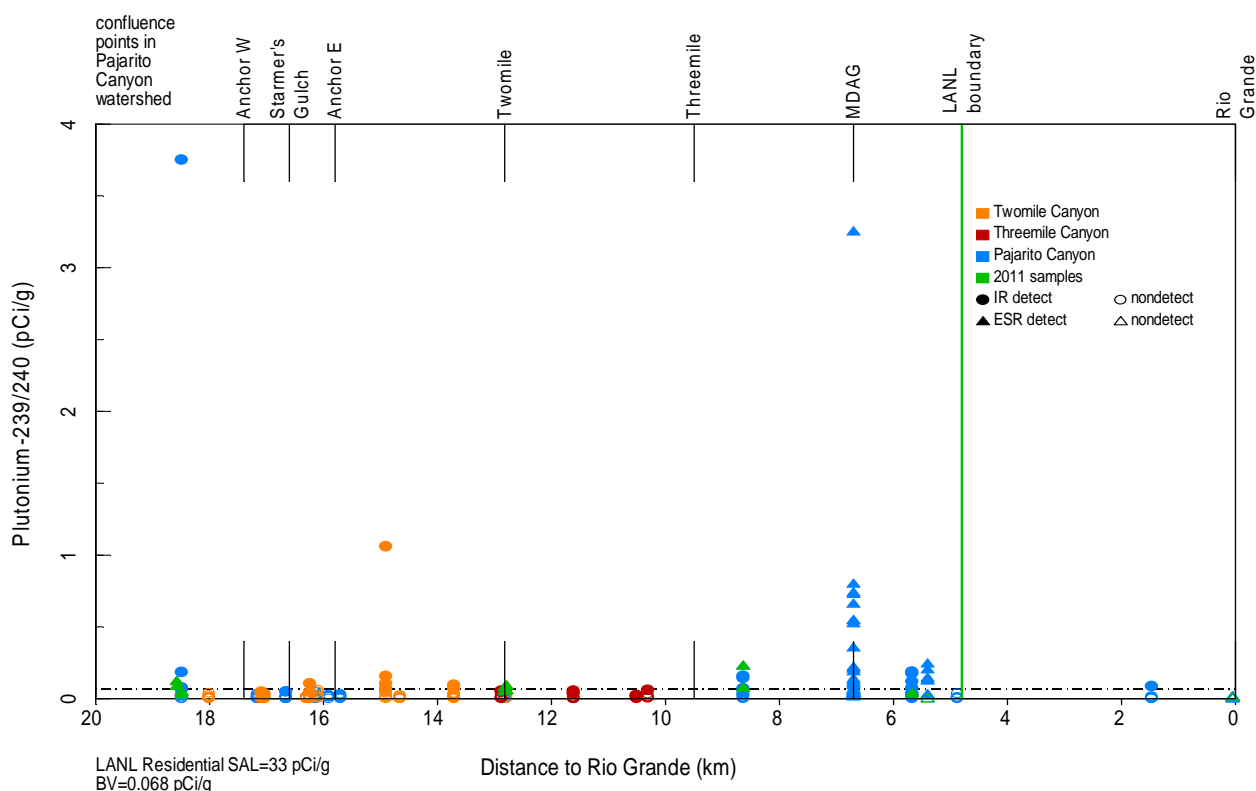


Figure 6-17d Pajarito Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

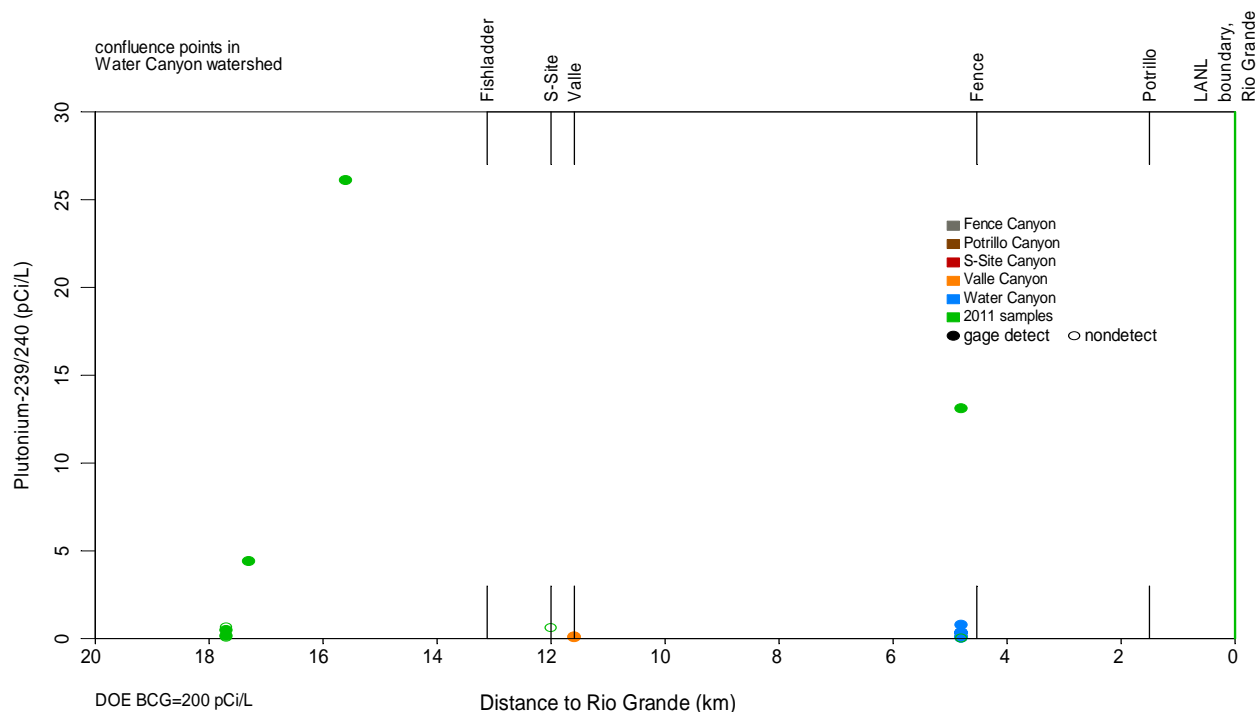


Figure 6-17e Water Canyon watershed plutonium-239/240 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

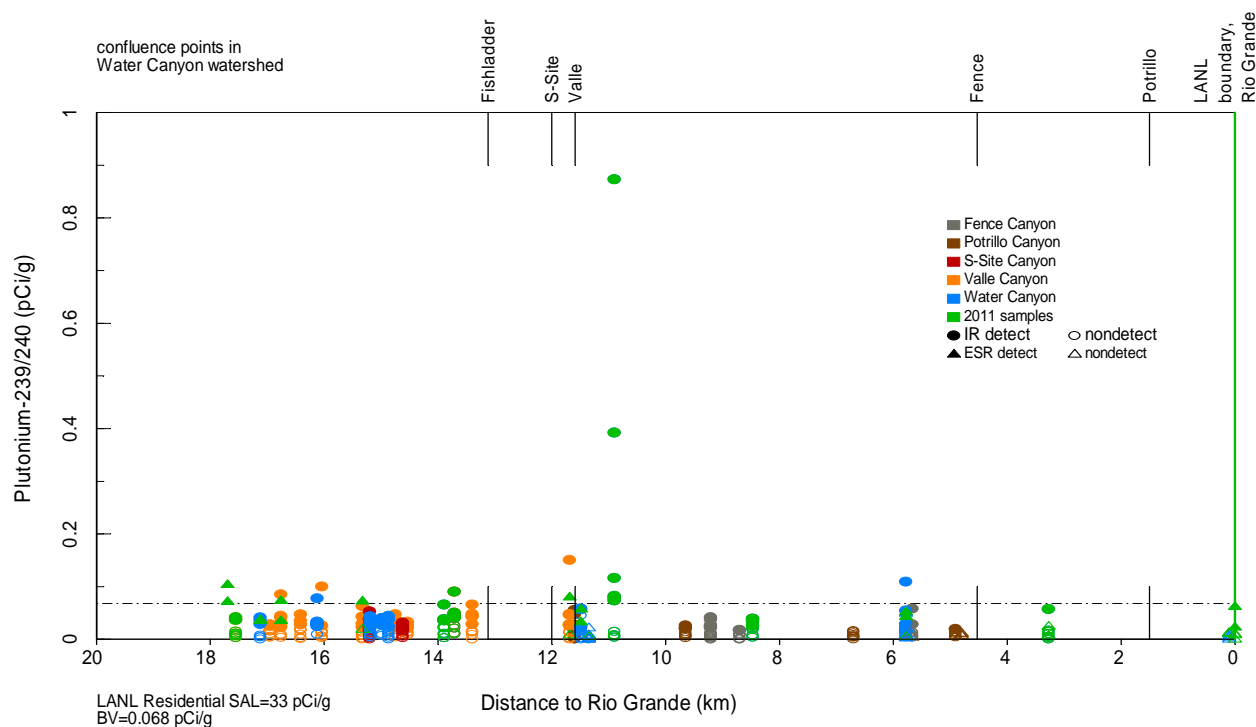


Figure 6-17f Water Canyon watershed plutonium-239/240 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

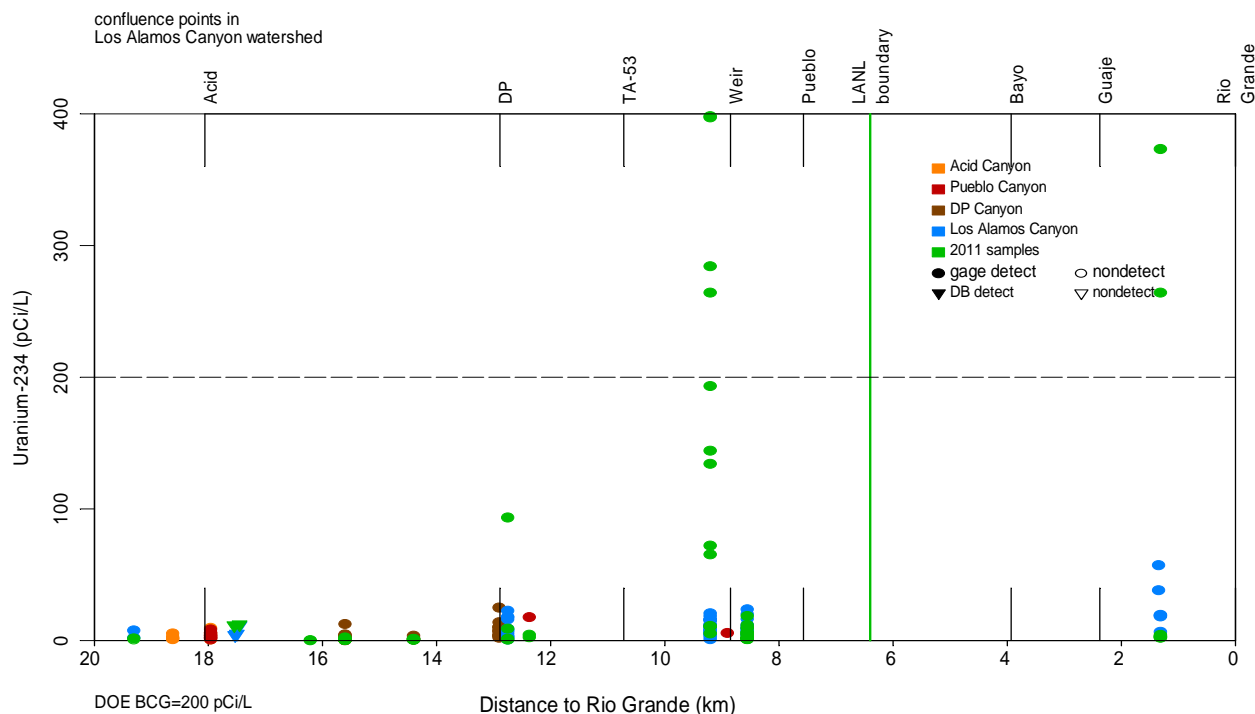


Figure 6-18a Los Alamos Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

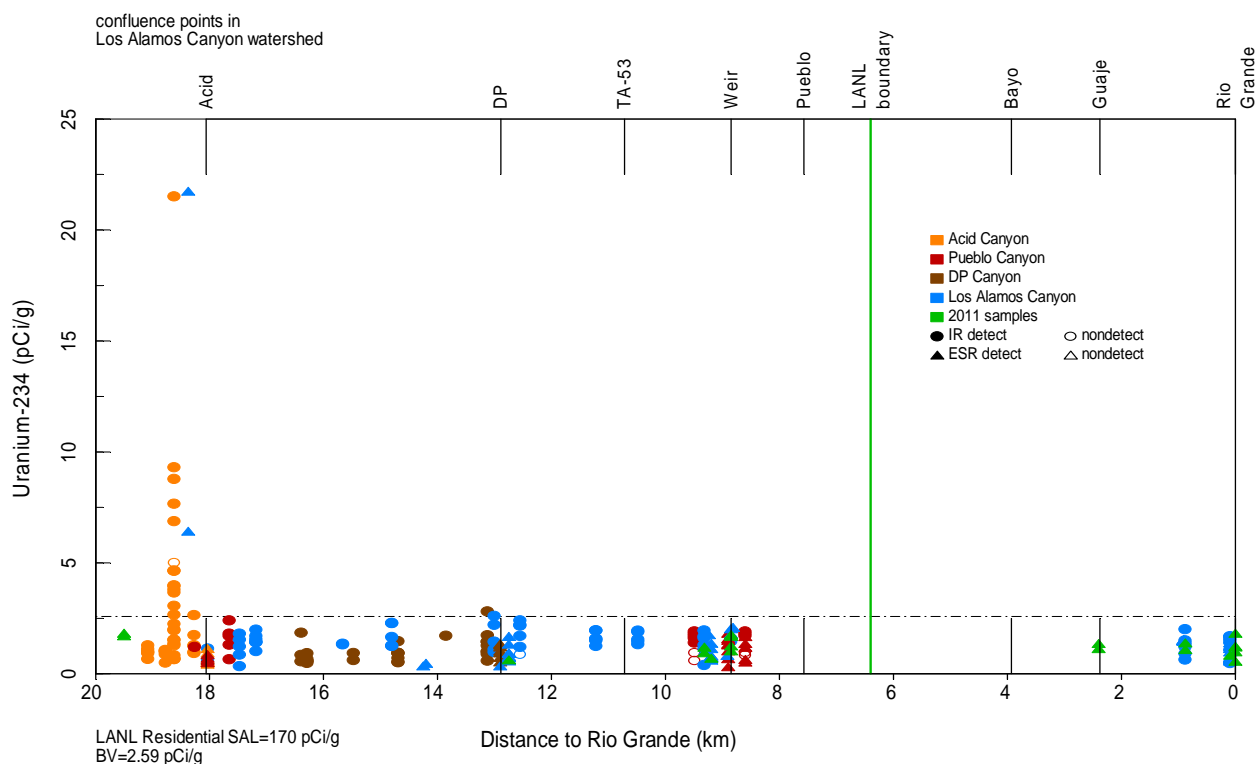


Figure 6-18b Los Alamos Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

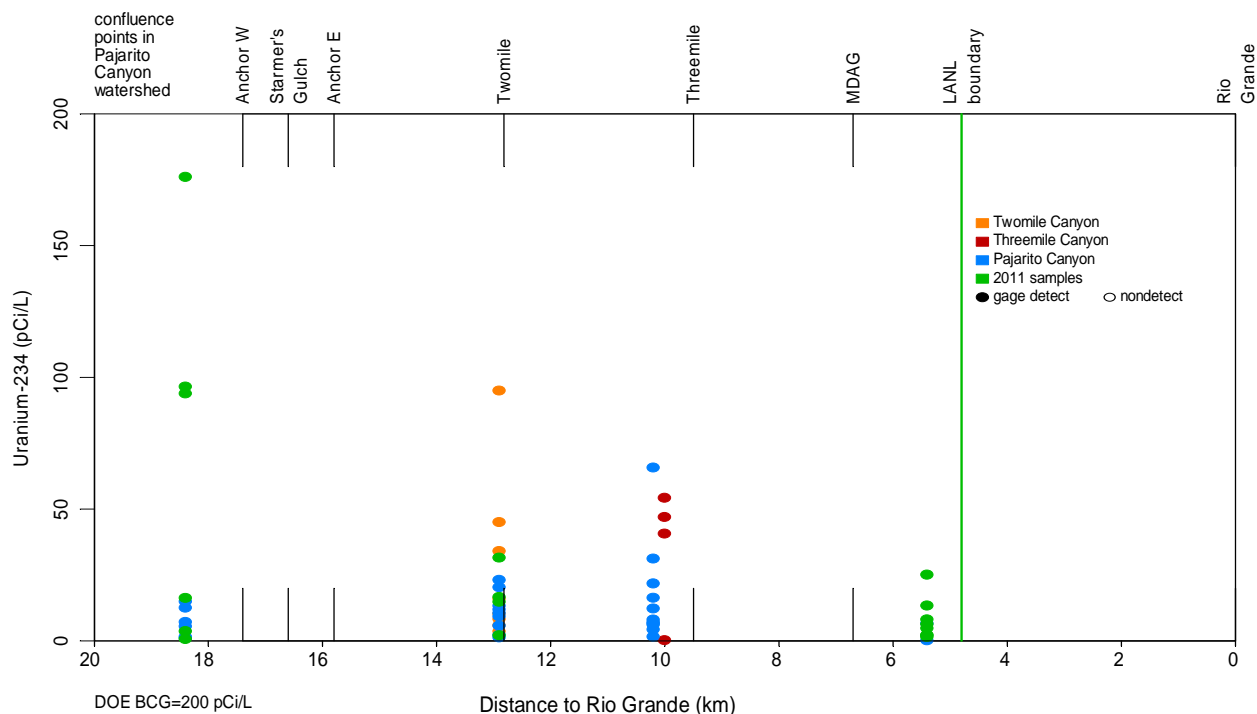


Figure 6-18c Pajarito Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

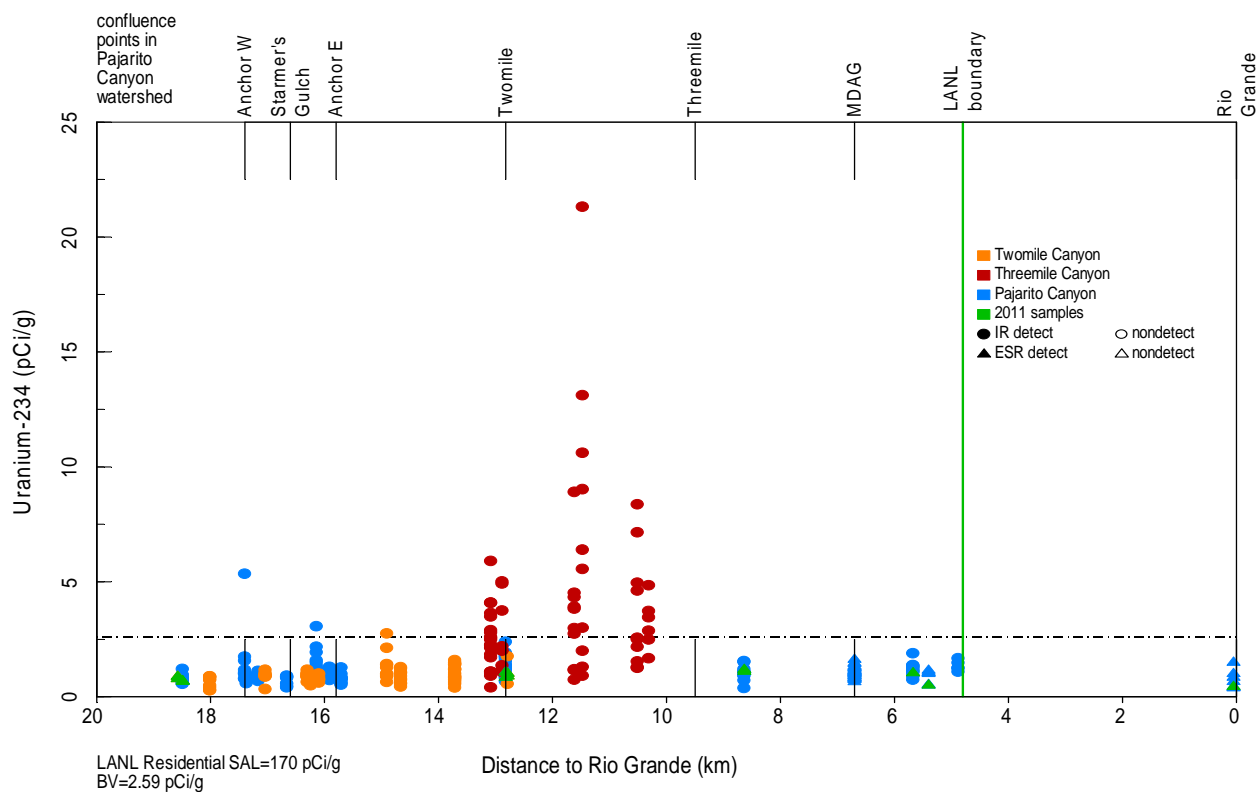


Figure 6-18d Pajarito Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

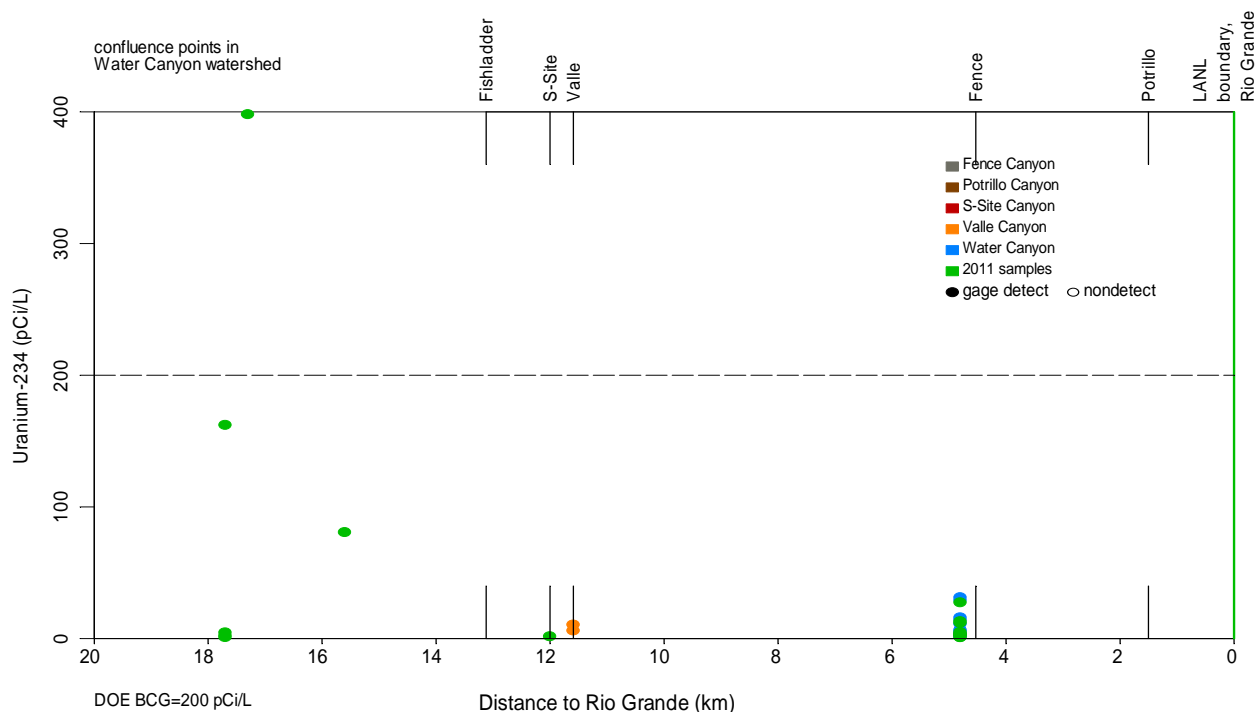


Figure 6-18e Water Canyon watershed uranium-234 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

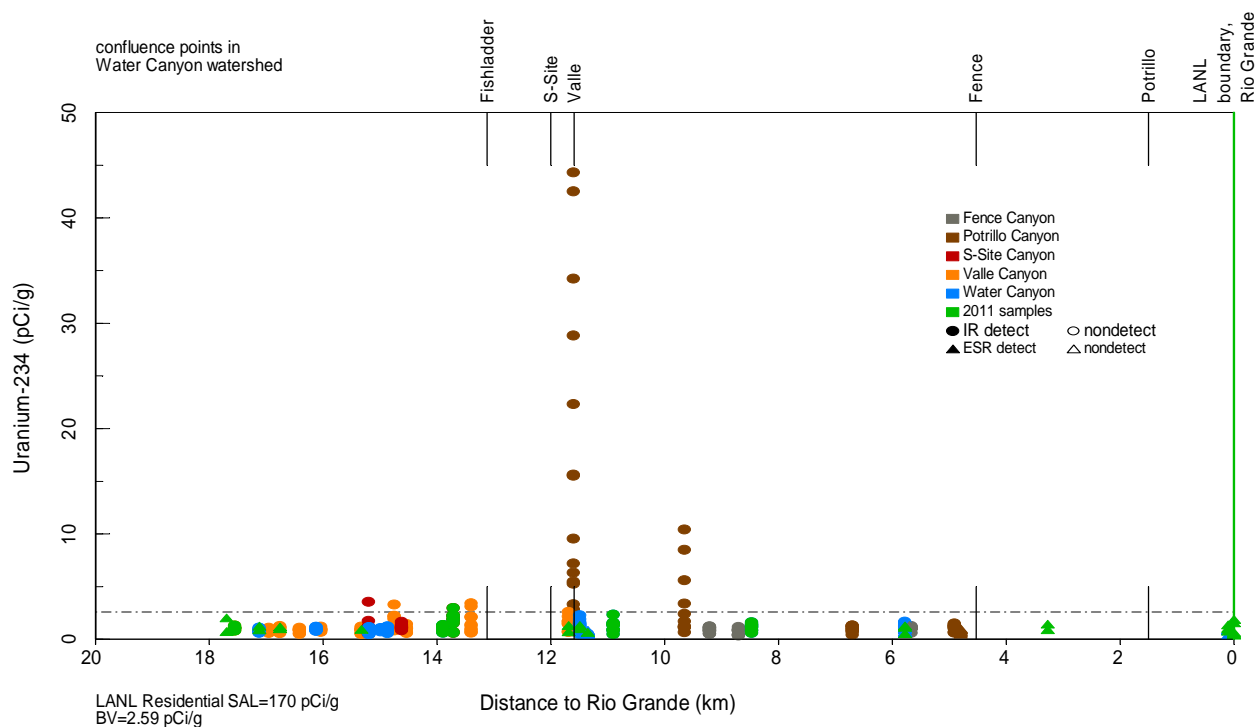


Figure 6-18f Water Canyon watershed uranium-234 concentrations in sediment from Canyons IR (data from 2000, 2008–2011) and ESRs (data from 2003–2011)

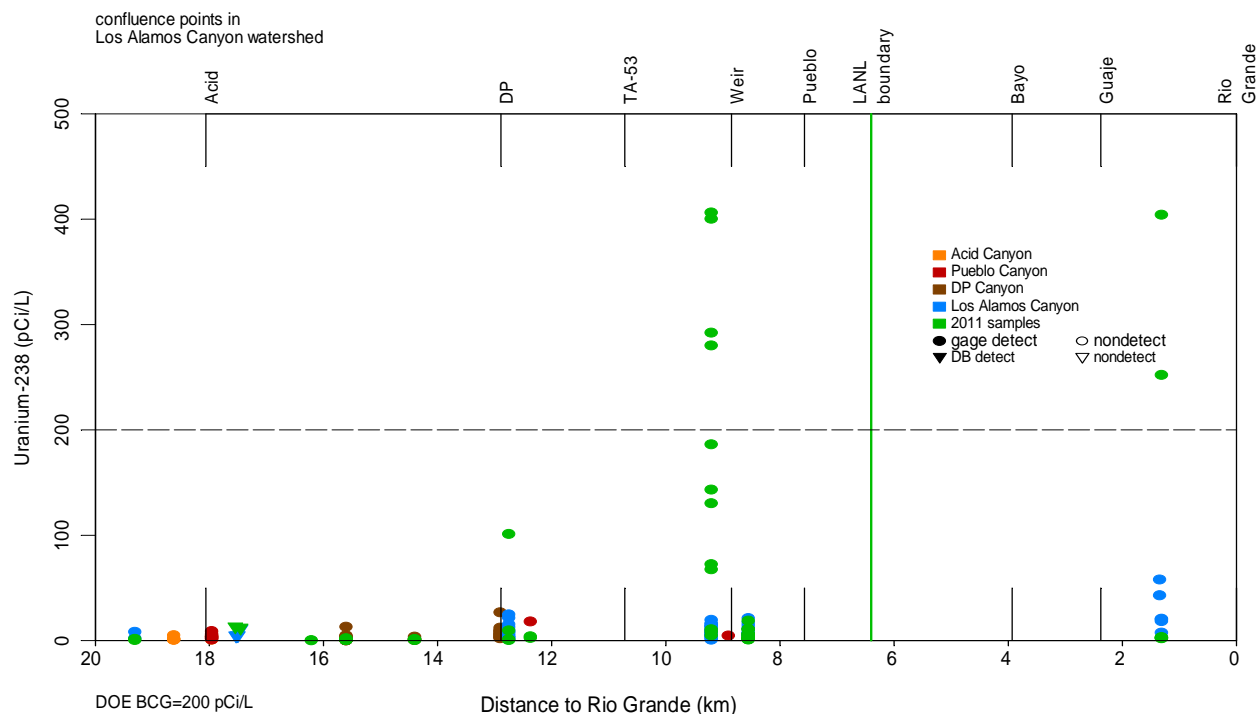


Figure 6-19a Los Alamos Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

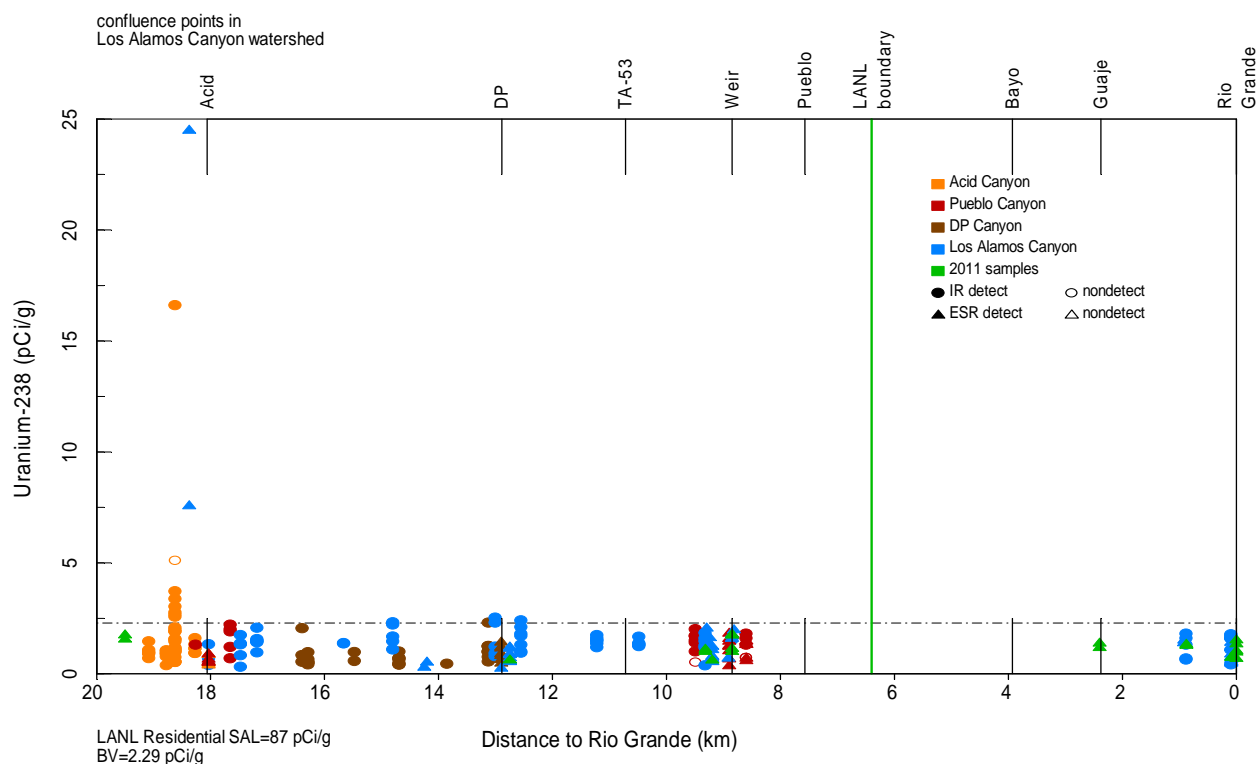


Figure 6-19b Los Alamos Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

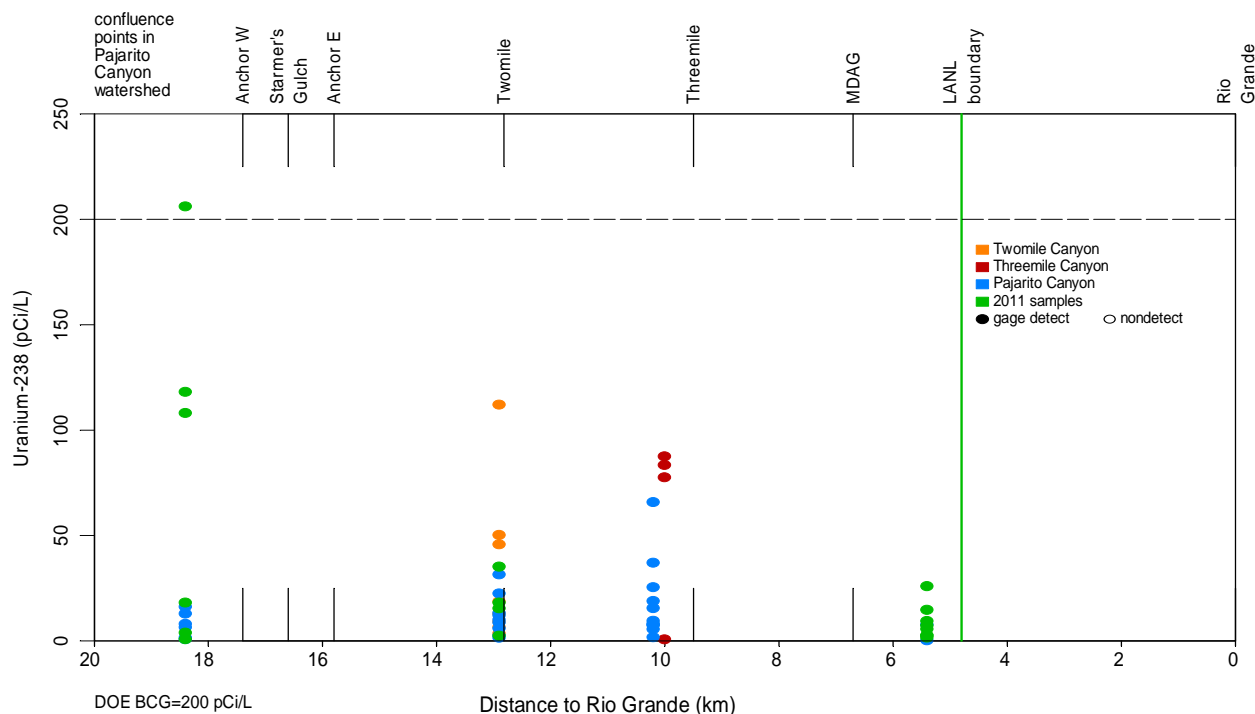


Figure 6-19c Pajarito Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

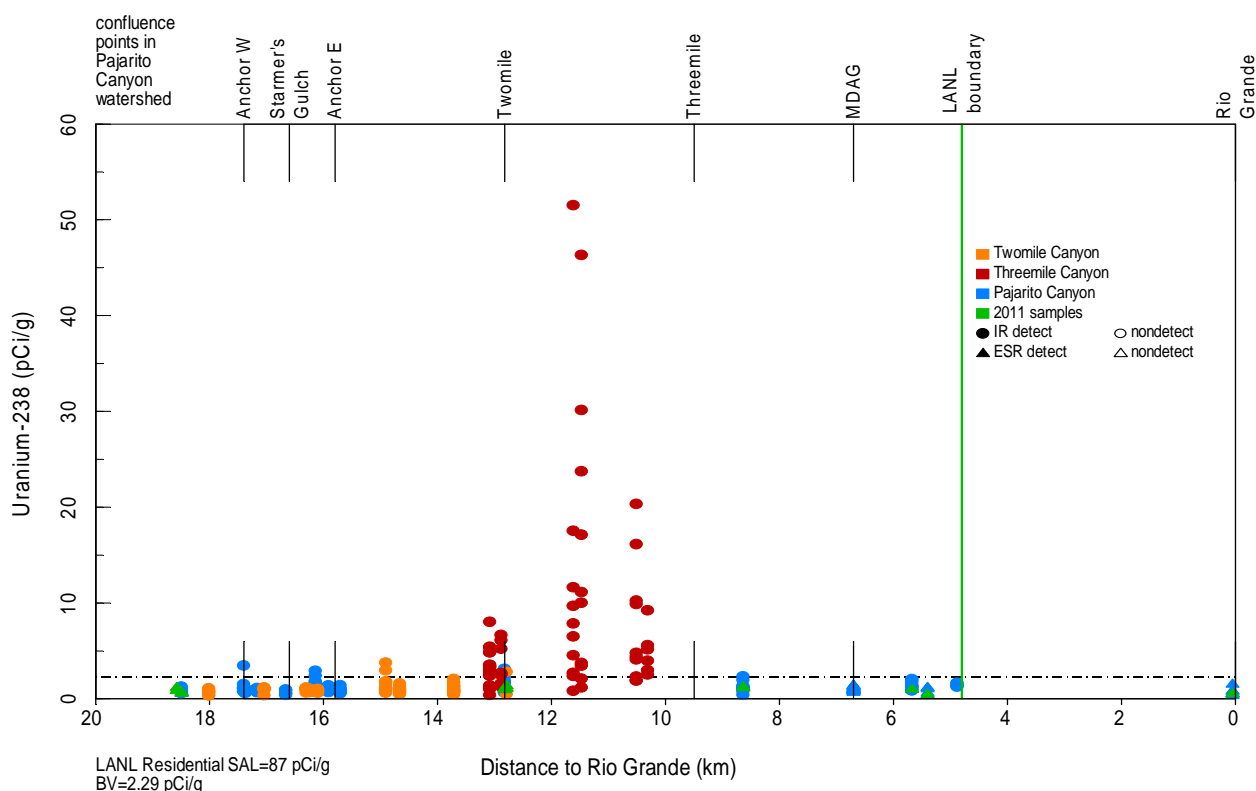


Figure 6-19d Pajarito Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 2000–2007) and ESRs (data from 2003–2011)

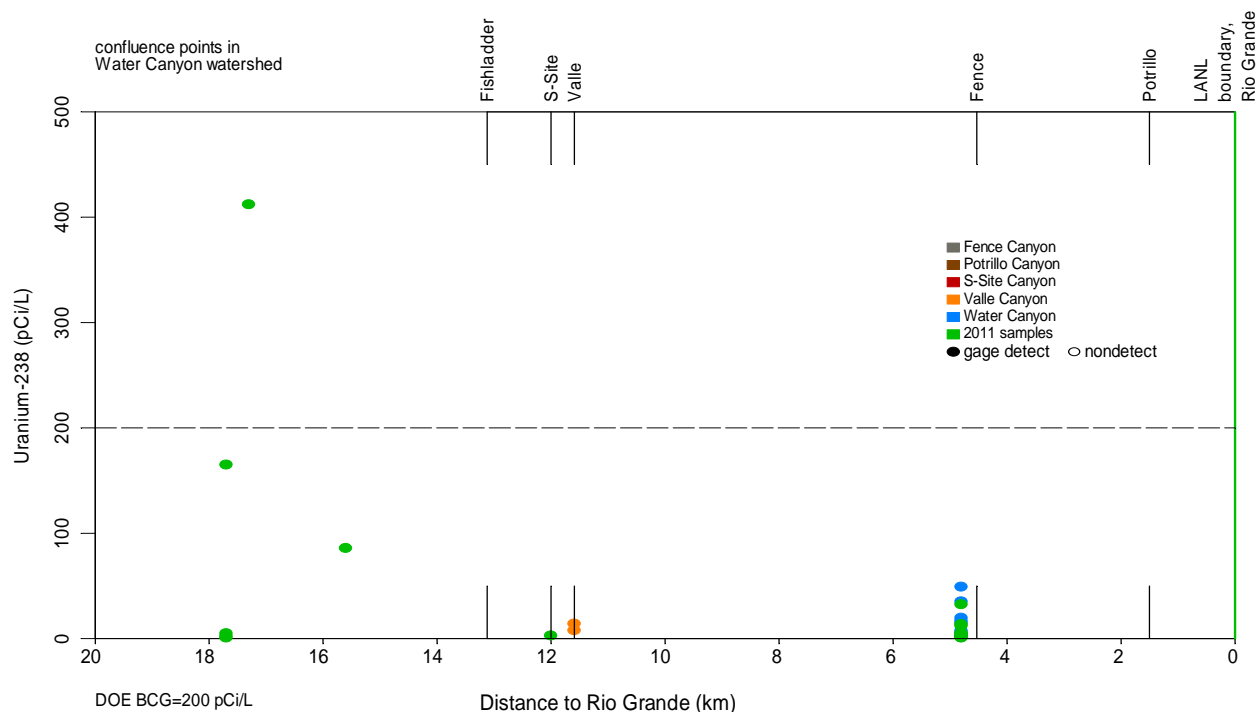


Figure 6-19e Water Canyon watershed uranium-238 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

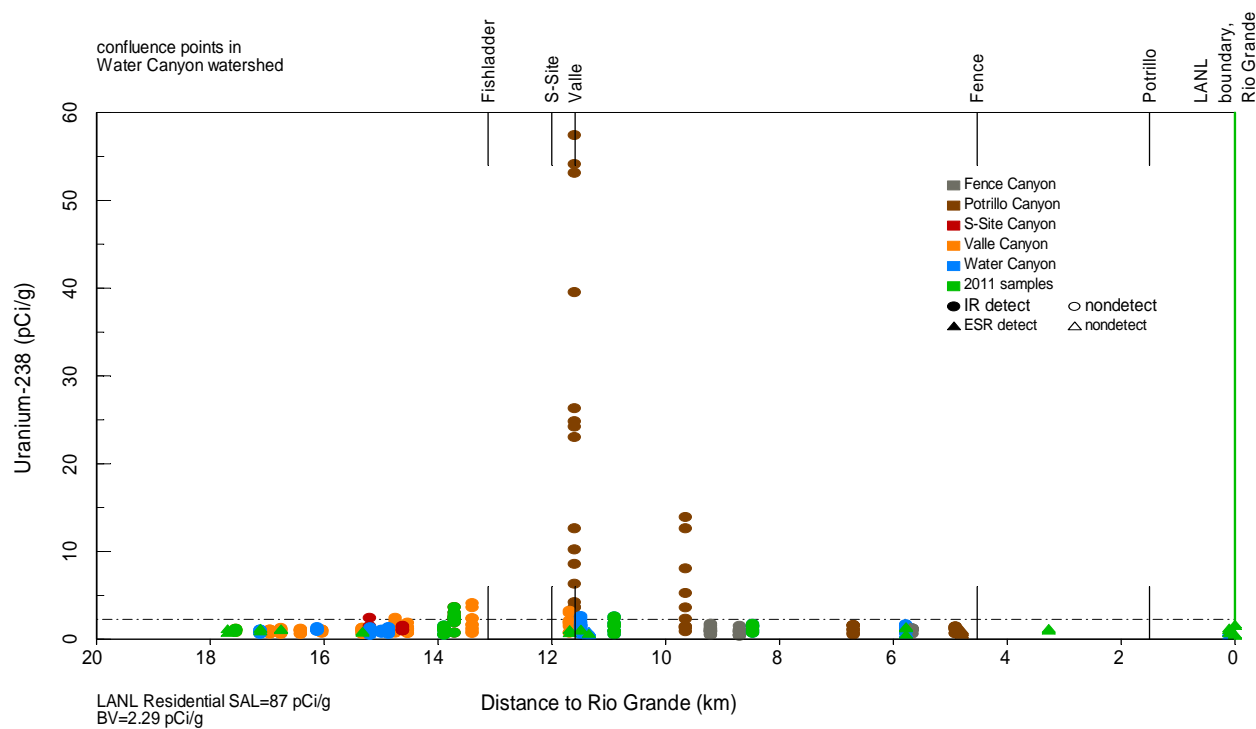


Figure 6-19f Water Canyon watershed uranium-238 concentrations in sediment from Canyons IR (data from 2000, 2008–2011) and ESRs (data from 2003–2011)

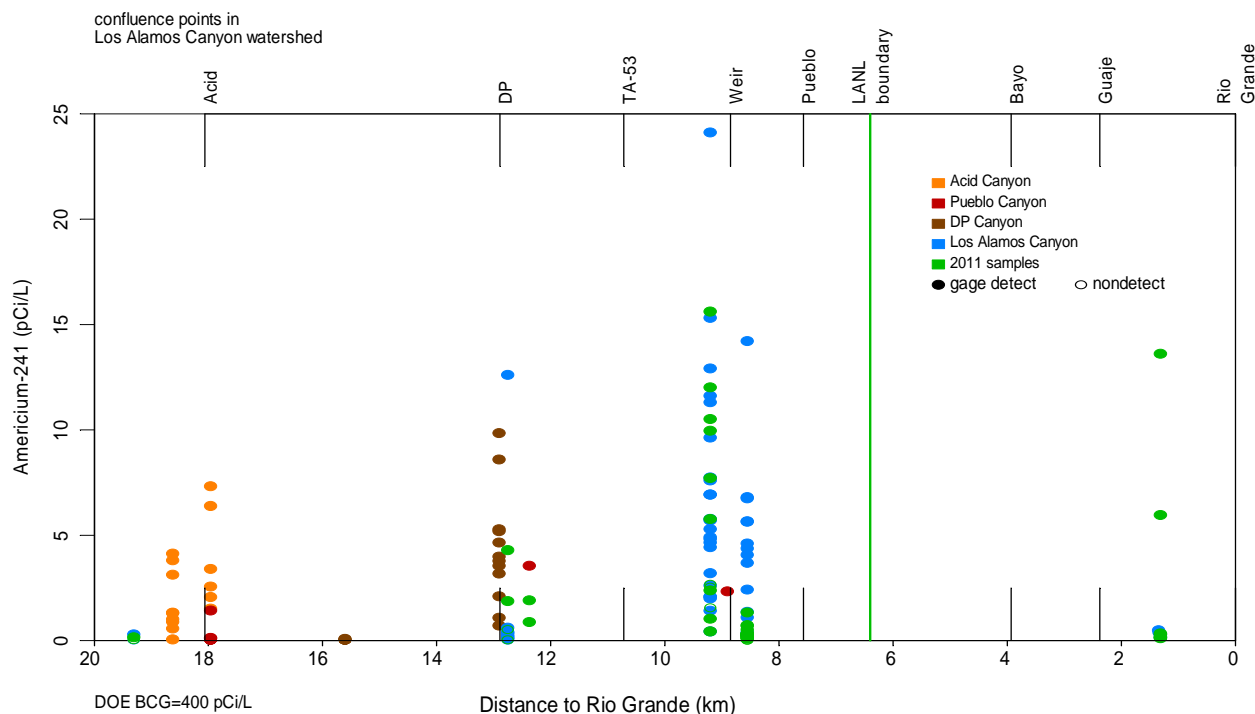


Figure 6-20a Los Alamos Canyon watershed americium-241 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

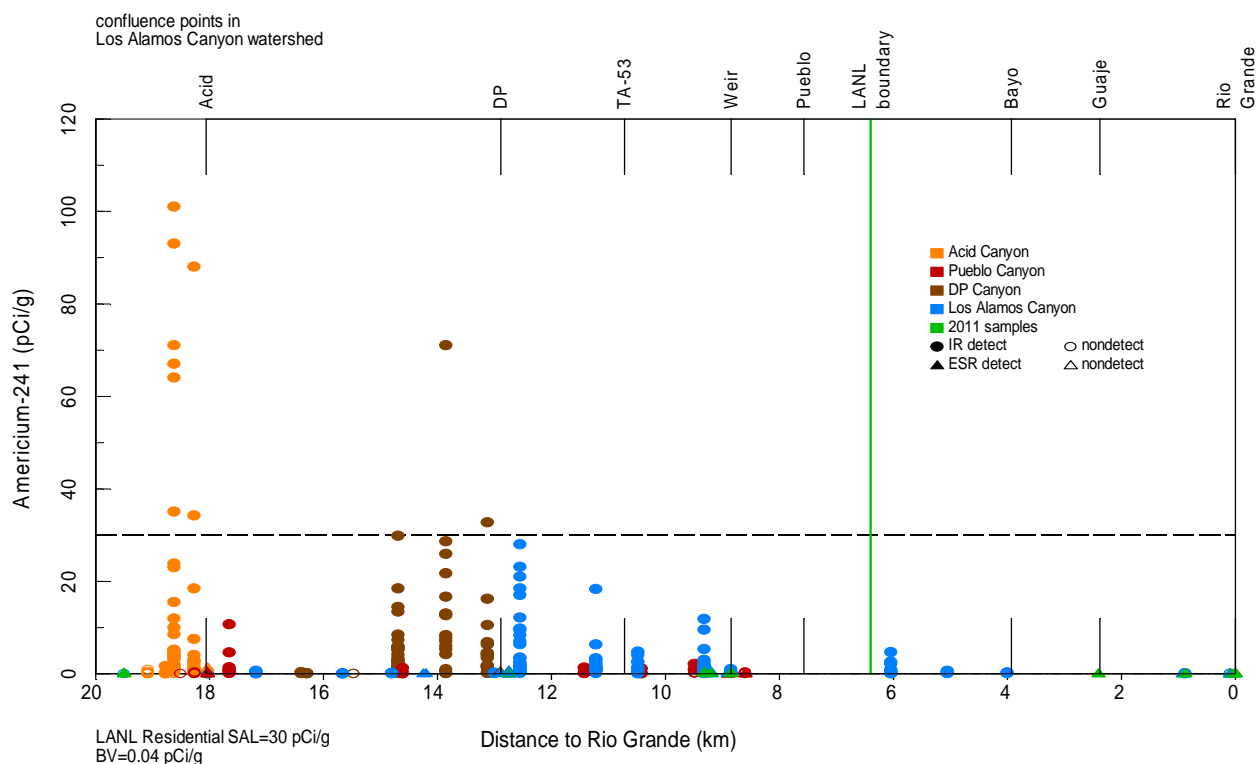


Figure 6-20b Los Alamos Canyon watershed americium-241 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

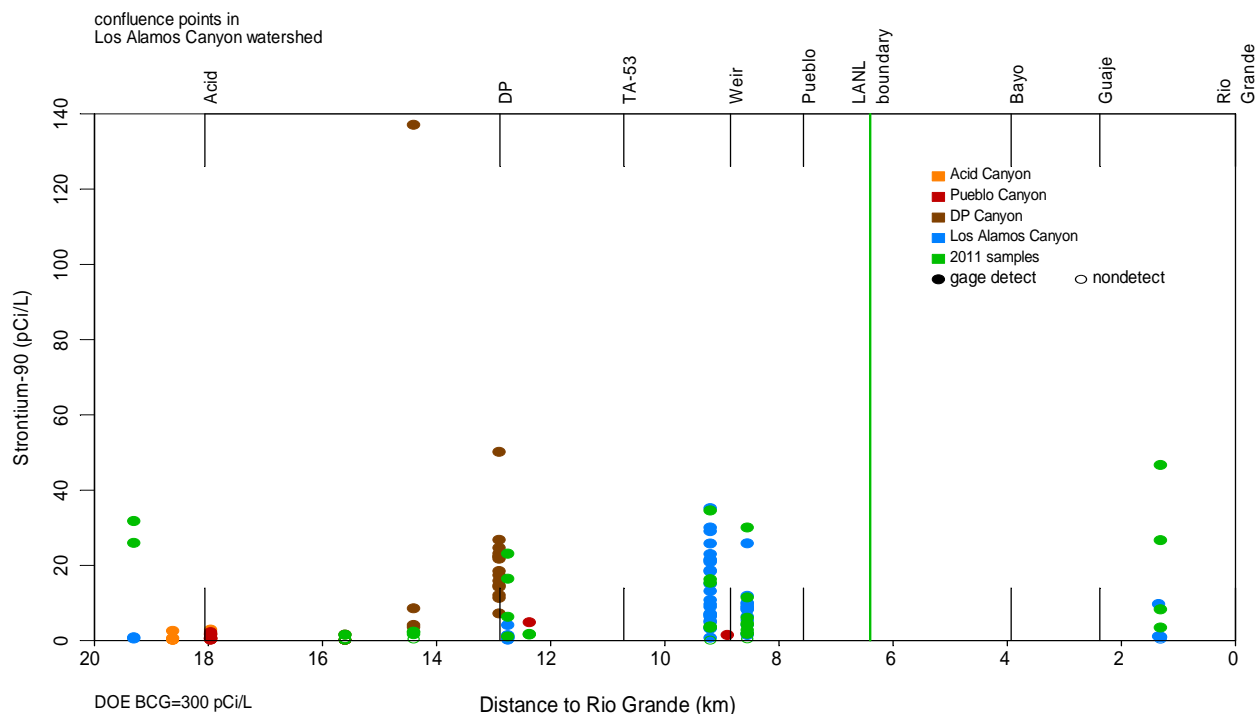


Figure 6-21a Los Alamos Canyon watershed strontium-90 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

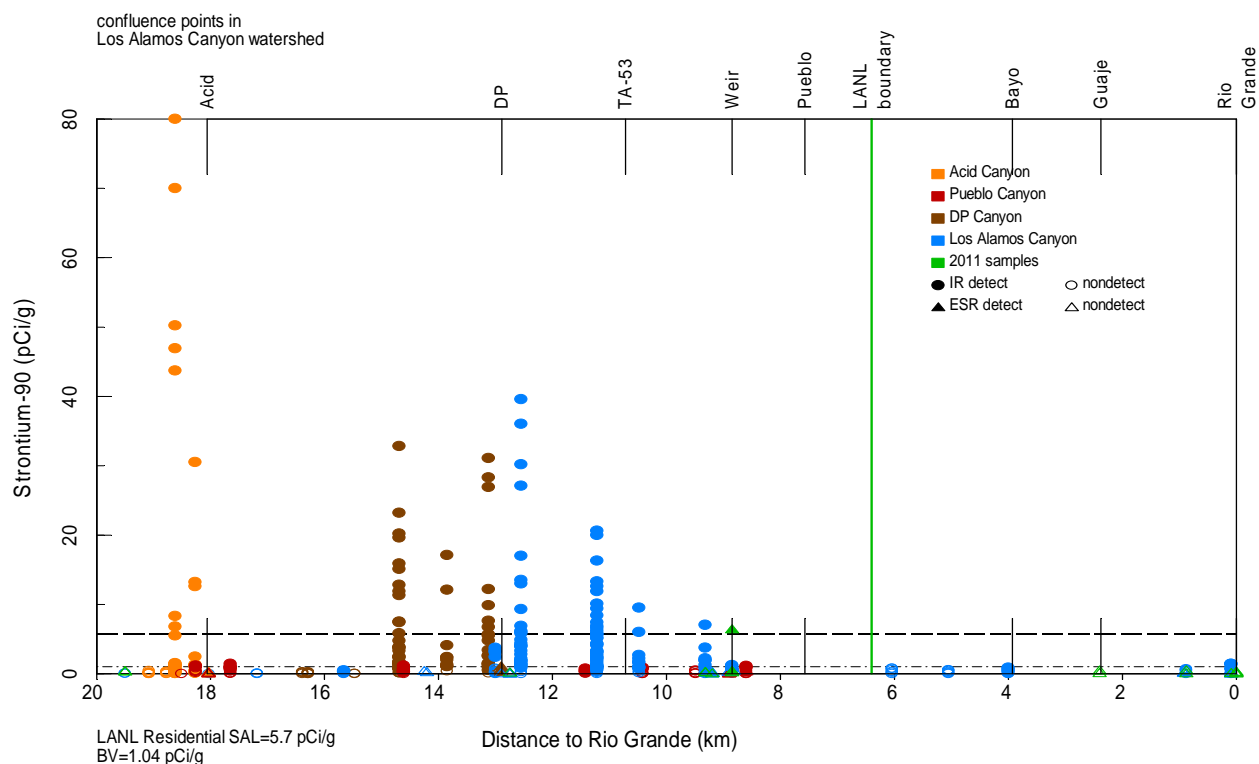


Figure 6-21b Los Alamos Canyon watershed strontium-90 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

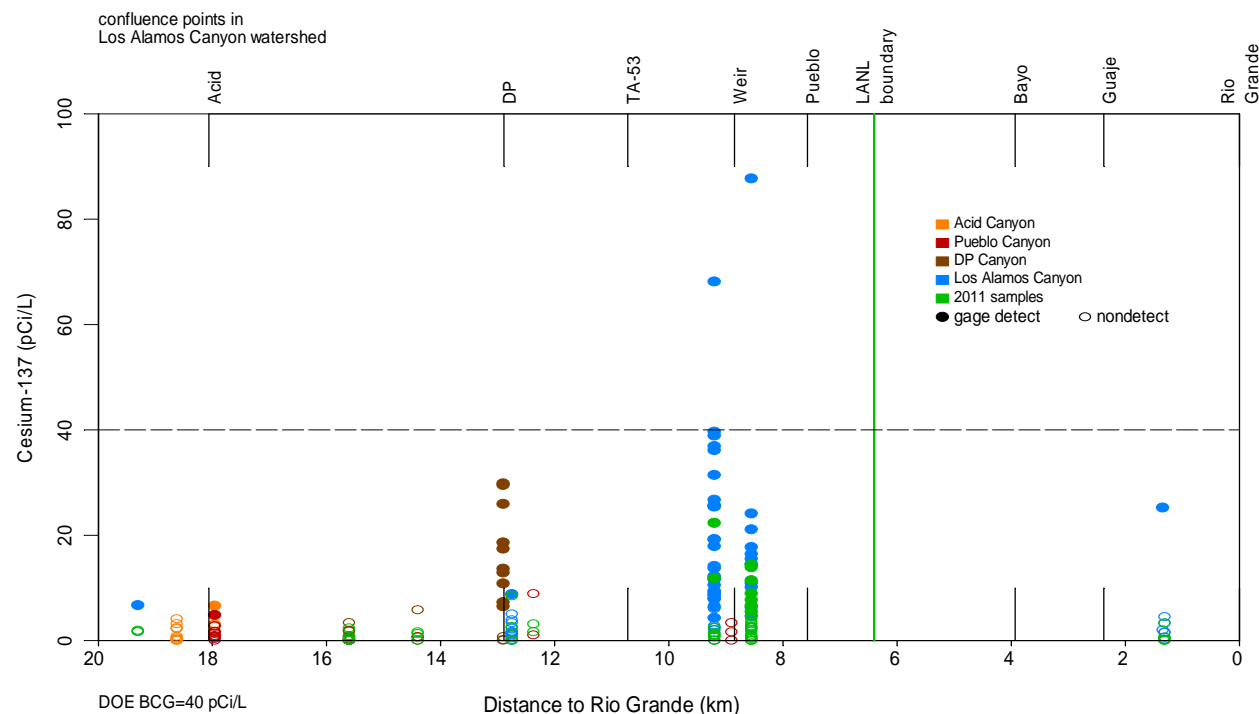


Figure 6-22a Los Alamos Canyon watershed cesium-137 concentrations in storm water from gauges (data from 2004–2011), no SMA samples analyzed

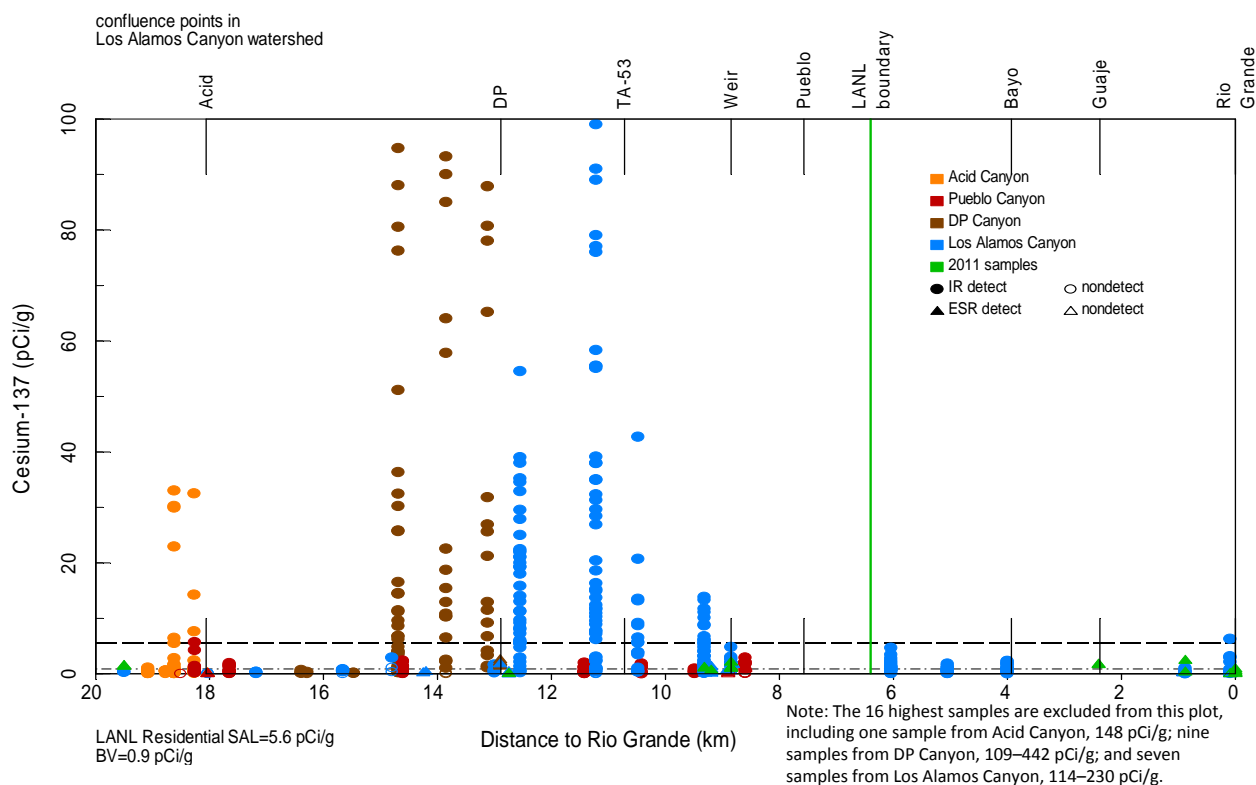


Figure 6-22b Los Alamos Canyon watershed cesium-137 concentrations in sediment from Canyons IR (data from 1994–2003) and ESRs (data from 2003–2011)

3. Inorganic and Organic Chemicals

a. Barium

There are no NMWQCC standards for barium. Concentrations of barium in storm water collected during 2011 are highest at the upgradient Laboratory boundary above contaminant sources of barium in sediment in Cañon de Valle (LANL 2011e), indicating that barium also occurs naturally in rocks and soils on and upgradient of the Pajarito Plateau (Figures 6-11a and b). Pre-2011 barium concentrations in sediment exceeded the residential SSL of 15,600 mg/kg in Cañon de Valle; however, 2011 barium concentrations in sediment did not exceed the residential SSL in Water Canyon watershed, nor throughout the Laboratory. Concentrations of barium in storm water and sediment decrease from Cañon de Valle to the confluence with the Rio Grande.

b. Lead

Pre-2011 storm water data indicated exceedances of the NMWQCC acute aquatic life standard (17 µg/L) in Pueblo and DP Canyons (Figures 6-12a through f). In 2011, no lead concentrations in storm water exceeded the NMWQCC standards, and there were two MTAL (17 µg/L) exceedances for lead in Los Alamos Canyon above the DP confluence. For sampling under the IP, the highest result for filtered lead was 42.1 µg/L at LA-SMA-1 in Los Alamos Canyon. The highest unfiltered lead result determined at ESR gauges in 2011 in Los Alamos Canyon was 1.9 µg/L. Concentrations of lead in storm water collected during 2011 are highest where lead has been detected in sediment associated with historical Laboratory operations in Acid, DP, Twomile, and S-Site Canyons and Cañon de Valle (LANL 2005a, 2009b, 2011e). Los Alamos, Pajarito, and Water Canyon watersheds had pre-2011 lead concentrations in sediment that exceeded the residential SSL of 400 mg/kg. No 2011 lead concentrations in sediment exceeded the residential SSL. Lead concentrations in sediment decrease to levels near background by the Laboratory boundary.

c. Mercury

Pre-2011 storm water results exceeded the NMWQCC wildlife habitat standard (0.77 µg/L) in Acid, Los Alamos, Pajarito, and Water Canyons (Figures 6-13a through d). For 2011, mercury concentrations in storm water exceeded the NMWQCC wildlife habitat standard in Los Alamos Canyon and Cañon de Valle and exceeded the average TAL (ATAL) (0.77 µg/L) in Water Canyon and Cañon de Valle. Mercury concentrations are similar at ESR gauges and IP SMAs. For samples collected under the IP, the highest result for unfiltered mercury was 1.6 µg/L at CDV-SMA-6.02 in Water Canyon. The highest unfiltered mercury result determined at ESR gauges in 2011 in Water Canyon was 1.4 µg/L. Mercury concentrations decrease from their sources in Acid and S-Site Canyons (LANL 2005a, 2011e) to below background in sediment collected near the Laboratory boundary. Mercury exceedances in Water Canyon storm water sampling at SMAs will be controlled by best management practices installed under the IP. One pre-2011 mercury concentration in sediment exceeded the residential SSL of 23.5 mg/kg in Threemile Canyon (LANL 2009b). No 2011 mercury concentrations in sediment exceeded the residential SSL.

d. Silver

Pre-2011 silver concentrations in storm water exceeded the NMWQCC acute aquatic life standard of 0.4 µg/L in Acid Canyon, Cañon de Valle, and Pajarito Canyon (Figures 6-14a through d). In 2011, one storm water sample exceeded the NMWQCC acute aquatic life standard for silver in lower Water Canyon. No pre-2011 or 2011 sediment concentrations of silver exceeded the residential SSL of 391 mg/kg. Silver concentrations in sediment decrease from their Laboratory sources in Cañon de Valle and Pajarito Canyon (LANL 2009b, 2011e) to below background in sediment collected near the Laboratory boundary.

e. Total PCBs

PCBs were detected in 93% of storm water samples collected in 2011 and within all LANL watersheds at concentrations above the NMWQCC human health standard of 0.00064 µg/L (Figures 6-15a through f). Data from storm water runoff from non-urban, non-industrial areas on the Pajarito Plateau indicate that atmospheric deposition of PCBs can result in storm water that exceeds the human health standard. These PCB detections are categorized into three statistically different categories (LANL 2012):

- 1) *Storm water runoff from non-urban, non-industrial areas on the Pajarito Plateau (upper threshold limit, [UTL] = 0.013 µg/L).* A total of 45 of 170, 26%, of PCB results from storm water at gauge stations contain concentrations below this threshold, indicating only atmospheric deposition of PCBs.
- 2) *Storm water runoff from Los Alamos County town site without point sources of concentrated PCBs (UTL = 0.098 µg/L).* A total of 100 of 170, 59%, of PCB results from storm water at gauge stations contain concentrations below this threshold, indicating non-point sources of PCBs including atmospheric deposition.
- 3) *Storm water runoff from point sources of concentrated PCBs.* A total of 41% of storm water results from gauge stations contain concentrations above the UTL of 0.098 µg/L, indicating a source of PCBs to storm water.

The highest PCB concentrations were detected in storm water runoff entering the DBs below SWMU 01-001(f) in Los Alamos Canyon. These DBs function to capture PCBs prior to runoff entering the main channel in Los Alamos Canyon. PCBs were detected at 9.07 µg/L in storm water runoff flowing into the upper DB during a storm on August 19, 2011. Water was not detected flowing out of a small wetland below the lower of the two DBs during 2011. Concentrations of PCBs running onto the Laboratory from burned areas are as high as 0.295 µg/L in Los Alamos Canyon, indicating that PCBs are concentrated in forest fire ash. Concentrations of PCB Aroclor mixtures do not directly correspond to PCB congener concentrations so are not presented in figures.

f. RDX

In the Cañon de Valle watershed, no pre-2011 or 2011 RDX concentrations in storm water exceeded the NMWQCC standards, nor the MTALs or ATALs for IP-related sampling. Pre-2011 RDX concentrations in sediment exceeded the residential SSL of 58.2 mg/kg and are associated with the former high explosives-machining facility, including material disposal areas (MDAs), burning grounds, and settling ponds. In 2011 no RDX concentrations in sediment were above the residential SSL.

g. Radionuclides

All of the radionuclides present in global atmospheric fallout, americium-241, cesium-137, plutonium-238, plutonium-239/240, and strontium-90, are present above the regional background for sediment contained in storm water runoff from Las Conchas burn areas. Also, uranium isotopes concentrations are present above the regional background for sediment in highly sediment-laden storm water derived from burn areas. The uranium is likely associated with erosion of soils in post-fire runoff rather than being a fallout constituent contained in ash (Gallaher and Koch 2004, 2005).

h. Plutonium-238 and Plutonium-239/240

No storm water samples collected in Los Alamos, Pajarito, and Water Canyon watersheds from 2004 to 2010 had plutonium-238 concentrations above the DOE BCG of 200 pCi/L (Figures 6-16a through f). Storm water samples collected in Los Alamos Canyon watershed from 2004 to 2010 had plutonium-239/240 concentrations above the DOE BCG of 200 pCi/L (Figures 6-17a through f). In 2011, no storm water samples collected on the Pajarito Plateau had plutonium-238 or plutonium-239/240 concentrations above the DOE BCG. In Pajarito Canyon and Cañon de Valle, slightly elevated concentrations of plutonium-238 and plutonium-239/240 were found in storm water at the upgradient boundary stations; however, all of these samples were collected during the first large storm event after the Las Conchas Fire on August 21, when the storm water was highly laden with ash and sediment from burn areas. Slightly elevated concentrations of

plutonium-238 and plutonium-239/240 in storm water at the lower boundary of Los Alamos Canyon are associated with Guaje Canyon runoff during the August 22 storm event, which also contained ash and sediment. In addition, the Los Alamos Canyon low-head weir significantly reduced the slightly elevated concentrations of plutonium-238 and plutonium-239/240 in storm water laden with ash and sediment.

In Los Alamos Canyon watershed, only one pre-2011 sediment sample in Acid Canyon had plutonium-238 concentrations that exceeded the LANL residential SAL of 37 pCi/g. From the historical Laboratory sources in Acid Canyon (LANL 2005a), down canyon to Pueblo Canyon then to Los Alamos Canyon, and from the historical Laboratory sources in DP Canyon and TA-53 (LANL 2005a), down canyon to Los Alamos Canyon, pre-2011 and 2011 plutonium-238 concentrations in sediment decrease to near background (0.006 pCi/g) or non-detectable levels before reaching the confluence with the Rio Grande. Pre-2011 plutonium-239/240 concentrations in Los Alamos Canyon watershed exceeded the LANL residential SAL (33 pCi/g) in Acid, Pueblo, and DP Canyons, yet decrease to near background levels (0.068 pCi/g) at the confluence with the Rio Grande.

In Pajarito Canyon watershed, no pre-2011 sediment concentrations of plutonium-238 and plutonium-239/240 exceeded the LANL residential SALs, although MDA G had concentrations above sediment background values. However, both pre-2011 and 2011 plutonium-238 and plutonium-239/240 concentrations in sediment decrease from the LANL historical source at MDA G (LANL 2009b) to near background values before the LANL boundary and are at non-detectable levels at the confluence with the Rio Grande.

In Water Canyon watershed, only one pre-2011 sediment sample in Cañon de Valle had plutonium-238 concentrations that exceeded the LANL residential SAL, and no pre-2011 sediment samples had plutonium-239/240 concentrations that exceeded the LANL residential SAL. From the historical Laboratory source in Cañon de Valle (LANL 2011e) downstream, the concentrations of plutonium-238 in sediment decrease to near background or non-detectable levels before reaching the confluence with the Rio Grande.

In sediment samples collected in Los Alamos, Pajarito, and Water Canyon watersheds in 2011, plutonium-238 and plutonium-239/240 concentrations did not exceed the LANL residential SALs. In Los Alamos and Pajarito Canyons, plutonium-238 and plutonium-239/240 concentrations in sediment were above background values; however, all samples contained ash and sediment from Las Conchas burn areas. The highest plutonium-239/240 concentration was found at the upgradient boundary of Pajarito Canyon, and the highest plutonium-238 concentration was found upstream of the Los Alamos Canyon low-head weir (downstream of which, concentrations decreased). In Water Canyon, only plutonium-239/240 concentrations in sediment were above background values, and these samples also contained ash and sediment from Cañon de Valle.

i. Uranium-234 and Uranium-238

No storm water samples collected in Los Alamos, Pajarito, and Water Canyon watersheds from 2004 to 2010 had uranium-234 or uranium-238 concentrations above the DOE BCG of 200 pCi/L (Figures 6-18a through f and Figures 6-19a through f). The following samples, collected in 2011 from storm water containing ash and sediment, exceeded the DOE BCG: six each for uranium-234 and uranium-238 in Los Alamos Canyon, one for uranium-238 in Pajarito Canyon, and one each for uranium-234 and uranium-238 in Water Canyon. Note that BCG screening levels are based on chronic exposure, thus comparing them with a one-time, acute event will overestimate risk. In Cañon de Valle and Water and Pajarito Canyons, elevated concentrations of uranium-234 and uranium-238 in storm water were found at the upgradient boundary stations; however, all of these samples were collected during the first large storm event after the Las Conchas Fire on August 21. Elevated concentrations of uranium-234 and uranium-238 in storm water at the lower boundary of Los Alamos Canyon are associated with Guaje Canyon runoff during the August 22 storm event, which also contained ash and sediment. In addition, the Los Alamos Canyon low-head weir significantly reduced the elevated concentrations of uranium-234 and uranium-238 in storm water with ash and sediment.

In Los Alamos, Pajarito, and Water Canyon watersheds, no pre-2011 sediment samples had uranium-234 and uranium-238 concentrations that exceeded the LANL residential SALs of 170 pCi/g and 87 pCi/g,

respectively. In fact, almost all samples had uranium-234 and uranium-238 concentrations below or near background levels (2.59 pCi/g and 2.29 pCi/g, respectively), with the exception of samples from Acid, Threemile, and Potrillo Canyons. However, all pre-2011 uranium-234 and uranium-238 sediment concentrations in Los Alamos, Pajarito, and Water Canyon watersheds originating from the historical LANL sources in Acid (LANL 2005a), Threemile (LANL 2009b), and Potrillo Canyons (LANL 2011e) were below background at the LANL boundary and the confluence with the Rio Grande.

In sediment samples collected in Los Alamos, Pajarito, and Water Canyon watersheds in 2011, uranium-234 and uranium-238 concentrations did not exceed the LANL residential SALs. In Los Alamos and Pajarito Canyons, all 2011 uranium-234 and uranium-238 concentrations in sediment were below background values. In Water Canyon, uranium-234 and uranium-238 concentrations in sediment were slightly above background values downstream of the upgradient LANL boundary (these samples contained ash and sediment from burn areas) but decreased to below background before the LANL boundary and the confluence with the Rio Grande.

j. Americium-241, Cesium-137, and Strontium-90

No storm water samples collected in Los Alamos Canyon watershed from 2004 to 2011 had americium-241 (Figures 6-20a and b) or strontium-90 (Figures 6-21a and b) concentrations above the DOE BCGs of 400 pCi/L and 300 pCi/L, respectively. In Los Alamos Canyon prior to 2011, two storm water samples collected above and below the low-head weir contained cesium-137 (Figures 6-22a and b) concentrations above the DOE BCG of 40 pCi/L. Note that BCG screening levels are based on chronic exposure, thus comparing them with a one-time, acute event will overestimate risk. In 2011, elevated concentrations of americium-241 and strontium-90 in storm water samples are associated with Guaje Canyon runoff during the August 22 storm event, which contained ash and sediment from burn areas. Elevated concentrations of strontium-90 in 2011 storm water samples at the upgradient LANL boundary of Los Alamos Canyon are also associated with ash and sediment. In addition, the Los Alamos Canyon low-head weir significantly reduced the elevated concentrations of americium-241, cesium-137, and strontium-90 in storm water with ash and sediment.

In Los Alamos Canyon watershed, pre-2011 americium-241 concentrations in sediment exceeded the LANL residential SAL (30 pCi/g) in Acid and DP Canyons because of historical Laboratory sources (LANL 2005a), yet decrease to near background levels (0.04 pCi/g) before the confluence with the Rio Grande. Pre-2011 cesium-137 concentrations in sediment exceeded the LANL residential SAL (5.6 pCi/g) in DP and Los Alamos Canyons because of historical Laboratory sources (LANL 2005a), yet decrease to below background levels (0.9 pCi/g) near the LANL boundary and before the confluence with the Rio Grande. Pre-2011 strontium-90 concentrations in sediment exceeded the LANL residential SAL (5.7 pCi/g) in Acid, DP, and Los Alamos Canyons because of historical Laboratory sources (LANL 2005a), yet decrease to below background levels (1.04 pCi/g) near the LANL boundary and before the confluence with the Rio Grande.

In sediment samples collected in Los Alamos Canyon watershed in 2011, americium-241 and cesium-137 concentrations did not exceed the LANL residential SALs and were near background levels. One sediment sample collected in the Los Alamos Canyon low-head weir had strontium-90 concentrations above the LANL residential SAL, and is associated with ash and sediment from burn areas that settled out of storm water while in the weir. All other 2011 sediment samples collected in Los Alamos Canyon watershed had strontium-90 concentrations below background levels.

F. CONCLUSIONS

The Las Conchas Fire burned areas of Santa Fe National Forest upgradient of Laboratory property, resulting in increased ash and sediment transport into Water, Pajarito, and Los Alamos Canyon watersheds in 2011. Ash and sediment are collected in storm water during active flooding and in floodplain deposits after monsoonal rains have ended. Following the Cerro Grande Fire in May 2000, ash and sediment transport

returned to pre-fire levels in three to five years (Gallaher and Koch 2004, 2005). A similar return to pre-fire conditions is expected for the Las Conchas Fire.

Storm water samples collected in 2011 downgradient of burned areas contained increased concentrations of ash and sediment. These samples contained correspondingly increased concentrations of background and fallout constituents transported with ash and sediment in storm water. In storm water elevated concentrations of inorganic and organic chemicals and radionuclides were observed, including aluminum, arsenic, barium, copper, cyanide, manganese, selenium, zinc, PCBs, gross alpha, radium-226, radium-228, americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, and uranium-238.

Concentrations of constituents in storm water decrease as ash and sediment are deposited on floodplains and at other LANL-constructed and -maintained flood- and sediment-control features such as wetlands, DBs, sediment traps, and weirs. In 2011, the Pueblo Canyon wetland reduced storm water discharge such that the gauge station downstream of the wetland and grade-control structure did not measure discharges over 5 cubic feet per second. The Los Alamos Canyon low-head weir reduced storm water concentrations of almost all constituents, particularly those elevated because of ash and sediment from Las Conchas burn areas. Ash and sediment were trapped upstream of the Pajarito Canyon flood-control structure, reducing sediment transport downstream.

Human health and ecological assessments have been conducted as part of each of the Canyons IRs conducted under the Consent Order. The human health risk assessments in those reports have concluded that concentrations of contaminants present in canyons media are within acceptable limits for applicable exposure scenarios. The sediment data presented in this report are used to verify the conceptual model that the scale of storm water related contaminant transport observed in LANL canyons generally results in lower concentrations of contaminants in the new sediment deposits than previously existed in deposits in a given reach. The results of the sediment data comparisons collected from flood-affected canyons in 2011 verify the conceptual model and support the premise that the risk assessments presented in the Canyons IRs represent an upper bound of potential risks in the canyons.

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To Read About**Turn to Page**

<i>Introduction</i>	7-1
<i>Soil Comparison Levels</i>	7-1
<i>Institutional Monitoring</i>	7-2
<i>Facility Monitoring</i>	7-7
<i>Special Monitoring Studies</i>	7-14
<i>Quality Assurance for the Soil, Foodstuffs, and Biota monitoring Program</i>	7-14
<i>References</i>	7-15

A. INTRODUCTION

A soil monitoring program offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities (DOE 1991). Soil is an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous emissions, indirectly from resuspension of contaminants, or through liquid effluents released to a stream that may be used for irrigation on farmlands. Consequently, soil contaminant data may provide information about potential pathways (e.g., soil ingestion, food ingestion, resuspension into the air, and groundwater contamination) that could deliver radioactive materials or chemicals to humans and biota.

The overall soil surveillance program implemented by Los Alamos National Security, LLC (LANS), at Los Alamos National Laboratory (LANL or the Laboratory) consists of the following:

- 1) An institutional component that monitors surface soil within and around the perimeter of LANL in accordance with US Department of Energy (DOE) Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b);
- 2) A facility component that monitors surface soil (and sediment) within and around the perimeter of two Laboratory sites:
 - Principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b) and
 - Principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test Facility [DARHT]) in accordance with the mitigation action plan (DOE 1996); and
- 3) A special studies component that investigates cases where there may be an absence of data concerning a localized (or potential) contaminant source that has the potential to impact human health and/or the environment as mandated from mitigation action plans, the Laboratory's Environmental Surveillance Program, or public concern.

The objectives of LANL's soil surveillance program are to

- 1) Measure concentrations of radionuclides and other chemicals of concern that have had a history of use at LANL in soil from on-site, perimeter, and regional background areas;
- 2) Assess radionuclides and/or chemical concentrations in soil over time (i.e., are concentrations increasing or decreasing?); and
- 3) Estimate the committed effective dose equivalent from radionuclides potentially received by surrounding area residents and biota (see Chapter 3 for the potential radiation doses that individuals and biota may receive from exposure to soil) and risk to residents and biota from heavy metal and organic chemical exposures.

B. SOIL COMPARISON LEVELS

To evaluate potential Laboratory impacts from radionuclides and chemicals in surface soil, we first compare the analytical results of samples collected from the Laboratory's on-site and perimeter areas with regional

statistical reference levels (RSRLs). Where the results exceed these regional background levels, we then compare the concentrations with human health- (dose-) based screening levels (SLs) and, finally, if needed, with the appropriate regulatory standard, if available. A more detailed description of the levels and/or the standard used to evaluate the results of radionuclides and chemicals in soil is given below. An overall summary can be found in Table 7-1.

- **Regional Statistical Reference Levels:** RSRLs are the mean plus three standard deviations (= 99% confidence level) of the activity of radionuclides or the concentration of nonradioactive chemicals in surface soil collected from background locations away from the influence of the Laboratory (> 9 miles) (DOE 1991). RSRLs, which represent natural (or anthropogenic sources not from the Laboratory) and fallout levels, are calculated as additional data become available and can be found in the supplemental data tables of this report.
- **Screening Levels:** SLs for radionuclides are set below the DOE single-pathway dose constraint of 25 mrem/yr (DOE 1999c, 2011b) so that potential human health concerns may be identified in advance, i.e., a “yellow flag.” If a radionuclide exceeds the SL, we investigate the basis for the higher amounts, check laboratory records, and reanalyze the sample, if possible, and/or resample the site to determine the possible cause for the higher-than-normal result. LANL developed SLs to identify radionuclides of potential human health concern on the basis of a 15-mrem/yr protective dose limit for several scenarios (residential or industrial) (LANL 2009) using the residual radioactivity (RESRAD) computer model (Yu et al. 1995).

For other chemicals (inorganic and organic), we compare concentrations to the New Mexico Environment Department (NMED) residential or industrial SLs that are set at a 10^{-5} risk level for carcinogens and a hazard quotient (HQ) of 1 for noncarcinogens (NMED 2006).

To evaluate radionuclide and other chemicals in soil, the results from on-site areas are evaluated against industrial screening levels (ISLs), and perimeter areas are compared with residential screening levels (RSLs). The RSLs assume that families live at these locations on a year-round basis.

- **Standard:** If an SL for a radionuclide is exceeded, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available for a given year. (These data are presented in Table S7-1.) The calculated dose is based on a residential scenario with soil ingestion, inhalation of suspended dust, external irradiation, and ingestion of homegrown fruits and vegetables as the exposure pathways. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis we used are presented in a report by Fresquez et al. (1996). This calculated dose is compared with the 25-mrem/yr DOE single-pathway dose constraint.

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

Constituent	Sample Location	Standard	Screening Level (Scenario)	Background Level
Radionuclides	Perimeter	25 mrem/yr	15 mrem/yr (residential)	RSRL
	On-site, Area G, DARHT	25 mrem/yr	15 mrem/yr (industrial)	RSRL/BSRL ^a
Chemicals	Perimeter	na ^b	10^{-5} risk (residential) or HQ = 1	RSRL
	On-site, Area G, DARHT	na	10^{-5} risk (industrial) or HQ = 1	RSRL/BSRL ^a

^a BSRL = Baseline statistical reference level. A discussion of these levels is provided in Section D.3.

^b na = Not available.

C. INSTITUTIONAL MONITORING

1. Monitoring Network

Institutional surface-soil samples are collected from 17 on-site (LANL) and 17 off-site (11 perimeter and six regional background) locations on a triennial basis (every third year) (Figure 7-1). Most sites have been sampled for radionuclides since the early 1970s (Purtymun et al. 1980, 1987). The last

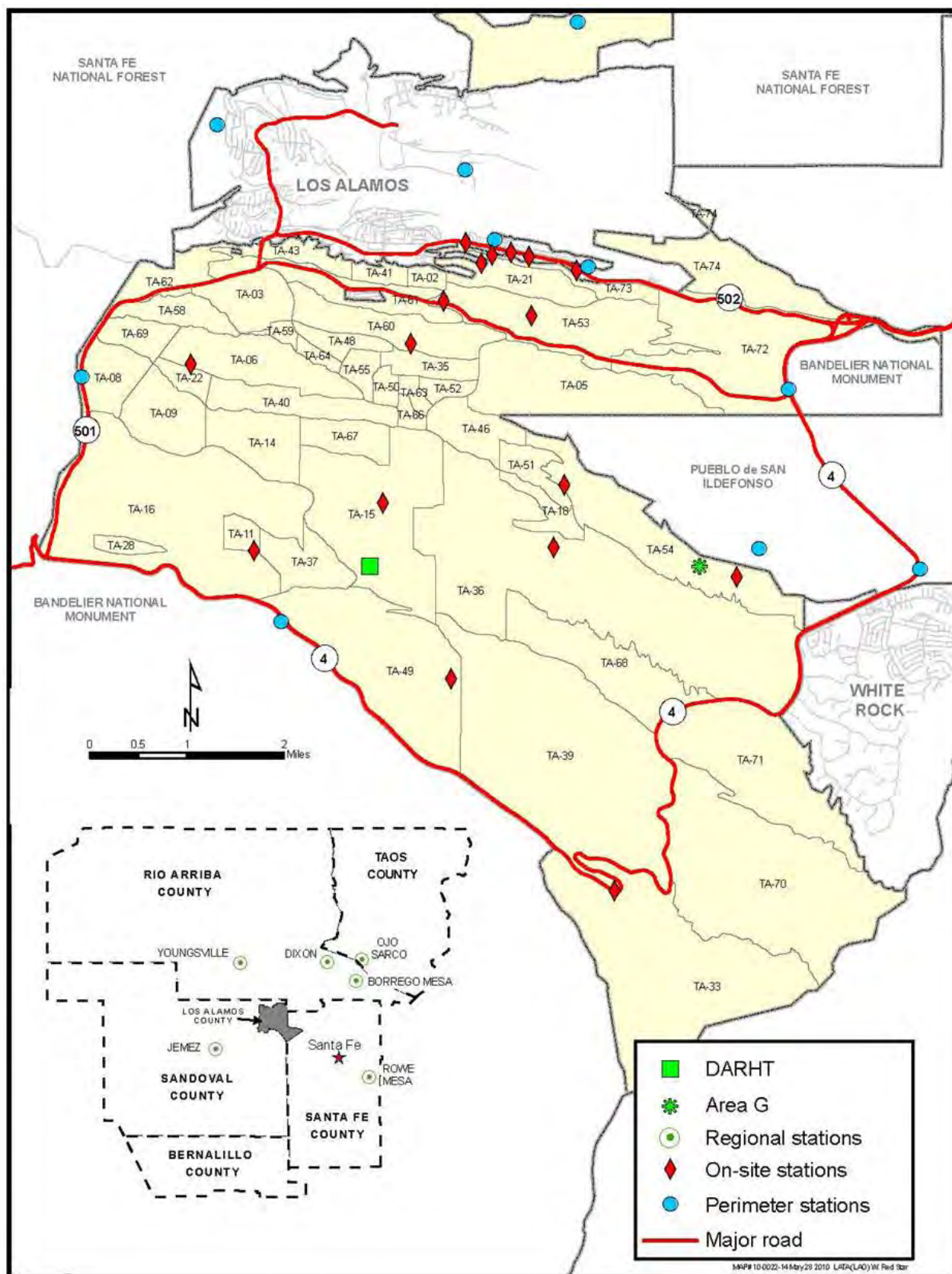


Figure 7-1 On-site, perimeter, and regional soil-sampling locations. The Otowi perimeter station is not shown but is about five miles east of LANL on NM 502.

comprehensive soil survey, which included the analysis of radionuclides, target analyte list (TAL) inorganic elements (mostly metals), polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and high explosives (HE), occurred in 2009 (Fresquez 2010). In general, all radionuclides and TAL elements were far below ISLs for on-site soils or far below RSLs for perimeter soils. Moreover, no HE was detected above the reporting level of quantification in any soil collected from on-site, perimeter, or regional locations. And only trace amounts of a few PCB Aroclors (Aroclor-1254 and Aroclor-1260) and SVOCs (aniline and fluoranthene) in soil from a few sites were detected; however, all levels were far below either ISLs or RSLs, and no increasing trends were evident. The next planned full-scale institutional soil assessment will occur in 2012.

Although the institutional soil sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we collect two perimeter soil samples on an annual basis for radionuclides and TAL elements on Pueblo lands that are downwind of Area G, the Laboratory's principal low-level radioactive waste disposal site. Area G, approximately 63 acres in size, is located in Technical Area 54 (TA-54) at the Laboratory's eastern boundary. Soil samples on Pueblo de San Ildefonso lands were collected in October 2011 from relatively level, open (unsheltered by trees or buildings), and rock-free areas. One sample, identified as "San Ildefonso," was collected across Cañada del Buey about 0.5 mile northeast of Area G, and the other sample, identified as "Tsankawi/PM-1," was collected just a little over two miles away and is also located northeast of Area G.

We compared soil sample (analysis) data from these two perimeter stations with RSRLs. These RSRLs are derived from samples collected from northern New Mexico regional background locations that surround the Laboratory in all major directions and from samples in which radionuclides and chemicals in the soil are primarily from natural sources or worldwide fallout events. These regional areas are located near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast; Rowe Mesa (near Pecos) to the southeast; Youngsville to the northwest; and Jemez Springs to the southwest. As required by DOE, all locations are at elevations similar to LANL elevations, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (> nine miles) (DOE 1991).



2. Methods and Analysis

At each site, soil composite samples for radionuclides and TAL elements (mostly metals) were collected with a stainless-steel soil ring 4 in. in diameter pushed 2 in. deep at the center and corners of a 33-ft by 33-ft square area. The five samples per site were combined and mixed thoroughly in a large Ziploc bag to form a composite sample. Composite samples were then placed in prelabeled 500-mL polyethylene bottles, sealed with chain-of-custody tape, placed into individual Ziploc bags, and submitted to the LANL Sample Management Office. All samples were handled and shipped under full chain-of-custody procedures to ALS (formerly Paragon) Laboratory Group for analysis. These samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, and uranium-238 and for 23 TAL inorganic elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). The results from these sample analyses are presented in supplemental Tables S7-1 and S7-2.

3. Radionuclides

All radionuclide (activity) concentrations in soil collected from the two perimeter areas on Pueblo de San Ildefonso lands downwind of Area G in 2011 were very low (pCi/g range), and most were either not detected or detected below the RSRLs (based on 1999–2009 data; $n=29$) (Table S7-1). A non-detected value is one in which the result is lower than three times the counting uncertainty and is not significantly different ($\alpha = 0.01$, or 99% confidence level) from 0 (Keith 1991, Corely et al. 1981) or less than the minimum detectable activity.

The only radionuclide that was detected in higher concentrations than the RSRL was plutonium-238 in the Pueblo de San Ildefonso soil location closest to Area G. The amount of plutonium-238 in soil from the San Ildefonso sample site, however, was far below the RSL and generally not increasing over time. (The overall long-term pattern showed normal variability along the RSRL line over time.) (Figure 7-2). Other radionuclides associated with Area G operations like tritium and plutonium-239/240 in the San Ildefonso soil sample were very similar to past years, are not increasing over time, and remain below the RSL (Figures 7-3 and 7-4).

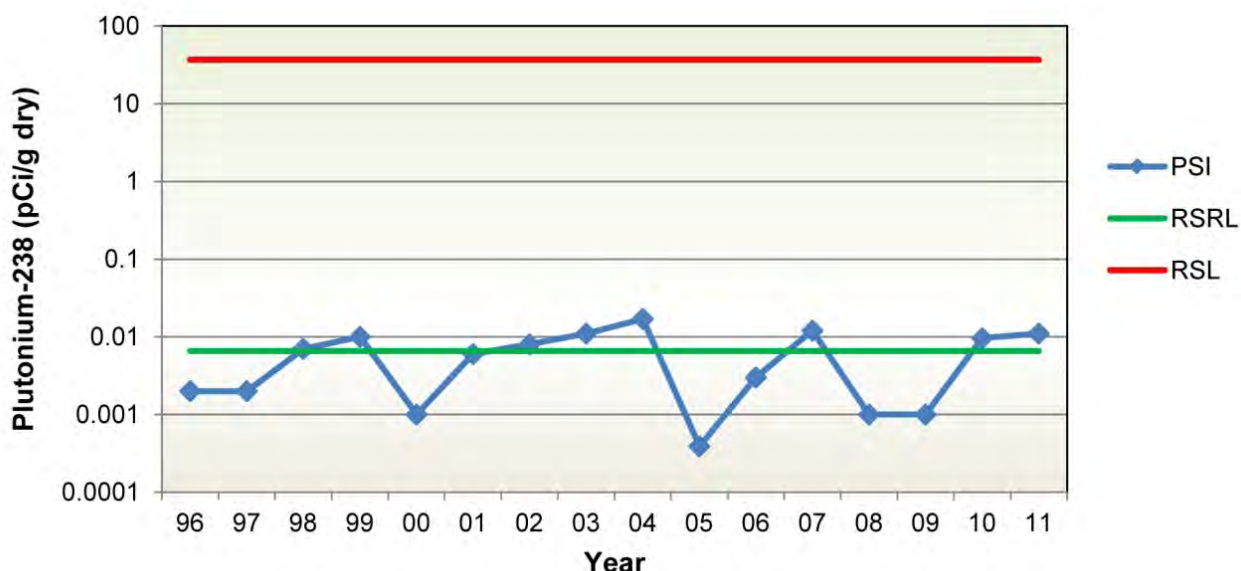


Figure 7-2 Plutonium-238 (detectable and nondetectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL

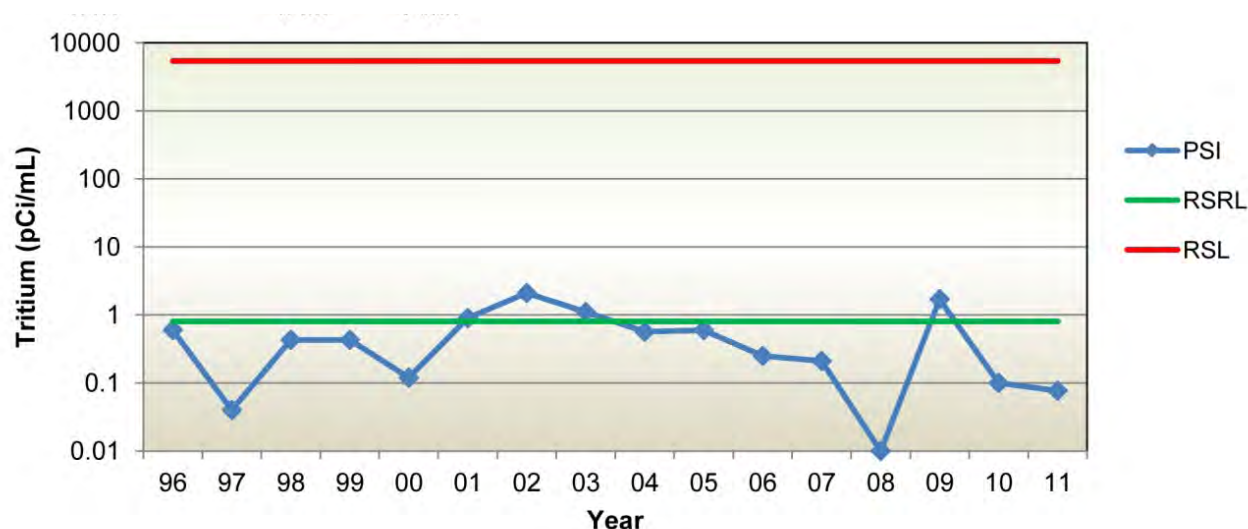


Figure 7-3 Tritium (detectable and nondetectable) concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL

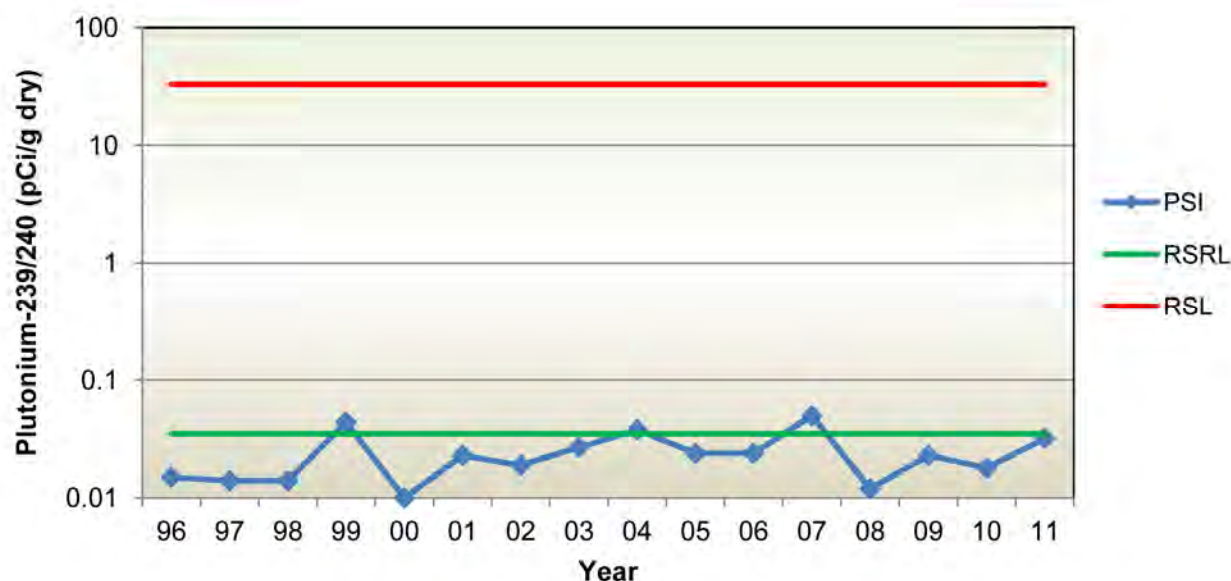


Figure 7-4 Plutonium-239/240 (detectable and nondetectable) concentrations in soil samples collected from PSI lands approximately 0.5 mile northeast of Area G from 1996 through 2011 compared with the RSRL and the RSL

4. TAL Elements

Table S7-2 shows the results of the TAL element analyses in surface soil collected from the two perimeter sites located on Pueblo de San Ildefonso lands in 2011. All heavy metal concentrations were either not detected or detected below RSRLs (based on 1999–2009 data; n=12 to 29), and other TAL elements like barium, sodium, and selenium that were higher than the RSRLs were far below RSLs.

D. FACILITY MONITORING

1. Monitoring Network for Area G at TA-54

The Laboratory has conducted facility-specific soil monitoring at Area G since 1980 (Environmental Surveillance Group 1981; Mayfield and Hansen 1983). Area G is a 63-acre radioactive waste processing area located on the east end of Mesita del Buey at TA-54 (Lopez 2002) (Figure 7-1). Established in 1957, Area G is the Laboratory's primary low-level radioactive solid waste burial and storage site (Hansen et al. 1980, Sohlt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials disposed at Area G (DOE 1979).

Thirteen surface-soil samples were collected in May 2011 at designated locations around the perimeter of Area G, and one surface-soil sample (site #T3) was collected at the LANL/Pueblo de San Ildefonso boundary line approximately 800 ft. northeast and downwind and downgradient of Area G in Cañada del Buey (Figure 7-5). (Note: We report on the analyses of vegetation collected around the Area G facility in Chapter 8, Section B.5.a.)

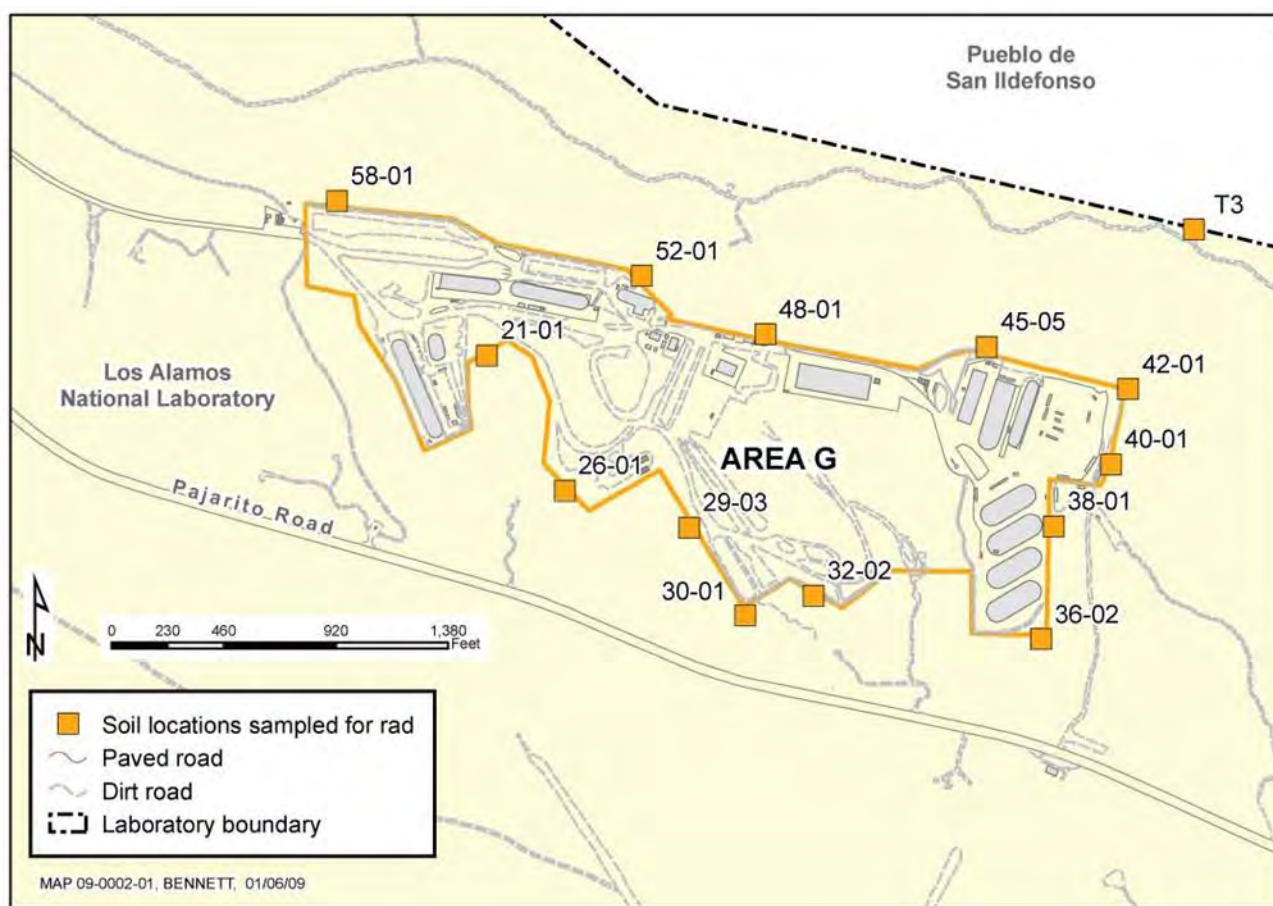


Figure 7-5 Locations of soil samples collected around Area G in 2011

All samples were analyzed by ALS Laboratory Group for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. The results from these samples are presented in supplemental Table S7-3.

TAL elements at Area G were not analyzed in 2011 because previous sampling showed no levels of concern. Results from previous sampling periods for most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007), and the few detected above RSRLs were far below the ISLs with no trends were evident.

2. Radionuclide Analytical Results for Area G

a. Perimeter Results

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected at concentrations above the RSRLs in several of the 13 soil samples collected around the perimeter of Area G in 2011 (Table S7-3).

Specifically, tritium was detected above the RSRL (0.80 pCi/mL) in 23% of the samples collected around Area G. The highest concentrations were detected in the southern portion where the tritium shafts are located; site #29-03 had 70 pCi/mL and site #30-01 had 164 pCi/mL. Although these data are within the range of concentrations detected in past years, they are quite variable from year to year (Figure 7-6).



Figure 7-6 Tritium concentrations in surface-soil samples collected from the southern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

The degree of variability in tritium concentrations in surface soil from year to year may be influenced by engineering and environmental factors (Purtymun 1973, Abeele and Nyhan 1987, Vold 1997, Childs and Conrad 1999, Budd et al. 2004). Nonetheless, the concentrations of tritium in soil at Area G are far below the ISL of 3.1E06 pCi/mL (equivalent to 4.4E05 pCi/g at 12% moisture), and the migration of tritium from the Area G boundary at surface depths is not extensive. In a 2003 study, the measurement of tritium in trees at the southern portion of Area G, starting from the perimeter fence line outward (approximately 33, 165, 330, 490, and 660 ft), showed that the concentrations of tritium decreased greatly with distance; and at about 330 ft away, the concentrations of tritium were similar to the RSRL (Fresquez et al. 2003).

More than 50% of the soil samples collected around the perimeter of Area G contain concentrations of americium-241, plutonium-238, and plutonium-239/240 greater than their respective RSRLs, particularly around the perimeter of the northern, northeastern, and eastern sections (Table S7-3). The highest concentrations of americium-241 (0.40 pCi/g dry at site #45-05), plutonium-238 (2.2 pCi/g dry at site #40-01), and plutonium-239/240 (37 pCi/g dry at site #38-01) were detected in soil samples located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project domes. Although the concentrations of these radionuclides in soil collected around the perimeter of Area G are higher than the RSRLs, all levels are still far below ISLs, and except for their high variability from year to year at some points, the concentrations of most radionuclides at most sites are generally not increasing over time (Figures 7-7, 7-8, and 7-9). An exception may be concentrations of plutonium-239/240 in soil collected from the eastern side of Area G (site #38), which may be increasing over time.

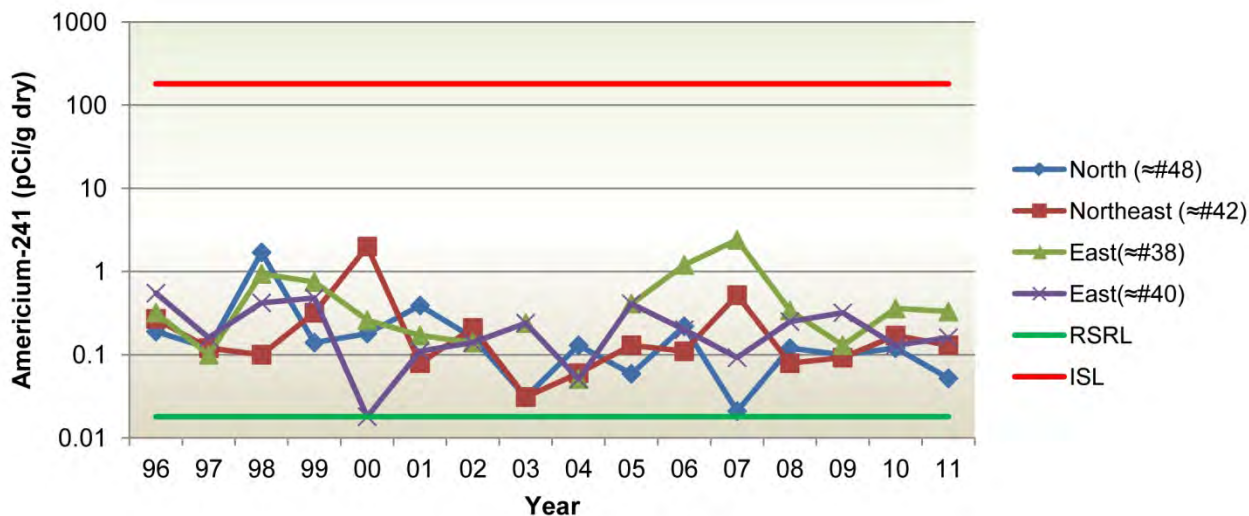


Figure 7-7 Americium-241 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

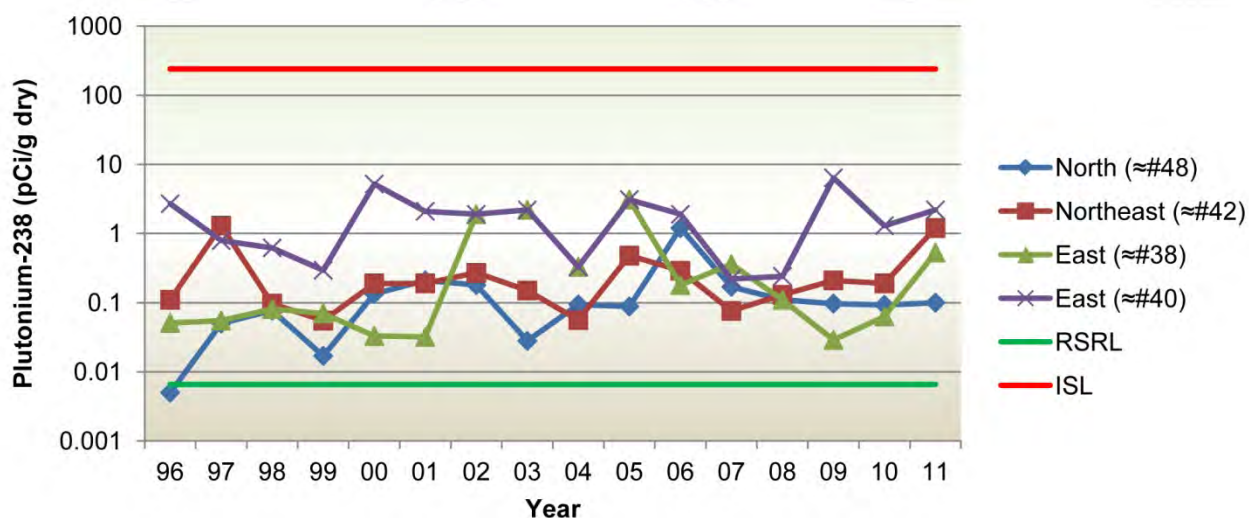


Figure 7-8 Plutonium-238 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

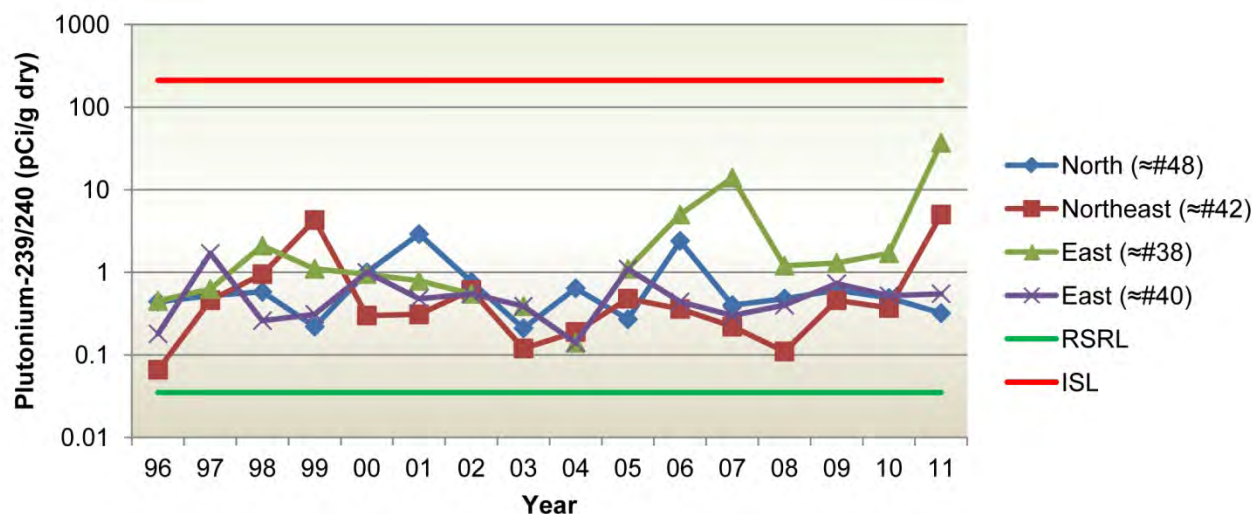


Figure 7-9 Plutonium-239/240 concentrations in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2011 compared with the RSRL and the ISL. Note the logarithmic scale on the vertical axis.

b. Results at the Pueblo de San Ildefonso Boundary

Americium-241, plutonium-238 and plutonium-239/240 in a soil sample collected at the LANL/Pueblo de San Ildefonso boundary northeast, downwind, and downgradient of Area G in Cañada del Buey (Site #SI-T3) were detected at concentrations just above the RSRLs in 2011 (Table S7-3). However, the levels of these radionuclides were far below the RSLs and have generally remained stable over the six-year period of study (Figures 7-10, 7-11, and 7-12).

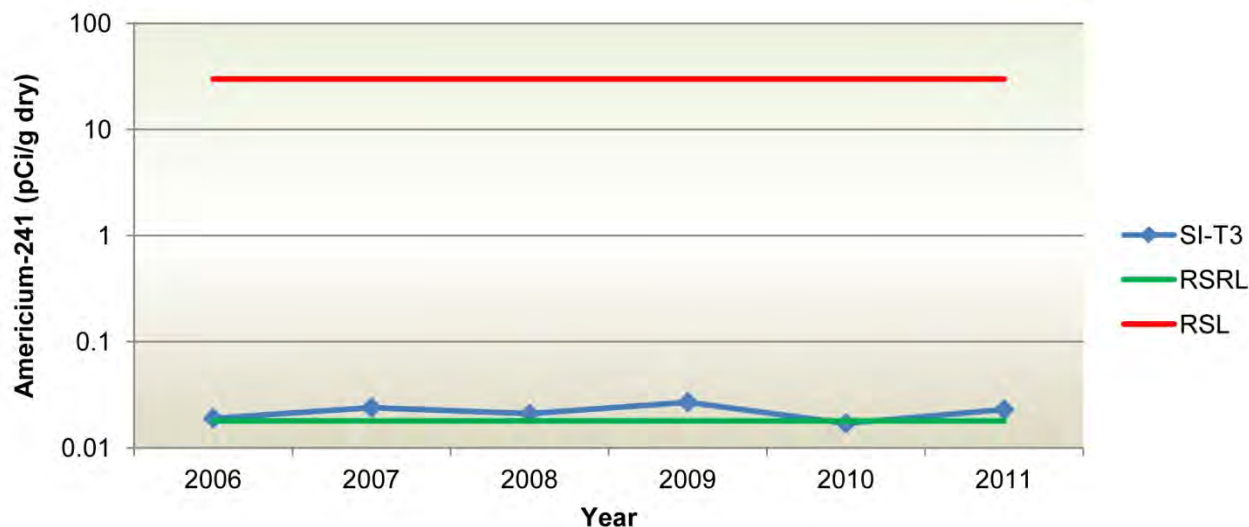


Figure 7-10 Americium-241 (detectable and nondetectable) concentrations in surface soil collected from the LANL/Pueblo de San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2011 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

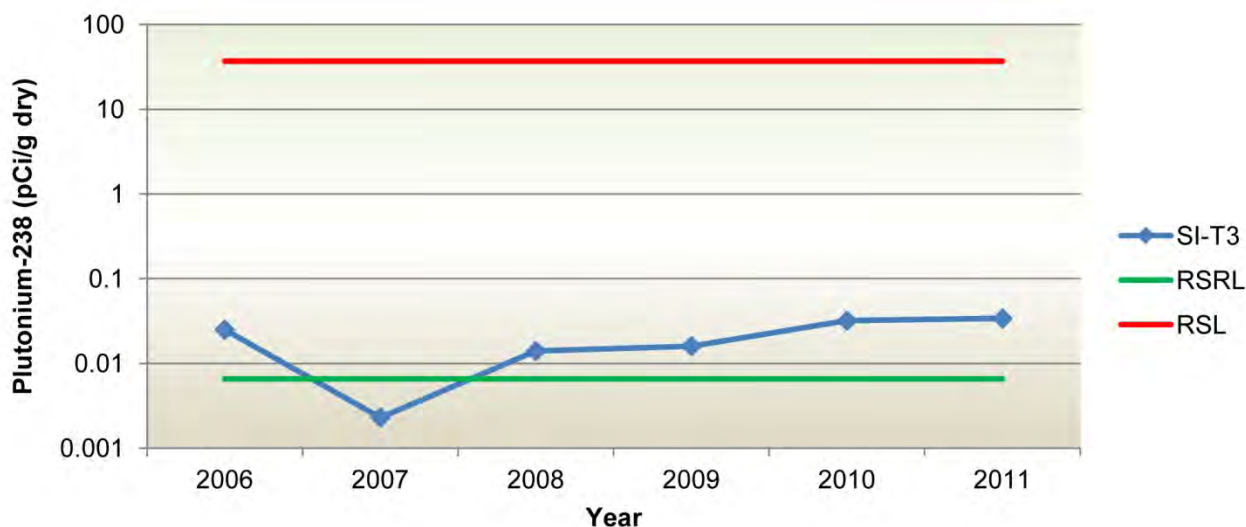


Figure 7-11 Plutonium-238 (detectable and nondetectable) concentrations in surface soil collected from the LANL/PSI boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2010 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

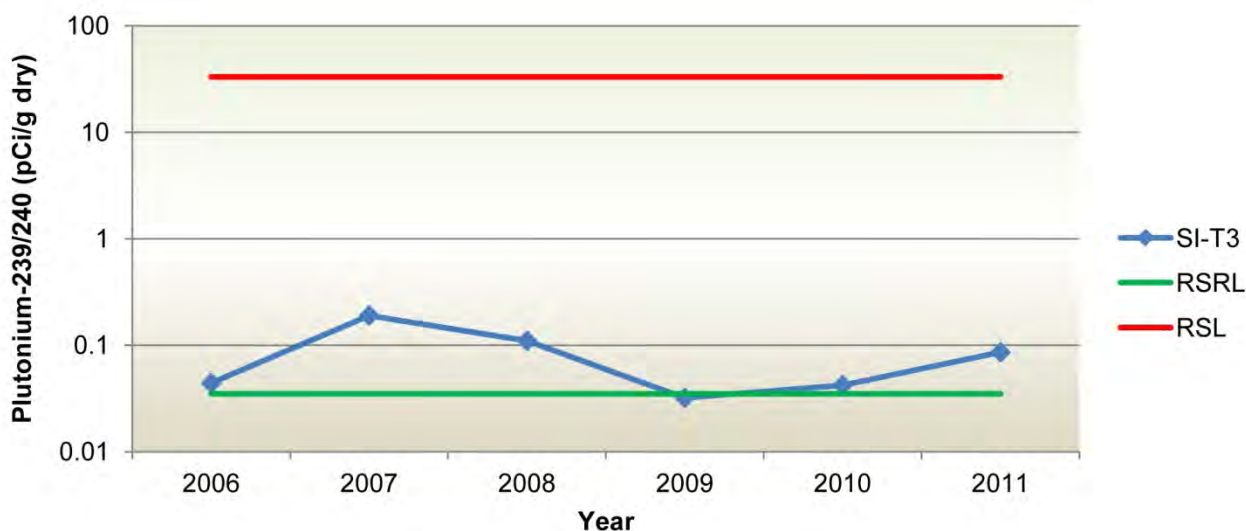


Figure 7-12 Plutonium-239/240 (detectable and nondetectable) concentrations in surface soil collected from the LANL/PSI boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2011 compared with the RSRL and the RSL. Note the logarithmic scale on the vertical axis.

3. Monitoring Network for DARHT at TA-15

The Laboratory has conducted facility-specific soil and sediment monitoring on an annual basis at DARHT since 1996 (Nyhan et al. 2001). Approximately 20 acres in size, DARHT is located at R-Site (TA-15) at the Laboratory's southwestern side (see Figure 7-1). Activities at DARHT include the use of very intense x-rays to radiograph a full-scale non-nuclear mockup of a nuclear weapon's primary during the late stages of the explosively driven implosion of the device (DOE 1995). Open-air detonations occurred from 2000 to 2006; detonations using foam mitigation were conducted from 2002 to 2006; and detonations within closed steel containment vessels were conducted starting in 2007 (three in fiscal year [FY] 2007, two in FY08, none in

FY09, four in FY10, and three in FY11) (DOE 2012). Potential contaminants of concern include radionuclides, beryllium (and other heavy metals), and organic chemicals like PCBs, SVOCs, and HE.

Soil samples were collected in July 2011 on the north, east, south, and west sides (Figure 7-13) of the DARHT perimeter along the outside fence line. An additional soil sample was collected about 75 ft north of the firing point. (The firing point has since been paved and this was the closest soil site.) Sediment samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed by ALS Laboratory Group for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, TAL elements, and HE. The firing point sample was also analyzed for dioxins and furans by Cape Fear Analytical. Although not analyzed for in 2011, PCBs and SVOCs were not detected in soil and sediment samples collected within and around the perimeter of the DARHT facility in 2007 (Fresquez 2008). (Note: We report on the analyses of vegetation, small mammals, bees, and birds collected around the DARHT facility in Chapter 8, Section B.5.b.)

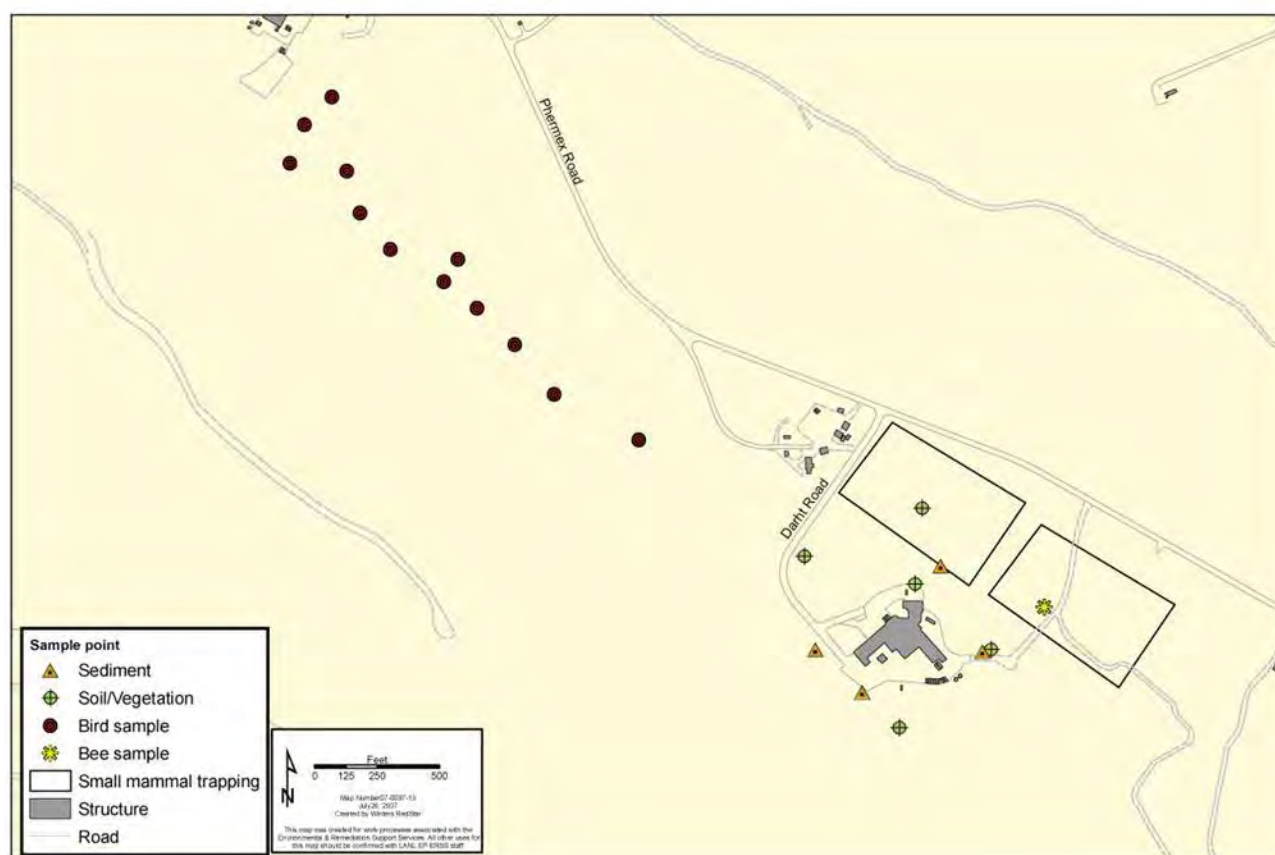


Figure 7-13 Soil, sediment, and biota sample locations at DARHT in 2011

We compared the radionuclide and TAL element results in soil and sediment from the DARHT sampling with both RSRLs and BSRLs. The BSRLs are the concentrations of radionuclides and inorganic chemicals (mean plus three standard deviations) in soil and sediment collected from around the DARHT facility from 1996 through 1999 before the start-up of operations (Fresquez et al. 2001), per the DARHT mitigation action plan (DOE 1996). Both reference levels are employed because the BSRLs for some elements may be

biased as a result of changes in pre- and post-sampling locations and a change in analytical techniques. A comparison of BSRLs with RSRLs, for example, shows that some baseline radionuclide concentrations, such as cesium-137 from fallout, may be biased low and some baseline inorganic chemical concentrations, such as silver, may be biased high regardless of DARHT activities. Moreover, some TAL elements analyzed recently have no baseline levels at all. To accommodate parking spaces and storage areas within the DARHT complex after operations began, soil sampling locations had to be moved from within the fenced perimeter boundary (< 100 ft. from the facility) to sites located outside the perimeter fence boundary (> 300 ft. from the facility). This may have affected the concentrations of some radionuclides, particularly cesium-137 (fallout) because the pre-operation samples were collected in mostly disturbed soil and the post-operation start-up samples were collected in mostly undisturbed soil.

Higher amounts of fallout radionuclides would be expected in the undisturbed soil rather than the disturbed soil because of the mixing associated with disturbed soil. Moreover, the change in analytical techniques may have improved detection capabilities for some metals. The use of inductively coupled plasma mass spectrometry instrumentation to analyze post-operation start-up samples, for example, substantially decreased the detection limits of silver, from 2 to 0.2 mg/kg.

4. Radionuclide and Chemical Analytical Results for DARHT

Most radionuclides in soil and sediment collected from within and around the perimeter of the DARHT facility were either not detected or below the statistical reference levels (Table S7-4). Tritium, americium-241, and uranium-238 in only one soil sample on the south side were detected above the statistical reference level; but the amounts were far below the ISLs and do not pose an unacceptable dose to any site workers. In the past, uranium isotopes, but predominantly uranium-238, were detected above the BSRL in soil samples collected on the north side of the firing point. Uranium-238 concentrations peaked in 2008 (55 pCi/g dry), and since operations have changed to closed containment vessels (and subsequent cleanup of debris around the site), the concentrations of uranium-238 within and around the facility have decreased dramatically to baseline levels (Figure 7-14).

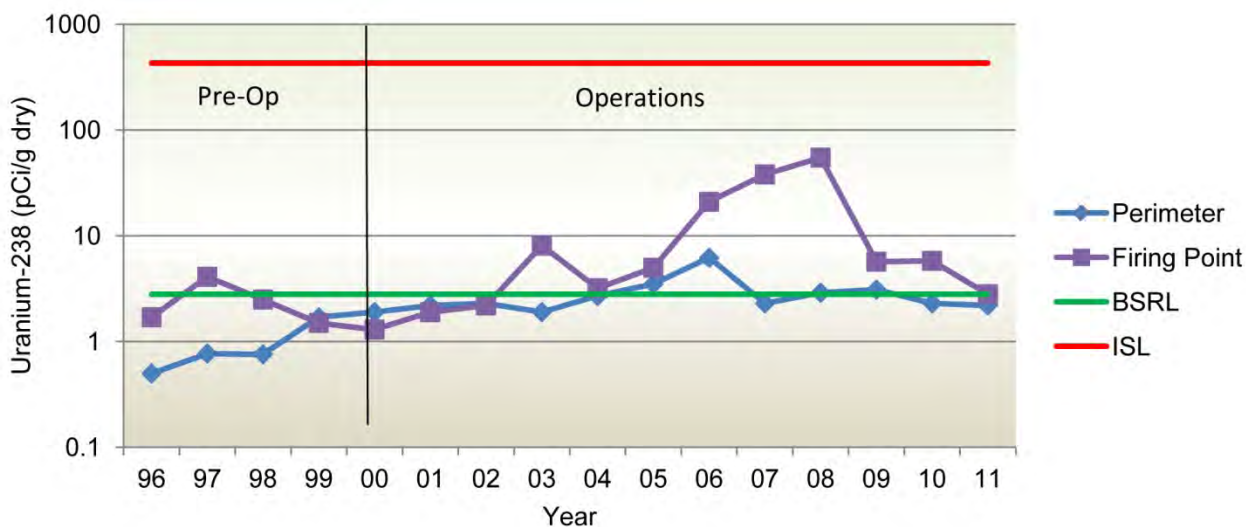


Figure 7-14 Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2011 (operations) compared with the BSRL and the ISL. Note the logarithmic scale on the vertical axis.

All of the TAL elements, including beryllium, in the soil and sediment samples collected within and around the DARHT facility were below both the baseline and regional statistical reference levels (Table S7-5). Beryllium, listed as a chemical of concern before the start-up of operations at DARHT (DOE 1995), was not

detected in any of the soil or sediment samples above reference levels. Also, beryllium concentrations in soil over the 12-year operations period have remained relatively stable over time (Figure 7-15).

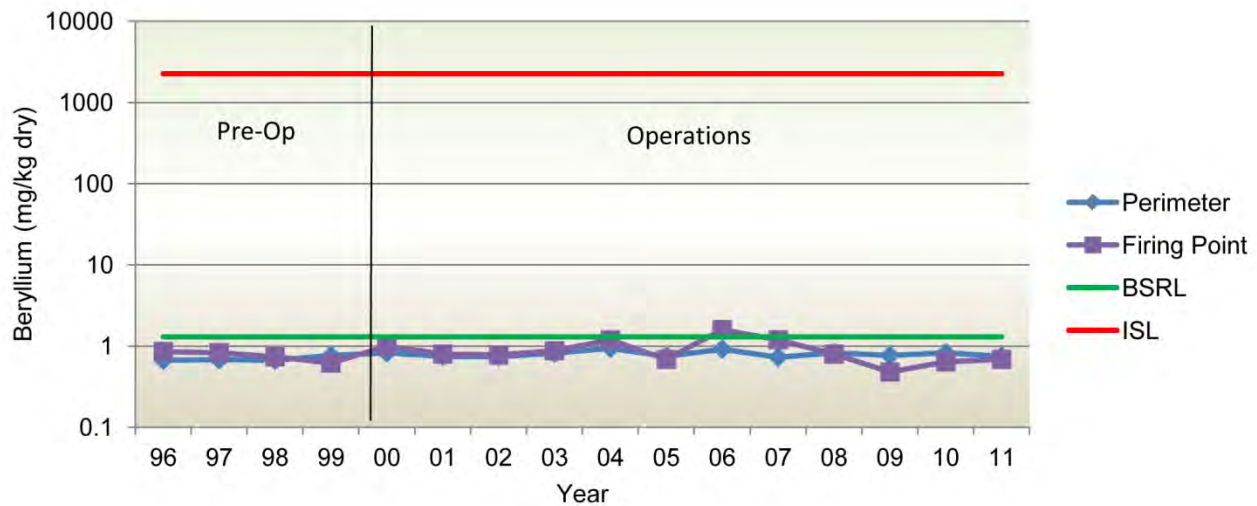


Figure 7-15 Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north-, west-, south-, and east-side average) at TA-15 from 1996–1999 (preoperations) to 2000–2011 (operations) compared with the BSRL and the ISL. Note the logarithmic scale on the vertical axis.

HE were not detected in any of the soil or sediment samples collected within and around the perimeter of the DARHT facility, including the sample closest to the firing point (Table S7-6). Also, dioxins and furans were not detected above the limit of quantification (reporting limit) in the soil sample nearest the firing point (Table S7-7).

E. SPECIAL MONITORING STUDIES

No special soil monitoring studies were conducted in 2011.

F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

1. Quality Assurance Program Development

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

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program (SOP-5132)
- Sampling Soil and Vegetation at Facility Sites (SOP-5139)

These procedures, which are available on the LANL public website (<http://www.lanl.gov/environment/all/qa.shtml>), ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

2. Field Sampling Quality Assurance

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

The sampling team collects all samples under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, we hand-deliver the samples to the LANL Sample Management

Office, which ships them via express mail directly to an external analytical laboratory under full chain-of-custody control. The project leader of the Soil, Foodstuffs, and Biota monitoring program tracks all samples. Upon receipt of data from the analytical laboratory (electronically and in hard copy), the completeness of the field-sample process and other variables is assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

Field data completeness for SFB in 2011 was 99%.

3. Analytical Laboratory Quality Assessment

We had no analytical laboratory data quality issues related to the SFB sampling program during 2011. Detailed discussion of overall analytical laboratory quality performance is presented in Chapter 11. Analytical data completeness for all SFB sampling programs was 99% in 2011.

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To Read About**Turn to Page**

<i>Foodstuffs Monitoring</i>	8-1
<i>Biota Monitoring</i>	8-22
<i>Special Monitoring Studies</i>	8-31
<i>Quality Assurance for the Soil, Foodstuffs and Biota Program</i>	8-40
<i>References</i>	8-40

A. FOODSTUFFS MONITORING**1. Introduction**

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains, are grown and/or harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). Also, many food products from domestic livestock (e.g., milk, eggs, and meat) and apiaries (honey) are available, and fishing in waters downstream of the Laboratory (e.g., Rio Grande) and hunting (e.g., rabbits, turkey, deer, and elk) on neighboring properties around LANL are a common occurrence.

The purpose of the foodstuff monitoring program is to determine whether Laboratory operations are affecting human health via the food chain. US Department of Energy (DOE) Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b) define the framework and requirements for this monitoring program. We accomplish this effort through the following tasks:

- 1) Measure the concentrations of radionuclides and other chemicals (which have a history of use at LANL) in foodstuffs on Laboratory land, if available, at the perimeter of LANL land (neighboring communities and potentially impacted regions), and in regional (background) areas (areas > 9 miles from LANL);
- 2) Assess radionuclide and other chemical concentrations in foodstuffs over time (e.g., are concentrations increasing or decreasing?); and
- 3) Estimate LANL-derived dose, if any, from the consumption of the foodstuffs. (See Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs.)

As part of the soil (Chapter 7), foodstuffs, and biota (Chapter 8) program, we conduct sampling of major area resources on a three-year rotating schedule. The collection of surface soil- and native vegetation-related samples was completed in 2009 (Fresquez 2010), and the collection of agriculture-related samples (produce crops, goat milk, chicken eggs, and honey) from the neighboring communities surrounding the Laboratory was accomplished in 2010 (Fresquez et al. 2011). This year, we present the results of Rio Grande-related samples (fish, crayfish, and benthic macroinvertebrates) upstream and downstream of the Laboratory.

Other foodstuffs like wild edible food plants, livestock, and game animals are analyzed as they become available and an adequate number of samples can be submitted to the laboratory. This year we present the results of several (road-killed) elk and deer collected along roads that cross LANL lands.

2. Foodstuffs Comparison Levels

Concentrations of detected radionuclides and chemicals in foodstuffs potentially impacted by LANL operations are first compared with background-based screening levels. Regional statistical reference levels (RSRLs) are the upper-level background concentration (mean plus three standard deviations = 99% confidence level) for radionuclides (both detected and nondetected values are used) and chemicals calculated from foodstuffs collected from regional locations away from the influence of the Laboratory (more than nine miles away) (DOE 1991). The concentrations of radionuclides and chemicals in foodstuffs collected from regional background areas are the result of worldwide fallout and natural processes (e.g., elements in soil to plants to animals). (Note: In some cases where there are numerous detections above RSRLs [$>25\%$] and there is an adequate number of samples collected from both potentially impacted and non-impacted areas, a statistical test at the 0.05 probability level may be used to aid in comparisons and interpretation.)

If any radionuclide/chemical concentration in a foodstuff exceeds the RSRL(s), we would then compare the concentration with dose- or risk-based screening levels (SLs). For radionuclides, the SLs in concentration units are based on 4% (= 1 mrem/yr) (LANL 2003) of the 25-mrem/yr DOE single-pathway constraint (DOE 1999, 2011b) so that potential concerns may be identified in advance of the standard, i.e., a “yellow flag.” If a radionuclide concentration exceeds an SL, the basis for that increase is investigated. For target analyte list (TAL) elements, with the exception of mercury in aquatic animals, there are no SLs for the majority of foodstuffs collected around LANL. The SL for mercury in aquatic animals, based on US Environmental Protection Agency (EPA) guidelines, is 0.30 mg/kg wet weight (parts per million) (EPA 2001). (Note: Although not SLs, per se, EPA guidelines for limited consumption of fish are based on the amounts of mercury, cadmium, selenium, and arsenic [EPA 2007]. They are presented as a range and as the concentrations increase, the number of fish that can be consumed decreases.) Similarly, for polychlorinated biphenyls (PCBs) in fish, we use EPA guidelines for SLs; in this case, we would compare total PCBs with the EPA risk-based consumption limits for human health (EPA 2007).

If radionuclides, mercury, or PCB concentrations exceed an SL, they would then be compared with the applicable action limit. In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured within a single pathway and compared with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999, 2011b). In the case of mercury and PCBs, the concentrations would be compared with the Food and Drug Administration (FDA) action limits of 1 mg/kg (fish) and 3 mg/kg (red meat and poultry), respectively (FDA 2000). Table 8-1 presents a summary of the RSRLs, SLs, and the standards used to evaluate the results of radionuclides, mercury, and PCBs in foodstuffs.

3. Fish Monitoring

a. Monitoring Network

Fish have been collected for radionuclide analysis from two general reaches as they relate to the location of LANL since 1981 (Fresquez et al. 1994); these locations are upstream of LANL (background) on the Rio Chama/Rio Grande and downstream of LANL on the Rio Grande (Figure 8-1). This year, samples were mostly collected during and after the Las Conchas Fire—a large wildfire that started on June 26, 2011, and by August 1, 2011, had burned approximately 156,593 acres (63,371 ha) of watershed above and adjacent to LANL on the western side. As a result of the fire, several flooding events occurred from many canyon confluences upstream and downstream of LANL to the Rio Grande during the fish sampling period; this included the Los Alamos Canyon (LAC) as evidenced by ash residue at the LAC/Rio Grande confluence.

Of the major drainages that cross LANL lands, the LAC drainage system has been identified as containing the highest concentrations of LANL-derived substances (e.g., plutonium and PCBs) (Gallaher and Efurud 2002, Reneau and Koch 2008, Fresquez et al. 2008). The LAC drainage system also has the greatest potential for transporting these substances to the Rio Grande, which is approximately 5 miles (8 km) away (Abee et al. 1981). As a result of this and because of the Cerro Grande Fire, a low-head weir in LAC was constructed in 2001 to reduce potential contaminant-laden sediments past the northeastern boundary of LANL (Fresquez 2006). The weir consists of a gabion rock-filled structure that lies across the streambed in LAC near the junction of NM 4 and NM 502. Non-Laboratory sources also contribute radionuclides and chemicals to the LAC drainage; these include constituents in storm water carried from roads and grounds from the Los Alamos town site, treated effluent from the Los Alamos sewage treatment plant, atmospheric fallout of radionuclides, and some naturally occurring and anthropogenic materials in ash from the forest fires surrounding the Laboratory (Cerro Grande Fire in May 2000 and the Las Conchas Fire in June of 2011) (Miranda 2009, LANL 2011a). In addition, there are other tributaries (Guaje Canyon and Pueblo Canyon) that contribute storm water to the LAC drainage.

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

Constituent	Media	Standard	Screening Level	Background Comparison Level
Radionuclides	All foodstuffs	25 mrem/yr	1.0 mrem/yr	RSRLs
Mercury	Aquatic animals	FDA: 1 ppm (wet) in edible portion (complete consumption restrictions)	EPA: 0.30 ppm (wet) in edible portion	RSRLs
TAL Elements per EPA Risk-Based Consumption Limits of Edible Portions				
Mercury	Fish		0.029–1.9 ppm (wet)	RSRLs
Cadmium	Fish		0.088–5.6 ppm (wet)	
Selenium	Fish		1.5–94 ppm (wet)	
Arsenic	Fish		0.002–0.13 ppm (wet)	
PCBs	Red meat and poultry	FDA (complete consumption restrictions). Total PCBs = 3 ppm		RSRLs
	Fish		EPA (limited consumption restrictions). Total PCBs = 0.0015–0.094 ppm	RSRLs

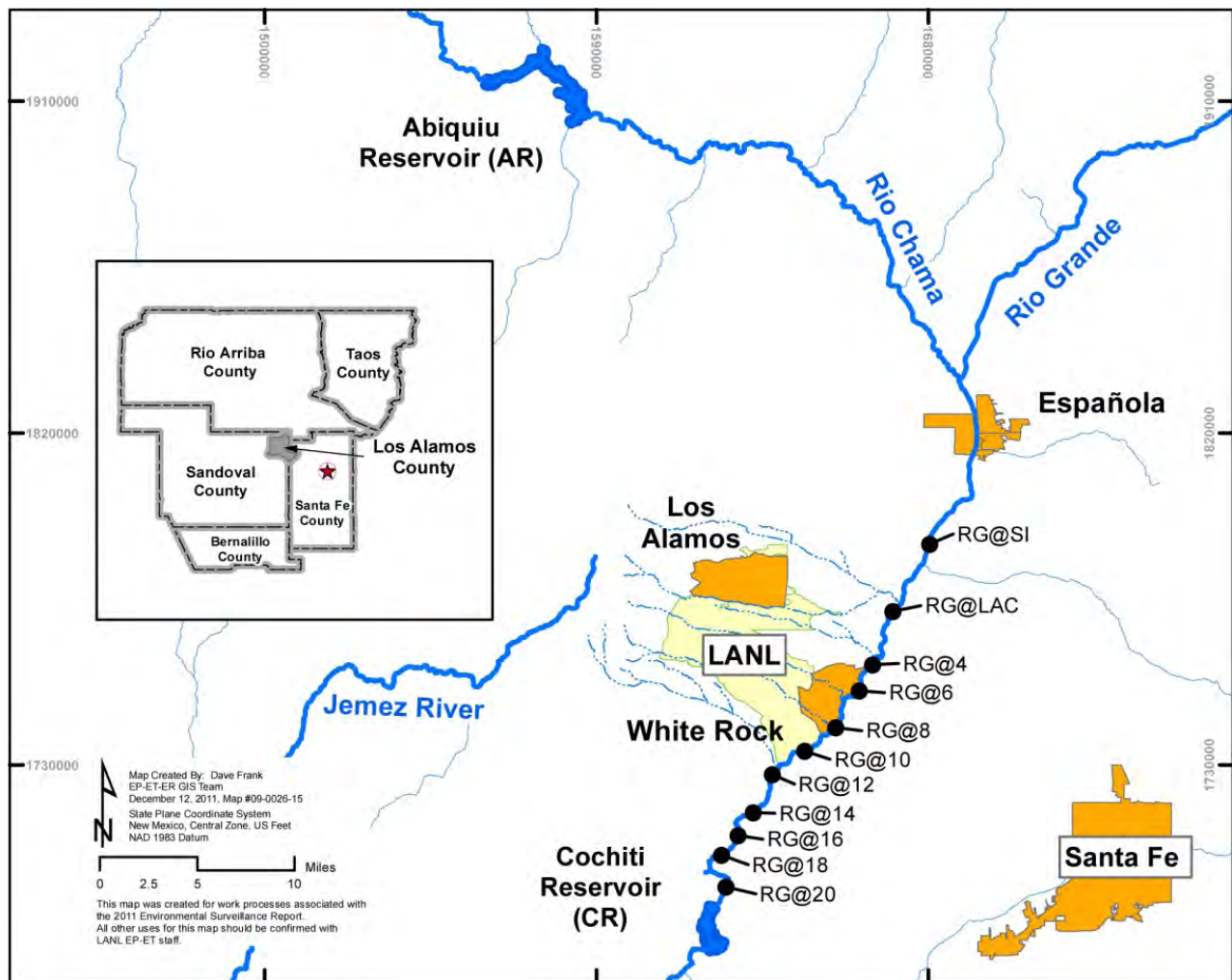


Figure 8-1 Locations of fish collected upstream and downstream of LANL on the Rio Chama and Rio Grande

Background fish samples were collected from two locations upstream of LANL: (1) Abiquiu Reservoir (AR) on the Rio Chama and (2) along the Rio Grande as it passes through the Pueblo de San Ildefonso (SI) lands to the Otowi Bridge.

Downstream samples were collected from the following locations: (1) Rio Grande below the confluence of LAC, (2) Rio Grande at 4, 6, 8, 10, 12, 14, 16, 18, and 20 river miles from LAC (collected in 2010), and (3) Cochiti Reservoir (CR).

Two types of fish were collected for study based on their principal feeding strategy: predator fish and bottom-feeding fish. Predator fish are mostly carnivorous (eat other fish) and were collected solely from AR and CR. These fish included the northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieu*), white crappie (*Pomoxis annularis*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and walleye (*Stizostedion vitreum*). Bottom-feeding fish are mostly omnivores (eat anything) and feed at the bottom of lakes and rivers. These fish were collected from every upstream and downstream location and include the white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpionodes carpio*). Table 8-2 is a summary table showing all locations, dates of collection, and the number and types of fish collected.

Table 8-2
Locations and Types of Fish Collected

River System/Location/Collection Date	Location as Related to LANL Confluences	Type and Number of Fish Collected
Rio Chama/Abiquiu Reservoir/8-3-2011	Approximately 44 miles upstream of LAC (LAC is the first and most significant canyon that passes through LANL.)	Predator (4) and Bottom Feeders (9)
Rio Grande/San Ildefonso/6-22-2011 and 8-9-2011	Approximately 2 to 4 miles upstream of LAC (above the Otowi Bridge to Black Mesa).	Bottom Feeders (9)
Rio Grande/Los Alamos Canyon/8-11-2011 and 8-17-2011	LAC—first LANL canyon confluence (below Otowi Bridge)	Bottom Feeders (5)
Rio Grande/Nine Reaches from LAC/8-2-2010	4, 6, 8, 10, 12, 14, 16, 18, and 20 river miles from LAC	Bottom Feeders (9)
Rio Grande/Cochiti Reservoir/7-13-2011	Downstream of all LANL/canyon confluences	Predator (10) and Bottom Feeders (7)

Fish were collected using nets, electroshocking devices (by the New Mexico Department of Game and Fish), and rod and reel. At each collection site, fish were processed according to standard operating procedures to obtain samples for radionuclides, TAL elements (mostly metals), and PCBs. In general, samples of fish for radionuclide analysis were processed by removing the viscera and head, rinsing the fish thoroughly, and then placing the remaining muscle plus bone tissues into Ziploc plastic bags. (Note: A fish sample for radionuclide analysis sometimes contained more than one fish of the same species in order to obtain an adequate sample size; about 3 lb of material was required.) Samples for TAL elements and PCB analysis were obtained from the same single fish. A fillet (muscle plus skin) for TAL elements was collected from one side of the fish and placed in a Ziploc bag, and a sample for PCBs was collected from the other side of the fish and placed into a 500-mL amber glass jar. All samples were labeled, sealed with chain-of-custody tape, placed into a cooled ice chest, and submitted under full chain-of-custody procedures to our Sample Management Office (SMO), where they were then sent to ALS Laboratory Group (Fort Collins, CO) for radionuclide and TAL element analysis and to Cape Fear Analytical, LLC, (Wilmington, NC) for PCB analysis.

The radionuclides analyzed were tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL basis. Results of the other radionuclides were reported in pCi/g dry after multiplying the results obtained from the analytical laboratory (in ash) by the ash-to-dry weight conversion factor of 0.12 for predator fish and 0.095 for bottom-feeding fish (Fresquez et al. 2007a).

TAL elements analyzed were aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a wet weight basis in mg/kg.

PCBs were analyzed for 209 possible chlorinated congeners; a congener is a specific PCB compound with a certain number of chlorine atoms in certain positions around a biphenyl ring (EPA 1996). For summary and reporting purposes, PCB congeners were grouped together into 10 homologs; a homolog is a group of congeners with the same number of chlorine atoms, which allows visual comparison of similarities or differences between samples or groups of samples. The designations for the 10 homologs range from monochlorobiphenyl (monoCB) to decachlorobiphenyl (decaCB). Homologs and total PCBs are reported on a pg/g (parts per trillion) wet weight basis.

b. Radionuclide Analytical Results

All radionuclide concentrations (activities) in both predator and bottom-feeding fish collected on the Rio Grande at all locations downstream of LANL, including CR, were either not detected (majority of results) or were similar to RSRLs (Tables S8-1 and S8-2, respectively). A nondetected value is one that is less than the minimum detectable activity or one in which the result is lower than three times the counting uncertainty and is not significantly different ($\alpha = 0.01$, or 99% confidence level) from 0 (Keith 1991, Corely et al. 1981), and RSRLs were based on the last five sampling events (2001–2011 data; $n=30$).

A comparison of radionuclides in bottom-feeding fish from AR and CR over a 30-year span shows that there are generally no radionuclides that are increasing in concentrations in fish from CR that are independent of AR from 1981 to present (Figures 8-2 to 8-7). (Note: Bottom-feeding fish were chosen for this example over predator fish because they are the more sensitive of the two fish types—they feed on the bottom where radionuclides readily bind to the sediment.) In fact, a decreasing trend in cesium-137 and strontium-90 concentrations in bottom-feeding fish from both AR and CR is clearly evident and is probably related to the relatively short half-lives (30 years) of these radionuclides (Whicker and Schultz 1982). These findings indicate that transport of legacy materials from the LANL site is not affecting the radionuclide concentrations in fish tissues from CR.

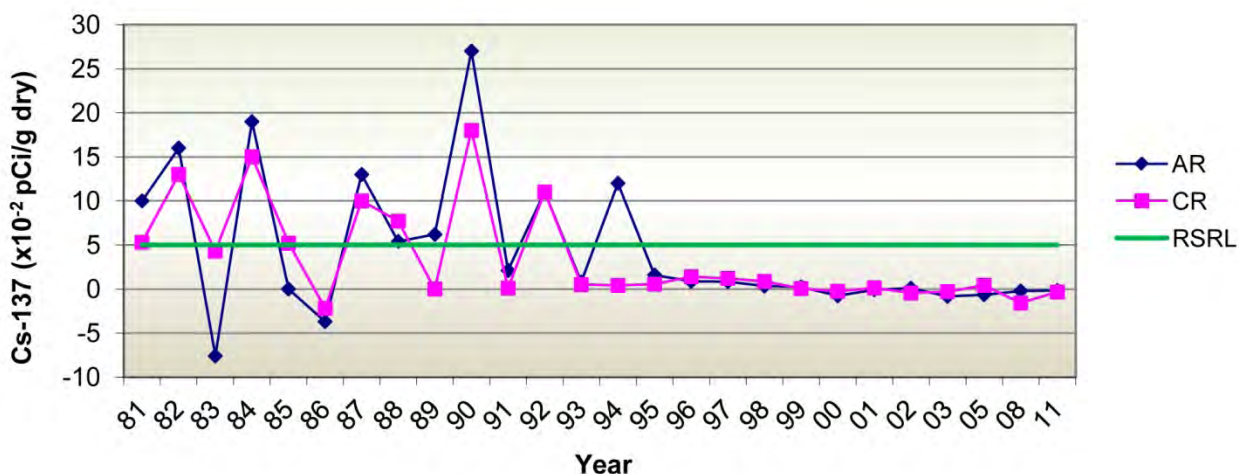


Figure 8-2 Mean cesium-137 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir [AR]) and downstream (Cochiti Reservoir [CR]) of LANL from 1981 through 2011 compared with the RSRL. (Note: The high variability during the early years compared with the latter years was mainly due to the stabilization of instrument background, normalization in counting times, and improvements in the counting technology.)

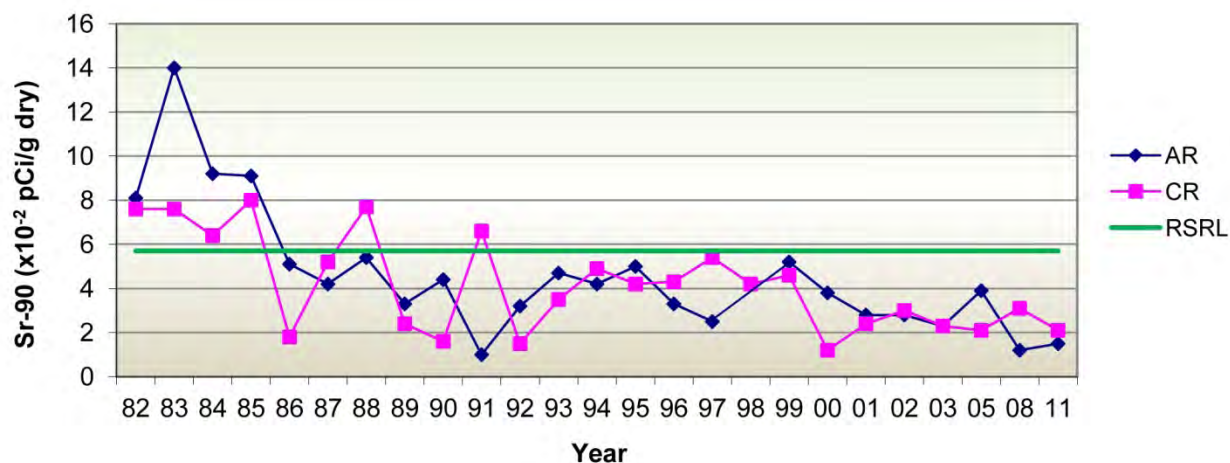


Figure 8-3 Mean strontium-90 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1982 through 2011 compared with the RSRL

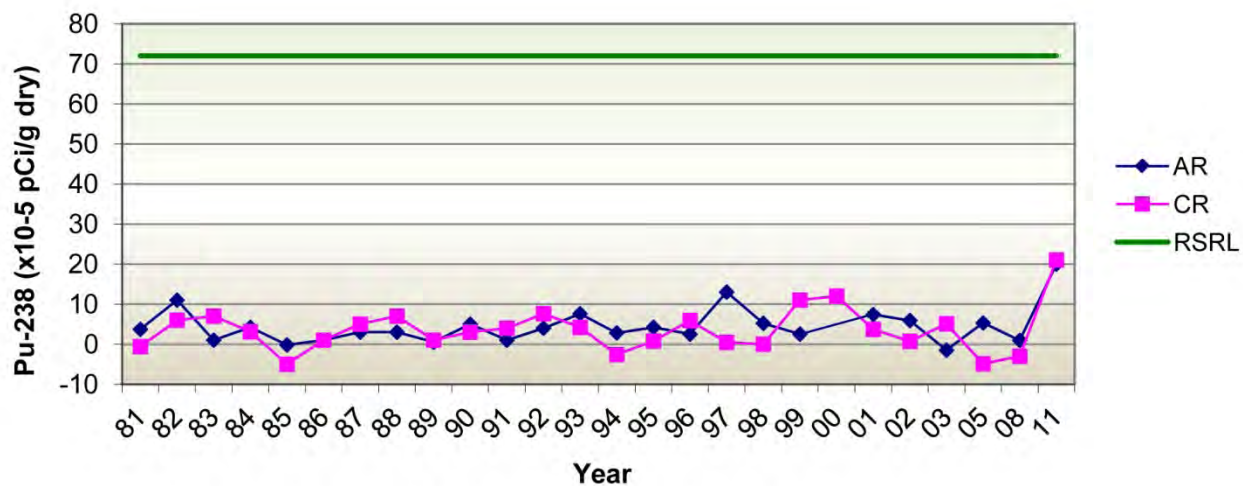


Figure 8-4 Mean plutonium-238 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL

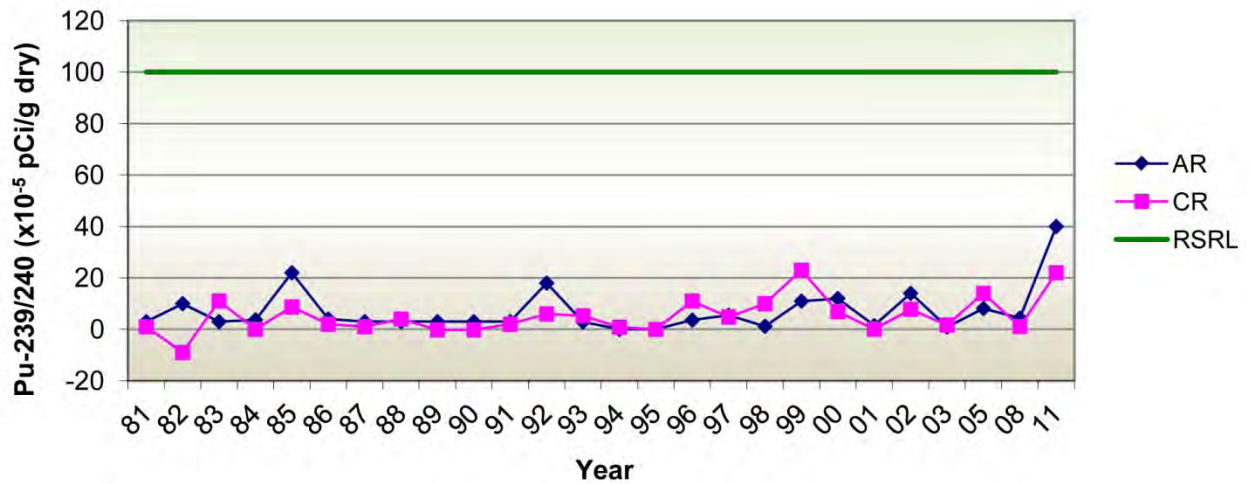


Figure 8-5 Mean plutonium-239/240 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL

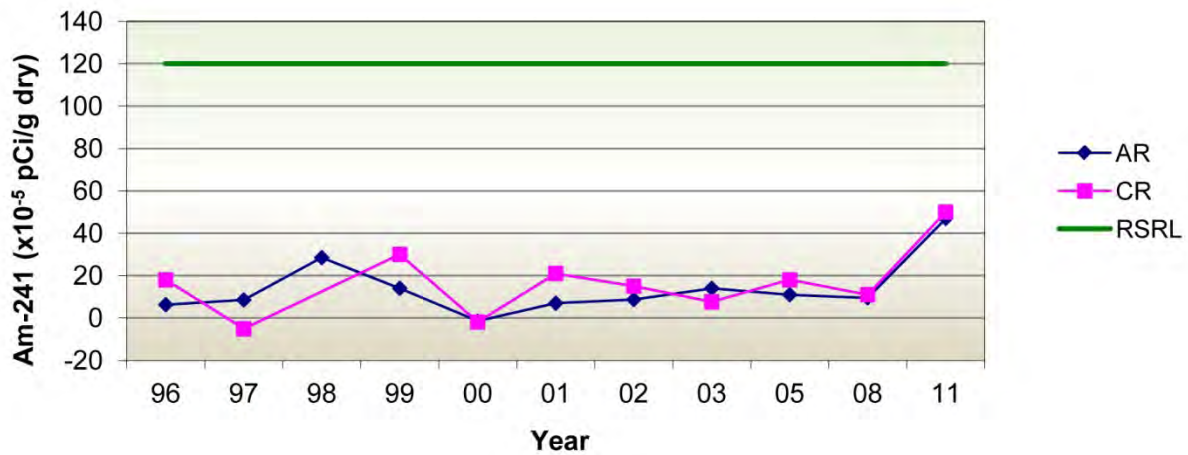


Figure 8-6 Mean americium-241 concentrations in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1996 through 2011 compared with the RSRL

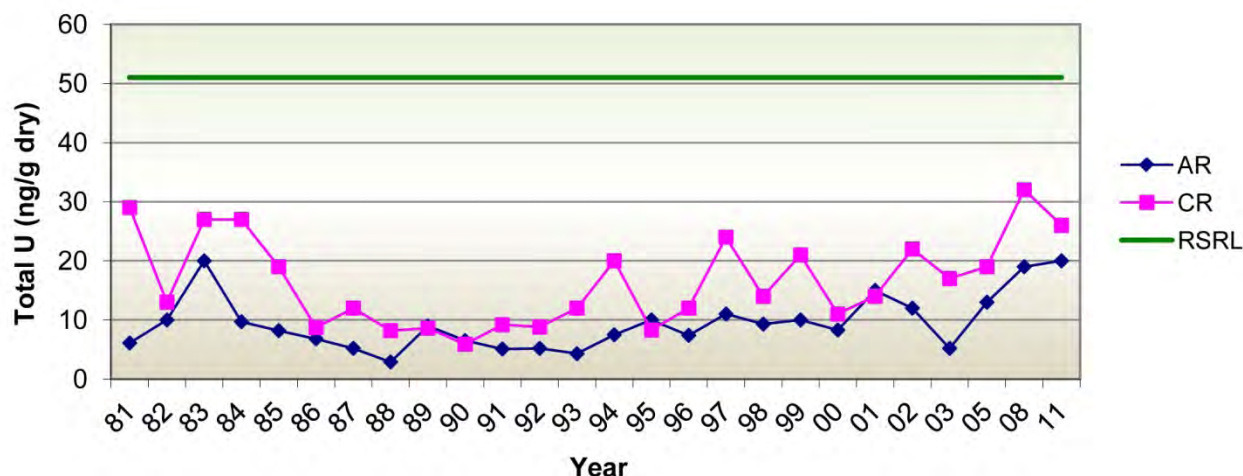


Figure 8-7 Mean total uranium concentrations (all isotopes combined) in bottom-feeding fish upstream (AR) and downstream (CR) of LANL from 1981 through 2011 compared with the RSRL

c. TAL Elements Analytical Results

Most of the 23 TAL elements in the muscle fillet of both predator and bottom-feeding fish collected along the Rio Grande downstream of LANL to CR were either not detected or were below the RSRLs (based on 2005–2011 data; $n=50$) (Tables S8-3 and S8-4). The only TAL element in fish that was detected above the RSRL (an order of magnitude) from some reaches along the Rio Grande downstream of LANL was antimony in bottom-feeding fish collected in 2010. These data do not agree with the other bottom-feeding fish samples collected in 2011 from reaches above (RG @ LAC) and below (CR) those collected the year before. Also, a survey of antimony in sediments collected from LANL canyons and from along the Rio Grande in 2010 shows no detectable concentrations of antimony (LANL 2011b). Therefore, there is no evidence that the higher amounts of antimony detected in bottom-feeding fish collected at some reaches along the Rio Grande downstream of LANL in 2010 are a result of Laboratory-derived releases. Antimony is a natural constituent of soil and is transported into waterways in runoff from either natural weathering or from the disturbance of soil. Nevertheless, the amounts of antimony detected in bottom-feeding fish are still very low (< 0.015 mg/kg wet) and are within concentrations reported for crustacean tissue (0.030 mg/kg wet) (Maher 1986) and marine fish (0.004 to 0.20 mg/kg) (Bowen, 1979), and there is little indication that antimony would bioconcentrate appreciably in fish and aquatic organisms (Callahan et al. 1979, ATSDR 1992).

Although the amounts of mercury in both fish types collected upstream and downstream of LANL were similar to each other, the level of mercury in many fish samples, and primarily in predator fish from CR (Tables S8-3 and S8-4), exceeded the EPA SL of 0.30 mg/kg wet (Figure 8-8). The main sources of mercury into the water systems in New Mexico are natural sources and the burning of fossil fuels (NMED 1999). After entering water systems, the inorganic mercury is converted to methyl mercury by anaerobic sulfate-reducing bacteria using carbon from flooded vegetation as an energy source. Virtually all of the mercury found in the edible portions of fish is methyl mercury (EPA 2001), a highly toxic neurotoxin in humans, where it may bioaccumulate (larger fish $>$ smaller fish) and biomagnify (carnivorous fish $>$ omnivorous fish) up the aquatic food chain (Ochiai 1995).

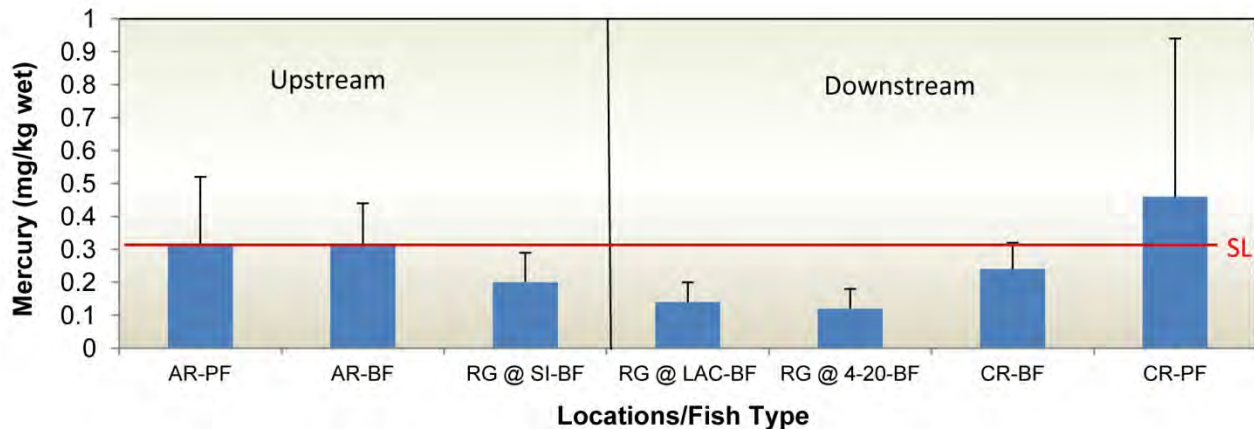


Figure 8-8 Mean (± 1 standard deviation) total mercury concentrations in predator (PF) and bottom-feeding (BF) fish upstream (Abiquiu Reservoir [AR] and Rio Grande at San Ildefonso [RG @ SI]) and downstream (Rio Grande at Los Alamos Canyon [RG @ LAC], Rio Grande at 4–20 miles from LAC [RG @ 4–20], and Cochiti Reservoir [CR]), compared with the SL

Predator fish would be expected to contain more mercury than the bottom-feeding fish because mercury normally biomagnifies up the food chain, and in fact, one of the predator fish (walleye) from CR was above the FDA standard of 1 mg/kg wet. Also, since the conversion of inorganic mercury to methyl mercury is primarily conducted by bacteria under anaerobic conditions, it would be expected that there would be higher amounts in reservoir fish than in river fish (Driscoll et al. 1994, Bunce 1991).

Based on the long-term trend (1991 through 2011), the concentrations of mercury in predator fish from both AR and CR show a highly variable pattern from year to year but decrease from the last sampling event in 2008 towards the SL in 2011 (Figure 8-9). Likewise, the trend line for mercury in bottom-feeding fish from both reservoirs tends to be highly variable from year to year but contrary to the trend for predator fish, the amounts of mercury in bottom-feeding fish tend to increase over the latter years towards the SL (Figure 8-10). Regardless of the variability in fish from year to year, there are no increasing trends in any of the fish types at CR that are independent of AR. Currently, there are 26 fish consumption advisories for mercury in New Mexico, including the Rio Grande (NMDG&F et al. 2011).

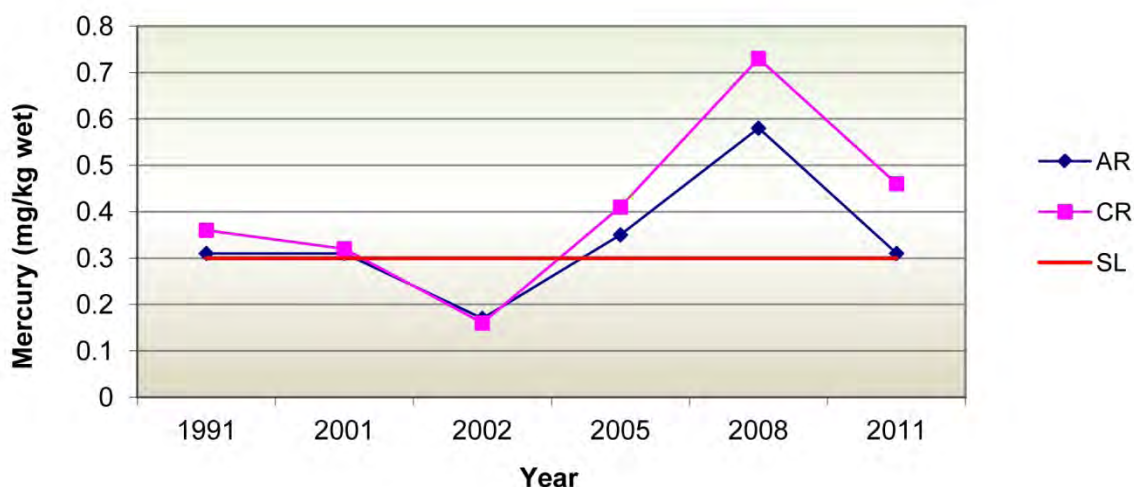


Figure 8-9 Mean mercury concentrations in predator fish collected upstream (AR) and downstream (CR) of LANL from 1991 through 2011 compared with the SL

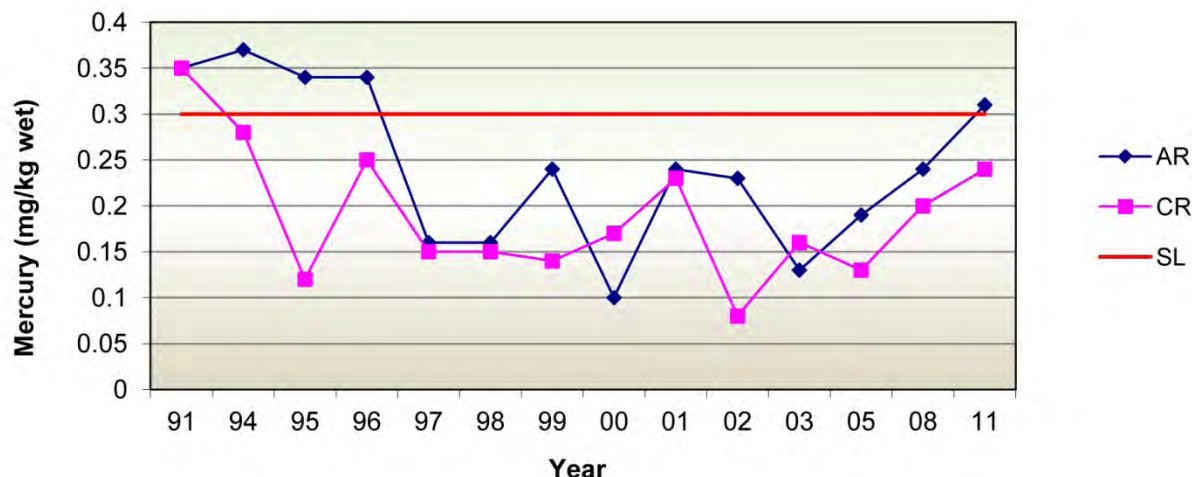


Figure 8-10 Mean mercury concentrations in bottom-feeding fish collected upstream (AR) and downstream (CR) of LANL from 1991 through 2011 compared with the SL

d. PCB Analytical Results

i. General Background

PCBs are a category of toxic, long-lived synthetic organic chemicals manufactured in the United States between 1930 and 1976 (ATSDR 2001). They were developed predominantly for use as coolants and lubricants because of their general chemical inertness and heat stability in electrical equipment such as capacitors and transformers (EPA 1996, 2002). Also, they have been used in oil in motors and hydraulic systems, flame retardants, inks, adhesives, carbonless copy paper, paints, wood-floor finishes, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings. Although banned over three decades ago, PCBs continue to enter the environment from various sources (e.g., landfills, urban runoff, sewage sludge, incineration of municipal refuse, and illegal disposal).

Aroclor was the trade name for technical mixtures of PCBs manufactured in the United States. Nine Aroclor mixtures were produced with the bulk being Aroclor-1016 (13%), -1242 (52%), -1248 (7%), -1254 (16%), and -1260 (11%). Each was prepared to a specific chlorine weight percentage given in the last two digits of its name, with the exception of Aroclor-1016, which contains 41% chlorine by weight. Each contains a specific mixture of 209 congeners.

With respect to their behavior in the aquatic environment, PCBs are hydrophobic and tend to accumulate in the sediment, are highly soluble in lipids (lipophilic), and are absorbed and retained by fish.

We collected 14 predator fish from AR and CR, and we collected 39 bottom-feeding fish from 13 locations (AR and 12 locations along the Rio Grande [Rio Grande at SI; below the confluence of LAC; Rio Grande at 4, 6, 8, 10, 12, 14, 16, 18, and 20 river miles from LAC; and CR]) for the analysis of 209 PCB congeners.

In general, total PCBs (all congeners combined) in predator and bottom-feeding fish from all locations are lower and in some cases an order of magnitude lower than what were measured in past surveys. Total PCB concentrations in muscle fillet tissue of the bottom feeders are higher than in muscle fillet tissue of the predator fish. The higher concentrations of PCBs in muscle tissue of the bottom-feeding fish (omnivores) compared with predator fish (carnivores) may be a reflection of their feeding habits (location of food sources) and/or the higher amounts of lipid content (fat) in bottom-feeding fish tissues. Owing to their low solubility in water, PCBs are most prevalent in sediment at the bottom of lakes and rivers (Ashley and Baker 1999), and fish with higher lipid (fatty tissues) content usually contain higher PCB levels than fish with lower lipid content (Grafton et al. 2008). Specific results are described in the following sections.

ii. *Predator Fish*

Table S8-5 is a summary table showing physical data (weight, length, girth) and total PCBs for each of the predator fish from AR (upstream) and CR (downstream). Homolog data for all fish samples collected from AR and CR can be found in Table S8-6.

In general, only two out of the 10 predator fish at CR contained total PCBs in higher concentrations than the RSRL (based on 2005, 2008, and 2011 data; n=14) and were more than 50% lower than those reported in 2008 (Figure 8-11).

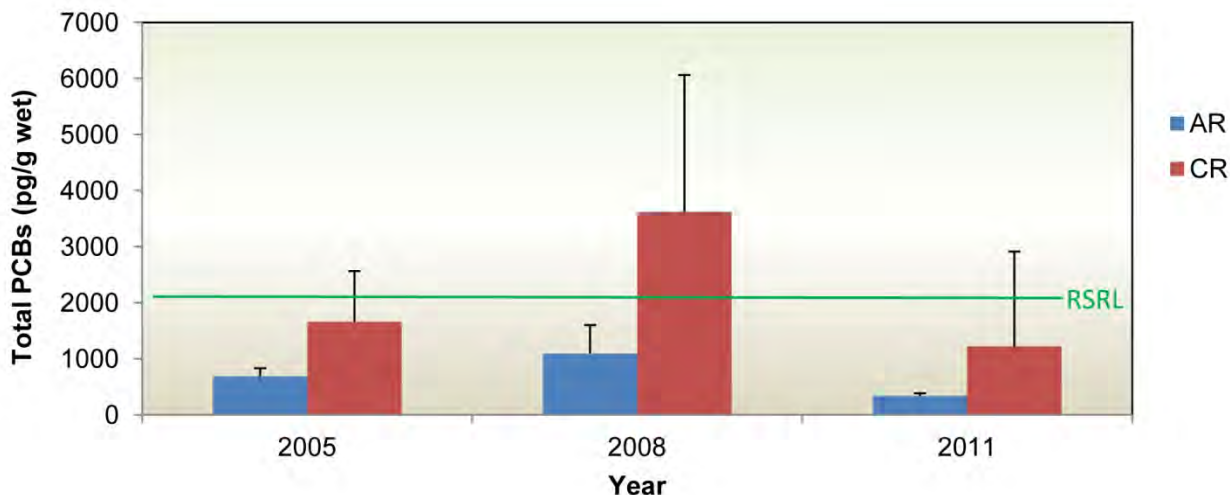


Figure 8-11 Mean (± 1 standard deviation) total PCBs in muscle fillets of predator fish collected from AR (upstream of LANL) and Cochiti Reservoir (CR, downstream of LANL) in 2005, 2008, and 2011 compared with the RSRL

A comparison of the mean PCB homolog distributions in muscle fillets of predator fish between AR and CR (Figure 8-12) shows that the profiles are dissimilar to one another. Whereas the PCB homolog pattern for predator fish from CR agrees with the results obtained in 2005 (Gonzales and Fresquez 2006) and 2008 (Fresquez et al. 2009), the homolog pattern for AR shifted from the highly chlorinated biphenyls to the lower chlorinated biphenyls and may reflect the low amounts of PCBs available for uptake by the predator fish at AR; total PCBs in predator fish from AR were over 50% lower than in previous years. As in prior years, the homolog distribution pattern revealed by the bottom-feeding fish at CR is consistent with Arochlor-1260.

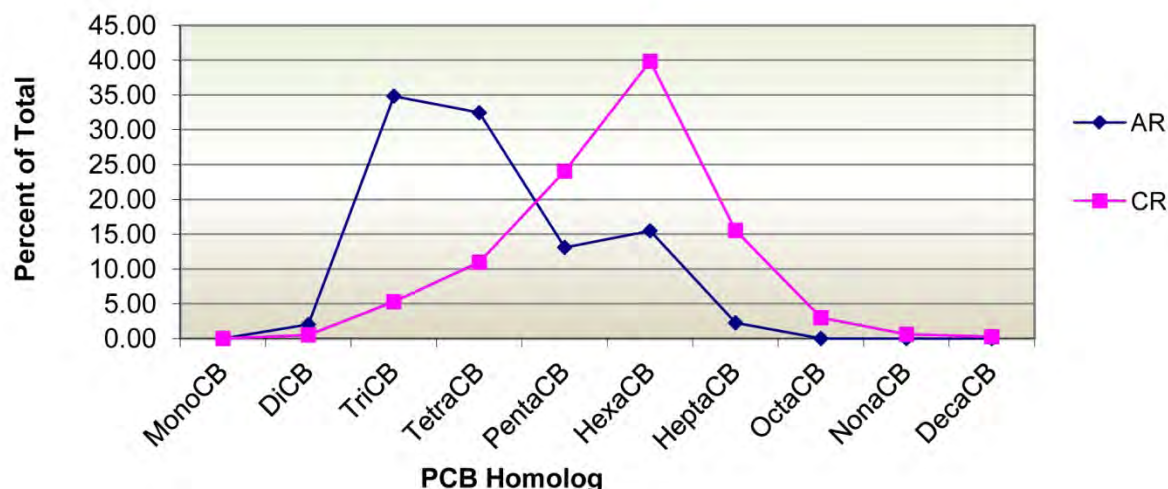


Figure 8-12 The mean homolog distribution in muscle fillets of predator fish collected upstream (AR) and downstream (CR) of LANL in 2011

iii. Bottom-Feeding Fish

Table S8-7 summarizes physical and total PCB data in muscle fillets in bottom-feeding fish from two upstream locations (AR and RG @ SI) and various downstream locations (RG @ LAC, RG @ 4–20 miles from LAC, and CR) relative to LANL. The PCB homolog list associated with each fish sample at each location can be found in Table S8-8.

In general, total PCB concentrations in bottom-feeding fish from most locations were about 50% lower than those reported in prior years. Because of the significantly lower amounts of total PCBs this year compared with past fish surveys, the RSRL, based on the RG @ SI, was calculated from the present data (2011; n=9). This reach was used for the background calculation because this site includes both the Rio Chama and the Rio Grande. Based on the RSRL, only one out of three fish from the Rio Grande at the 10–14 mile point from LAC (carp), and three of the seven bottom-feeding fish from CR were higher than the RSRL (Figure 8-13). The mean concentrations of total PCBs in bottom-feeding fish at most downstream locations were not statistically higher ($p > 0.05$) than the mean concentration of total PCBs from the upstream location at RG @ SI, and the mean homolog distributions in bottom-feeding fish collected upstream of LANL (at AR and RG @ SI) are very similar to the patterns directly downstream of LANL (RG @ LAC, RG @ 4–20 miles from LAC, and CR) (Figure 8-14). (Note: As expected, and based on log-transformed data from CR because of the high variability in the data, the mean total PCBs in bottom-feeding fish were statistically higher ($p = 0.047$) than the mean total PCB concentrations in the same fish from the upstream location at RG @ SI.)

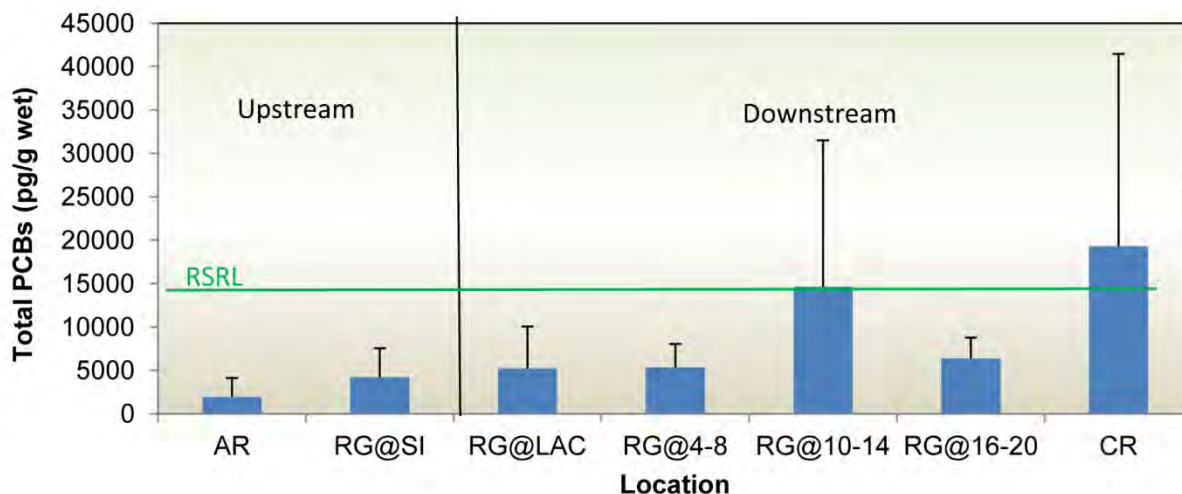


Figure 8-13 Mean (± 1 standard deviation) total PCB concentrations in muscle fillets of bottom-feeding fish collected upstream (AR and Rio Grande at San Ildefonso [RG@SI]) and downstream (RG @ LAC, RG @ 4-8, 10-14, and 16-20 river miles from LAC, and CR) of LANL in 2011 compared with the RSRL

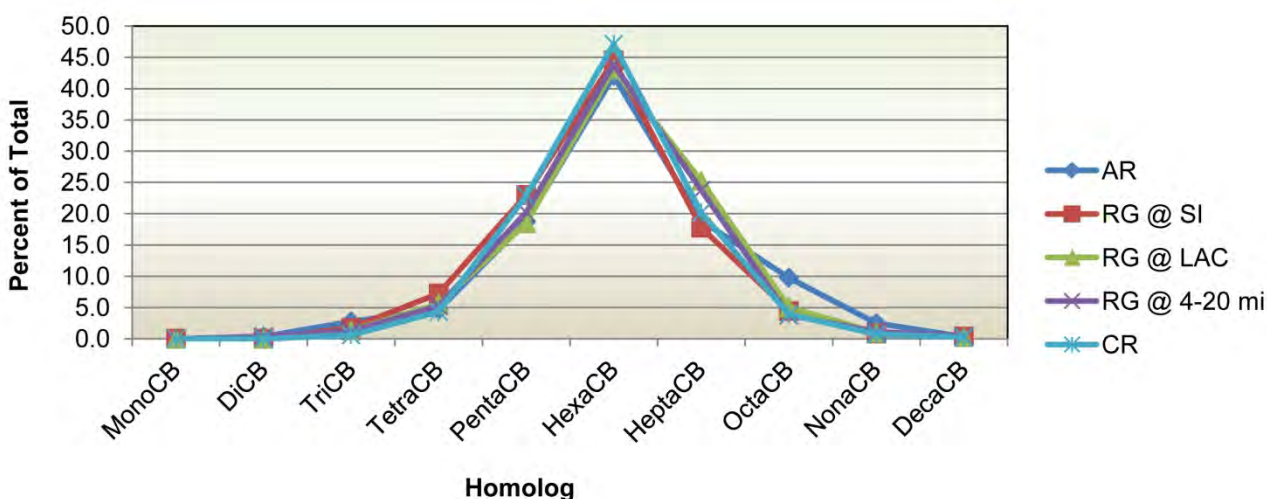


Figure 8-14 The mean homolog distribution in the muscle tissues of bottom-feeding fish collected upstream (AR and RG @ SI) and downstream (RG @ LAC, RG @ 4-20 miles from LAC, and CR) of LANL in 2011

These data, particularly those directly upstream and downstream of LANL, are in agreement with other studies, mainly the following: (1) the placement of stationary semipermeable membrane devices (e.g., artificial fat bags) upstream (RG @ SI) and downstream (RG @ LAC) of LANL that showed similar PCB concentrations between locations (Gonzales and Montoya 2005) and (2) the collection of sediment samples along the same general reach of waters upstream and downstream of LANL in previous years that showed mean PCB concentrations and homolog patterns generally similar to those of the present data (Reneau and Koch 2008, LANL 2011b).

There is considerable variability in total PCB concentrations in bottom-feeding fish from CR compared with AR over time; probably because CR is the recipient of greater sources of debris, sediment, and potential contaminants migrating down from both the Rio Chama and Rio Grande than AR, whose source is only the Rio Chama (Figure 8-15). Mean total PCBs in bottom-feeding fish from AR are considerably lower than CR and do not vary widely from year to year. Lastly, the mean total PCBs in bottom-feeding fish collected from

the Rio Grande directly above (RG @ SI) and below LANL (RG @ LAC and RG @ 4 miles below LAC) have generally decreased an order of magnitude from 2002 to 2011.

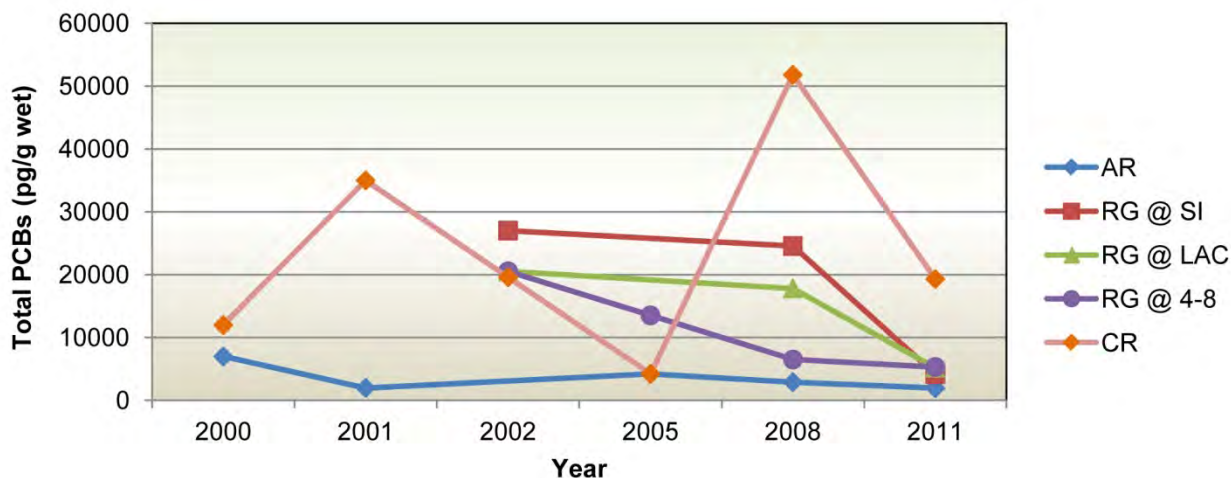


Figure 8-15 Mean total PCB concentrations in bottom-feeding fish collected upstream (AR and RG @ SI) and downstream (RG @ LAC, Rio Grande @ 4-8 miles from LAC, and CR) of LANL from 2000 to 2011

4. Crayfish Monitoring

a. Monitoring Network

Crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp.) samples were collected along the Rio Grande within two reaches (upstream and downstream) relative to the location of LANL from August 10–15, 2011. (Figure 8-16). These samples were collected after the Las Conchas Fire.

Upstream (or background) samples of crayfish were collected starting from the Otowi Bridge north to the Black Mesa area (about a 3-mile stretch), and downstream samples were collected from the LAC confluence south (about a 1-mile stretch). Of the major drainages that cross LANL lands, the majority of LANL-derived substances that may reach the Rio Grande are carried by storm water flow down LAC (Gallaher and Efurd 2002, Reneau and Koch 2008, Fresquez et al. 2008). Note that other non-Laboratory sources and tributaries (Guaje and Pueblo Canyons) may also contribute contaminants to the LAC drainage; these include constituents in storm water carried from roads and grounds from the Los Alamos town site, treated effluent from the Los Alamos sewage treatment plant, atmospheric fallout of radionuclides, and some naturally occurring and anthropogenic materials in ash from the Cerro Grande Fire in May 2000 (Mirenda 2009, Katzman et al. 2001) and the Las Conchas Fire in 2011 (LANL 2011a).

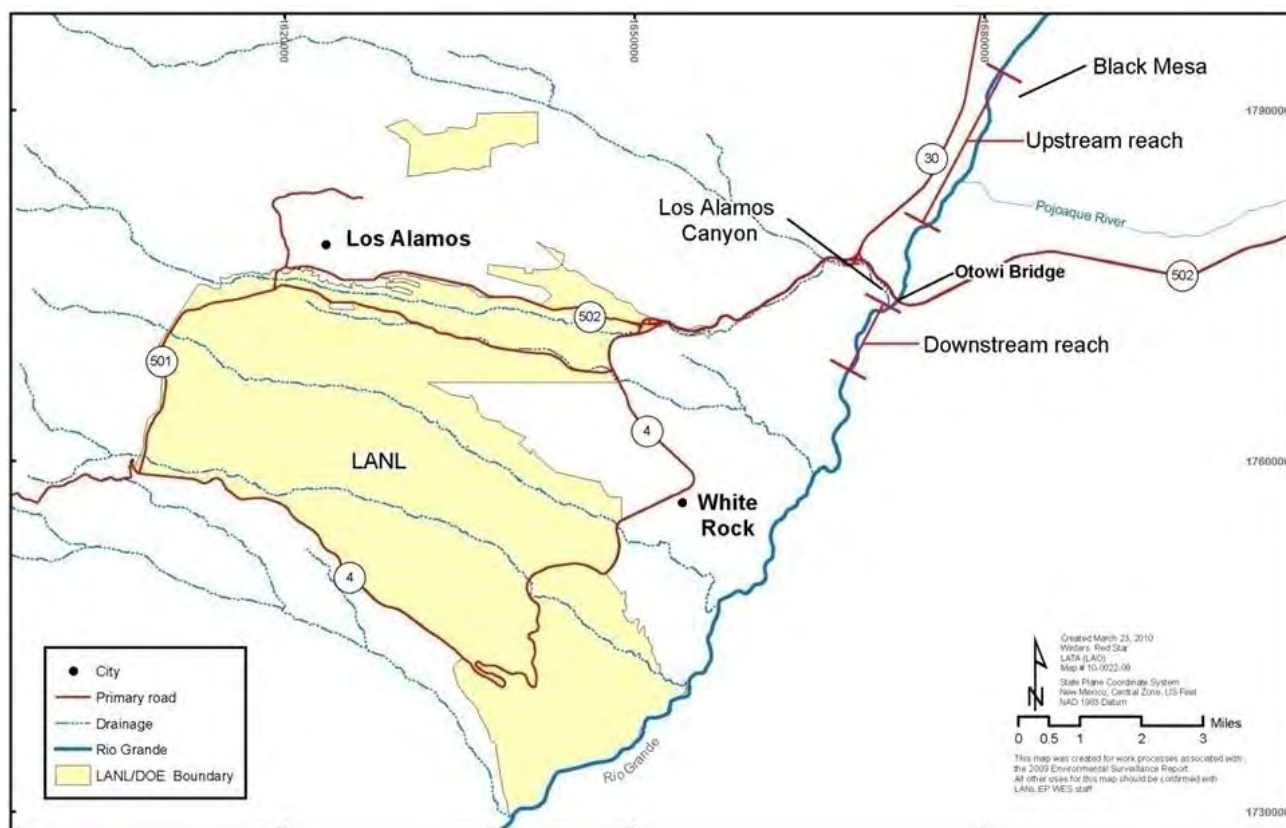


Figure 8-16 Location of crayfish and benthic macroinvertebrate sampling reaches within the Rio Grande in relation to the location of LANL. The upstream reach is above the Otowi Bridge north to Black Mesa, and the downstream reach starts below the Los Alamos Canyon confluence south.

b. Methods and Analysis

Within each reach, crayfish traps were randomly set with fresh fish bait acquired from AR at the 1-ft depth. Traps were checked every day for about two weeks (Figure 8-17). Approximately 12 crayfish were collected from the upstream reach: seven were used for radionuclide analysis (composite sample), two each for TAL analysis, and three each for PCB analysis. Similarly, approximately 19 crayfish were collected from the downstream reach: seven were used for radionuclide analysis (composite sample), five each for TAL analysis, and seven each for PCB analysis. All sample portions were weighed and placed into Ziploc bags, cooled to 4°C, and submitted under full chain-of-custody procedures to our SMO, where they were then sent to ALS Laboratory Group for radionuclide and TAL element analysis, and to Cape Fear Analytical for PCB congener analysis.



Figure 8-17 Collection of crayfish samples from the Rio Grande

Whole-body crayfish were analyzed for tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL basis. Results of the other radionuclides are reported in pCi/g ash.

Edible (meat) and nonedible (head, gut, claws, and shell) portions of crayfish were analyzed for 23 TAL elements; these included aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a wet weight basis in mg/kg. (Note: Whole-body concentrations of the crayfish were estimated from the divided portions by multiplying the concentrations of each portion by the percentage of the total [edible = 13% and nonedible = 87%] and then summing the two).

PCBs were analyzed for 209 possible chlorinated congeners. For summary and reporting purposes, PCB congeners were grouped together into 10 homologs. Homologs and total PCBs are reported on a pg/g wet weight basis.

c. Radionuclides

Most radionuclides in a composite whole-body crayfish sample ($n=7$) collected from the Rio Grande directly downstream of the LAC confluence were either not detected (most results) or were detected below the RSRLs (based on 2009 and 2011 data; $n=2$) (Table S8-9). The only radionuclides in a composite whole-body crayfish sample collected downstream of LANL that were detected in higher concentrations than the RSRLs were uranium-234, uranium-238, and strontium-90. These particular radionuclides are usually more associated with the bone portions of animals than the meat portions (Whicker and Schultz 1982). Nevertheless, all of these radionuclides were still far below dose-based SLs and would be expected to be lower

in the edible meat portions of the crayfish, and the (1:1) ratio between uranium-234 and uranium-238 indicate that this was naturally occurring uranium. These data, with the exception of strontium-90, are similar in concentrations to data from the past survey conducted in 2009 (Fresquez et al. 2010). Strontium-90 is higher in whole-body crayfish collected from both upstream (RG @ SI) and downstream (RG @ LAC) locations in 2011 than in 2009 and may be associated with the increased ash in the river from the Las Conchas Fire (Figure 8-18). In a past study, Katzman et al. (2001) reported higher concentrations of global fallout strontium-90 in ash collected west of the Laboratory after the Cerro Grande Fire compared with pre-fire soil amounts and concluded that the amounts of fallout strontium-90 in ash transported to the Rio Grande may be unrelated to the Laboratory.

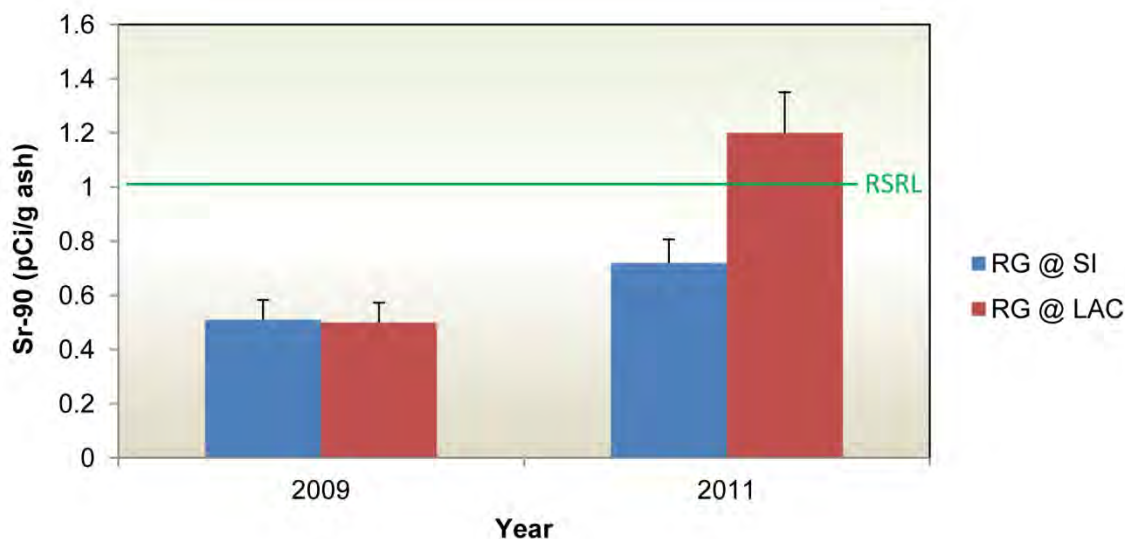


Figure 8-18 Strontium-90 concentrations (± 1 standard deviation) in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2009 and 2011 compared with the RSRL

d. TAL Elements

All of the TAL elements in the edible portions of the crayfish collected along the Rio Grande directly downstream of the confluence of LAC were below or similar to the RSRLs (based on 2010 and 2011 data; $n=5$) (Table S8-10). Also, all concentrations of mercury in the edible portion of crayfish collected from both reaches were an order of magnitude below the screening level of 0.30 mg/kg (EPA 2001). Mercury sources and contamination in fish inhabiting the Rio Grande upstream and downstream of LANL are well documented (see Section E); however, the amount of mercury in crayfish compared with bottom-feeding fish within these same reaches is an order of magnitude lower and does not appear to be a significant risk factor to humans if ingested.

e. PCBs

Table S8-11 summarizes the weights and total PCBs for whole-body crayfish collected from the Rio Grande, upstream and downstream, relative to the location of LANL. Homolog data for all crayfish samples can be found in Table S8-12.

In general, the total PCBs (pg/g wet) in whole-body crayfish from both upstream and downstream reaches were markedly lower than the PCB levels in bottom-feeding fish collected from these same reaches, and only one out of the seven crayfish from the downstream reach was higher than the RSRL (based on 2009 and 2011 data; $n=9$). Overall, the mean total PCB concentrations in whole-body crayfish from the downstream reach are similar to those amounts reported in last survey conducted in 2009 (Figure 8-19) and are below the EPA risk-based SL for unrestricted fish consumption ($< 1,500$ pg/g wet).

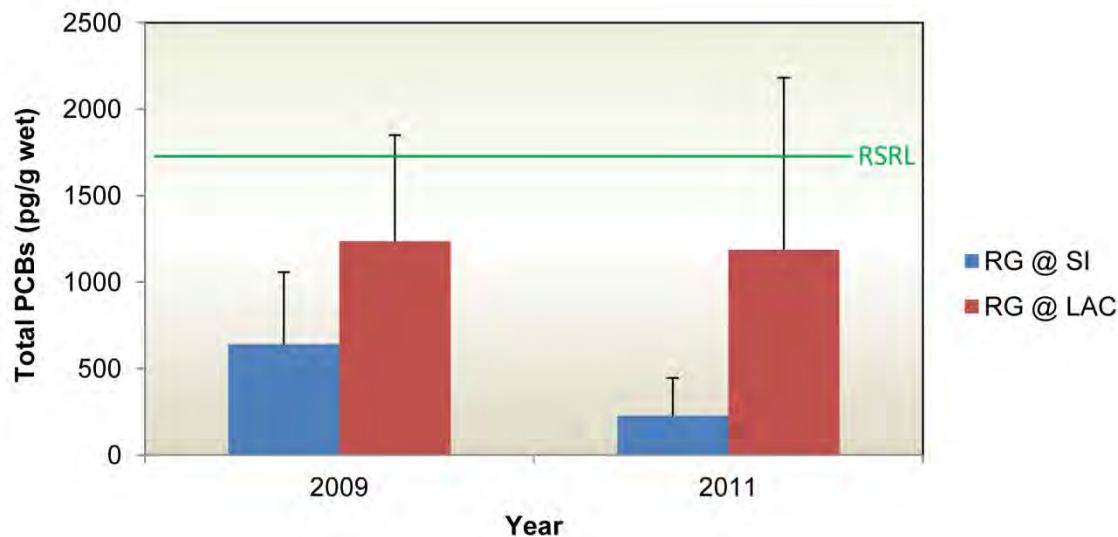


Figure 8-19 Mean (± 1 standard deviation) total PCBs in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2009 and 2011 compared with the RSRL

A comparison of the mean PCB homolog distributions in whole-body crayfish collected from reaches along the Rio Grande directly upstream and downstream relative to the location of LANL shows that the profiles are generally similar to one another, with both profiles peaking at the hexachlorinated biphenyl level (Figure 8-20). These data agree with past results.

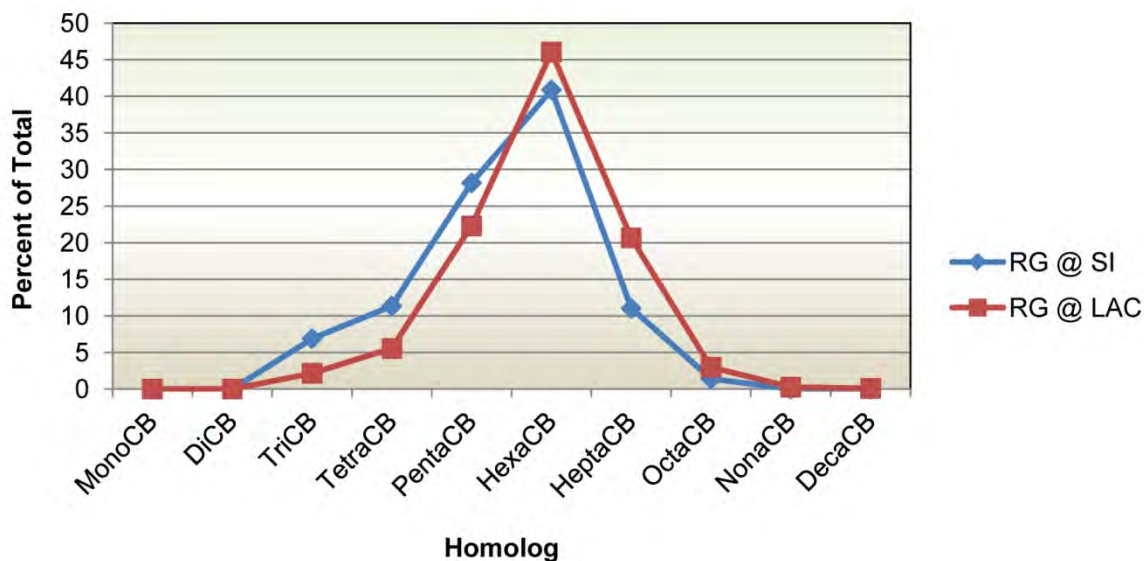


Figure 8-20 The mean PCB homolog distribution in whole-body crayfish collected directly upstream (RG @ SI) and downstream (RG @ LAC) of LANL in 2011

5. Deer and Elk Monitoring

a. Monitoring Network

Since 1991, we have routinely picked up deer and elk as road kills alongside highways from within LANL lands, around the perimeter of LANL, and from regional background locations (Fresquez et al. 1999). At the present time, we have collected muscle and bone tissue samples from 28 deer and from 47 elk; all of these samples have been analyzed for radionuclide concentrations. Recently (since 2009), we have included the analysis of TAL and PCB constituents for muscle tissue of deer and elk. For these constituents, however, we do not yet possess a large enough regional background data set on which to make statistical comparisons. The TAL and PCB analysis data are included in this report for future reference, however.

At each kill site, the front shoulder of the animal is collected, placed into a large plastic bag, and transported to the laboratory in a cooled ice chest. At the laboratory, the muscle and bone of the animals are separated and placed into the appropriate containers and submitted under chain-of-custody procedures to the SMO. Muscle and bone samples are then submitted to ALS Laboratory Group for the analysis of radionuclides and/or TAL elements, and muscle samples are submitted to Cape Fear Analytical for the analysis of PCB congeners.

Radionuclides analyzed were tritium, strontium-90, cesium-137, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per-mL of water basis. Results of the other radionuclides were reported in pCi/g dry weight after being converted from pCi/g ash weight. The 23 TAL elements include aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury; these elements are reported on a mg/kg wet weight basis. PCBs were analyzed for 209 possible chlorinated congeners and summarized as homologs on a pg/g wet weight basis.

b. Elk

This year, one elk was collected in June alongside NM 502 near Jacona, New Mexico (Figure 8-21). Although not for certain, the Jacona elk may be from the Tesuque Pueblo resident elk herd, which is approximately 4 miles south from where it was killed, rather than from the elk that inhabit LANL lands, which is further away to the west across the Rio Grande. The Jacona elk may be regarded either as a perimeter or regional sample since it is further than 9 miles away from the Laboratory.

Other elk samples collected this year include three road-killed elk along Pajarito Road within LANL property: one within Technical Area 48 (TA-48) and two within TA-46.

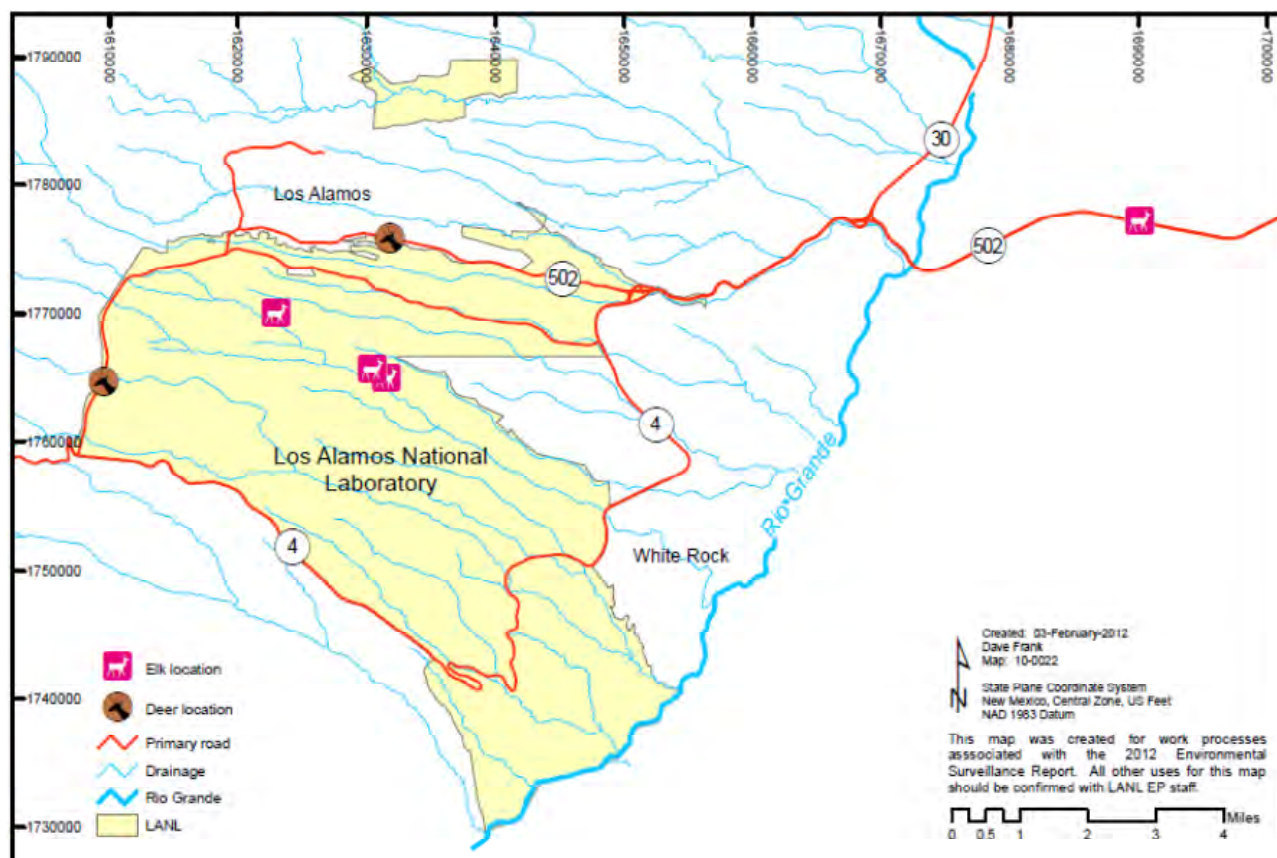


Figure 8-21 Location of deer and elk collected as road kills from within and around the perimeter of LANL in 2011

i. Radionuclides

All of the radionuclides in both muscle and bone tissues from the one perimeter/regional elk and from the three elk collected on LANL lands were either not detected (most results) or below the RSRLs (based on 1991-2003 data; n=9) (Table S8-13). These data agree with past results.

ii. TAL Elements

Results of TAL elements in muscle tissues from the one perimeter/regional and three road-killed elk collected along Pajarito Road at TA-46 and TA-48 can be found in Table S8-14. As of yet, we do not have a large enough regional background data set with which to statistically compare TAL elements from elk collected from LANL lands. However, based on the one perimeter/regional elk collected this year, the TAL elements in muscle from the three LANL elk are very similar to those for this elk. Also, since all of the radionuclide elements in muscle and bone from all three elk collected from LANL lands were not different from those in elk collected from regional background areas, the TAL elements are also not expected to be any different. We plan to continue to analyze elk muscle tissues for TAL elements to increase the amount of data to support a statistical assessment of the data.

iii. Polychlorinated Biphenyls

PCB homologs and totals in muscle tissues of road-killed elk collected alongside NM 501 near Jacona and from along Pajarito Road at TA-46 and TA-48 can be found in Table S8-15. The amounts of total PCBs in most LANL elk muscle tissues were negligible, as were the amounts in the perimeter/regional elk. Some trace amounts of hexachlorinated and heptachlorinated biphenyls were detected in the elk collected at TA-48, but the total PCB amount (0.00032 mg/kg wet) was far below the FDA standard of 3 mg/kg wet for red meat. We plan to continue to analyze elk muscle tissues for PCBs to increase the amount of data to support a statistical assessment of the data.

c. Deer

Two road-killed deer were collected alongside roadways that border the perimeter of the Laboratory. One deer was collected alongside NM 502 near the west end of the airport, and the other deer was collected on the western side of LANL alongside NM 501 (West Jemez Road).

i. Radionuclides

All of the radionuclide concentrations in both muscle and bone tissues from two road-killed deer collected from around the perimeter of the Laboratory were either not detected or below RSRLs (based on 1991–2000 data; n=5) (Table S8-16). These data are similar to past years.

ii. TAL Elements

Results of TAL elements in muscle tissues from two road-killed deer collected along NM 501 and 502 around the perimeter of LANL lands can be found in Table S8-17. Based on only two background deer to date to estimate RSRLs (based on 2010 data; n=2), most TAL elements in deer collected from around the perimeter of the Laboratory were similar to the background values. We plan to continue to analyze deer muscle tissues for TAL elements to increase the amount of data to support a statistical assessment of the data.

iii. Polychlorinated Biphenyls

Total PCBs and homolog distributions in muscle tissues of road-killed deer collected alongside the perimeter of the Laboratory can be found in Table S8-18. Whereas one of the perimeter deer (NM 501) contained negligible amounts of total PCBs, the other deer collected alongside NM 502 near the airport contained trace amounts of hexachlorinated and heptachlorinated biphenyls, and although the total amount of PCBs in the deer collected from alongside NM 502 (0.00030 mg/kg wet) was just above the RSRL (based on 2010 data; n=2), the amounts were far below the FDA standard of 3 mg/kg for red meat. The homolog distributions between the perimeter deer collected alongside NM 502 and regional background appear to have different patterns, with the perimeter deer possibly containing trace amounts of Aroclor-1260 (Figure 8-22). We plan to continue to analyze deer muscle tissues for PCBs to increase the amount of data to support a statistical assessment of the data.

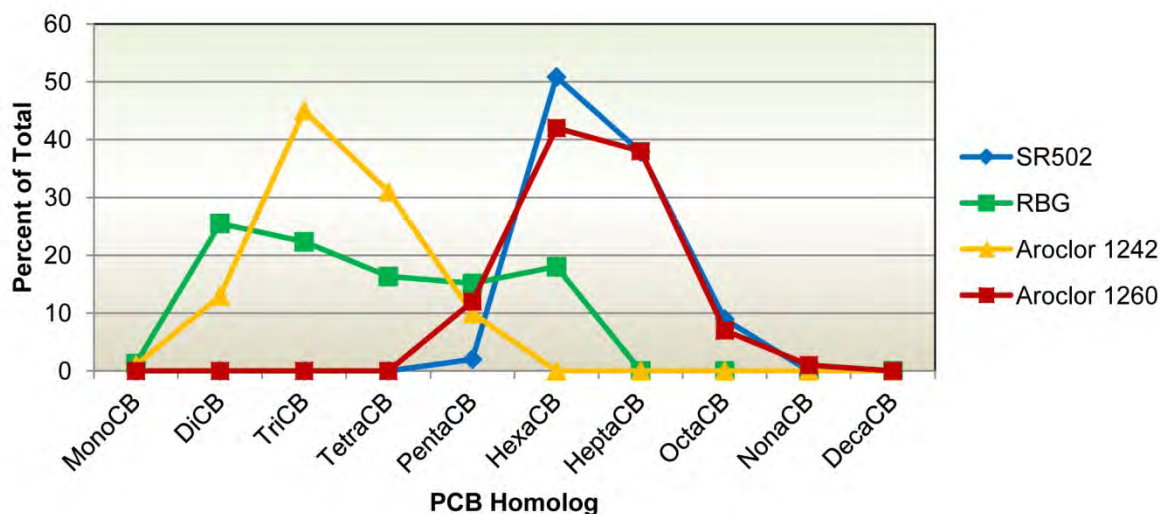


Figure 8-22 The PCB homolog distribution in muscle tissue of a road-killed deer collected alongside State Road 502 (SR 502) in 2011 compared with regional background (RBG) and with Aroclor-1242 and -1260 formulations

B. BIOTA MONITORING

1. Introduction

DOE Orders 436.1 (DOE 2011a) and 458.1 (DOE 2011b) define requirements for the monitoring of biota (plants and animals not normally ingested by humans) for the protection of ecosystems. Monitoring of biota, mostly in the form of site-specific studies, began in the 1970s with the Environmental Surveillance Program, while sitewide native vegetation monitoring started in 1994. Presently, in addition to native vegetation, we also monitor benthic macroinvertebrates, small mammals, amphibians, reptiles, birds, and bees within and around LANL on a systematic basis or for special studies. The number and types of organisms may indicate environmental changes and stress. Also, detection of contaminants in biota may indicate that these animals may be entering contaminated areas (e.g., burrowing in waste burial grounds) or that material is moving out of contaminated areas (e.g., blowing dust, transported soil/sediment via storm water, or food-chain transport).

The objectives of the biota program are to

- 1) Assess populations, composition, and diversity of biota species potentially impacted by LANL operations,
- 2) Measure radionuclide and chemical concentrations (that have a history of use at LANL) in biota from on-site (LANL property), perimeter, and regional (background) areas,
- 3) Evaluate radionuclide and chemical concentrations over time (i.e., are concentrations increasing or decreasing?), and
- 4) Estimate potential radiation dose to plants and animals. (Chapter 3 presents the results of the 2011 biota dose assessments at LANL.)

2. Biota Comparison Levels

Population, composition, species richness, diversity, and evenness metrics and indices are discussed in Section B.4, Benthic Macroinvertebrate Monitoring of the Rio Grande, and Section B.5.b.v., *Birds at DARHT*. In general, metrics and indices from biota collected from Laboratory lands are compared with the same from regional background locations.

As for the comparison of radionuclides and chemical concentrations in biota from Laboratory areas, they are first compared with background based SLs (e.g., RSRLs). If the contaminant levels at potentially impacted areas are higher than the contaminant levels at nonimpacted areas (RSRLs), then we would compare the concentrations with the dose- or risk-based SLs, if available, and then with the standards, if available. More information about comparison levels are summarized below and presented in Table 8-3:

- **Regional Background Levels:** RSRLs are the upper-level background concentrations (mean plus 3 standard deviations = 99% confidence level) for radionuclides and chemicals calculated from biota data collected from regional locations away from the influence of the Laboratory (more than nine miles away) (DOE 1991). RSRLs represent natural and fallout levels; they are calculated annually and presented in this report.
- **Screening Levels:** SLs are set below DOE dose standards so that potential concerns may be identified in advance, i.e., a “yellow flag.” If a constituent exceeds an SL, then the reason for the higher levels is thoroughly investigated. For radionuclides in biota, SLs were set at 10% of the standard by the dose assessment team at the Laboratory to identify the potential radionuclides of concern (McNaughton 2006). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL (or baseline statistical reference level [BSRL]), then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2010). ESLs are derived from the literature and reflect the (highest) concentration of a substance in the soil that is not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the concentrations that are protective of ecological receptors under chronic exposure conditions).

- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/day DOE dose standard for terrestrial animals (DOE 2002).

Table 8-3
Standards and Other Reference Levels Applied to Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs
	DARHT ^a	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs/BSRLs ^b
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Chemicals	On-site and perimeter	Biota	na ^c	ESLs ^d	RSRLs
	DARHT	Biota	na	ESLs	RSRLs/BSRLs

^a DARHT = Dual-Axis Radiographic Hydrodynamic Test Facility.

^b Baseline statistical reference levels and a discussion of these levels can be found in Section 5.b.i.

^c na = Not available.

^d Ecological Screening Levels are based on the concentration in the soil.

3. Institutional Vegetation Monitoring

No wide-scale institutional monitoring of native vegetation was performed in 2010. Native understory (grasses and forbs) or overstory (trees) vegetation is collected on a triennial basis at the same time and at the same locations as the soil (17 on-site, 11 perimeter, and six regional locations) described in Chapter 7, Section C.1 (Figure 7-1). The next sampling period for the collection of native (understory) vegetation is in 2012. Past sampling shows that, in general, all radionuclide and TAL element concentrations in native understory and overstory vegetation sampled from Laboratory and perimeter areas are very low, and most concentrations are indistinguishable from those of regional background areas.

4. Benthic Macroinvertebrate Monitoring of the Rio Grande

a. Monitoring Network

Benthic macroinvertebrates (BMIs) are defined as insects, oligochetes, leeches, mollusks, and crustaceans that live on the river bottom and are retained by a Standard No. 35 sieve (0.50-mm opening). The numbers and types of organisms, quantified by metrics or indices, provide an indication of water quality within a stream system (EPA 1998). Because they are continually exposed during their life cycles to extremes in the environment, BMIs can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987).

We collected six composite BMI samples using kick nets at each of two reaches (a total of 12 composite samples)—upstream (north of the Otowi Bridge to the Black Mesa area) and downstream (south of the LAC confluence) relative to the location of LANL—in an effort to determine if the populations and communities of BMIs varied upstream and downstream of LANL (see Figure 8-23).

These samples were collected on October 11-12, 2011, approximately 1.2 months after the Las Conchas Fire was fully contained (June 26-August 1, 2011); the wildfire burned approximately 156,593 acres (63,371 ha) of watershed above and adjacent to LANL on the western side. As a result of the fire, several flooding events from canyon confluences upstream and downstream of LANL to the Rio Grande occurred before the BMI sampling period—the upstream reach was influenced by the Santa Clara tributary and the downstream reach was influenced by both the Santa Clara and the LAC (via Guaje Canyon) drainage systems on August 21, 2011. Another significant flooding event occurred a week after the August event (September 4th, 2011) but only through Guaje Canyon to LAC to the Rio Grande, affecting only the downstream reach. Guaje Canyon is located north of LANL in an east-to-west direction and empties into LAC approximately 1 mile west of the Rio Grande (Figure 8-1). Both the Santa Clara and Guaje Canyon drainages are largely unrelated to lab property.



Figure 8-23 Collecting benthic macroinvertebrates (BMIs) in the Rio Grande using a kick net

b. Methods and Analysis

Within each reach, six composite samples each were collected from shallow riffle locations upstream and downstream of LAC on the Rio Grande (Figure 8-24). A composite sample consisted of 10 subsamples collected in a downstream direction along a 10-m-long transect at the 0.15 (0.50 ft) to 0.30 m (1 ft) depth. Using a Turtox® bottom kick net 0.23 m (0.75 ft) by 0.46 m (1.5 ft) in size (0.50-mm mesh), a subsample was collected by holding the net approximately 1 m (3.3 ft) downstream and then waddling/shuffling towards the net; BMIs were lofted into the net. The total sample area was approximately 5m^2 ($0.46\text{ m} \times 10\text{ m} = 4.6\text{ m}^2$).



Figure 8-24 Rinsing the net free of BMIs with water in a 5-gallon poly bucket

Each composite sample (net) was immersed and inverted in a 5-gallon poly bucket filled one-half full of water and gently rinsed clean of BMIs and accompanying debris. The contents in the bucket were separated by pouring the water plus organisms onto a Standard No. 35 sieve; rinsed into a 500-mL poly bottle; decanted of water; and preserved with 70% ethanol; after 24 h, the old ethanol was replaced with a fresh mix.

Samples were submitted under chain-of-custody procedures to Jacobi Ph.D. (McGuire Consulting assisted with the Chironomidae identification) for the identification and classification of BMIs to the lowest practical taxonomic level. This was accomplished by pouring each sample into a 40- (16 in.-) \times 30- (11 in.-) \times 6.4- (2.5 in.-) cm white gridded 3 \times 3 sorting pan (9 cells) and spreading the contents evenly throughout the pan. Cells were randomly selected, and all the organisms were removed (separated from the debris) from the selected cells until approximately 500 organisms had been counted and identified. The number of cells sorted was recorded and used to calculate the total number of organisms in the sample.

The contents of the pan were further examined for any other uncommon or infrequently collected organisms. These were then added to the organism count for that sample (this count occurrence was not included for the multiplier but was added to the total after the multiplier had been used). A list of species and their occurrence was generated, and from this list various metrics/indices, including Shannon diversity and evenness (Zar 1974) and the Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987) was calculated.

c. Results and Conclusions

The numbers and types of organisms collected upstream and downstream of LANL can be found in Table S8-19, and a summary of some standard (bioassessment) metrics/indices calculated from the data can be found in Table S8-20.

In general, the average numbers of BMIs between reaches were statistically similar to each other ($p > 0.05$) (Table S8-19). In contrast, the average numbers of taxa between reaches were statistically different from one another ($p < 0.05$). Although species richness was different between reaches, both reaches were dominated by *Baetis tricaudatus*, a mayfly, and the percent composition of the most pollution-intolerant species within the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) were very high and similar to one another (upstream = 93% and downstream = 95%). Other indices such as the HBI, which considers select BMIs that are sensitive to low dissolved oxygen caused by organic loading, showed similar results between reaches; and based on the HBI of <4.0 from both sites, the water-quality classification for these reaches rated very good with slight organic impacts.

Overall, the biological condition, a multimetric assessment that takes selected community attributes (such as structure, density, community balance, diversity, tolerance to disturbance, and functional feeding groups) into consideration as they relate to the reference (background) reach, showed that in Fall 2011 the downstream reach was approximately 72% of the reference reach (condition=slightly impaired) (Jacobi 2012) (Table S8-20).

The numbers and types of organisms collected in 2011 using kick nets are generally different from the BMI assessment conducted in 2009 using rock basket samplers. Owing to the differences in collection methods during those years plus the significant flooding event(s) that occurred less than 2 months before the collection of BMIs in 2011 because of the Las Conchas Fire the total number and types of BMIs collected during the two collection periods would be expected to be different. The downstream reach contained lower species richness than the upstream reach in 2011. This finding may be a result of the greater intensity and number of flooding events downstream of LAC because there were no differences in species richness/diversity in 2009 (Fresquez et al. 2010).

However, based on the similarity of BMI metrics/indices, composition of the BMI community favoring pollution-intolerant taxa (EPT % and HBI score), and bioassessment scores between the upstream reach and the downstream reach in 2009 and 2011, Laboratory operations, if any, via the LAC system to the Rio Grande are not significantly impacting water quality of the Rio Grande.

5. Facility Monitoring

a. Area G at TA-54

i. Monitoring Network

Native overstory vegetation (branches and needles) around Area G was collected at the same general locations as the soil samples described in Chapter 7, section D.1 (Figure 7-5). Radionuclides analyzed by the ALS Laboratory Group included tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Results for tritium in vegetation are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash weight basis; and results for the TAL elements are reported on an mg/kg dry weight basis.

ii. Vegetation at Area G

With the exception of tritium and plutonium-239/240, all of the other radionuclides in tree samples collected around the perimeter of Area G were mostly not detected or below the RSRLs (based on 1998–2009 data; $n=15$) (Table S8-21).

Tritium was detected above the RSRL in 85% of the tree samples collected around the perimeter of Area G with the highest amounts (33 to 295 pCi/mL) occurring in trees growing in the southern sections near the tritium disposal shafts. All levels of tritium, however, are far below the SL, and despite the large variation in tritium concentrations from year to year, the concentrations are generally not increasing over time (Figure 8-25).

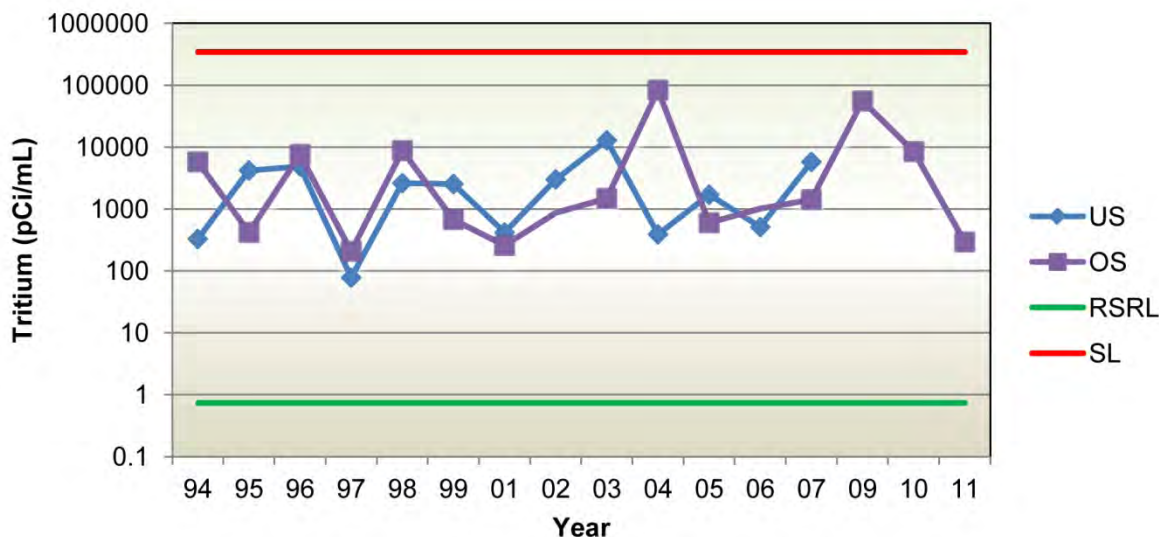


Figure 8-25 Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G at TA-54 (site #29-03 or 30-01) from 1994 through 2011 compared with the RSRL and the SL. Note the logarithmic scale on the vertical axis.

Another radionuclide that was detected above the RSRL in considerable quantities (an order of magnitude) in trees around Area G was plutonium-239/240 in three samples; these samples were collected on the north and northwestern side of Area G (around site #48-01, 52-01, and 58-01). Nevertheless, the highest plutonium-239/240 concentrations in trees growing around the perimeter of Area G are far below the SL and do not pose an unacceptable dose to the tree.

All radionuclides collected from trees located downwind and northeast of Area G at the LANL/Pueblo of San Ildefonso boundary were either not detected or below RSRLs.

b. Dual-Axis Radiographic Hydrodynamic Test Facility at TA-15

i. Monitoring Network

The Laboratory conducts facility-specific biota monitoring on an annual basis at the Dual-Axis Radiographic Hydrodynamic Test (DARHT) facility—the principal firing site at LANL—as required by the mitigation action plan (MAP) resulting from the environmental impact statement for the construction and operation of the DARHT facility (DOE 1996). The history of operations at the site has included open-air detonations from 2000–2006; detonations using foam mitigation from 2002–2006; and detonations within closed steel containment vessels starting in 2007 to present (three in fiscal year [FY] 2007, two in FY08, none in FY09, four in FY10, and three in FY11). Another factor that may influence the amount of potential contamination around the DARHT site (and cleanup) is that the firing point was paved with an asphalt surface in 2007.

The biota samples collected at DARHT include overstory vegetation (tree), field mice, bees, and birds (see Chapter 7, Figure 7-13, for sample locations). Vegetation, field mice, and bee samples are collected for chemical analysis, whereas birds are mostly collected (and released) for population, composition, and diversity estimates.

Overstory samples (branches plus needles) were collected on the north, south, west, and east sides of the DARHT perimeter and analyzed for radionuclides and TAL elements. Small mammals, mostly deer mice (*Peromyscus* spp), were collected on the north and northeast side of the DARHT perimeter and analyzed for radionuclides, TAL elements, and dioxin/furans. Bee samples were collected from two hives located on the northeast side of the DARHT perimeter and analyzed for radionuclides and TAL elements. Bird samples were collected using 12 mist capture net traps spaced about 200 ft to 1600 ft outward from the west side of the DARHT facility. (Spacing of the nets was about 150 ft from one another.)

Vegetation, field mice, and bee samples were submitted to ALS Laboratory Group, where they were processed and analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and/or TAL elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash weight basis; results for the TAL elements in vegetation are reported on an mg/kg dry weight basis; and results for the TAL elements in field mice and bees are reported on an mg/kg wet weight basis. Field mice were submitted to Cape Fear Analytical and analyzed for dioxins/furans; results for dioxins/furans are reported on a pg/g (parts per trillion) wet weight basis.

Results of most of the biota chemical analysis were compared with BSRLs per the MAP (DOE 1996). BSRLs are the upper-limit baseline data established over a 4-year period (1996–1999) before the start-up of DARHT operations in 2000 (Nyhan et al. 2001). The BSRLs, at the 3 sigma level, are based on summaries provided by Fresquez et al. (2001) for vegetation, Haarmann (2001) for bees, and Bennett et al. (2001) for small mammals. Similarly, the population, composition, and diversity of birds collected from DARHT were compared with bird samples collected before the operation of the DARHT facility (Fresquez et al. 2007b). In cases where there are no BSRLs, then the biota chemical analysis results were compared with RSRLs.

ii. *Vegetation at DARHT*

All radionuclide concentrations, including uranium-238, in overstory vegetation collected from around the perimeter of the DARHT facility, were either not detected (most results) or detected below the BSRLs (or RSRLs when BSRL data were not available) (Table S8-22). In the past, uranium-238 was usually the only radionuclide to be detected in overstory vegetation around the DARHT facility (probably as a result of foliar deposition more than by root uptake), but since 2007 the concentrations have generally decreased from all sides of the DARHT perimeter. This general decrease in uranium-238 concentrations with respect to the BSRL was probably due to the change in contaminant mitigation procedures from open-air and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation starting in 2007 (Figure 8-26).

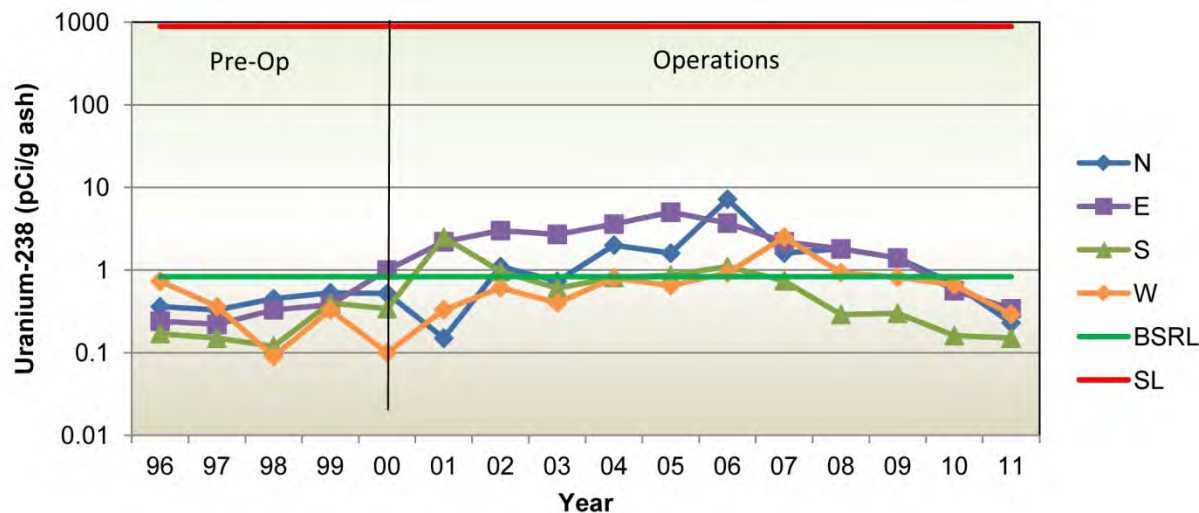


Figure 8-26 Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) sides of the DARHT facility at TA-15 from 1996–1999 (preoperations) through 2000–2011 (during operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.

The TAL element results in overstory vegetation collected from around the DARHT facility are summarized in Table S8-23. All of the metals were either not detected or below the BSRLs (or below the RSRLs).

iii. *Small Mammals at DARHT*

All radionuclides in a composite field mouse sample (n=7) collected from the north and northeast side of the DARHT facility were either not detected (most results) or below the BSRLs (Table S8-24).

The isotopic distribution of uranium-234 to uranium-238 in the field mouse sample collected from the north-northeast side of DARHT indicates the type of uranium is depleted uranium.

Using uranium-238 concentrations to model trends over time, the amounts, as seen with vegetation, exhibit an increase until the year 2007 and then decrease thereafter to the BSRL; this is concurrent with the change in detonation mitigation practices from open-air and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment starting in 2007 (Figure 8-27).

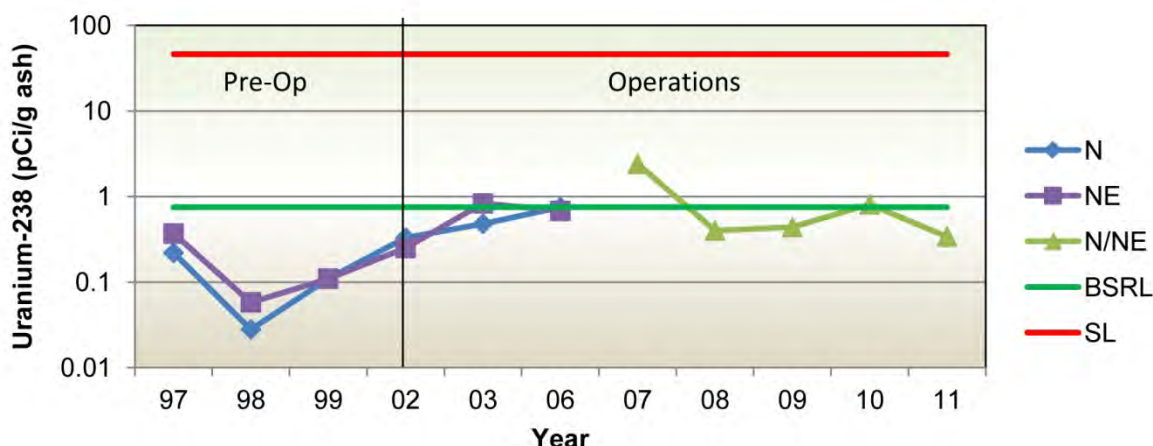


Figure 8-27 Uranium-238 concentrations in (whole-body) mice ($n > 5$) collected from the north (N) and northeast (NE) sides of the DARHT facility at TA-15 from 1997–1999 (preoperations) through 2002–2011 (during operations) compared with BSRL and the SL. Note the logarithmic scale on the vertical axis.

Most TAL elements, with the exception of barium, in a field mouse sample collected from the northeastern perimeter of the DARHT facility were either not detected or similar to RSRLs (based on 2007–2009 data; $n=9$) (Fresquez 2011a) (Table S8-25). The amounts of barium detected were an order of magnitude higher than the RSRL, but the amounts in soil (120 mg/kg) from the north-side perimeter of DARHT were far below the ESLs (< 1800 mg/kg) for the deer mouse (LANL 2010).

Most dioxin or furan chemicals in a field mouse sample were not detected above the method detection limit; only an estimated trace amount (greater than the method detection limit but less than the standard quantification limit) of total tetrachlorodibenzofuran was listed, but the level was similar to the RSRL (based on 2011 data; $n=8$) (Fresquez 2011a) (Table S8-26). Tetrachlorodibenzofuran in soil near the firing point was not detected (Table S7-7).

iv. Bees at DARHT

All radionuclide concentrations in two honey bee samples collected from hives located on the northeastern perimeter of the DARHT facility were either not detectable (most results) or below the BSRLs (Table S8-27). The isotopic distribution of uranium-234 to uranium-238 in both bee samples indicates that the uranium is in a depleted form.

A comparison of uranium-238 in bee samples over the preoperational and operational period at DARHT reveals the same general trend observed with the other biotic samples: that there is an increase in activity to around 2006 and then a sharp decrease concurrent with the change in detonation mitigation practices from open-air/foam (2000–2006) to closed vessel containment starting in 2007 (Figure 8-28).

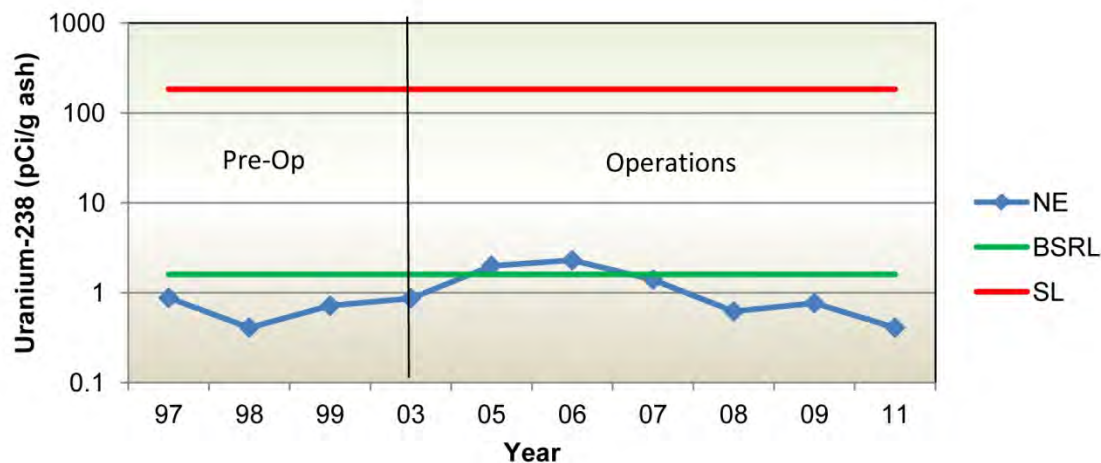


Figure 8-28 Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (preoperations) through 2003–2011 (during operations) compared with the BSRL and the SL. Note the logarithmic scale on the vertical axis.

About 50% of the TAL elements in bee samples collected from hives northeast of the DARHT facility were higher than the RSRLs (based on 2010 data; $n=3$) (Table S8-28). Most of these TAL elements, however, were within the same order of magnitude as the RSRLs. The TAL element metals that were an order of magnitude higher than the RSRLs included copper, iron, sodium, and lead; they were also higher than last year's results (Fresquez et al. 2011). There are no ESLs listed for these metal elements in soil for bees, but the highest levels of these elements in soil around the grounds at DARHT (Table S7-5) are far below ESLs for other indicator biota receptors.

v. *Birds at DARHT*

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2011 compared with (average) samples collected in 1997 through 1999 (preoperational phase) are presented in Table S8-29. The purpose of the bird monitoring project is to determine the general ecological stress levels around the vicinity of DARHT that may be associated with facility operations (e.g., noise, disturbance, traffic, etc.). The number of birds, number of bird species, and the diversity and evenness (distribution) of birds collected in 2011 are similar to those collected before the start-up of operations at DARHT (Figures 8-29 and 8-30). There are a large number of birds and types of birds located in the vicinity of the DARHT complex; a new entry in 2011 included the white-winged dove (*Zenaidura macroura*) and the five most common bird species collected regardless of time periods were the chipping sparrow (*Spizella passerina*), Virginia's warbler (*Vermivora virginiae*), western tanager (*Piranga ludoviciana*), western bluebird (*Sialia mexicana*), and the broad-tailed hummingbird (*Selasphorus platycercus*). The Virginia's warbler is listed in the top 100 birds at risk in North America in the Birder's Conservation Handbook (Well 2007) and is a common inhabitant of the ecosystem near the DARHT facility.



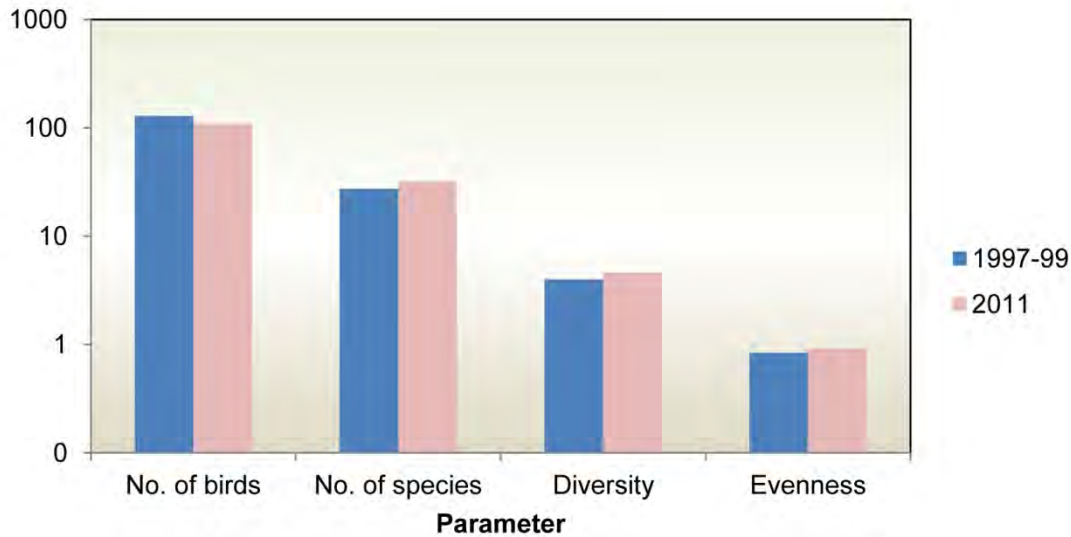


Figure 8-29 Populations, number of species, diversity, and evenness of birds occurring before (1997–99) and during (2011) operations at DARHT. Note the logarithmic scale on the vertical axis.

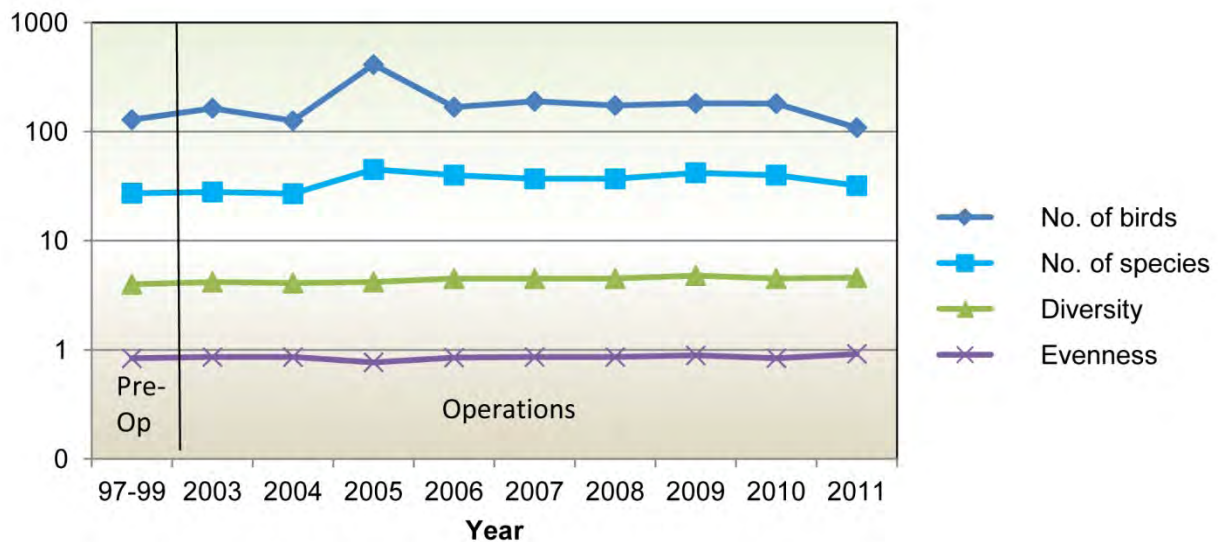


Figure 8-30 Populations, number of species, diversity, and evenness of birds occurring before (1997–99) and during (2003–2011) operations at DARHT. Note the logarithmic scale on the vertical axis.

C. SPECIAL MONITORING STUDIES

In general, special studies are conducted when there is a lack of biological data (populations, composition, and diversity) or data concerning a contaminant(s) that has the potential to impact human health and/or the environment. The following special studies were conducted in 2011 in support of mitigation action plans, the Biological Resources Management Plan, and the Environmental Surveillance Program.

1. Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Basins: Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 43,000 acres of federal and pueblo land, including approximately 7,500 acres on LANL property. Because the Cerro Grande Fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the US Army Corps of Engineers constructed two large erosion control structures to control storm water and sediment runoff from burned areas. These structures consist of (1) a low-head, rock-filled gabion weir that lies across the streambed in LAC near the junction of NM 4 and NM 502 and (2) a large cement flood retention structure located downstream of the confluence of Twomile and Pajarito canyons.

As part of the Special Environmental Analysis actions taken in response to the Cerro Grande Fire at LANL (DOE 2000), the DOE identified various mitigation measures that must be implemented under the MAP as an extension of the fire suppression, erosion, and flood-control actions. One of the tasks identified in the plan Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface water, groundwater, and biota at areas of water or silt retention upstream (upgradient) of flood-control structures, within silt retention basins, and within sediment traps to determine if there has been an increase in contaminant concentrations in these areas and to determine to what extent they impact the biota.

To this end, we collect native understory vegetation (grasses and forbs) and field mice (mostly deer mice, *Peromyscus* spp) in the areas upgradient (the retention basin) of the Los Alamos Canyon Weir (LACW) and the Pajarito Canyon Flood Retention Structure (PCFRS). Native plants are monitored because they are the primary food source of biota, and field mice are monitored because they have the smallest home range of the mammals.

ALS Laboratory Group analyzed the field mouse (whole-body) samples for radionuclides and TAL elements. PCBs (congeners, homologs, and totals) in whole-body field mice were analyzed by Cape Fear Analytical. The following two sections report the 2011 results of this monitoring.

a. Los Alamos Canyon Weir

The LACW structure was installed in 2001 and was partially excavated of sediments for the first time in 2009; the accumulated sediment was placed along the north slope of the LACW retention basin. The following biota samples were collected on May 24–25, 2011.

The concentrations of radionuclides and TAL elements in a composite understory vegetation sample that was collected within the LACW retention basin can be found in Tables S8-30 and S8-31, respectively. As in previous years, radionuclides such as strontium-90, plutonium-238, plutonium-239/240, and americium-241 in vegetation growing within the LACW retention basin were in higher concentrations than the RSRLs (based on 1999–2006 data; n=11). With the exception of strontium-90, these radionuclides are not usually taken up very readily by plants, so the higher amounts of these radionuclides on vegetation on the upgradient side of the LACW compared with the RSRL may be due to either wind deposition or rain splash from the old or newly accumulating sediment. In either case, the concentrations of these radionuclides, including strontium-90, are still very far below the dose-based SLs and, with the exception of possibly plutonium-238, generally not increasing over the 5-year period (Figure 8-31). All TAL elements, with the exception of sodium, in understory vegetation were below the RSRLs (based on 1998–2003 data; n=17).

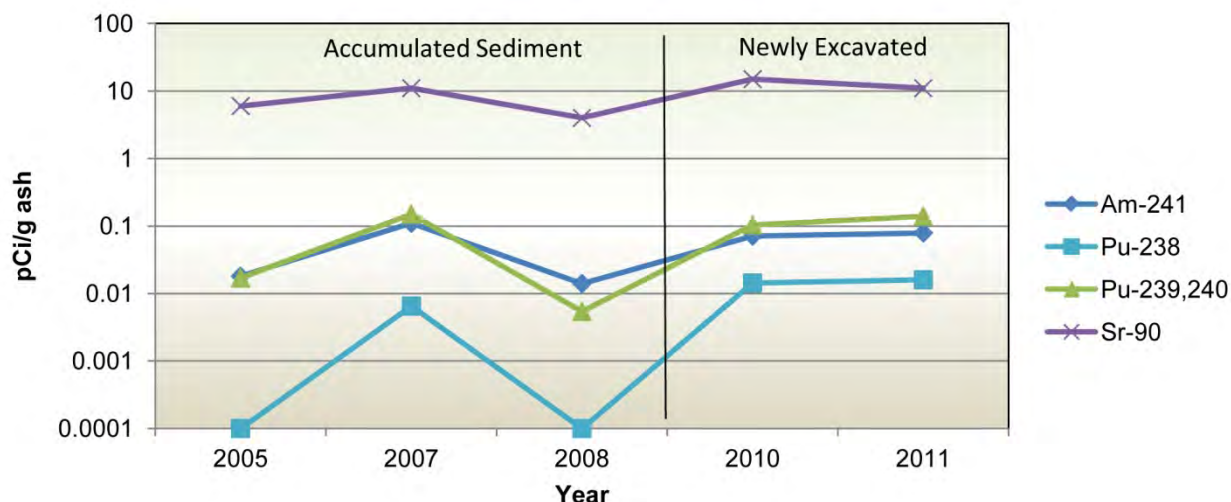


Figure 8-31 Americium-241, plutonium-238, plutonium-239/240, and strontium-90 concentrations in understory vegetation collected on the upgradient side (retention basin) of the LACW from 2005 through 2010. Note the logarithmic scale on the vertical axis.

Basically, all of the same radionuclides (americium-241, plutonium-238, and plutonium-239/240), with the exception of strontium-90, detected in vegetation from within the LACW retention basin were detected in a composite field mouse sample ($n=5$) in higher concentrations than the RSRLs (based on 2002–2009 data; $n=7$) (Fresquez et al. 2011) (Table S8-32). All radionuclides detected in a composite field mouse sample above RSRLs are still far below dose-based SLs but appear to be increasing over the last 2 to 3 years (2009 to 2011) (Figure 8-32).

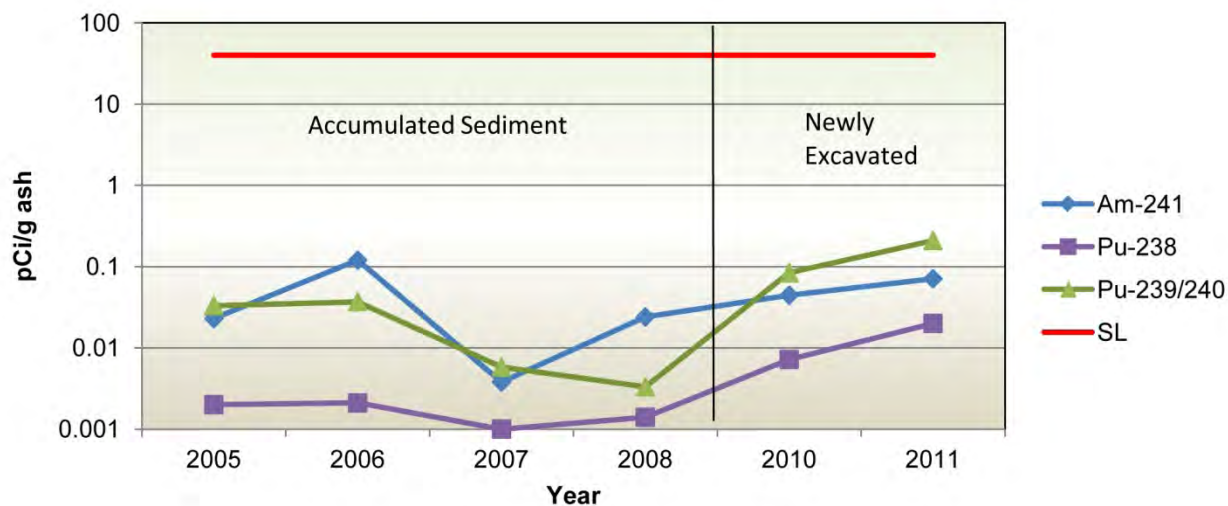


Figure 8-32 Americium-241, plutonium-238, and plutonium-239/240 in composite whole-body field mouse samples ($n>5$) collected on the upgradient side (retention basin) of the LACW from 2005 through 2011, compared with the SL. Note the logarithmic scale on the vertical axis.

Results of the TAL elements in whole-body field mice can be found in Table S8-33. All TAL elements in field mice ($n=3$) collected on the upgradient side of the LACW were lower than or similar to the RSRLs.

All concentrations of total PCBs in field mice ($n=3$) collected from the retention-basin side of the LACW were higher than the RSRL by one to two orders of magnitude (Table S8-34). Although the amounts of PCBs in field mice collected upgradient of the LACW were higher than the RSRL, the levels in surface

sediment, based on the highest total PCB concentration within the LACW retention basin in 2011 (0.038 mg/kg) (Reneau 2012), were far below the ESL for field (deer) mice of 20 mg/kg for Aroclor-1260 (LANL 2010) and are not expected to significantly impact the field mice population. Also, the levels of total PCBs in field mice collected around the LACW greatly decrease after 2008 to present (Figure 8-33) and would be expected to decrease along the length of the tributary towards the Rio Grande. In a past study, Fresquez et al. (2010) reported that the mean total PCB amounts in field mice collected approximately 4.5 miles downgradient from the LACW in 2009 were about 90% lower than those detected in field mice collected from within the LACW retention basin. Therefore, based on this relationship, the estimated concentration of total PCBs in field mice 4.5 miles downgradient of the LACW, based on the mean total PCB amount in field mice collected from the LACW in 2011 (7657 pg/g wet), would amount to about 766 pg/g wet; this amount would be similar to the RSRL (885 pg/g wet).

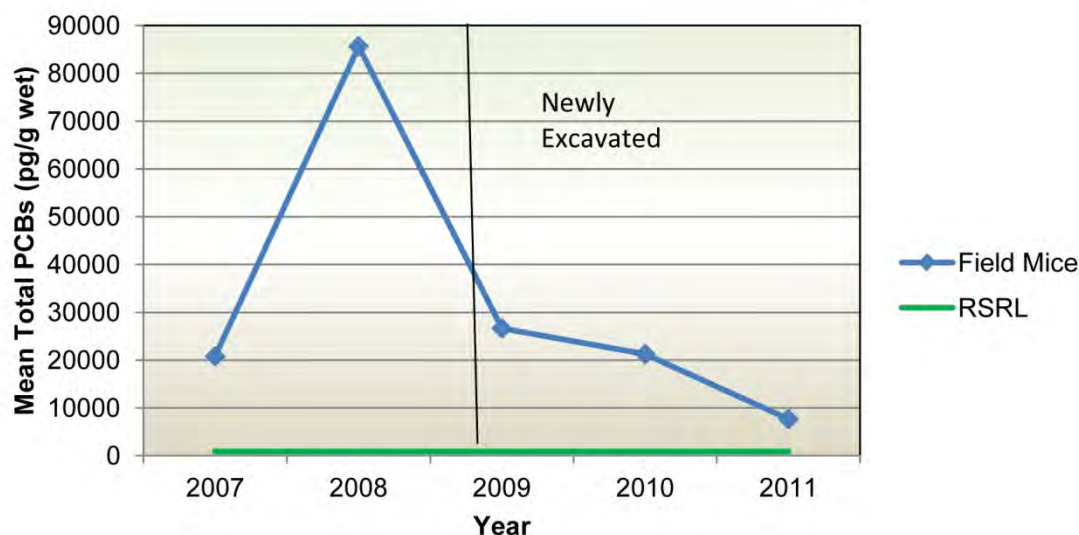


Figure 8-33 Mean total PCB concentrations in whole-body field mice collected on the upgradient side (retention basin) of the LACW from 2007 through 2011 compared with the RSRL (885 pg/g wet)

A comparison of the mean PCB homolog distribution of field mice collected around the LACW shows that the pattern is mostly within the Aroclor-1260 profile formulation (Figure 8-34). Aroclor-1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW (Fresquez et al. 2007c, 2008; Reneau and Koch 2008).

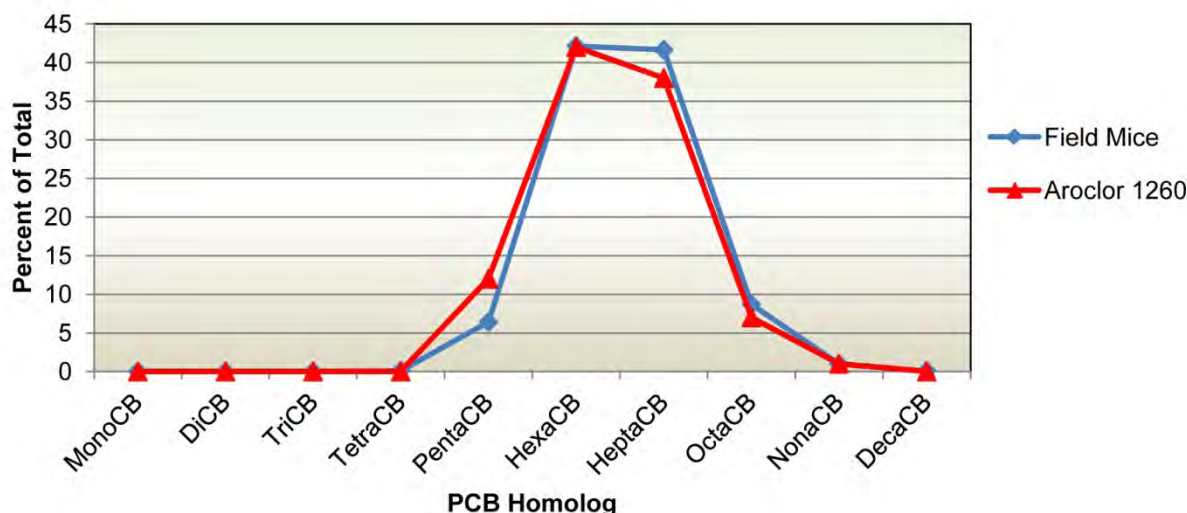


Figure 8-34 The mean total PCB homolog distribution for whole-body field mice samples collected on the upgradient side of the LACW in 2011 compared with Aroclor-1260

b. Pajarito Canyon Flood Retention Structure

Concentrations of radionuclides and TAL elements in native understory vegetation (grasses and forbs) and radionuclides, TAL elements, and PCBs in field mouse samples collected from within the silt/sediment retention basin (upgradient side) of the PCFRS on June 1–15, 2011, are presented in Tables S8-33 through S8-37.

All of the radionuclides (Table S8-35) and TAL elements (Table S8-36) in a composite native understory vegetation sample collected within the upgradient side of the PCFRS were either not detected or were below the RSRLs.

Last year, the concentrations of antimony in vegetation (4.2 mg/kg dry) collected upgradient of the PCFRS were higher than the RSRL. Past levels of antimony in vegetation from this area ranged from undetected to 0.53 mg/kg; so the reported value in 2010 was unusually high. This year, antimony in vegetation collected from the retention area of the PCFRS is at normal concentrations (0.010 mg/kg dry).

All of the radionuclides in a composite field mouse sample (n=5 subsamples) collected from the upgradient side of the PCFRS were below RSRLs (Fresquez et al. 2011) (Table S8-37). Similarly, most of the TAL elements were below or similar to the RSRLs (Table S8-38).

Compared with last year (2010), larger amounts of total PCBs were detected in field mice (n=3) from the upgradient side of the PCFRS; this is mainly a result of one of the three field mouse samples containing large amounts of total PCBs compared with the others. The mean total was also two orders of magnitude higher than the RSRL (Fresquez et al. 2011) (Table S8-39) and generally similar to the levels reported in past years (Figure 8-35). Based on the highest total PCB concentration in sediment from the closest sampling point upgradient of the PCFRS (at the confluence of Twomile Canyon with Pajarito Canyon= 0.023 mg/kg) (Reneau 2012), the level was below the ESL for field (deer) mice of 20 mg/kg for Aroclor-1260 (LANL 2010) and is not expected to significantly impact the field mouse population.

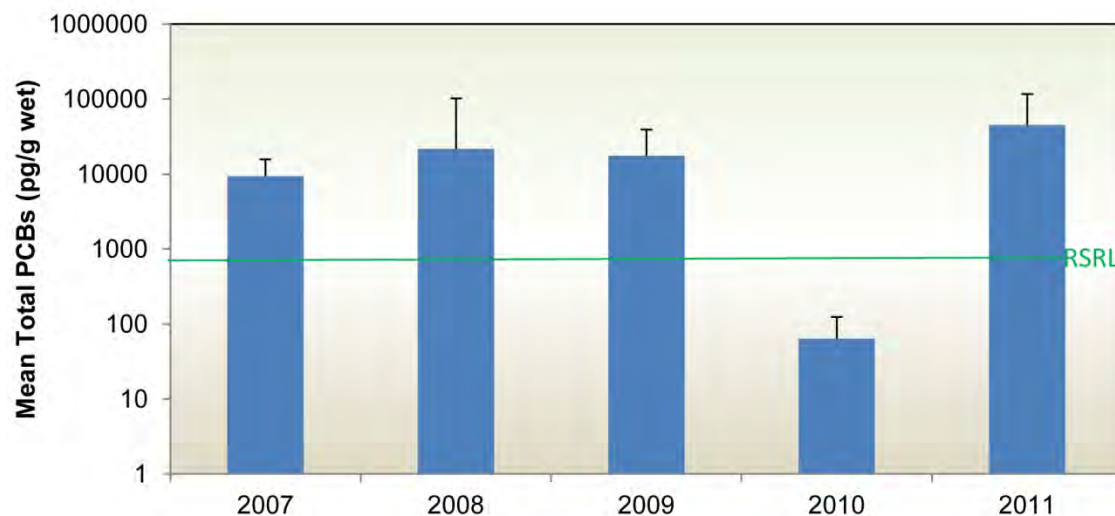


Figure 8-35 Mean total PCB concentrations (± 1 standard deviation) in whole-body field mouse samples collected on the upgradient side (retention basin) of the PCFRS from 2007 through 2011 compared with the RSRL

The mean PCB homolog distribution of field mice collected from the PCFRS overlaps the distribution pattern of Aroclor-1260 (Figure 8-36). Trace amounts of Aroclor-1254 and Aroclor-1260 have been detected in sediment collected upgradient (Fresquez et al. 2007c, 2008, 2009; Reneau and Koch 2008) and downgradient of the PCFRS in past years (LANL 2008).

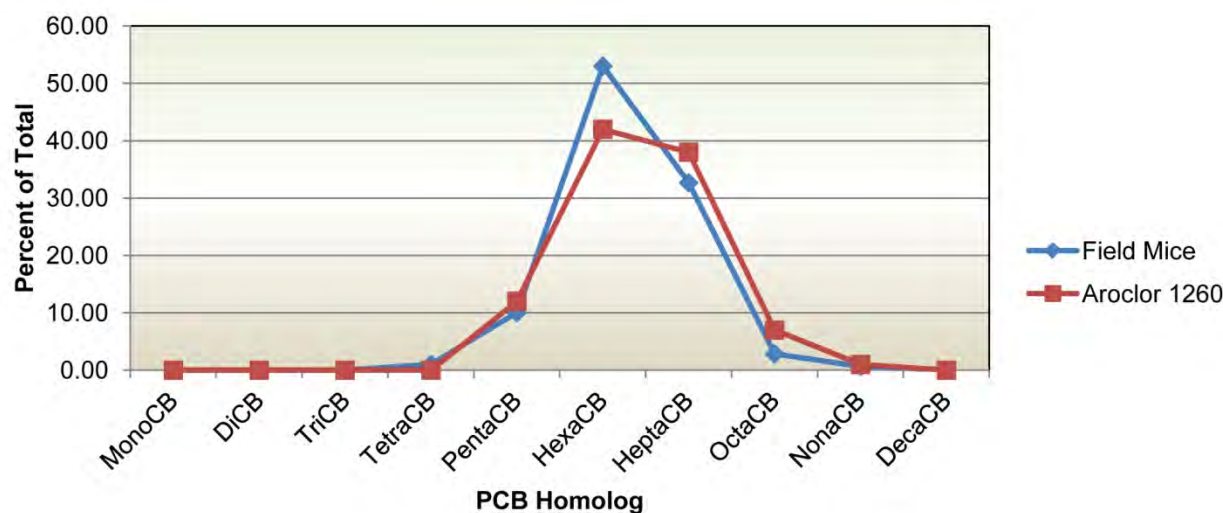


Figure 8-36 Mean PCB homolog distribution of whole-body field mouse samples collected on the upgradient side of the PCFRS in 2011 compared with Aroclor-1260

2. Winter and Breeding Bird Surveys at Los Alamos National Laboratory

LANL initiated a multiyear study of migratory birds in FY11 to implement the Biological Resources Management Plan and to comply with Federal laws, executive orders, and regulations related to migratory birds. The objective of the ongoing study is to monitor patterns of bird abundance, richness, and population trends over time at the Laboratory. LANL biologists completed point-count surveys beginning in the winter of 2010 and again in the summer of 2011. Four habitat types were surveyed for this project based on the .25 hectare physiognomic cover classes in the LANL land cover map. Habitat types included (1) mixed conifer forest, (2) ponderosa forest, (3) wetland/riparian, and (4) piñon-juniper woodland. Transects were approximately 2.50 to 2.75 km in length and contained 10 survey points spaced approximately 250 m apart. Winter surveys took place in each of the four habitat types in December, January, and February. The summer

breeding bird surveys were conducted in each of the four habitat types between May and July 2011. The third and final survey in the mixed conifer habitat was cancelled because of the Las Conchas Wildfire.

More than 1,900 birds, representing 81 species were recorded during the FY11 surveys. Thirty-one species were detected during the winter surveys, and 73 species were detected during the summer breeding surveys. Two of the species detected at LANL, the willow flycatcher and juniper titmouse, are listed in the Birds of Conservation Concern compiled by the US Fish and Wildlife Service. One species detected at LANL, the Virginia's Warbler, is listed in the top 100 birds at risk in North America in the Birder's Conservation Handbook (Well 2007). For more detailed information about this study see Hathcock et al. (2011).

3. Los Alamos National Laboratory Fall Avian Migration-Monitoring Report 2010

During 2010, LANL biologists completed a monitoring effort to document fall migration patterns of passerines (songbirds) at LANL. A mist-netting station was established in wetland/riparian habitat at LANL. Birds were captured and banded with US Fish and Wildlife Service migratory bird bands. The 2010 fall migration-monitoring began on August 4, and the station's 11 nets were opened once a week until October 7. Monitoring did not continue through October because the majority of the wintering species had arrived by October 7.

A total of 472 birds, representing 42 species, were banded as part of this effort. Broad-tailed, black-chinned, and Rufous hummingbirds were also routinely captured in August and released without being banded. The number of birds banded per net hour for the entire season was 0.84. The ecological importance of LANL's wetlands complex is supported by the results of this study. A large diversity of birds uses this area, including willow flycatchers, a subspecies of which is federally endangered. There are many risk factors that may affect these wetlands in the future, including possible development, so understanding the role that LANL lands play in bird migration is important for developing strategies for biological resources protection and management. For more detailed information about this study see Hathcock (2010).



4. Los Alamos National Laboratory Fall Avian Migration Monitoring Report 2011

During the fall of 2011, LANS biologists completed the second year of monitoring fall migration passerines at LANL. Songbirds were captured at a mist-netting station located in a large wetland/riparian complex in TA-36 on the north side of Pajarito Road. Captured birds were identified, measured, and banded with a US Fish and Wildlife Service migratory bird band. The 2011 fall migration monitoring effort began on August 11, 2011, and was operated one morning per week until October 12, 2011. A total of 10 mist-netting sessions were completed. This project facilitates LANL's compliance with the 2006 memorandum of understanding between the US Fish and Wildlife Service and the Department of Energy and adds value to the Environmental Protection Division's compliance programs.

A total of 146 birds, representing 31 species, were banded in 2011. Broad-tailed, black-chinned, calliope, and Rufous hummingbirds were also captured in August and September but are not analyzed as part of this project. There were substantial declines in songbird diversity and density compared with 2010 at this site. Comparing 2010 with 2011, the total number of birds captured dropped from 474 to 146, a decline of 70%. Likewise the total number of species banded dropped from 42 to 31 species. For more detailed information about this study see Hathcock et al. (2012).

5. Small Mammal Sampling at Open-Detonation Firing Sites

In August and September 2010, a small mammal study was initiated at LANL at two open-detonation firing sites, Minie in TA-36 and Point 6 in TA-39, and at a background location in TA-49. The purpose of the study was to evaluate small mammal species population abundance and occurrence at the open-detonation

firing sites relative to the background site. A total of 131 small mammals were captured at the three study locations with about 60 percent new captures and about 40 percent recaptures. TA-36 had the highest number of new and total captures. TA-49 had the lowest number of new captures and the lowest total captures. Species diversity and evenness were the highest for the TA-36 lower grid, and the TA-39 lower grid had the lowest diversity and evenness. The mean percent daily capture rate was highest for the TA-36 upper grid (7.5 percent), and the lowest at the 5 by 20 grid at TA-49 (3.75 percent). There was slight difference in species composition at the three study sites. There was a potential for seven different species at each location. Captures at TA-36 included five different species, and captures at TA-39 and TA-49 included four different species. At TA-39, an additional species, not included in the seven potential species expected, was captured. This species, the rock pocket mouse (*Chaetodipus intermedius*) had not previously been captured during LANL small mammal trapping efforts. The deer mouse (*Peromyscus maniculatus*) was the dominant species captured at TA-36 and TA-39, and the brush mouse (*Peromyscus boylii*) was the dominant species captured at TA-49. Sex ratios were compared using a chi-square analysis. Only species with sufficient sample size ($n \geq 5$) were evaluated. Deer mice were analyzed at all three locations and showed no differences in sex ratio. Three other species were analyzed at one location each, brush mouse (TA-49), harvest mouse (TA-36), and silky pocket mouse (*Perognathus flavus*) (TA-36), and no differences were detected in sex ratio. A reproductive category was assigned to each animal, but because of the small sample size, statistical analysis of differences in reproductive status by species could not be analyzed. Mean weights were analyzed only for the male deer mouse, female deer mouse, and female harvest mouse because of insufficient sample size. The body weights of the male deer mouse were compared at all three locations, and no significant differences between locations were detected. The body weights of female deer mice were compared at TA-36 and TA-39, and the body weights of female harvest mice were compared at TA-36 and TA-49, with no significant differences detected in body weights between locations. Because of nonlinear daily captures at TA-39 and TA-49, density estimates could be calculated only for TA-36, Minie (43.5 animals/ha). For more detailed information about this study see Bennett and Robinson (2011).

6. Chemical Concentrations in Field Mice Collected from Open-Detonation Firing Sites

Field mice (mostly *Peromyscus* spp.) were collected at two LANL open-detonation (high explosive) firing sites—Minie at TA-36 and Point 6 at TA-39—in August of 2010 and in February of 2011 for chemical analysis. Samples of whole-body field mice from both sites were analyzed for TAL elements (mostly metals), dioxins/furans, PCB congeners, high explosives, and perchlorate. In addition, uranium isotopes were analyzed in a composite sample collected from TA-36, Minie. In general, all constituents in whole-body field mouse samples collected from these two open-detonation firing sites were either not detected or they were detected below RSRLs, SLs, and/or soil ESLs. Lead at TA-39, Point 6, was the exception. The amount of lead in field mouse tissue collected from TA-39, Point 6 was higher than regional background, and some lead levels in the soil were higher than the ESL for the field mouse; however, these levels are not expected to affect the viability of the populations over the site as a whole. For more detailed information about this study, see Fresquez (2011b).

7. Chemical Concentrations in Field Mice/Voles Collected from an Open-Burn Site at Technical Area 16

Field mice and voles were collected around a LANL open-burn (high-explosive waste) site, TA-16-388, at TA-16 in March of 2011 for the analysis of 23 TAL elements (mostly metals) and 17 dioxin/furan chemicals. All TAL elements in whole-body field mouse samples ($n=3$) were either similar to regional background or below screening levels. Dioxins and furans were not detected above the analytical limit of quantification in any of the whole-body field mouse/vole samples ($n=6$). For more detailed information about this study, see Fresquez (2011c).

8. Preliminary Results of Chytrid Fungus Testing of Amphibians at Los Alamos National Laboratory

As part of a cooperative study with the New Mexico Department of Game and Fish (NMDG&F), various amphibian species (canyon tree frog, chorus frog, Woodhouse's toad and Jemez Mountains salamander) at LANL were tested for chytridiomycosis fungus (*Batrachochytrium dendrobatidis*) (Bd) infection. Bd is linked to amphibian declines worldwide—more than 40% of all amphibian species are currently in decline

(Cheng et al. 2011). Bd has a flagellated infective life stage called the zoospore that imbeds itself into the keratinized skin of amphibians causing hyperkeratosis, loss of skin function, osmoregulatory failure, and death (Voyles et al. 2009). Bd has been documented throughout New Mexico, and a preliminary investigation into whether Bd exists on LANL property was initiated in 2007 as part of the Biological Resources Management Plan. Amphibians opportunistically encountered in the field were swabbed for Bd between 2007 and 2011. Samples were transferred to the NMDG&F, who submitted them to Pisces Molecular for analysis. Eight samples total have been submitted from amphibians found in the following watersheds in or adjacent to LANL: Los Alamos Canyon, Pajarito Canyon, Twomile Canyon, Pueblo Canyon, and Chaquehui Canyon. All eight samples were negative for Bd. Continued and expanded sampling is warranted because the Jemez Mountains salamander has been documented on LANL property, and it is anticipated that this species will be federally listed under the endangered species act within the next two years. A Jemez Mountains salamander has been documented with Bd on the Valles Caldera National preserve west of LANL (Cummer et al. 2005). For more information, contact Chuck Hathcock, ENV-ES (505-665-3366, hathcock@lanl.gov).

9. Life in the Fast Lane: Road-Crossing Behavior of Mule Deer in a Wildland-Urban Interface

In 2009, approximately 260,000 animal-vehicle collisions were reported in the United States, resulting in 12,000 human injuries and 173 human fatalities. Research has focused on identifying factors associated with high densities of animal-vehicle collisions, including variables such as traffic speed and volume, road design, topographic features, vegetative cover, and local deer or elk (*Cervus elaphus*) abundance. The purposes of this study were to document how often and where mule deer (*Odocoileus hemionus*) crossed roads in a western United States wildland-urban interface area at Los Alamos, NM, and to relate deer road-crossing behavior to deer vehicle-collision locations. Seven adult mule deer (four males [M] and three females [F]) were captured on DP Mesa and TA-49 and collared with global positioning system-enabled collars during December 2001 and January 2002. Five of the seven deployed collars were recovered.

None of the roads in the study area appeared to act as a substantial barrier to deer passage. Deer home ranges straddled highways and primary, secondary, and tertiary arterial roads. Deer crossed all types of roads. The average number of times deer crossed roads during 24 hours of monitoring ranged from 2.1 to 7.0. Deer in the Los Alamos town site avoided crossing roads during the day and before sunset.

Deer-vehicle accidents occurred at 350 percent of the level expected after sunset. All other time periods had fewer accidents than expected. The distribution of accidents across time periods was not similar to the distribution of road crossings across time periods for any deer. Within Los Alamos County, there was a clear trend for deer-vehicle collisions to occur on roads with speed limits greater than 35 mph. Deer in the town site frequently crossed roads with lower speed limits; therefore, the reason for the paucity of accidents along these roads was evidently the ability of drivers to detect deer (or the ability of deer to detect vehicles) and respond before an accident occurred. There was a significant but not strong correlation between the density of accidents and the density of road crossings. This was probably related to the high number of deer crossings of tertiary arterial roads, where accidents were not likely to occur. For more detailed information about this study, see Hansen et al. (2012).

10. Bat and Small Mammal Use of Burned and Unburned Ponderosa Pine Forest following the Cerro Grande Fire in Los Alamos, New Mexico

We placed Anabat™ detectors and small mammal tracking tubes in five unburned and five severely burned ponderosa pine plots on LANL property following the May 2000 Cerro Grande Fire. We examined species richness and abundance of bat calls during 2001, and taxa richness and amount of sign for small mammals in 2001 and 2002. Unburned plots had a range of 51–737 ponderosa pine per acre, and burned plots had a range of 0–33 ponderosa pine per acre. In unburned plots average forb cover was 0.25%, and average graminoid cover was 11.21%. In burned plots average forb cover was 8.16%, and average graminoid cover was 17.33%. Up to six bat species were identified on individual plots. There was no significant difference in bat species richness between burned and unburned plots. For small mammals, taxa richness and total activity were significantly higher in burned plots than in unburned plots in 2001. There were no significant differences in these measures for small mammals in 2002. Small mammal taxa diversity increased significantly on both burned and unburned plots in 2002 relative to 2001. Drought, which contributed to the severity of the

Cerro Grande Fire, may also have contributed to the observed response of small mammals following the fire. For more detailed information about this study see Hansen et al. (2009).

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

This program uses the same quality assurance (QA) protocols described in Chapter 7 (QA program development, field sampling QA, analytical laboratory quality assessment) and also some of the same standard operating procedures (SOPs) used by analytical laboratories, plus the following SOPs:

- Produce sampling (SOP-5134)
- Fish sampling (SOP-5135)
- Game animal sampling (SOP-5136)
- Collection of crawfish in the Rio Grande (SOP-5249)
- Collection of macroinvertebrates in the Rio Grande (SOP-5247)
- Processing biota samples for analysis (SOP-5137)

These procedures, which are available on the LANL public website (<http://www.lanl.gov/environment/all/qa.shtml>), ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results are conducted in a manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

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To Read About**Turn to Page**

<i>Introduction</i>	9-1
<i>Corrective Actions Program</i>	9-11
<i>TA-54 Closure Program</i>	9-17
<i>TA-21 Closure Program</i>	9-17
<i>Quality Assurance Program</i>	9-21
<i>References</i>	9-22

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is characterizing and remediating, as necessary, sites to ensure that chemicals and radionuclides in the environment associated with past operations do not pose a potential unacceptable risk or dose to human health or the environment. The LANL Environmental Programs (EP) Directorate is leading the site investigations with the objectives of (1) determining the nature (the origin, type, and concentration of chemicals/radionuclides, either natural or man-made, that are present in the environment) and extent (where a chemical/radionuclide is distributed in the environment) of these constituents; (2) identifying, evaluating, and implementing, where needed, remediation or other corrective measures to remove or mitigate the presence and/or migration of chemicals and radionuclides; and (3) ensuring that concentrations of chemicals and radionuclides are protective of human health and the environment.

An investigation involves the collection and evaluation of data from and information about sites. The sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs). Each investigation collects samples of the environmental medium of interest and the data are utilized to support site decisions. Once the nature and extent of chemicals and radionuclides have been determined, risk assessments are conducted, and if necessary, appropriate/approved cleanup activities are implemented. Long-term stewardship activities, including surveillance and monitoring, might be implemented where material remains in place to ensure that there are no changes in potential risk/dose and concentrations.

The general process for evaluating and remediating sites is called the corrective action process. A corrective action is taken, when necessary, to rectify conditions potentially adverse to human health and the environment. There are two potential outcomes when a corrective action is performed; the site is restored by reducing concentrations to acceptable levels that protect human health and the environment, or as much of the material as possible is removed and long-term stewardship activities are implemented, such as containing the material on the site, restricting exposure to chemicals and radionuclides on the site, restricting access to the site, and/or performing surveillance and monitoring. Corrective actions are complete at a site when LANL has demonstrated and documented to the regulatory authority's satisfaction that the site poses no unacceptable risk or dose to humans and ecological resources, such as plants and animals.

In January 2012, the New Mexico Environment Department (NMED) and the US Department of Energy/National Nuclear Security Administration (DOE/NNSA) announced a framework agreement between the two agencies to address prioritization of environmental work at the Laboratory. This non-binding agreement in principle calls for the Laboratory to accelerate the shipment of transuranic (TRU) wastes from Technical Area 54 (TA-54) to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico. The DOE/NNSA agreed to ship 3,706 cubic meters (m³) of TRU waste from TA-54 to WIPP by June 30, 2014. In order to achieve the accelerated waste shipments within existing and anticipated budgets, NMED agreed that some work that would have been performed under the Consent Order during this timeframe be delayed so that funding originally assigned to the Consent Order work could be transferred to the TRU waste disposition activities. As a result, fewer activities than originally scheduled under the Consent Order will be performed in 2012.

1. Programs

The Corrective Actions Program investigates consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as sites located within the Los Alamos town site (property currently owned by private citizens, businesses, or Los Alamos County) and property administered by the US Forest Service (USFS), the National Park Service, and DOE. The Corrective Actions Program also includes the canyons investigations, the groundwater monitoring program (implemented through the annual Interim Facility-Wide Groundwater Monitoring Plan [Interim Plan] [LANL 2011a]), storm water and surface water monitoring, and the implementation of best management practices to minimize erosion.

The TA-21 Closure Program involves all of the sites associated with TA-21 and includes Material Disposal Areas (MDAs) A, B, T, U, and V; various process waste lines; a radioactive waste treatment system; and the DP Site Aggregate Area sumps, outfalls, leach fields, historic container storage areas, and other former facilities. The Laboratory received additional funding for environmental cleanup projects as part of the American Recovery and Reinvestment Act (ARRA), which included the decontamination and demolition (D&D) of most of the buildings at TA-21, removal and disposal of waste from MDA B, and the installation of groundwater monitoring wells.

The TA-54 Closure Program involves all of the sites associated with TA-54 and includes MDAs G, H, and L. Activities involve periodic monitoring of the groundwater and vadose zone as well as the development and implementation of corrective measures for the MDAs.

2. Work Plans and Reports

The EP Directorate programs developed and/or revised 18 investigation work plans and 27 investigation reports, which were submitted to the NMED during 2011. A work plan proposes investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, and/or canyons. Samples of designated environmental media are collected from approved locations and depths and analyzed for some or all of the following analytical suites/analytes: target analyte list metals, cyanide, perchlorate, nitrate, volatile organic compounds (VOCs), semivolatile organic compounds, polychlorinated biphenyls (PCBs), dioxins and furans, explosive compounds, total petroleum hydrocarbons, isotopic uranium, americium-241, isotopic plutonium, gamma-emitting radionuclides, strontium-90, and tritium. The data are presented in an investigation report, which presents and assesses the sampling results, and recommends additional investigation, remediation, monitoring, or no further action, as appropriate.

Table 9-1 summarizes the investigation work plans submitted and/or approved in 2011. The table also provides general information and details regarding the sampling and/or remediation to be conducted under these plans when implemented. Table 9-2 presents the investigation reports submitted and/or approved in 2011 as well as the status of the reports/sites through 2011. NMED granted Certificates of Completion for 83 SWMUs and AOCs in 2011 (Table 9-3). The certificates indicated that corrective actions were complete with or without controls, meaning either no further corrective actions are needed but some type of institutional controls (e.g., land use) must be in place to maintain current conditions (with controls) or no additional corrective actions or conditions are necessary (without controls). Figure 9-1 shows the sites, aggregate areas, and canyons where significant environmental characterization and/or remediation work was reported in 2011. In addition to the work plans and reports presented in the tables, numerous other documents related to groundwater, surface water, vapor monitoring, and well installations were written and submitted to NMED. These include periodic monitoring reports, drilling work plans, and well completion reports as well as annual updates to the Interim Plan and the General Facility Information report.

Table 9-1
Summary of Work Plans Submitted and/or Approved in 2011

Document	Date Submitted	Date Approved	TAs	Types of Sites to be Investigated	Number of Sites to be Investigated	Number of Samples Proposed	Sites where Cleanup Proposed
DP West Building 21-002 Footprint Letter Work Plan	1/14/2011	3/9/2011	TA-21	Building 21-002 was a laboratory for plutonium research.	1	180	D&D of building 21-002 is completed. Sampling will occur after removal of the building concrete pad (footprint) is completed. Any additional piping or structures encountered will be removed under this work plan.
Investigation Work Plan for Upper Water Canyon Aggregate Area, Revision 1	1/14/2011	2/18/2011	TA-11, TA-16	Firing pit, sumps, septic systems, outfalls, potential soil contamination areas, dry well, grease trap, oil switches, building footprints, landfill, surface disposal areas, former magazines, underground storage tanks, above ground storage tanks, former transformer areas, spill areas, former manhole, former incinerator, hydraulic press and associated drain	129	Approximately 2,500	Drain lines, sumps, septic tanks, manhole, dry well, debris as found and/or as appropriate
Phase II Investigation Work Plan for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary	2/15/2011	6/10/2011	TA-49	Landfills, underground calibration chamber, and elevator shaft	3	56	0
Work Plan for Chaquehui Canyon Aggregate Area, Revision 2	2/18/2011	3/3/2011	TA-33	Disposal pits, septic systems, seepage pits, outfalls, incinerator, surface disposal areas, storage areas, shot chamber, firing sites, landfill, potential soil contamination, burn area, drain lines, transformer	43	Approximately 11,000	SWMU 33-015 incinerator and concrete pad; AOC 33-008(c) and SWMU 33-006(a) debris, if present; SWMUs 33-004(d) and 33-004(b) septic tanks removed; SWMU 33-008(a) landfill and SWMU 33-010(f) surface disposal area excavated

Table 9-1 (continued)

Document	Date Submitted	Date Approved	TAs	Types of Sites to be Investigated	Number of Sites to be Investigated	Number of Samples Proposed	Sites where Cleanup Proposed
Investigation Work Plan for Starmer/Upper Pajarito Canyon Aggregate Area, Revision 1	3/7/2011	3/29/2011	TA-08, TA-09, TA-22, TA-40	Off-gas system, gun site, septic tanks, drain lines, floor drains, outfalls, incubator, landfills, silver recovery unit, storage areas, underground tank, building footprints, surface disposal areas, sumps, firing chambers, manhole, burn pit, surface impoundments and ponds, firing sites, magazines, potential soil contamination area, open detonation area, seepage pit, basket washing pit	74	Approximately 2,200	SWMU 08-002 debris removal. SWMU C-09-001 soil removal. SWMU 04-003(a) unexploded ordnance (UXO) surveys will be conducted and debris removed.
Phase II Work Plan for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary	3/18/2011	6/30/2011	TA-49	Experimental shafts, drain field, drain lines, potential soil contamination area, bottle house and cable pull test facility	10	104	0
Monitoring Plan for Los Alamos/Pueblo Canyons Sediment Transport Mitigation Project	3/23/2011	6/3/2011	n/a	Monitoring of geomorphic changes associated with the mitigation measures will be conducted using repeat cross-section surveys, channel thalweg surveys, and general area surveys. Storm water monitoring will be conducted throughout watershed.	Geomorphic changes at 11 locations and storm water at 16 locations (including 13 gauge stations).	Up to 94 storm water samples per event (unfiltered except for metals, which includes filtered).	n/a
Phase II Investigation Work Plan for North Ancho Canyon Aggregate Area, Revision 1	3/28/2011	5/13/2011	TA-39	Landfill, storage areas, satellite accumulation area, soil dump, inactive septic system components (former sand filter, former septic tank, former chemical seepage pit)	5	116	SWMU 39-007(a) contaminated soil removal, abandonment of 5 shallow wells and 12 angled boreholes at SWMUs 39-001(a) and 39-001(b), final removal of remaining waste and contaminated media at SWMUs 39-001(a) and 39-001(b)
Phase II Investigation Work Plan for Upper Sandia Canyon Aggregate Area	4/20/2011	Revised	TA-03, TA-60, TA-61	See below	See below	See below	See below

Table 9-1 (continued)

Document	Date Submitted	Date Approved	TAs	Types of Sites to be Investigated	Number of Sites to be Investigated	Number of Samples Proposed	Sites where Cleanup Proposed
Phase II Investigation Work Plan for Upper Sandia Canyon Aggregate Area, Revision 1	9/2/2011	9/13/2011	TA-03, TA-60, TA-61	Storage areas, transformer pad, surface disposal areas, outfalls, wastewater treatment plant, landfill, waste lines, storm drains/drainages, surface and subsurface soil contamination, operational release, floor drain, septic system, kerosene tanker trailer	41	Approximately 520	0
Phase II Investigation Work Plan for Upper Mortandad Canyon Aggregate Area, Revision 1	5/3/2011	5/24/2011	TA-03, TA-35, TA-42, TA-48, TA-50	Storage areas, outfalls, firing sites, discharge area, unintentional industrial release, drains, building, storage tanks, septic systems, air exhaust system, shaft, industrial waste lines, underground vault	31	Approximately 270	0
Phase III Investigation Work Plan for DP Site Aggregate Area	5/27/2011	6/10/2011	TA-21	Container storage areas, seepage pits, sumps, pipeline, outfalls, septic systems, drain line, surface disposal area, wastewater treatment plant, sludge drying/sand filter beds, dosing siphon chamber, cooling tower, diesel spill	29	62	Six sites proposed (including consolidated units with multiple SWMUs). Four sites or parts of sites will not be remediated because the outfall areas cannot be excavated safely with mechanical equipment, and the likelihood of future receptor exposure to these areas is low. Four sites, including parts of two sites, will be remediated.
Phase II Investigation Work Plan for Threemile Canyon Aggregate Area	6/6/2011	Revised	TA-12, TA-14, TA-15, TA-36	See below	See below	See below	See below
Phase II Investigation Work Plan for Threemile Canyon Aggregate Area, Revision 1	10/31/2011	11/22/2011	TA-12, TA-14, TA-15, TA-36	Firing pits, soil contamination areas, junction box, radiation test site, pipe, storage areas, shafts, surface disposal areas, septic systems, outfalls, sumps	25	Approximately 630	SWMU 15-007(c), SWMU 15-008(b), SWMU 36-008, SWMU C-36-003 soil removal, fill septic tanks with concrete at SWMUs 15-009(h) and 15-010(b)
Work Plan for Vadose Zone Moisture Monitoring at Material Disposal Area T at Technical Area 21	8/1/2011	9/1/2011	TA-21	MDA T	1	Approximately 66	n/a

Table 9-1 (continued)

Document	Date Submitted	Date Approved	TAs	Types of Sites to be Investigated	Number of Sites to be Investigated	Number of Samples Proposed	Sites where Cleanup Proposed
Phase II Investigation Work Plan for S-Site Aggregate Area	9/23/2011	Reviewed in 2012	TA-16	Septic systems, catch basins, outfalls, drain lines, sumps, soil contamination areas, building footprints, firing sites, burn pits, magazines, wastewater treatment plant, shared drainages, liquid waste trunk line, V-Site Courtyard	63	Approximately 600	0
Phase II Investigation Work Plan for Upper Cañada del Buey Aggregate Area	11/23/2011	12/29/2011	TA-04, TA-46	Septic systems, outfalls, drain lines, soil contamination areas, dry wells, alkali-metal cleaning tank, surface impoundments, storage areas, storage shed, surface disposal area	47	Approximately 400	AOC 04-004, SWMUs 46-004(b2), 46-008(b), and 46-008(g) soil removal
Work Plan and Final Design for Stabilization of the Sandia Canyon Wetland	9/29/2011	11/15/2011	Sandia Canyon	Sandia Canyon Wetland (Reach S-2)	1	Groundwater monitoring at 12 wells installed in the wetland and vicinity. Surface-water/storm water monitoring at gauges E121, E122, and E123. Monitoring of vegetation and geomorphic changes.	Measures (construction of a grade-control structure and hardening of stilling basin near the head of the wetland) are intended to physically stabilize the Sandia wetland. Measures will reduce sediment and associated contaminant transport into the lower sections of the canyon.

Table 9-2
Reports Submitted and/or Approved in 2011

Document	Date Submitted	Date Approved	Status
Erosion Controls Associated with Fishladder Canyon [Solid Waste Management Unit 16-003(o)]	2/11/2011	n/a ^a	Revised in 2012 Inspection of erosion controls will continue.
Annual Inspection and Maintenance of Erosion Controls in the Drainages to the 90s Line Pond at Technical Area 16	11/30/2011	n/a	Inspection of erosion controls will continue.
Investigation Report for S-Site Aggregate Area, Revision 1 ^b	2/25/2011	3/16/2011	Phase II work plan submitted
Remedy Completion Report for Upper Los Alamos Canyon Aggregate Area Former Technical Area 32, Revision 1 ^b	2/28/2011	n/a	Additional work ongoing as part of Upper Los Alamos Canyon Aggregate Area investigation
Investigation Report for Ancho/Chaquhui/Indio Canyons	2/28/2011	n/a	Revised
Investigation Report for Ancho/Chaquhui/Indio Canyons, Revision 1	7/8/2011	8/3/2011	Investigation complete
Investigation Report for Lower Sandia Canyon Aggregate Area	3/24/2011	n/a	Revised
Investigation Report for Lower Sandia Canyon Aggregate Area, Revision 1	8/25/2011	9/26/2011	Phase II work plan to be developed
Investigation Report for Potrillo and Fence Canyons, Revision 1 ^b	3/28/2011	n/a	Phase II work plan to be developed
Phase II Investigation Report for Middle Los Alamos Canyon Aggregate Area	3/31/2011	n/a	Revised
Phase II Investigation Report for Middle Los Alamos Canyon Aggregate Area, Revision 1	8/15/2011	— ^c	Phase III work plan to be developed
Supplemental Interim Measure Report for Solid Waste Management Unit 01-001(f), Revision 1	4/27/2011	6/2/2011	Additional work ongoing as part of Upper Los Alamos Canyon Aggregate Area investigation
Investigation Report for Upper Cañada del Buey Aggregate Area, Revision 1 ^b	5/6/2011	5/31/2011	Phase II work plan approved
Investigation Report for Potrillo/Fence Canyons Aggregate Area	5/13/2011	n/a	Revised
Investigation Report for Potrillo/Fence Canyons Aggregate Area, Revision 1	11/29/2011	12/14/2011	Phase II work plan to be developed
Phase III Investigation Report for Material Disposal Area C	7/15/2011	12/8/2011	Continue vapor and groundwater monitoring Conduct corrective measures evaluation
Corrective Measures Evaluation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 2	9/9/2011	—	Pending review by NMED
Corrective Measures Evaluation Report for Material Disposal Area G, Revision 3	9/9/2011	—	Pending review by NMED
Corrective Measures Evaluation Report for Material Disposal Area H, Revision 1	9/9/2011	—	Pending review by NMED
Bandelier Tuff Unit 4 Background Study Report	9/9/2011	12/14/2011	Investigation complete
Investigation Report for Water Canyon/Cañon de Valle	9/30/2011	—	Biota investigation work plan proposed; surface water and groundwater will continue to be monitored
Investigation/Remediation Report for Material Disposal Area B, Solid Waste Management Unit 21-015	9/30/2011	—	Pending review by NMED Excavation of waste and remediation of trenches is complete.

Table 9-2 (continued)

Document	Date Submitted	Date Approved	Status
2010/2011 Monitoring Summary Report for the Technical Area 16 Permeable Reactive Barrier and Associated Corrective Measures Implementation Projects	9/30/2011	n/a	Monitoring of corrective measures to continue
Investigation Report for Lower Mortandad/Cedro Canyons Aggregate Area	10/11/2011	—	Pending review by NMED No further investigation or remediation activities proposed Sites recommended for corrective action complete without controls
2011 Biennial Ordnance Survey Report, Solid Waste Management Units 00-011(a, c, d, and e) and AOC C-00-020, Guaje/Barrancas/Rendija Canyons Aggregate Area	12/14/2011	12/28/2011	No need to conduct further surveys at SWMU 00-011(c) or AOC C-00-020, but continue biennial surveys for SWMUs 00-011(a, d, and e)
2011 Biennial Asphalt Monitoring and Removal Report for Area of Concern C-00-041, Guaje/Barrancas/Rendija Canyons Aggregate Area	12/14/2011	2/10/2012	Biennial monitoring of asphalt to continue
Investigation Report for DP Site Aggregate Area Delayed Sites [Consolidated Unit 21-004(b)-99 and Solid Waste Management Unit 21-011(b)] and DP East Building Footprints at Technical Area 21	12/15/2011	n/a	To be revised Phase II work plan to be developed

^a n/a = Not applicable.

^b This is a revision to a report previously discussed in the 2010 Environmental Report. No new information was provided; the report was revised based on NMED comments.

^c Document not yet approved.

Table 9-3
SWMUs and AOCs Granted Certificates of Completion in 2011

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
AOC 00-018(b)		X	1/14/2011
AOC C-00-037		X	1/31/2011
AOC C-00-038		X	1/31/2011
SWMU 03-003(c)		X	2/18/2011
AOC 03-003(n)		X	2/18/2011
AOC 03-003(o)		X	2/18/2011
SWMU 03-014(q)		X	2/18/2011
AOC 03-014(v)		X	2/18/2011
AOC 03-027		X	2/18/2011
SWMU 03-028		X	2/18/2011
SWMU 03-036(a)		X	2/18/2011
AOC 03-036(b)		X	2/18/2011
SWMU 03-036(c)		X	2/18/2011
SWMU 03-036(d)		X	2/18/2011
AOC 03-038(c)		X	2/18/2011
AOC 03-043(a)		X	2/18/2011
AOC 03-043(b)		X	2/18/2011
AOC 03-043(d)		X	2/18/2011
AOC 03-043(f)		X	2/18/2011

Table 9-3 (continued)

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
AOC 03-043(g)		X	2/18/2011
AOC 03-043(h)		X	2/18/2011
AOC 03-047(d)		X	2/18/2011
SWMU 03-056(l)		X	2/18/2011
AOC C-03-016		X	2/18/2011
AOC 60-004(b)		X	2/18/2011
AOC 60-004(d)		X	2/18/2011
SWMU 03-056(c)	X		2/18/2011
AOC 49-005(b)		X	2/21/2011
SWMU 49-006		X	2/21/2011
AOC 18-005(b)		X	4/14/2011
AOC 18-005(c)		X	4/14/2011
AOC 51-001		X	4/14/2011
AOC 54-007(d)		X	4/14/2011
SWMU 21-013(b)	X		6/3/2011
AOC 21-013(g)	X		6/3/2011
SWMU 21-018(a)	X		6/3/2011
SWMU 21-018(b)		X	6/3/2011
SWMU 21-023(c)	X		6/3/2011
SWMU 05-006(h)		X	6/30/2011
SWMU 35-002		X	6/30/2011
SWMU 35-004(b)		X	6/30/2011
SWMU 35-004(g)		X	6/30/2011
AOC 35-004(m)		X	6/30/2011
AOC C-35-007		X	6/30/2011
SWMU 35-009(b)		X	6/30/2011
SWMU 35-009(c)		X	6/30/2011
SWMU 35-010(a)		X	6/30/2011
SWMU 35-010(b)		X	6/30/2011
SWMU 35-010(c)		X	6/30/2011
SWMU 35-010(d)		X	6/30/2011
AOC 35-011(d)		X	6/30/2011
SWMU 35-014(a)		X	6/30/2011
AOC 35-014(f)		X	6/30/2011
AOC 35-014(g2)		X	6/30/2011
SWMU 52-002(a)		X	6/30/2011
AOC 52-003(a)		X	6/30/2011
AOC 60-004(c)		X	6/30/2011
AOC 60-004(e)		X	6/30/2011
SWMU 60-005(a)		X	6/30/2011
SWMU 63-001(a)		X	6/30/2011
SWMU 63-001(b)		X	6/30/2011
SWMU 35-003(a)	X		6/30/2011
SWMU 35-003(b)	X		6/30/2011
SWMU 35-003(c)	X		6/30/2011

Table 9-3 (continued)

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 35-003(d)	X		6/30/2011
SWMU 35-003(e)	X		6/30/2011
SWMU 35-003(f)	X		6/30/2011
SWMU 35-003(g)	X		6/30/2011
SWMU 35-003(j)	X		6/30/2011
SWMU 35-003(k)	X		6/30/2011
SWMU 35-003(l)	X		6/30/2011
SWMU 35-003(m)	X		6/30/2011
AOC 35-003(misc)	X		6/30/2011
SWMU 35-003(n)	X		6/30/2011
SWMU 35-003(o)	X		6/30/2011
SWMU 35-003(q)	X		6/30/2011
SWMU 35-009(e)	X		6/30/2011
SWMU 35-014(b)	X		6/30/2011
AOC 35-014(d)	X		6/30/2011
SWMU 35-015(a)	X		6/30/2011
SWMU 35-015(b)	X		6/30/2011
AOC 35-016(j)	X		6/30/2011
AOC 35-018(a)	X		6/30/2011

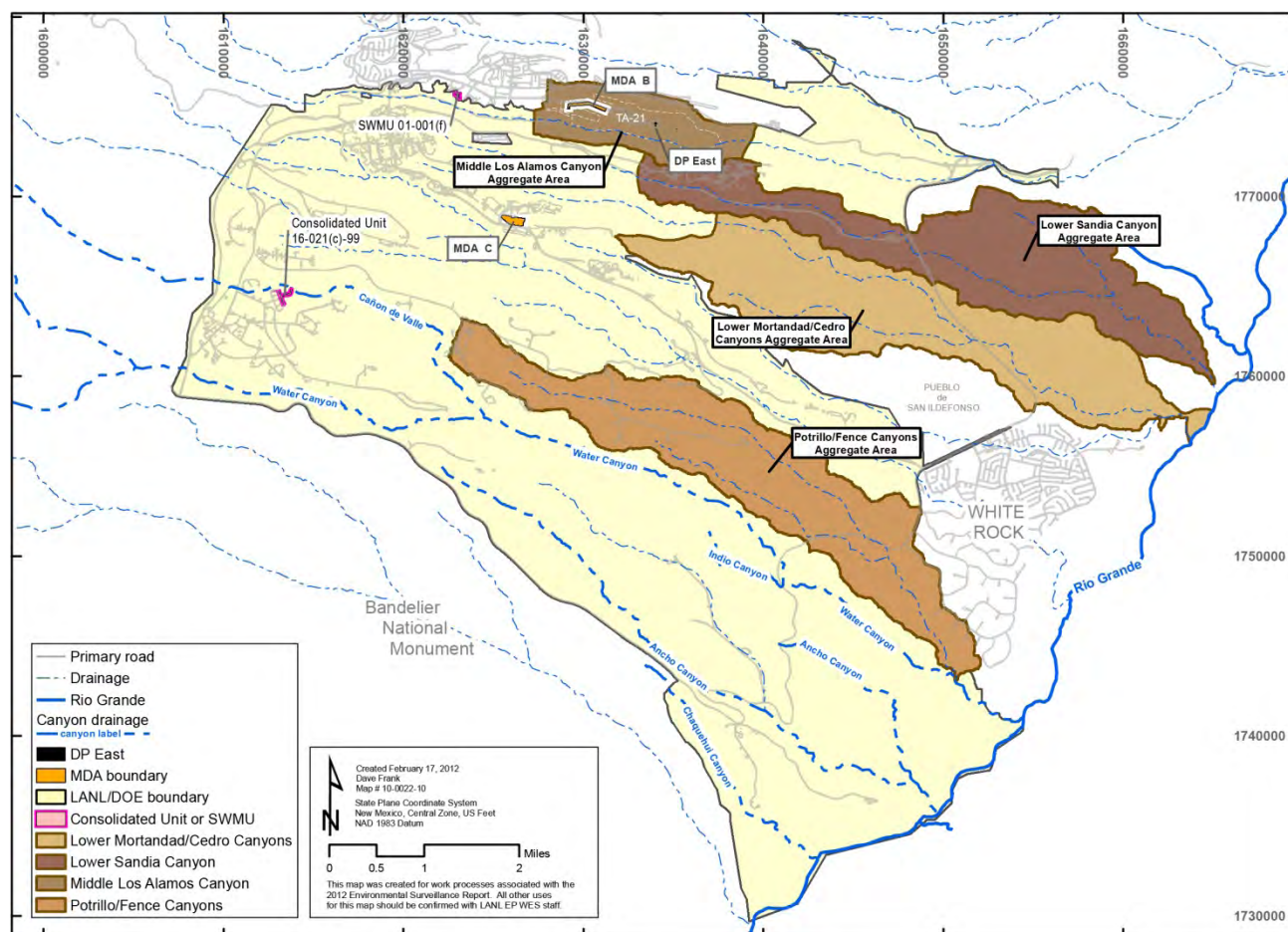


Figure 9-1 Location of MDAs, SWMUs/AOCs, canyons, and aggregate areas where remediation and/or characterization work was performed in 2011

B. CORRECTIVE ACTIONS PROGRAM

In 2011, investigation work plans were either developed or revised for 13 aggregate areas or TAs (Table 9-1). Of this total, nine work plans were for Phase II investigations, which are designed to address issues remaining following initial site investigations. In addition, investigation reports were written or revised for seven aggregate areas, three canyon systems, one SWMU, two MDAs, and one former TA in 2011 (Table 9-2); one investigation was conducted in 2011 but reported on in 2012. Reports were also written/revised and submitted for inspections, surveys, a background study, and corrective measures evaluations (CMEs) in 2011 (Table 9-2). Table 9-4 presents a summary of the site, aggregate area, and canyon investigations associated with field sampling campaigns related to the Corrective Actions Program conducted and/or initially reported in 2011.

1. Consolidated Unit 16-021(c)-99 (260 Outfall) Corrective Measures Implementation

a. Site Description and History

Building 16-260, located on the north side of TA-16, has been used for high-explosives (HE) processing and machining since 1951. Wastewater from machining operations contained dissolved HE and may have contained entrained HE cuttings. Wastewater treatment consisted of routing the water to 13 settling sumps for recovery of any entrained HE cuttings. From 1951 through 1996, the water from these sumps discharged to the 260 Outfall, which drained into Cañon de Valle. As a result of the discharge, both the 260 Outfall and the drainage channel from the outfall were contaminated with HE and barium.

Table 9-4
Summary of Site, Aggregate Area, and Canyon Investigations
Conducted and/or Initially Reported on in 2011 under the Corrective Actions Program

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites where Cleanup Conducted	Number of Sites where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Investigation Report for Ancho/Chaquehui/Indio Canyons, Revision 1	TA-33, TA-39, TA-49	Eleven reaches, four springs and four gaging stations	Total of 126 sediment samples and 97 water samples (72 non-storm water/ spring water and 25 storm water/snow melt)	n/a ^a	Concentrations decrease down canyon, and no Laboratory-derived COPCs have been identified in the farthest downcanyon reaches.	Entire canyon system evaluated. No potential unacceptable human health risks or doses and no adverse ecological effects exist under current conditions.	Storm water in the Ancho and Chaquehui watersheds will continue to be monitored under the requirements of the Individual Permit. Corrective actions are not needed to mitigate unacceptable risks in Ancho, Chaquehui, and Indio Canyons.
Investigation Report for Lower Sandia Canyon Aggregate Area, Revision 1	TA-20, TA-53	21	Approx. 400	AOC 53-013 excavated approx. 75 yd ³ of soil because of lead.	Three sites extent defined; 18 sites extent not defined.	Two sites do not pose potential human health and ecological risks/doses. (No COPCs were identified at AOC 53-014.)	Three sites recommended for complete without controls [AOCs 53-013 and 014 and SWMU 53-001(b)]. Additional sampling needed for 17 sites to define extent and remediation recommended for one site. Eight other sites are recommended for delayed characterization and investigation pending D&D of building and structures. Phase II work plan to be developed.
Phase II Investigation Report for Middle Los Alamos Canyon Aggregate Area, Revision 1	TA-02, TA-21, TA-26	40	Total of approx. 2200 samples collected to date; additional 670 samples collected as part of Phase II.	Four sites [AOC 02-004(a) excavated approx. 7 yd ³ because of PAHs; AOC 02-004(f) excavated approx. 46 yd ³ because of PCBs; AOC 02-010 excavated approx. 15 yd ³ because of cesium-137; AOC 02-011(a) excavated approx. 230 yd ³ because of PCBs and PAHs]	Thirty-one sites extent defined; nine sites extent not defined.	Thirty-two sites do not pose potential human health risks/doses for one or more scenarios. No potential ecological risk was found for any receptor at SWMU 02-006(a) (ecological risk-screening assessment will be conducted for the sites within the TA-02 core area as one exposure unit once extent defined).	Additional sampling needed to define extent at 9 sites; additional soil removal needed at one of these sites. SWMU 02-006(a) recommended for complete without controls. Phase III work plan to be developed.

Table 9-4 (continued)

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites where Cleanup Conducted	Number of Sites where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Supplemental Interim Measure Report Solid Waste Management Unit 01-001(f), Revision 1	TA-01	1	Thirteen confirmation samples (total of 117 confirmation samples)	Total of 98 yd ³ of additional material removed from the outfall area and the drainage. (Total of approx. 2,900 yd ³ of material removed from the site.)	Extent not defined for this SWMU.	PCB concentrations above recreational SSLs remain in some locations of the SWMU 01-001(f) outfall area and drainage; no risk assessments conducted.	Additional removal and stabilization activities are recommended for the mesa-top portion of the site. Need to define the lateral and vertical extent of PCBs. Run-on should be diverted from the outfall area and hillside drainage portions of the site and additional stabilization measures implemented within the hillside drainage. Risk assessment is recommended for this area. Surface water monitoring to be performed below the riparian vegetation zone.
Investigation Report for Potrillo/Fence Canyon Aggregate Area, Revision 1	TA-15, TA-36	26	Approx. 530	Three sites [SWMU15-007(a) excavated approx. 125 yd ³ of concrete and 1500 yd ³ soil and overburden to remove landfill; SWMU 15-008(a) excavated approx. 18.5 yd ³ ; SWMU 36-006 excavated approx. 12.5 yd ³ .]	Fourteen sites extent not defined; also 10 sites deferred or delayed; 2 other sites require remediation and characterization/confirmation sampling.	0	Additional sampling needed to define extent at 14 sites; two other sites require remediation and characterization/confirmation sampling; 10 sites recommended for deferred/delayed investigation; one site is a duplicate of another and requires no further investigation. Phase II work plan to be developed.
Bandelier Tuff Unit 4 Background Study Report	TA-06, TA-14, TA-16, TA-49, TA-58, TA-67, TA-69	Ten locations sampled	Thirty subsurface unweathered Qbt 4 samples	n/a	n/a	n/a	Qbt 2,3,4 BVs are not appropriate for comparison with analytical results from weathered Qbt 4. The concentrations of inorganic chemicals and naturally occurring radionuclides in weathered tuff should be bounded by soil BVs because soil represents a very high degree of weathering.

Table 9-4 (continued)

Document	TAs	Number of Sites Investigated	Number of Samples Collected	Number of Sites where Cleanup Conducted	Number of Sites where Extent Defined/Not Defined	Risk/Dose Assessments	Conclusions/Recommendations
Investigation Report for Water/Cañon de Valle	TA-11, TA-14, TA-15, TA-16, TA-28, TA-29, TA-37, TA-49	Total of 25 reaches, 35 surface water locations, 15 storm water locations, 25 springs, 16 alluvial groundwater wells, 16 perched intermediate wells, 14 regional wells	Approx. 410 sediment samples; approx. 500 surface water samples; approx. 400 storm water/snowmelt samples; approx. 4000 groundwater samples	n/a	Concentrations decrease down canyon, and no Laboratory-derived COPCs have been identified in the farthest downcanyon reaches.	Entire canyon system evaluated. No potential unacceptable human health risks or doses. Most contaminants not likely to produce adverse ecological impacts. Barium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) in sediment and lead in water are exceptions and need further evaluation.	General down canyon decrease in contaminant concentrations in sediment with distance from a contaminant source area. Surface water and groundwater concentrations have generally remained stable or declined. Ongoing monitoring of surface water, storm water and groundwater will continue. Biota work plan to be developed.
Investigation Report for Lower Mortandad/Cedro Canyons Aggregate Area	TA-05	4	Approx. 170 samples	SWMU 05-006(c) approx. 2.1 yd ³ of soil, debris, and lead shielding excavated.	Four sites extent defined.	Four sites do not pose potential human health and ecological risks/doses.	Four sites recommended for complete without controls [SWMUs 05-003, 05-004, 05-005(b), and 05-006(c)]. Investigation complete.
Investigation Report for Cañon de Valle Aggregate Area, TA-14 ^a	TA-14	27	Approx. 260 samples	0	Five sites extent defined and two sites further sampling for extent not warranted; 10 sites extent not defined.	Seven sites do not pose potential unacceptable human health and ecological risks/doses.	Seven sites recommended for complete without controls [AOCs 14-001(a, b, c, d, e), C-14-001, SWMU 14-003]. Ten sites require further sampling for extent; two of these sites also recommended for remediation. Nine sites recommended for deferred/delayed characterization and investigation.

^a n/a = Not applicable.^b Report was submitted in 2012, but the investigation was conducted and completed in 2011.

b. Remediation and Sampling Activities

The Laboratory implemented the corrective measure implementation (CMI) plan (LANL 2007) in 2009 and completed the plan's remediation and investigation actions in 2010 (LANL 2010a, 2010b). The CMI characterization and remediation activities included (1) removing the concrete trough outfall adjacent to building 16-260 at the 260 Outfall channel; (2) removing soil and sediment within the former settling pond within the 260 Outfall drainage channel; (3) replacing a low-permeability cap on the former settling pond; (4) removing soil and tuff from the 260 Outfall drainage channel; (5) sampling soil in the Sanitary Wastewater Systems Consolidation (SWSC) Cut of Cañon de Valle; (6) installing surge bed injection grouting within the former settling pond at the 260 Outfall channel; (7) installing carbon filter treatment systems of spring waters at SWSC and Burning Ground Springs in Cañon de Valle and modifying the existing carbon filter at Martin Spring in Martin Spring Canyon; and (8) installing a pilot permeable reactive barrier (PRB) for treatment of HE and barium in Cañon de Valle.

c. Conclusions and Recommendations

Because of the extensive damage by flash flooding in Cañon de Valle following the Las Conchas Fire (see Chapter 1, Section E), the implementation of the CMI plan during the 2011/2012 operational period is limited to baseline monitoring of alluvial groundwater from intact wells and continued monitoring of the well located at the 260 Outfall.

In 2011, corrective measure monitoring focused on the performance of the pilot PRB installed in Cañon de Valle as well as the effectiveness of the other corrective measures implemented, including surge bed injection grouting, the low-permeability cap constructed in the 260 Outfall drainage, and carbon filters installed in Cañon de Valle (LANL 2011b). The performance objectives of the corrective measures were to reduce concentrations of barium and RDX in alluvial groundwater and to prevent their migration to recharge areas for deeper aquifers. Monitoring activities at the PRB consisted of water-level measurements, field-parameter measurements, and collection of samples for both on-site and off-site chemical analysis. The PRB alluvial wells were sampled and field parameters collected monthly for the first quarter and quarterly for the remaining quarters.

Groundwater flow through the barrier became impeded, probably due to the zero-valent iron (ZVI). Filter media assessment revealed mineral precipitation and biological accumulation within the media beds. Zeolite was moved to the first treatment cell, followed by ZVI in an attempt to have the zeolite remove the barium and possibly some of the carbonate minerals from the water before reaching the ZVI. Analytical results from the second operational period indicated a reduction in barium and RDX by the treatment media. RDX was reduced from 16 µg/L to below detection, and barium was reduced from 4,000 µg/L to 1,000 µg/L. However, flow through the barrier again declined and the use of ZVI for removing RDX was deemed problematic.

The filter medium was changed from ZVI to granular activated carbon (GAC), which has been demonstrated to effectively remove HE compounds at the Laboratory. The gravel cells were removed, and only zeolite and GAC were installed for filter material in the vessel. The first two cells contained zeolite, and the next two cells contained GAC. The additional volume of zeolite is intended to increase contact time and increase barium removal efficiency.

One week after the GAC filter media was installed, flash flooding (as noted above) following the Las Conchas Fire in Cañon de Valle damaged alluvial wells and sampling ports associated with the PRB. Additional flash flooding destroyed or severely damaged the PRB cutoff wall, inflow plumbing, and several additional alluvial wells in Cañon de Valle (LANL 2011b). Because of the substantial flash-flooding damage to the PRB system, the PRB is non-operational until repairs are made to the equipment or a modification to the corrective measure approach is found.

Site inspections in 2011 were performed to evaluate the structural integrity and efficacy of the low-permeability cap and carbon filters. No degradations in materials were noted for either corrective measure, and the alluvial well installed to monitor for infiltration did not indicate water had breached either the cap or the injection grouting. The carbon filters installed in Cañon de Valle were not activated pending resolution of discharge-permit issues.

Interim actions recommended as a result of field observations of flood damage in Cañon de Valle include plugging and abandoning damaged wells and monitoring intact wells to measure post-flood baseline conditions. In the event that a discharge permit is obtained for operation of the carbon filters at Burning Ground, SWSC, and Martin Springs, the carbon filters will also be operated, maintained, and monitored. The alluvial groundwater well installed next to the injection grouting site will continue to be monitored for the presence of water twice a year for one or more years. If water is encountered, samples will be collected for analysis of explosive compounds.

2. MDA C

a. Site Description and History

MDA C, an inactive 11.8-acre landfill, is located within TA-50 at the head of Ten Site Canyon. MDA C consists of seven disposal pits and 108 shafts; the depths of the pits range from 12 to 25 ft and the shafts range from 10 to 25 ft below the original ground surface. Shafts 98–107 are lined with 12-in.-thick concrete, while the rest of the pits and shafts are unlined. The pits and shafts are constructed in the Tshirege Member of the Bandelier Tuff. The regional aquifer is approximately 1,320 ft below ground surface (bgs). MDA C operated from May 1948 to April 1974 but received waste only intermittently from 1968 until it was decommissioned in 1974. Wastes disposed of at MDA C consisted of liquids, solids, and containerized gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials.

b. Remediation and Sampling Activities

The Laboratory developed a Phase III investigation work plan (LANL 2010c, 2010d), which was approved by NMED (NMED 2010). During 2010 and 2011, Phase III investigation activities were conducted to better define the lateral and vertical extent of subsurface VOC and tritium pore gas contamination at MDA C, install downgradient regional groundwater monitoring wells, and characterize background concentrations of inorganic chemicals detected in dacite rocks.

Field activities included installing one new regional aquifer monitoring well and four new vapor-monitoring wells, as directed by the Phase III work plan, collecting quarterly vapor samples, and collecting dacite samples from the Tschicoma Formation. Vapor samples were collected quarterly from 14 existing vapor-monitoring wells and, beginning in January 2011, from the four new vapor-monitoring wells. Vapor samples were analyzed for VOCs and tritium. During installation of the vapor-monitoring wells at MDA C, two of the boreholes to the south of MDA C were drilled into the dacite and samples collected to evaluate background concentrations for inorganic chemicals in the dacite lava flow. Dacite samples from the Tschicoma Formation were analyzed for inorganic chemicals. A new regional groundwater monitoring well (R-60) was also installed next to the downgradient boundary of MDA C (100 ft to the east of MDA C). Quarterly groundwater samples were collected from well R-60 (starting in first quarter of 2011) as well as from existing monitoring well R-46, also located downgradient of MDA C.

c. Conclusions and Recommendations

A Phase III investigation report for MDA C (LANL 2011c) was submitted and approved in 2011 (NMED 2011).

Based on the characterization data from the 2010 to 2011 investigation as well as previous investigations conducted at the site, the nature and extent of contamination in vapor are defined. Sampling results from the four deepest sampling ports, ranging from 632.5 ft to 688 ft bgs, indicate very low VOC concentrations in the deepest stratigraphic units sampled. The maximum concentrations of most organic chemicals in vapor were detected at a depth of approximately 250 ft, with concentrations decreasing sharply below that depth. The highest detected concentrations of tritium were generally at depths of less than 125 ft bgs. Tritium concentrations decreased with depth in most of, but especially in the deeper, boreholes. The vertical extent of both VOCs and tritium in vapor is defined. Vapor sampling results for VOCs and tritium were screened to evaluate the potential for the detected concentrations to result in groundwater contamination above cleanup

levels. Results of this screening evaluation show no current risk of groundwater contamination. Vapor monitoring is discussed in Chapter 10.

The results of dacite sampling indicate that concentrations of inorganic chemicals previously detected at the top of the dacite lava during the Phase II investigation appear to be naturally occurring and are associated with soil present at the top of the dacite.

Regional well R-60 was drilled to a total depth of 1,418 ft bgs. The regional aquifer was encountered at a depth of 1,319.5 ft bgs in the Puye Formation. Well R-60 has a single well screen set at a depth of 1330 ft to 1350 ft bgs. The results of sampling performed at wells R-46 and R-60 indicate no release of contaminants from MDA C to the regional aquifer. Water-level data collected from R-60 during the Phase III investigation were used to update an evaluation of the groundwater monitoring network for MDA C. This evaluation showed that wells R-46 and R-60 have a high efficiency for detecting potential releases from MDA C. Groundwater monitoring is discussed in Chapter 5.

Based on the results of the Phase III and previous investigations, it is recommended that a CME be conducted to assess alternatives for preventing future exposure. Additional focused subsurface vapor monitoring is recommended to ensure detected concentrations of VOCs and tritium remain protective of groundwater. Based on the results from monitoring wells R-46 and R-60, the evaluation of subsurface vapor data, and the proposed vapor monitoring in the deep stratigraphic units, installation of well R-59 is not recommended at this time.

C. TA-54 CLOSURE PROGRAM

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDAs H, G, and L as well as groundwater in and around these MDAs and TA-54. The Laboratory reports the monitoring results either in the respective MDA or monitoring group periodic monitoring reports. Vapor monitoring is discussed in Chapter 10, and groundwater monitoring is discussed in Chapter 5.

CME reports for MDAs H, G, and L were submitted to NMED prior to 2011. Revisions were made to each of the respective CME reports and submitted to NMED in 2011 (Table 9-3). The revisions did not change the original recommendations in the CME reports, but rather added or clarified the information provided for each MDA.

No other sampling, evaluations, or investigations were conducted in 2011 at the TA-54 sites.

D. TA-21 CLOSURE PROGRAM

TA-21 is located on DP Mesa on the northern boundary of the Laboratory and is immediately east-southeast of the Los Alamos town site. In 1945, plutonium research and metal production activities were conducted at the newly built facilities at TA-21.

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDAs V and T as well as groundwater in and around TA-21. The Laboratory reports these monitoring results in the respective MDA or monitoring group periodic monitoring reports. Vapor monitoring is discussed in Chapter 10 and groundwater monitoring is discussed in Chapter 5.

1. DP Site Aggregate Area

a. Site Description and History

The DP Site Aggregate Area includes container storage areas, surface disposal areas, PCB container storage areas, septic systems, sumps, drain lines, outfalls, a waste treatment laboratory, a sewage treatment plant, and seepage pits. Buildings 21-152, 21-155, and 21-209 were associated with various SWMUs, AOCs, and consolidated units at DP East and are part of the DP Site Aggregate Area.

The portion of the DP Site Aggregate Area addressed in 2011 (referred to as Delayed Sites and DP East building footprints) consists of the following

- Consolidated Unit 21-004(b)-99 consists of SWMUs 21-004(b) and 21-004(c), which are aboveground stainless-steel tanks, and AOC 21-004(d), which is the drain line and outfall area;
- SWMU 21-011(b) is an acid waste sump and associated waste lines;
- AOC 21-028(d) is a former storage site located on a concrete loading dock; and
- Footprints of former buildings 21-152, 21-155, and 21-209 and footprints of associated former structures.

b. Remediation and Sampling Activities

The 2010–2011 investigation activities included collecting 368 surface and subsurface soil and tuff samples from 173 locations to define the extent of contamination. Structures, waste lines, debris, and/or asphalt (approximately 30 yd³) were removed. Some structures could not be fully excavated because of the depth below the ground surface or nearby active utilities. In addition, it was necessary to remove construction and/or demolition debris from some areas. The debris and any associated soil were excavated and containerized as waste.

c. Conclusions and Recommendations

The Laboratory submitted the investigation report (LANL 2011c) to NMED in 2011. The extent of contamination is not defined at any of the sites (SWMUs/AOCs and building footprints). Limited additional soil removal and associated confirmation sampling may also be warranted for areas with contamination above soil screening levels/screening action levels (SSLs/SALs).

A Phase II investigation work plan will be developed to address the additional sampling and remediation required at the sites. The objectives of the Phase II sampling are to define the extent of contamination and to complete human health and ecological risk-screening assessments.

2. American Recovery and Reinvestment Act at TA-21

The Laboratory received \$212 million for environmental cleanup projects as part of the ARRA of 2009. The Laboratory's Recovery Act projects include the following:

- Decontamination and demolition of 24 buildings at TA-21
- Removal and remediation of early Laboratory waste from MDA B
- Installation of 16 groundwater monitoring wells

The status of the Recovery Act projects is as follows:

- The D&D and subsequent demolition of 24 buildings at TA-21 completed in December 2010
- The excavation activities at MDA B completed in 2011 (see below)
- The installation of 16 groundwater monitoring wells completed in 2010

3. MDA B

a. Site Description and History

MDA B is an inactive subsurface disposal site that occupies approximately six acres in TA-21. The MDA runs along the fence line on DP Road and is located about 1,600 ft east of the intersection of DP Road and Trinity Drive. MDA B consists of several disposal trenches approximately 300 ft long, 15 ft wide, and 12 ft deep and includes at least one smaller, shallower trench on the eastern end of the site. From 1944 until it closed in 1948, MDA B received process wastes from operations at DP East and DP West. The wastes disposed of at MDA B were highly heterogeneous, primarily radioactively contaminated laboratory wastes and debris, and limited liquid chemical waste.

b. Remediation and Sampling Activities

The Laboratory's Recovery Act projects included the removal and remediation of waste from MDA B. Excavation activities at MDA B commenced in June 2010 and were completed in September 2011. Remediation activities included the removal of an asphalt cover that was present over 75% of MDA B and removal of soil overburden from the east end of MDA B, as well as all waste contained within the disposal trenches. MDA B was completely excavated.

During the project, eight air-monitoring network (AIRNET) stations were located along the northern boundary of MDA B. Each AIRNET station collected airborne radionuclides, such as isotopic plutonium, americium, and uranium, on a particulate filter and a water vapor sample (for measuring tritium) in a silica gel cartridge. The particulate filters and silica gel cartridges were changed every two weeks, and the sample media were sent to a commercial laboratory for analysis using US Environmental Protection Agency (EPA)-approved methods. Each calendar quarter, six or seven of the biweekly filters from a given station were assembled into a single composite sample and prepared for isotopic analysis by dissolution and radiochemical separation techniques. Annual emissions reporting and compliance evaluations for a station were based on the sum of the four quarterly composite samples (for particulate matter) and the sum of biweekly tritium analyses.

MDA B was split into a grid of cells, each measuring 10 ft long by 10 ft wide. Excavation operations at each grid cell generally consisted of overburden removal, contaminated soil and waste removal, and confirmation sampling. Overburden material, consisting of soil and tuff capping the disposal trenches, was removed before the excavation of waste and contaminated soil. All excavated overburden material that met the overburden criteria was used as fill during backfilling operations. All wastes were removed from the trenches. As of September 14, 2011, a total of 43,222 yd³ of waste was removed from the disposal trenches at MDA B. The waste consists of 43,202 yd³ of low-level radioactive waste and 20 yd³ of mixed low-level waste. Overburden used as fill was placed deep in the excavation and then topped with clean backfill material obtained from an off-site source (per NMED direction).

Excavation within each grid cell continued until field screening for radioactive contaminants indicated no detectable activity. Once tuff was encountered, excavation proceeded 1 ft into the tuff until field screening revealed no abnormal or elevated readings. Confirmation samples were collected at a depth of 0 to 2 ft into the excavated surface. One hundred eighty-seven confirmation samples were collected, 21 of which were sampled in the same location by NMED. In cases where confirmation sample results indicated concentrations above residential SSLs or SALs, the area was excavated further and resampled unless deeper excavation could not be performed because of safety and/or the practical limitations of slope lay-back requirements.

Three vertical boreholes were drilled in the bottom of two of the excavated MDA B trenches. One borehole was drilled to a total depth of 325 ft bgs. The other two boreholes were located approximately 5 ft apart with one being drilled to a total depth of 50 ft bgs, and the other to a total depth of 24 ft bgs. Samples were collected at the base of both trenches as well as at total depth in each borehole. Three additional samples were collected from the deep borehole at intermediate depths. Soil pore gas samples were collected from the two deepest boreholes; one sample was collected from both boreholes at a depth equivalent to the base of the target disposal unit and a second sample was collected from the total depth of each borehole.

c. Conclusions and Recommendations

The Laboratory submitted the investigation report for MDA B (LANL 2011d) to NMED in September 2011.

The maximum biweekly dose measured at the eight AIRNET stations during the project period (June 21, 2010, through August 15, 2011) was 1.05 mrem. Most biweekly doses measured below 0.04 mrem. The maximum year-to-date accumulated total dose for any of these eight stations was 3.10 mrem. The average accumulated total for all stations during the project period was 0.98 mrem. These values were all less than the 5-mrem Laboratory administrative rolling 12-month allocation for the project. The EPA regulatory limit of 10 mrem/yr applies collectively to all Laboratory operations.

In order to determine whether the site was appropriately sampled and adequately characterized based on the work plan proposed sampling frequency, an analysis was conducted using confirmation samples collected and data from the MDA B trenches. This analysis included using statistical tools contained in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC et al. 1997). The results of the MARSSIM analysis indicated that the number of samples collected for each radionuclide detected from 0-10 ft and from all depths exceeded the number of samples needed to illustrate that the site was appropriately sampled. Therefore, there is a 95% confidence that the site is adequately characterized.

The trench walls and floors were inspected for the presence of any significant fractures that could serve as a migration pathway for waste constituents. Rock fractures are a common feature of welded ash-flow tuff such as in the Bandelier Tuff. Although fracture apertures were not measured or studied during the course of the excavation remediation, visual and video inspection of completed excavation walls and floor cuts into the Bandelier Tuff do not show any evidence of abnormal fracturing. This is supported by the fact that tuff walls were stable and did not show signs of weakening or collapse during excavation of MDA B. In addition, analytical results from the vertical boreholes indicate a pathway for contaminant infiltration and migration is not present.

The cleanup goal was to achieve residential SSLs for hazardous constituents and residential SALs for radionuclides. A primary assumption for the residential scenario is that exposure to contaminated media occurs from 0–10 ft bgs. This exposure depth interval (0–10 ft bgs) is the standard depth applied to the residential scenario in all Consent Order risk assessments, as well as associated dose assessments, and has been accepted by NMED and DOE in the investigation reports submitted to date.

Hazardous constituent data from the confirmation samples were compared with the applicable residential SSL. With the exception of arsenic in Enclosure 3, no hazardous constituent concentrations in the confirmation samples from the depth interval of 0–10 ft bgs at the MDA B trenches exceeded residential SSLs. However, the arsenic confirmation data were not statistically different from background data, thereby meeting the cleanup goal for arsenic. Benzo(a)pyrene was detected above the residential SSL in one sample from Enclosure 5 collected at a depth of 13.6 ft bgs, which is below the residential exposure depth.

Radionuclide data from the confirmation samples were compared with the applicable residential SAL. Concentrations for all radionuclides were below the residential SALs from 0–10 ft bgs, except for one location where a concentration slightly exceeded the residential SAL for plutonium 239/240 (33 pCi/g). The 95% UCL (9.85 pCi/g) for plutonium 239/240 from 0–10 ft bgs was below the residential SAL. There were also detected concentrations of plutonium-239/240 and cesium-137 above residential SALs at depths greater than 10 ft.

No hazardous constituents were detected at concentrations above residential SSLs in the new vertical borehole samples. Radionuclide results for the new vertical boreholes were below residential SALs. Both locations chosen for the vertical boreholes (i.e., the deep borehole and the collocated shallow boreholes) were based on previous confirmation sample locations with concentrations of cesium-137 and plutonium-239/240 above residential SALs at depth. The sample collected from the deep borehole at the base of the trench had no detected concentrations of cesium-137 or plutonium-239/240; other radionuclides were either not detected and were below background concentrations. At the shallow borehole location, plutonium-239/240 was detected (12.2 pCi/g) at the base of the trench, but decreased with depth from the bottom of the excavation and was not detected at total depth.

Eleven VOCs were detected in pore gas samples collected at MDA B. The VOC results were evaluated using screening levels based on groundwater screening levels, in the same manner as done in periodic monitoring reports for vapor sampling (e.g., LANL 2011e). The maximum detected concentration of trichloroethene (TCE) (2,800 µg/m³) slightly exceeded the screening level, which is the gas-phase TCE concentration (2,000 µg/m³) that would be in equilibrium with a water-phase concentration equal to the groundwater cleanup level for TCE. This screening evaluation is very conservative and does not consider processes that would dilute or attenuate vapors during migration to groundwater. All other detections of TCE were at least an order of magnitude less than the maximum detected concentration and well below the screening level, and

no other VOCs were detected above screening levels. Thus, the potential for VOCs present in subsurface vapor at MDA B to result in groundwater contamination is extremely low. Vapor monitoring is discussed in Chapter 10.

Tritium was detected in two of the four pore gas samples collected at MDA B. The potential for tritium in subsurface vapor to pose a risk of groundwater contamination was evaluated by comparing the tritium activities to the drinking water maximum contaminant level (MCL) for tritium (20,000 pCi/L). The maximum detected tritium activity (9,943 pCi/L) is less than half the MCL. Therefore, the potential for tritium present in subsurface vapor at MDA B to result in groundwater contamination is extremely low.

The nature and extent of any residual contamination at MDA B following the removal of the waste has been characterized by results from prior investigations at MDA B, confirmation sample data from MDA B, and the results from the three post-remediation boreholes. The prior MDA B investigations include installation of seven angled boreholes in 1998 and direct-push technology sampling at 87 locations in 2009. These data demonstrate that the nature and extent of any impact from historic waste disposal activities have been defined and that no contaminants from MDA B wastes have impacted the surrounding environment.

The network of boreholes defines the vertical extent of any residual contamination that may have been associated with past disposal practices across the MDA B site. The confirmation samples collected defined the vertical and lateral extent of any residual contamination from historic disposal practices at MDA B. Lateral extent is defined because the concentrations decreased from what was detected in the waste and decreased as areas were further excavated and sampled.

No perched aquifers or areas of high moisture content were observed during drilling of any of the borings associated with the MDA B boring network.

E. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The EP Directorate's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, and workers. All work is performed by using approved instructions, procedures, and other appropriate means that implement regulatory or contractual requirements for technical standards, administrative controls, and other hazard controls. The LANL Quality Management Plan establishes the principles, requirements, and practices necessary to implement an effective quality assurance program.

The use of a graded approach in accordance with DOE Order 414.1C determines the scope, depth, and rigor of implementing the quality assurance criteria for a specific activity. Activities are managed through systems that are commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows the Laboratory to apply extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity are covered in documents such as procedures, statements of work, project-specific work plans, and procurement contracts associated with the activity.

2. Field Sampling Quality Assurance

Overall quality of sample collection activities is maintained through the rigorous use of carefully documented procedures that govern all aspects of these activities. These procedures are reviewed on a regular basis and updated as required to ensure up-to-date processes are used.

Soil, water, vapor, and biota samples are collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and then prepared and stored in certified pre-cleaned sampling containers in a secure and clean area for shipment. The Laboratory delivers samples to analytical laboratories under full chain-of-custody, including secure FedEx shipment to all external vendors, and tracks the samples at all stages of their collection and analysis.

F. REFERENCES

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To Read About**Turn to Page**

<i>Introduction</i>	10-1
<i>Field Screening and Sampling</i>	10-2
<i>Facility Monitoring</i>	10-2
<i>Analytic Data Comparison and Trends</i>	10-3
<i>Summary</i>	10-12
<i>References</i>	10-12

A. INTRODUCTION

Subsurface vapor (pore-gas) monitoring is implemented as part of corrective action investigations at Los Alamos National Laboratory (LANL). Vapor monitoring is conducted beneath and surrounding several historic material disposal areas (MDAs) at the Laboratory. The data collected from vapor monitoring wells are used to help characterize the nature and extent of volatile organic compounds (VOCs) and tritium in the vadose zone. Analysis of pore gas also assists in evaluating whether VOCs and tritium may be a potential threat to the groundwater.

Periodic monitoring of pore gas was required in 2011 by the Compliance Order on Consent (Consent Order) at MDAs G, H, L, T, and V (Figure 10-1). The results of the pore-gas sampling are provided in periodic monitoring reports (PMRs) submitted to the New Mexico Environment Department (NMED) on a quarterly or annual basis as required by the Consent Order. In addition, pore-gas monitoring was conducted at MDA C for investigation purposes (Figure 10-1). The analytical data are also available on the online Intellus New Mexico website (<http://www.intellusnmdata.com>).

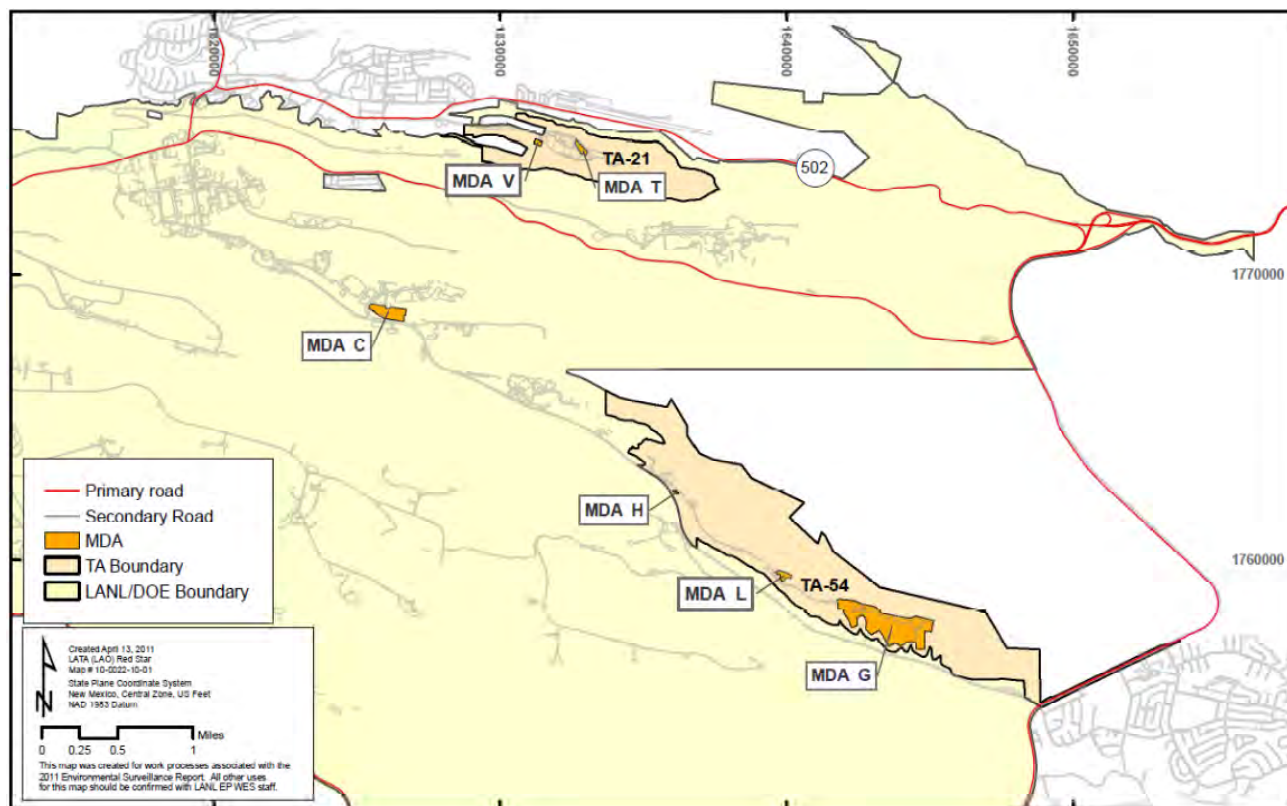


Figure 10-1 Location of MDAs where subsurface vapor monitoring was performed in 2011

Because no regulatory criteria currently exist for vapor-phase contaminants in soil, LANL evaluates VOC pore-gas data for the potential to contaminate groundwater above applicable government standards. A Tier I screening analysis is routinely presented in the vapor PMRs; the analysis evaluates the pore-water concentration that would be in equilibrium with the maximum pore gas concentration of each VOC detected at a given site. The equilibrium relationship between pore-gas and water concentrations is explained in the various PMRs for vapor sampling (e.g., LANL 2011a, 2011b, 2012a, 2012b). The Tier I screening ratio (SR) is the ratio of the measured VOC pore-gas concentration to the Tier I screening level, i.e., the pore-gas concentration corresponding to that VOC's groundwater standard; if the Tier I SR is above a value of 1, the VOC may have the potential to impact groundwater. This Tier I screening process yields conservative SRs because at each of the MDAs, the maximum vapor concentrations are located in the unsaturated zone several hundred feet above the regional groundwater. In addition, the screening evaluation does not account for aquifer dilution.

In the corrective measures evaluation (CME) reports for MDAs G and L and in the Phase III investigation report for MDA C, a Tier II screening process was developed and applied (LANL 2011c, 2011d, 2011e). To provide a more realistic estimate of the potential impact that the vapor plume may ultimately have on groundwater, the Tier II screening accounts for migration of VOCs through the unsaturated zone to the regional aquifer and subsequent dilution within the aquifer. The calculated groundwater concentrations are then compared with groundwater standards. Additional analyses were included in these CME reports for constituents with concentrations above the Tier II screening values.

B. FIELD SCREENING AND SAMPLING

Vapor monitoring during 2011 consisted of field screening and sample collection. Field screening included purging a specific sample interval, isolated at depth, within a vapor monitoring well with a gas monitor until pore-gas concentrations of carbon dioxide and oxygen stabilized, signifying that subsurface air was being collected. In addition to purging, VOC field screening included obtaining field measurements of organic vapors using a photoionization detector at MDAs G, H, and L.

Sample collection was carried out using one of three different sampling systems. VOC and tritium samples were collected with stainless steel tubing, down-hole packers, or a Flexible Liner Underground Technologies (FLUTE) sampling system. Each system is capable of isolating a specific depth interval from which pore gas is collected by applying a vacuum at the receiving end. VOC samples were collected in "SUMMA" canisters that capture and contain the air sample for transport to the analytical laboratory for analysis. Tritium samples were obtained by capturing subsurface water vapor in silica gel cartridges.

The analytical laboratory analyzed vapor samples according to the US Environmental Protection Agency (EPA) Method TO-15 for VOCs and EPA Method 906.0 for tritium.

C. FACILITY MONITORING

Table 10-1 includes the number of vapor monitoring wells, number of depth intervals sampled, type of sampling systems implemented, and the depth to groundwater at each MDA during the 2011 monitoring period. Vapor-monitoring wells and sampled depth intervals are determined by NMED-approved work plans or reports.

Table 10-1
Vapor Monitoring Locations

Material Disposal Area	Number of Vapor Monitoring Wells Sampled ^a	Number of Sampling Intervals per Sampling Event ^b	Type of Sampling System ^c	Number of Sampling Events	Approximate Depth to Groundwater (ft bgs) ^d
C	10 or 18	46, 144 or 153	F/SS	4	1,182
G	19	38	SS/P	1	930
H	3 or 4	25 or 28	SS	3	1,040
L	24 or 25	84, 85 or 86	SS/P	3	950
T	5	34	SS	3	1,270
V	2	9	SS/P	4	1,270

^a Multiple values indicate that a different number of wells were sampled during different sampling events.

^b Multiple values indicate that a different number of sampling intervals were sampled during different sampling events.

^c SS = Stainless steel, P = Packer, F = FLUTe.

^d Based on nearest groundwater monitoring well (bgs = below ground surface).

D. ANALYTIC DATA COMPARISON AND TRENDS

At MDAs G, H, and L, vapor monitoring has been required for several years, and consequently, a large data set exists. The data provide information on the nature and extent of subsurface VOC and tritium contamination. In 2011, based on data from 2009 and 2010, contour views of the VOC vapor plumes under MDAs G and L were developed as part of the CME reports (LANL 2011c, 2011d); those plots are also presented in the Laboratory's 2010 Environmental Report (LANL 2011f). At MDAs T and V, preliminary plots help to determine data trends (LANL 2012b, 2012c). Collection of vapor data for characterization at MDA C started recently. Analyses of the data were included in the Phase III investigation report for MDA C (LANL 2011e) and are summarized in subsection D.1 below.

Table 10-2 lists the VOCs for which the SRs were above 1 during 2011 for MDAs C, G, L, and T using the Tier I screening analysis. The maximum Tier I SRs calculated for these VOCs are also listed. Tier I SRs were not above 1 for any VOCs detected at MDA H in 2011. Only tritium samples were collected at MDA V; thus, the Tier I screening evaluation for VOCs does not apply. Table 10-2 also indicates the VOCs at MDAs C and L that were above the more realistic Tier II screening values developed through analyses performed in the Phase III investigation report for MDA C and the CME report for MDA L. No VOCs were above the Tier II screening values developed for MDA G during 2011.

Table 10-2
VOCs that Exceeded Tier I and Tier II Screening Values during 2011

Location	VOC	Maximum Pore-Gas Concentration ($\mu\text{g}/\text{m}^3$)	Calculated Concentrations in Pore Gas Corresponding to Groundwater Standard ($\mu\text{g}/\text{m}^3$)	Tier I Screening Ratio (unitless)
MDA C	Benzene	4,100	1,140	3.6
	Hexanone[2-]	1,500	180	8.3
	Methylene Chloride	3,900	650	6.0
	Trichloroethene*	93,000	2,000	46.5
MDA G	Dichloroethane[1,1-]	24,000	5,750	4.2
	Dichloroethane[1,1-]	25,000	5,500	4.6
	Tetrachloroethene	32,000	3,600	8.9
	Trichloroethane[1,1,1-]	740,000	42,300	17
	Trichloroethene	11,000	2,000	28
MDA L	Benzene	3,300	1,140	2.9
	Butanol [1-]	1,700	1,332	1.3
	Carbon tetrachloride	11,000	5,500	2.0
	Chloroform	120,000	15,000	8.0
	Dichloroethane [1,1-]	71,000	5,750	12.3
	Dichloroethane [1,2-]*	600,000	240	2500
	Dichloroethene [1,1-]*	65,000	5,500	11.8
	Dichloropropane [1,2-]*	280,000	600	467
	Dioxane [1,4-]	11,000	12.2	900
	Methylene chloride*	120,000	650	185
	Tetrachloroethene*	760,000	3,600	211
	Trichloroethane[1,1,1-]*	2,300,000	42,300	54.4
	Trichloroethane[1,1,2-]	1900	170	11.2
	Trichloroethene*	1,500,000	2,000	750
	Trimethylbenzene [1,2,4-]	16,000	3,750	4.3
MDA T	Methylene chloride	2,600	650	4.0
	Trichloroethane[1,1,2-]	210	170	1.2

*Denotes the VOC concentration exceeded the Tier II screening value; analysis performed for MDAs C, G, and L only.

The following sections summarize the 2011 data and discuss data trends and comparisons.

1. MDA C

Figure 10-2 illustrates the 18 vapor monitoring wells at MDA C sampled during 2011. MDA C was sampled four times during 2011. Subsurface vapor monitoring samples have been collected during three investigation phases at the site since 2004 (LANL 2011e). Vapor monitoring data collected indicate VOCs are present in the subsurface. The screening evaluation of the 2011 data identified four VOCs with vapor concentrations above their respective Tier I screening values and one above the more realistic Tier II screening value at MDA C (Table 10-2).

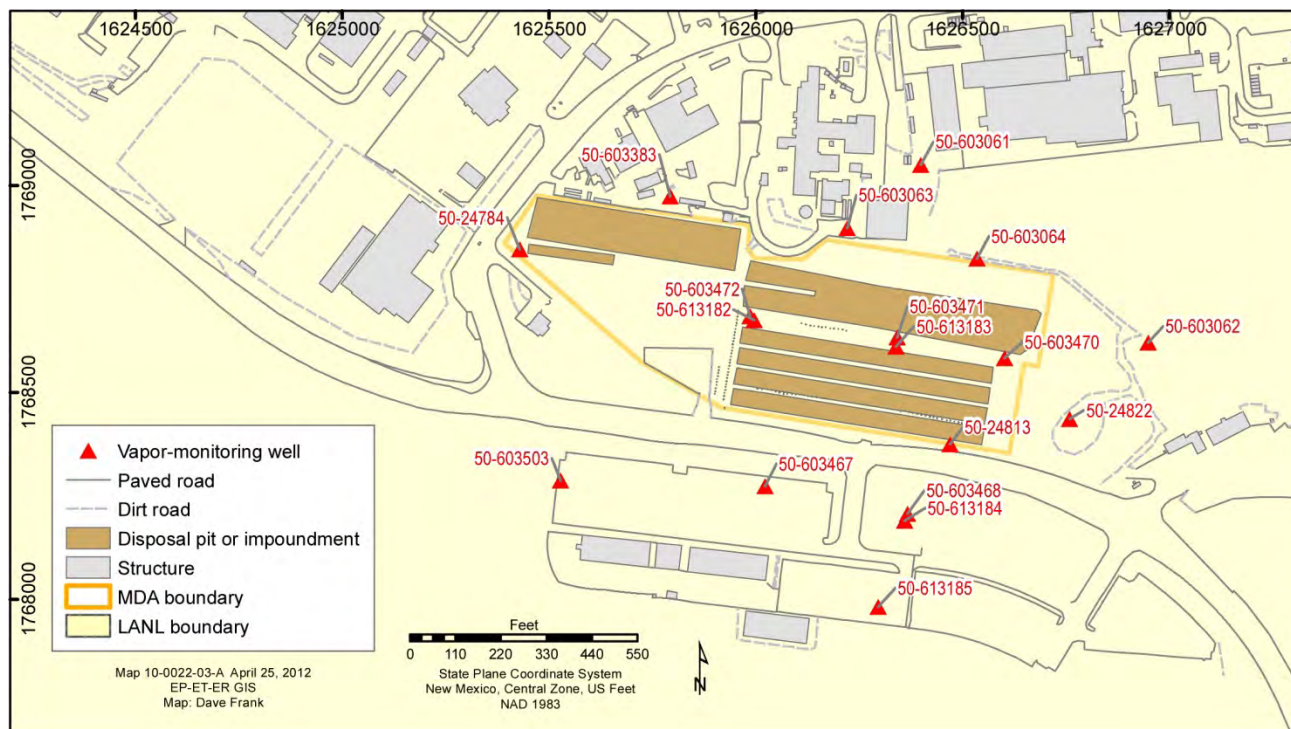
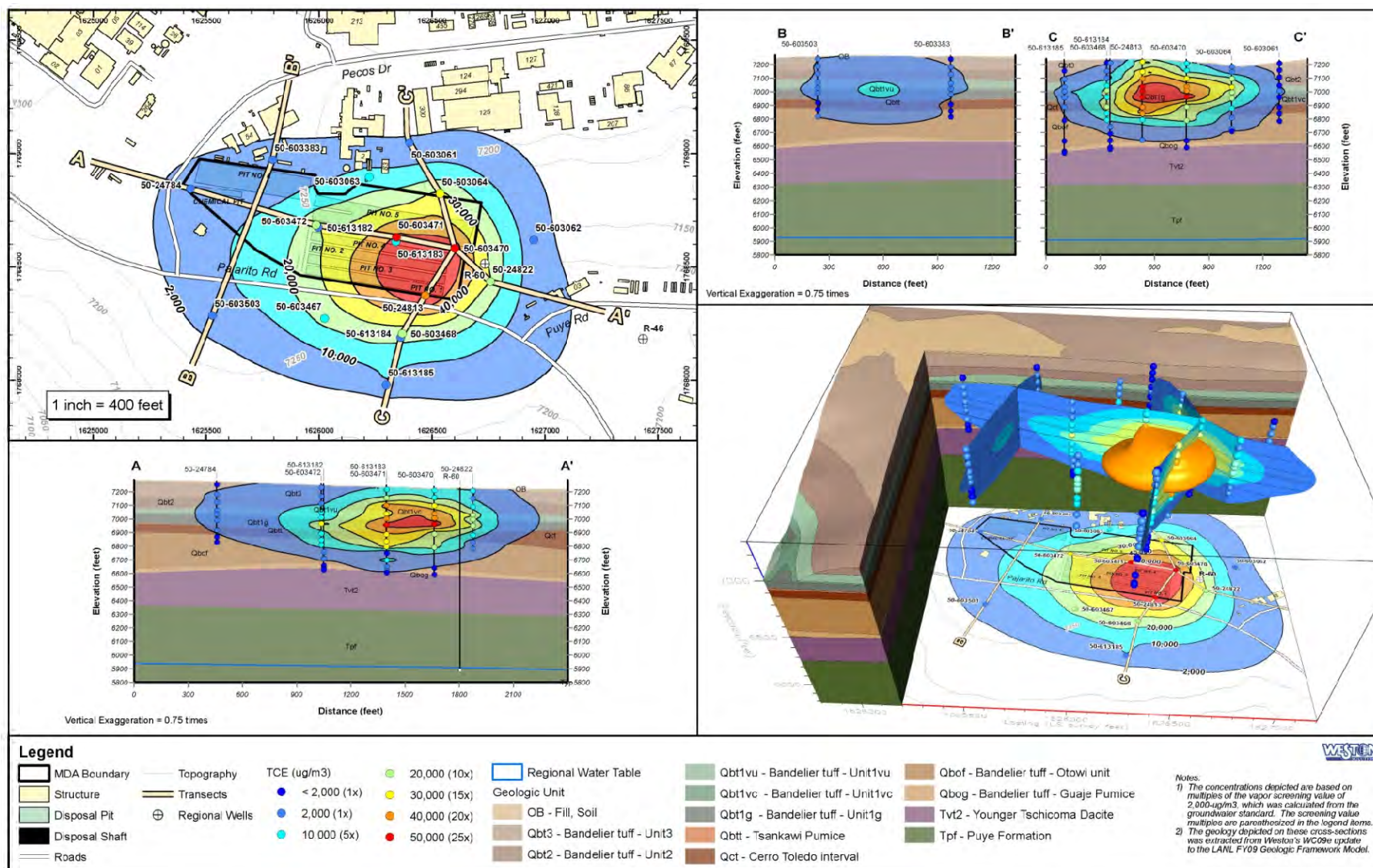


Figure 10-2 MDA C vapor monitoring wells

Trichloroethene (TCE) is the VOC identified as having vapor concentrations above its Tier II screening value in 2011. Contour views of the TCE plume were developed and presented in the MDA C Phase III investigation report based on data collected during the second, third, and fourth quarters of fiscal year (FY) 2010 and the first and third quarters of FY11 (see Figure 10-3). The lateral and vertical extents of the TCE plume that were above the TCE Tier I screening value of $2,000 \mu\text{g}/\text{m}^3$ (Table 10-2) are shown. The TCE plume is ellipsoidal in shape, with lateral extent being greater than vertical. The plume is almost entirely contained within the Bandelier Tuff. The TCE vapor concentrations were above the Tier II screening value (approximately $60,000 \mu\text{g}/\text{m}^3$) in a limited area at the eastern end of MDA C at a depth of 200 to 250 ft bgs and over 900 ft above the regional water table.

The plume is associated with disposal trenches and shafts that contain wastes with some solvent contamination. The plume distribution suggests the trenches and shafts near the eastern end of MDA C are likely the primary source of TCE. However, the characteristics of the vapor plume, particularly that the maximum concentrations occur below the disposal trenches and shafts, indicate the highest concentration portion of the plume is predominantly related to releases that occurred in the past rather than from ongoing releases. Further explanation for this interpretation is included in the MDA C Phase III investigation report (LANL 2011e).

The estimated mass of TCE in the subsurface is 129 to 209 kg (LANL 2011e). This estimate is for the mass contained within the area defined by the Tier I screening value. The estimate accounts for mass in the vapor phase, dissolved phase, and adsorbed to solids.



Tritium activity is detected in vapor samples collected at MDA C. Tritium was observed over the entire length of vapor monitoring well 50-603383, in nine ports ranging from 26 ft bgs to 450 ft bgs, during the four 2011 sampling events. This monitoring location is on the northern boundary of MDA C. The maximum activity reported during 2011 was 7,600,000 pCi/L at monitoring well 50-603468 (Figure 10-2). At most locations, the tritium activity decreases with depth, and most values are below the Tier I screening value of 20,000 pCi/L.

Vapor monitoring at MDA C will continue on a biannual basis to support the site CME. The CME report for MDA C is due to NMED in September 2012.

2. MDA G

Figure 10-4 illustrates the 20 vapor monitoring wells at MDA G, including the 19 that were sampled during 2011. Annual sampling of MDA G occurred once during 2011. Subsurface vapor monitoring data have been collected at MDA G since 1985. Vapor monitoring data collected indicate VOCs are present in the subsurface. The screening evaluation identified five VOCs above the Tier I screening values and none above the more realistic Tier II screening values at MDA G in 2011 (Table 10-2).

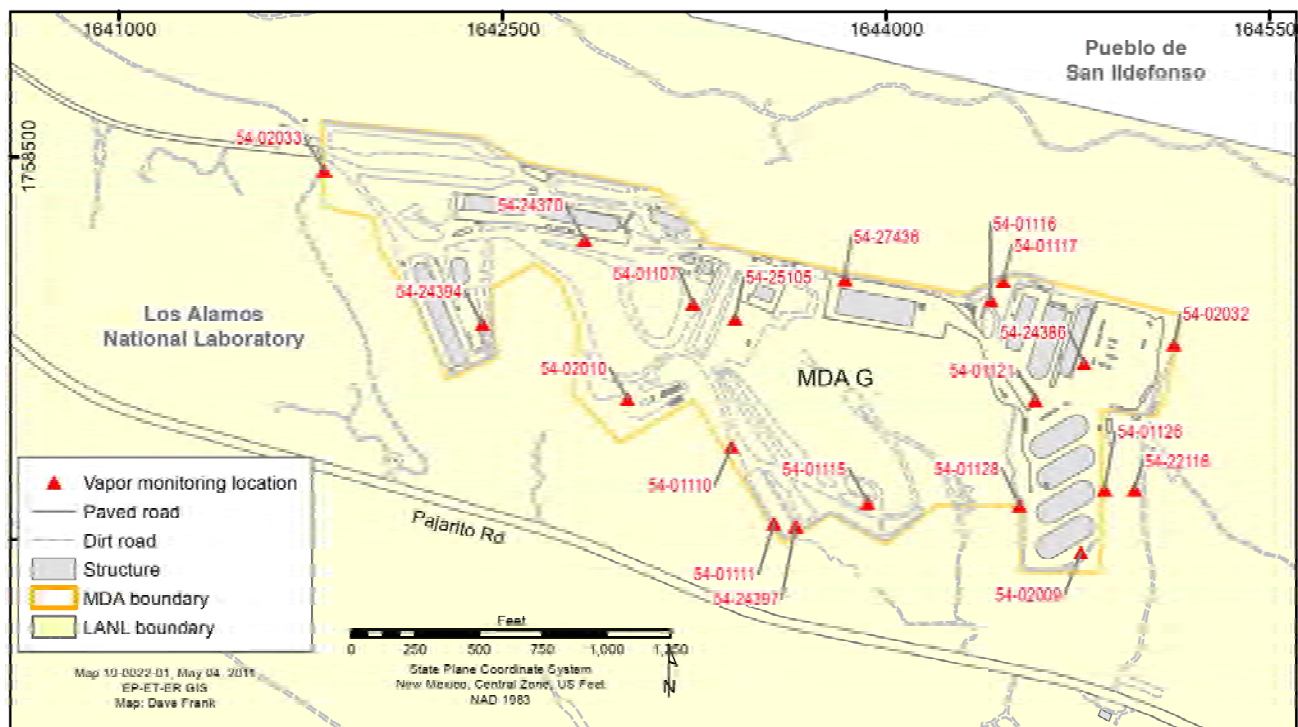


Figure 10-4 MDA G vapor monitoring wells

Trichloroethane-1,1,1 (TCA) and TCE are two VOCs of particular interest due to the consistency in detected concentrations and because their concentrations were above Tier II screening values in 2009 and 2010. The distributions of these plumes were illustrated in the Laboratory's 2010 Environmental Report (LANL 2011f). The concentration contours identified two plumes for TCA and three plumes for TCE at MDA G, and the current data are consistent with those distributions. The plumes are associated with disposal pits and shafts that contain wastes where VOCs are a secondary component of the waste, rather than a primary waste form. These areas are considered to be potentially ongoing sources of VOC vapors.

Data analysis indicates that most of the mass of VOCs is contained within the Bandelier Tuff several hundred feet above the regional water table. However, there is uncertainty related to the long-term transport of VOC vapors toward groundwater through the fractured basalts that are present beneath the tuff units at MDA G. Therefore, corrective measures related to removal of VOCs were recommended as a precautionary measure in the MDA G CME report, Revision 3 (LANL 2011c). NMED directed the Laboratory to discontinue vapor

sampling activities at MDA G until the implementation phase of the selected remedy at MDA G (NMED 2011a).

Tritium activity is also detected in vapor samples collected at MDA G. MDA G contains the highest detected tritium activities in pore gas observed at the Laboratory, with a maximum in 2011 of 2,240,000,000 pCi/L. Reported activities have been similar during each annual sampling event, and the greatest activities are consistently reported in vapor monitoring well 54-01111 (Figure 10-4), which is located near the tritium disposal shafts in the south-central portion of MDA G.

3. MDA H

Figure 10-5 illustrates the four vapor monitoring wells sampled at MDA H during 2011. Vapor monitoring was conducted for three quarters on a quarterly basis at MDA H. Subsurface vapor monitoring data have been collected since 2005. Vapor monitoring data indicate that VOC concentrations are low and frequently reported as not detected. No VOC concentrations were above Tier I screening values during 2011.

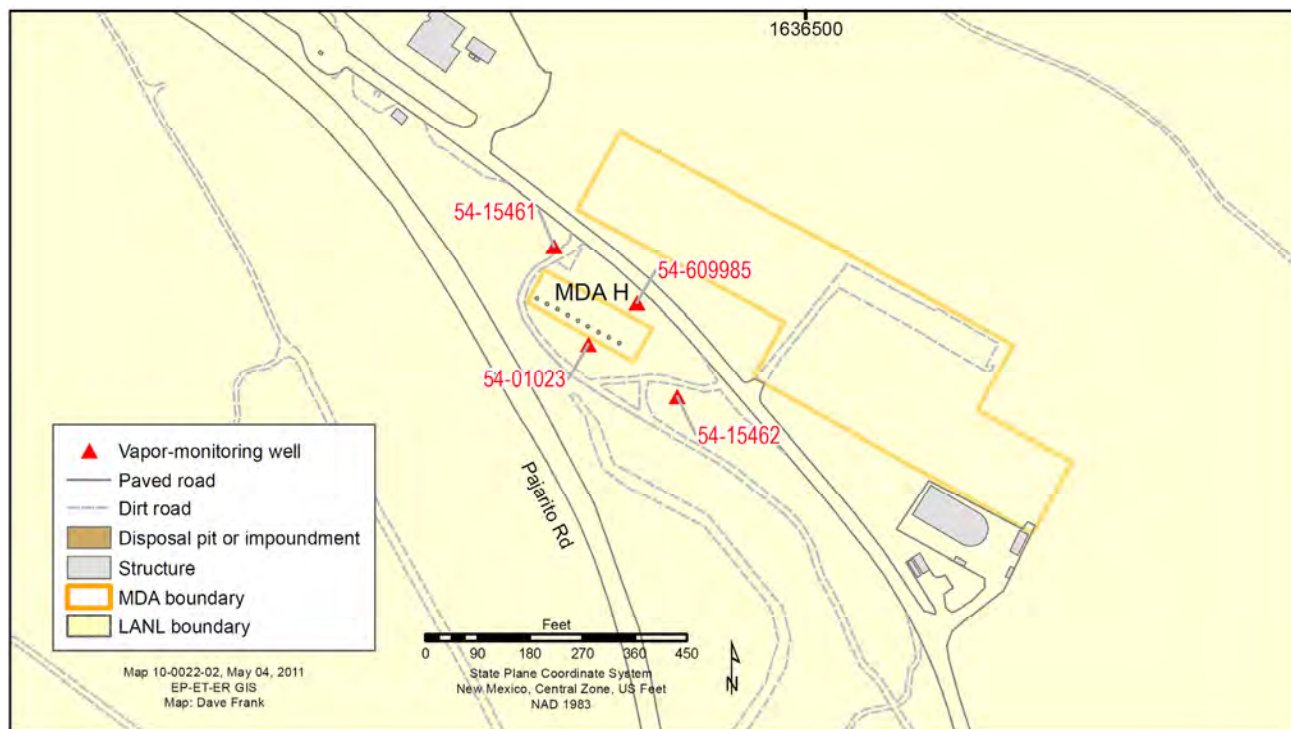


Figure 10-5 MDA H vapor monitoring wells

The MDA H CME report, Revision 1 (LANL 2011g), was submitted to NMED in September 2011. Bulk estimates of VOC masses were calculated based on data collected during 2010 and included in the CME. Halogenated VOCs (e.g., TCA and TCE), which are generally of the most concern for contamination of groundwater, comprise less than 5% of the total estimated mass; the estimated mass of halogenated VOCs is approximately 0.1 kg. This low mass estimate is consistent with disposal records from MDA H, which do not list bulk chemical wastes as being disposed of at the site. Based on the CME, VOCs measured in subsurface vapor at MDA H do not pose a potential threat to groundwater, and no remedy was proposed for VOC contamination (LANL 2011g). NMED granted a request from the Laboratory to discontinue vapor sampling at MDA H; NMED will select a remedy based on the data provided to date (NMED 2011b).

Tritium activity is also detected in vapor samples collected at MDA H. Reported activities are similar for each sampling event, and the greatest activities are consistently reported in vapor monitoring well 54-01023. The maximum activity reported during 2011 was 6,240,000 pCi/L in vapor monitoring well 54-01023.

4. MDA L

Figure 10-6 illustrates the 25 vapor monitoring wells sampled at MDA L during 2011. Vapor monitoring was conducted for three quarters at MDA L. Subsurface vapor monitoring samples have been collected since 1985. Vapor monitoring data show that MDA L contains the highest concentrations of VOCs in pore gas at the Laboratory, which is consistent with known liquid chemical waste disposal at the site. The screening evaluation identified 15 VOCs above the Tier I screening values during 2011 and seven VOCs above the Tier II screening values (Table 10-2). Plume maps showing the extents of six of the seven VOCs (1,2-dichloroethane, 1,2-dichloropropane, methylene chloride, tetrachloroethene [PCE], TCA, and TCE) with vapor concentrations above the Tier II screening values were presented in the Laboratory's 2010 Environmental Report (LANL 2011f). 1,1-Dichloroethene had a limited extent and was not mapped. Those maps illustrated that the plumes are located within the upper 200 ft bgs and generally centered on the two disposal shaft areas at MDA L. The 2011 vapor data are consistent with those previous data. The regional aquifer is well below the plume at approximately 950 ft bgs.

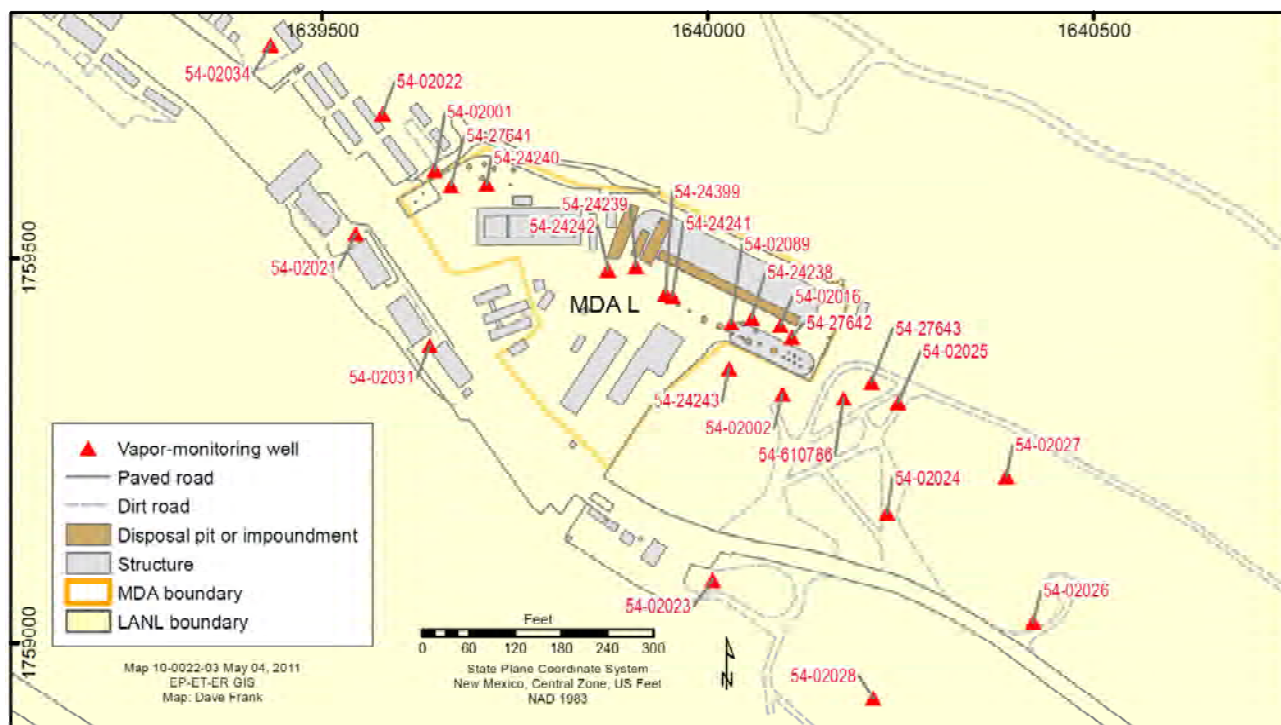


Figure 10-6 MDA L vapor monitoring wells

TCA and TCE are the dominant VOCs within the vapor plume at MDA L, making up more than 75% of the mass of the plume. Data for the TCA vapor plume at MDA L have been studied for over a decade, and the extent and concentrations within the plume are quite stable (Stauffer et al. 2005). However, because VOC concentrations are well above Tier II screening values at MDA L and because there is some uncertainty related to the long-term transport of these vapors toward groundwater through the fractured basalts that are present beneath the tuff units at MDA L, corrective actions related to VOCs were recommended as a precautionary measure in the MDA L CME report (LANL 2011d). NMED directed the Laboratory to discontinue vapor sampling activities at MDA L until the implementation phase of the selected remedy at MDA L (NMED 2011c).

Reported tritium activities in vapor samples collected at MDA L during 2011 were similar to previous year's data. Tritium is detected at various shallow depths in several vapor monitoring wells; however, most activities are relatively low compared with other sites ($< 10,000$ pCi/L). The highest tritium activities reported are in vapor monitoring well 54-24243, with a maximum activity reported in 2011 of 327,740 pCi/L.

5. MDA T

Figure 10-7 illustrates the five vapor monitoring wells sampled at MDA T during 2011. Vapor monitoring was conducted for three quarters at MDA T. Vapor monitoring data indicate that VOCs are present in the subsurface at MDA T. Two VOCs (methylene chloride and 1,1,2-trichloroethane) had Tier I SRs above 1 during 2011 (Table 10-2). The greatest Tier I SR reported at MDA T during 2011 was for methylene chloride with an SR of 4.0 (Table 10-2). Plots of concentrations versus depth are presented in the quarterly PMRs for the deeper vapor monitoring wells (locations 21-25262 and 21-607955) at MDA T to assist in evaluating trends (LANL 2012b). Plots for methylene chloride are presented in Figure 10-8. These plots indicate that methylene chloride concentrations consistently peak at a single depth: approximately 356 ft bgs in vapor monitoring well 21-607955 and 575 ft bgs in vapor monitoring well 21-25262. The data also indicate that concentrations decrease with depth below these peak locations. These data are consistent with previous data from the site. A formal Tier II screening analysis has not been performed for MDA T, but the analyses for MDAs G and L indicate that vapor concentrations at MDA T for these two constituents are not likely to be above Tier II screening values when developed. NMED directed the Laboratory to discontinue quarterly vapor monitoring at MDA T; NMED will evaluate the next phase of corrective action at MDA T based on the data accumulated to date (NMED 2011d).

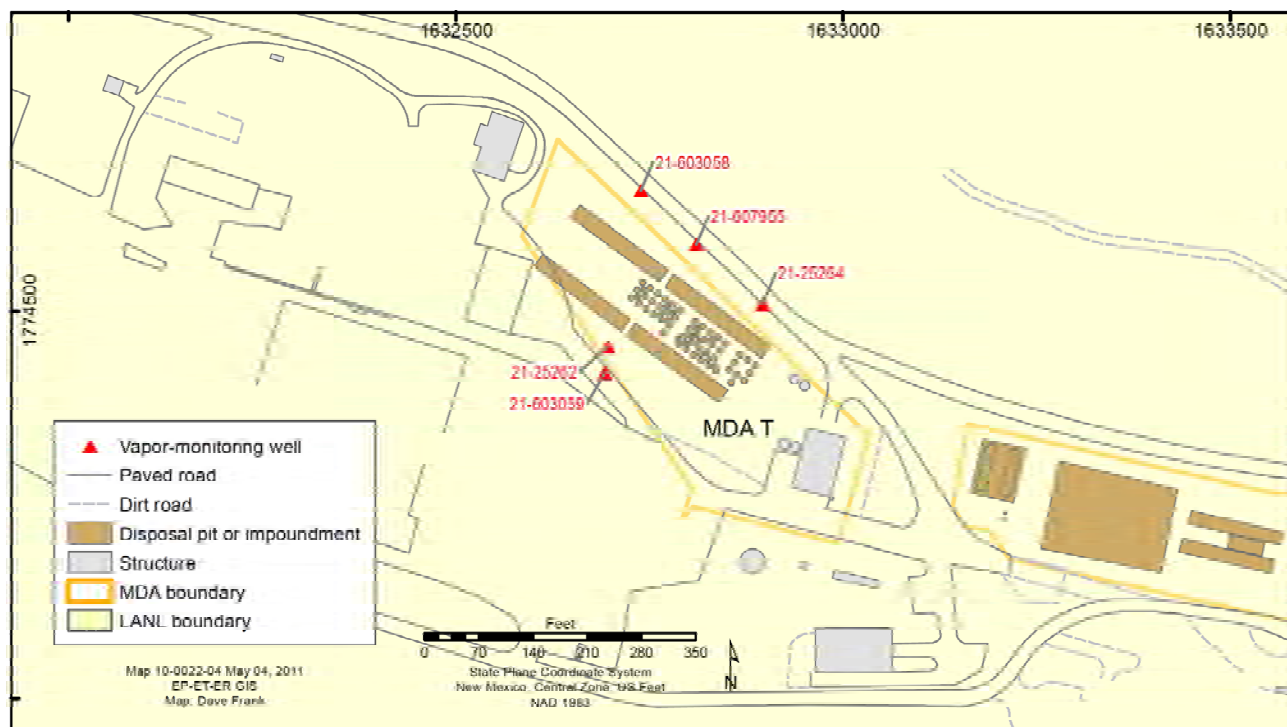


Figure 10-7 MDA T vapor monitoring wells

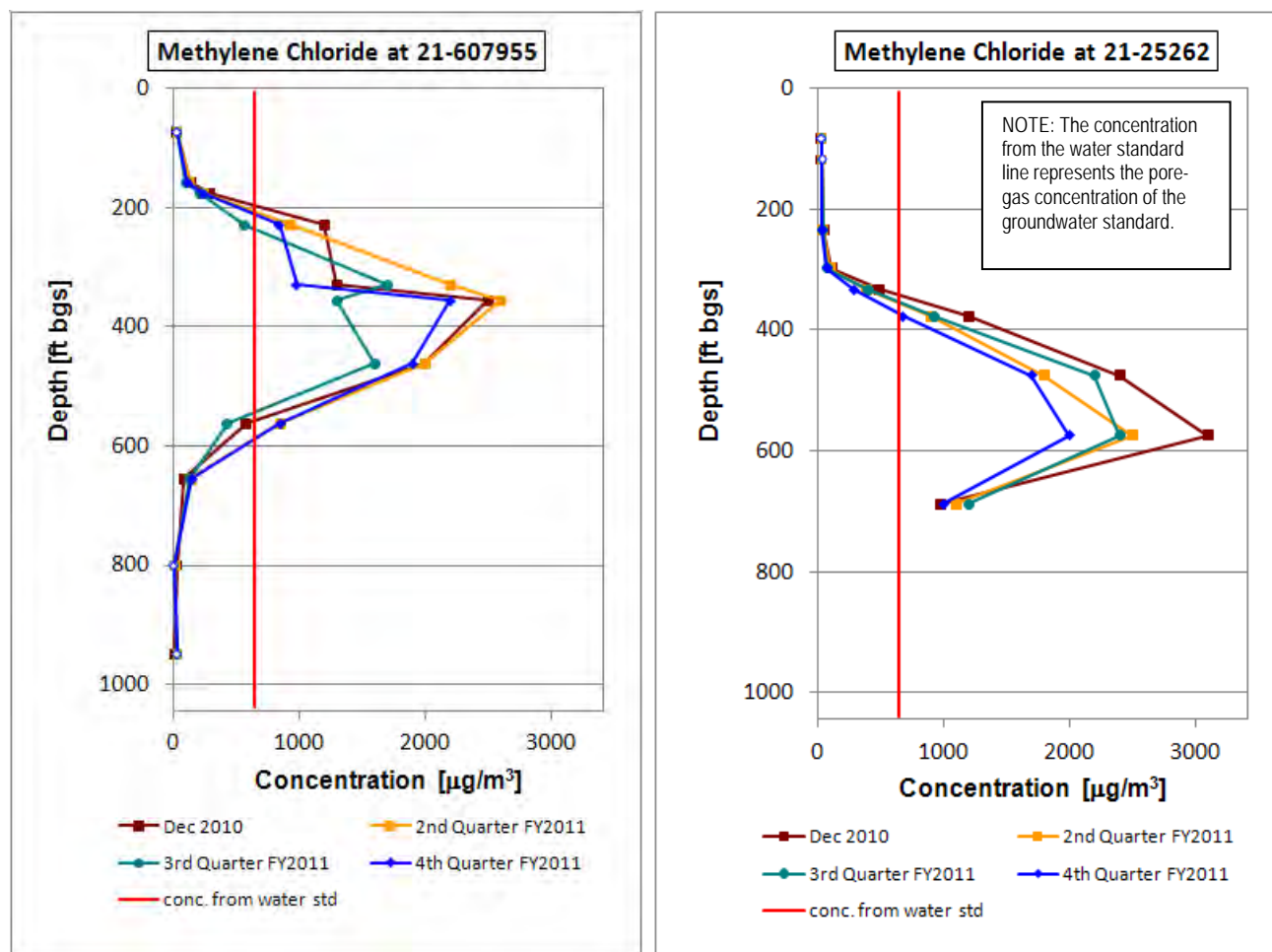


Figure 10-8 Vertical profiles of methylene chloride in vapor monitoring wells 21-607955 and 21-25262 at MDA T

Tritium activity is detected in vapor samples collected at MDA T. Reported activities from each sampling event are similar, and the greatest activities are consistently reported in vapor monitoring well 21-25264 at a depth of 150.5 to 155.5 ft bgs. The maximum activity reported during 2011 was 165,000 pCi/L in vapor monitoring well 21-25264. Existing tritium data collected to date will be evaluated further in the MDA T CME report. In addition, results of monitoring for VOCs and tritium in nearby groundwater wells will be included in the CME report.

6. MDA V

LANL completed characterization and remediation activities at MDA V in 2005 related to potential contamination from both hazardous and radioactive chemicals. The activities included the removal of the absorption beds and contaminated soil. However, the extent of tritium in pore gas was not determined during characterization, thus continued monitoring for tritium in pore gas was required. A two-part deep vapor monitoring well—21-24524W and 21-24524S, collectively known as well 21-24524—was completed to assist in defining extent, and vapor monitoring has been ongoing for four years. Figure 10-9 illustrates the two-part well sampled at MDA V and indicates where the absorption beds once existed. The maximum tritium activity detected during the four sampling events in 2011 was 71,500 pCi/L at 300 ft bgs (LANL 2012c). The location of the peak activity is consistent and within the Tsankawi pumice bed for all sampling rounds collected at MDA V, and concentrations decline sharply beneath that depth.

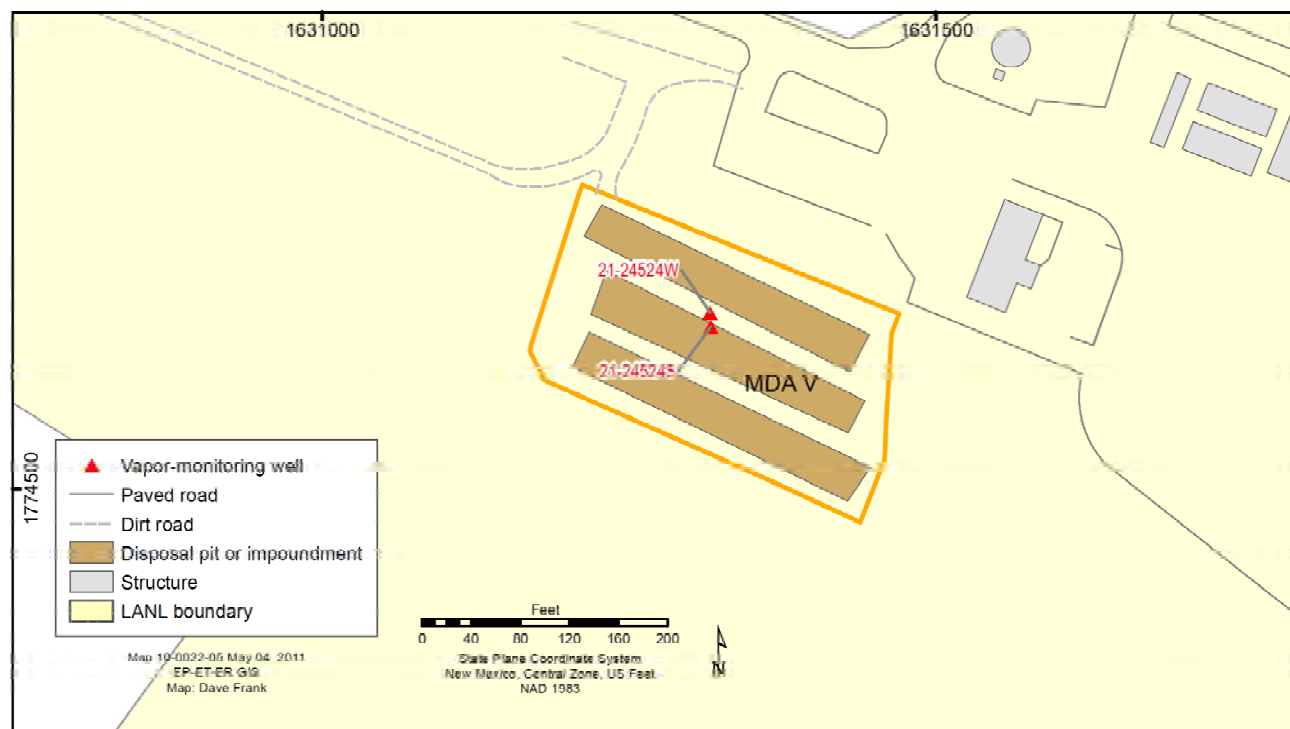


Figure 10-9 MDA V vapor monitoring wells

VOC and tritium data collection activities have been completed for MDA V. Certificates of completion for MDA V were issued by NMED in June 2011 (NMED 2011e). At NMED's request, vapor monitoring activities were performed at MDA V during September 2011 to support remediation of MDA B, which is located west of MDA V. Remediation of MDA B has been completed. In November 2011, NMED approved a request made by the Laboratory to discontinue vapor monitoring at MDA V (NMED 2011f).

E. SUMMARY

Vapor (pore-gas) monitoring was used to evaluate subsurface contamination of VOCs and tritium at six MDAs during 2011. Monitoring data have been used to determine the nature and extent of subsurface VOCs at these six sites. In addition, data have been used to estimate masses of VOCs in the vadose zone for MDAs C, G, H, and L and to support investigations and CMEs at the sites. Similarly, monitoring data have been used to help determine the nature and extent of tritium contamination.

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To Read About**Turn to Page**

<i>Introduction</i>	11-1
<i>Quality Control for Samples, Data Validation, and Analytical Results Review</i>	11-1
<i>Qualification and Performance Assessment of Analytical Laboratories</i>	11-3
<i>Department of Energy Contract Analytical Program Audits</i>	11-4
<i>References</i>	11-4

A. INTRODUCTION

The 2011 environmental sampling incorporated a graded approach to quality assurance (QA) in accordance with US Department of Energy (DOE) Order 414.1C, which determines the scope, depth, and rigor of implementing the QA criteria for a specific activity. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the quality requirements, risk, and hazards associated with each activity. In this chapter, we present the analytical laboratories' quality performance of Los Alamos National Laboratory's (LANL's or the Laboratory's) environmental data across all media. Overall, our analytical laboratories' performance met our high-quality standards.

All sampling, data reviews, and data package validations are conducted using standard operating procedures (SOPs), which are part of LANL's comprehensive QA program. Completed chain-of-custody forms serve as the analytical request form and include the requester or owner, sample number, program code, date and time of sample collection, total number of bottles, list of analytes to be measured, bottle sizes, and preservatives for each analysis requested.

All analytical laboratory results undergo validation following the guidelines in the National Nuclear Security Administration (NNSA) Model Data Validation Procedure (NNSA 2006) and US Environmental Protection Agency (EPA) Contract Laboratory Program National Functional Guidelines for Data Review (EPA 2004, 2005, 2008). This process includes review of the data quality and the documentation's correctness and completeness. An independent DOE contractor, Analytical Quality Associates, Inc. (AQA), in Albuquerque, New Mexico, performs the data validation and applies data qualifiers to the data according to LANL validation SOPs.

Field QA procedures and the quality plan documents were followed during 2011 sampling. Together, these plans and procedures describe or prescribe all the planned and systematic activities necessary to provide adequate confidence that sampling processes are performed satisfactorily.

The LANL data are available as part of the public Intellus New Mexico website, <http://www.intellusnmdata.com/>, which contains all the air, surface water, sediment, soils, and groundwater analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, LANL investigates the laboratory records, and the sample may be reanalyzed or the location resampled. Both the initial sample and the follow-up sample analyses are kept in the database and are available to the public. In some cases, comments are appended to the records to indicate existence of recognized analytical issues. See the Intellus website for SOPs for the laboratory qualifier codes, secondary validation flags, and validation reason codes.

B. QUALITY CONTROL FOR SAMPLES, DATA VALIDATION, AND ANALYTICAL RESULTS REVIEW

All samples are analyzed at analytical laboratories authorized by the LANL analytical services statement of work (SOW) for general inorganic, organic, radiochemical, and asbestos analytical laboratory service. LANL requires all laboratories to produce legally defensible data packages, which include the following types of quality control (QC) samples and data: instrument raw data, initial and continuing calibration verifications, method blanks, internal standards, laboratory duplicates, laboratory control samples, surrogate samples, tracers, and matrix spike samples. The results from the laboratory QC samples are used to check the accuracy and precision of the analytical data. Field QC samples are also submitted along with environmental samples so that field and analytical laboratory contamination can be tracked and analytical laboratory performance can

be assessed. Field QC samples collected include equipment blanks, field blanks, field duplicates, field trip blanks, and performance evaluation blanks.

LANL verifies and validates all analytical data used to support environmental activities to ensure they are defensible and of known quality. Analytical data packages sent to LANL by the analytical laboratories undergo a secondary validation review by AQA. When documentation or contract-compliance problems are identified during data validation, the analytical laboratory is contacted and attempts to resolve or clarify the related issues are established in Validation Corrective Action Reports submitted by AQA to LANL. The analytical laboratory reissues the corrected, modified documentation for revalidation. The majority of the issues of concern involve minor documentation and typographical errors, missing pages, and clarification of data results. Associated sample results are generally not affected. All 2011 Validation Corrective Action Reports are addressed and resolved appropriately by the analytical laboratory. AQA validated all of the 2011 data packages.

After data validation by AQA, approximately 98% of all results are of good quality and are usable; AQA assigned R qualifiers (rejected) to approximately 2% of the 2011 data. Overall, approximately 12% of the accepted results are qualified during data validation based on data quality issues such as surrogate, laboratory control sample, duplicate, tracer, and matrix spike recoveries that do not meet specifications; calibration of internal standards that are not met; or holding times that have expired. The analytical laboratory assigned J qualifiers to approximately 2% of the data, indicating that the results represent a detection, but the value is estimated. The analytical laboratory confirmed 15% of the analytes as detected. Even after validation, 69% of the data are qualified as non-detect with no QC issues. Table 11-1 displays the overall quality of the 2011 samples.

Table 11-1
Overall Quality of 2011 Samples

Qualifiers Affecting Quality Control	Percent of 2011 Data
U, U_LA: qualified not detected by lab with no QC issues	69
J, J_LAB: qualified detected between method detection limit and estimated quantitation limit	2
NQ: detected above the reporting limit with no QC issues	15
R: rejected in validation	2
UJ (estimated non-detect) or J because of QC issues discovered in validation	12

Table 11-2 shows the percentage of data qualified based on AQA's secondary data validation of laboratory QC samples. Two percent of all 2011 data were qualified as rejected (R).

Table 11-2
Routine Validation Summary for 2011 Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent 2011 Data
Blanks	3,167	0.43
Holding times	9,063	1.2
Initial calibration verifications or continuing calibration verifications	30,196	4.1
Interference check samples	23	0.003
Internal standards or surrogates	2,722	0.37
Laboratory control samples	2,079	0.28
Laboratory duplicates	1,076	0.15
Matrix spike samples	4,445	0.6
Tracers (rad only)	352	0.03

Table 11-2 (continued)

QC Sample Type	Number of Analytes Qualified as Rejected (R)	Percent 2011 Data
Holding times	6,765	1.4
Initial calibration verifications or continuing calibration verifications	103	0.01
Internal standards or surrogates	1,085	0.15
Laboratory control samples	156	0.02
Laboratory duplicates	12	0.002
Matrix spike samples	85	0.01
Spectra do not match	5	0.0007
Professional judgment	118	0.02

C. QUALIFICATION AND PERFORMANCE ASSESSMENT OF ANALYTICAL LABORATORIES

The Laboratory is responsible for acquiring analytical services that support environmental activities. The SOW for analytical services follows the DOE/NNSA Service Center Model Statement of Work for Analytical Laboratories (NNSA 2010). The SOW provides the contract analytical laboratories the general QA guidelines and includes specific requirements and guidelines for analyzing air, surface water, groundwater, soil, and sediment samples.

In 2011, the majority of the analyses were performed by GEL Laboratories in Charleston, South Carolina; TestAmerica, Inc., St. Louis in Earth City, Missouri; ALS Laboratory Group (formally Paragon) in Fort Collins, Colorado; Southwest Research Institute in San Antonio, Texas; and American Radiation Services, Inc., in Baton Rouge, Louisiana. Vista Analytical Laboratory in El Dorado Hills, California, is used as an additional laboratory to analyze samples for dioxins and furans.

Analytical laboratories undergo a pre-award assessment to evaluate their ability to perform the required analyses. The Laboratories must be certified by the National Environmental Laboratory Accreditation Program for the required analytical methods.

LANL requires analytical laboratories to participate in independent national performance evaluation programs. These performance evaluation studies address a majority of the parameters for which the analytical laboratories conduct analyses in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program, Water Study, proficiency testing, and other pertinent programs offered by Environmental Resource Associates and state-sponsored certification programs as available for the analytical methods they conduct for LANL.

The vast majority of the results of these studies were within acceptance limits. Acceptance limits are the range of percent recoveries that indicate sufficient accuracy of the analyses and results in data not being qualified. If the results for an analyte or group of analytes did not pass, the laboratories implemented corrective actions, and acceptable results are reported for 2011.

All of the laboratories provided detailed analytical laboratory performance evaluation studies, investigation reports, and corrective action plans to LANL for review. In addition, each laboratory conducts internal audits of their procedures, instrumentation, and reporting practices on a regular basis. When issues are found, each laboratory documents the issues and performs and records corrective actions.

D. DEPARTMENT OF ENERGY CONTRACT ANALYTICAL PROGRAM AUDITS

The DOE Office of Environmental Management mandates participation in the DOE Contract Analytical Program (DOECAP; <https://doecap.oro.doe.gov/>). DOECAP is a consolidated, uniform program for conducting annual audits of commercial laboratories to eliminate audit redundancy by involving all DOE program line organizations and field elements, to provide a pool of trained auditors sufficient to support consolidated audits, to standardize terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and to interface with state and federal regulatory agencies and other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers. In 2011, DOECAP audits were conducted at laboratory facilities that provided air, water, soil, and sediment data to LANL.

DOECAP audits result in findings and observations when there are items of concern that need to be addressed in the audit report. DOECAP audits found that the laboratories met established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods. The corrective action plans resulting from the audits have been approved and are available from the DOECAP website.

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GENERAL FORMATION OF A STANDARD

Standards are created to protect a target group from a variety of contaminants in a given exposure pathway for a specific time frame. A target group may refer to the general public, animals, or a sensitive population like adolescents, the elderly, or asthmatics. Contaminants of concern are addressed by a governing body, such as the US Environmental Protection Agency (EPA), which takes into consideration occurrence in the environment, human exposure and risks of adverse health effects, available methods of detection, cost of implementation, geographic location, and public health. After a contaminant of concern has been identified, all exposure pathways are considered to determine the most probable instances and the need for regulation. Pathways of exposure include air, water, soil, biota, and foodstuffs that can be ingested, absorbed, or inhaled. Time of exposure is also an important factor in the formation of standards because prolonged exposure to low levels of a contaminant can have similar health effects as a short exposure to a high level of a contaminant.

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. 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 US Department of Energy (DOE) Orders 450.1, Environmental Protection Program; 5400.5, Radiation Protection of the Public and the Environment; and 231.1A, Environmental Safety and Health Reporting.

RADIATION STANDARDS

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-year dose commitments were calculated using the EPA dose factors from Federal Guidance Report No. 13 (EPA 1999). The dose factors EPA adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 millirem per year (mrem/yr). For one specific activity or pathway, DOE guidance specifies a "dose constraint" of 25 mrem/yr (DOE 1999.) The public dose limits and the DOE occupational dose limits are

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

Exposure Pathway	Dose Equivalent at Point of Maximum Probable Exposure
Exposure of Any Member of the Public	
All pathways	100 mrem/yr ^a
One specific pathway (dose constraint)	25 mrem/yr ^b
Air pathway Only ^c	10 mrem/yr
Drinking water	4 mrem/yr
Occupational Exposure	
Stochastic Effects	5 rem/yr ^d (TEDE) ^e
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

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

^b Guidance (DOE 1999.)

^c This level is from EPA's regulations issued under the Clean Air Act (40 Code of Federal Regulation [CFR] 61, Subpart H) (EPA 1989a).

^d rem/yr = rem per year.

^e Refer to Glossary for definition.

based on recommendations from the ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure. External dose factors were obtained from Federal Guidance Report No. 12 (EPA 1993).

Radionuclide concentrations in water are compared with DOE's derived concentration guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem/yr.

Table A-2 shows the DCGs. For comparison with drinking water systems, the DCGs are multiplied by 0.04 to correspond with the EPA limit of 4 mrem/yr.

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

NON-RADIOACTIVE AIR QUALITY STANDARDS

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

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

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

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

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

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

^b pCi/L = picocuries per liter.

^c Drinking water DCGs are 4% of the DCGs for non-drinking water.

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

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm ^a	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total suspended particulates	Annual	µg/m ³ ^b	60		
	30 days	µg/m ³	90		
	7 days	µg/m ³	110		
	24 hours	µg/m ³	150		
PM-10 ^c	Annual	µg/m ³		50	50
	24 hours	µg/m ³		150	150
PM-2.5 ^d	Annual	µg/m ³		15	15
	24 hours	µg/m ³		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	µg/m ³		1.5	1.5

^a ppm = parts per million.

^b µg/m³ = micrograms per cubic meter.

^c PM-10 = Particles ≤10 µm in diameter.

^d PM-2.5 = Particles ≤2.5 µm in diameter.

DRINKING WATER STANDARDS

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

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

A screening level of 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 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.

SURFACE WATER STANDARDS

Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995)

<http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.htm>. The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

SOILS

If contaminant concentrations in soil exceed regional statistical reference levels (RSRLs), the concentrations are first compared with screening levels. The screening level for soils is the concentration that would produce (a) a dose of 15 mrem or greater to an individual, (b) a carcinogen risk of 10^{-5} , or (c) a hazard quotient greater than 1. Screening levels for radionuclides are found in a Laboratory document (LANL 2005); screening levels for non-radionuclides are found in an NMED document (NMED 2006). If radionuclide concentrations in soil exceed the screening levels, then a dose to a person is calculated using the residual radioactivity (RESRAD) computer model and all of the measured radionuclide concentrations available for a given year (these data are presented in Supplemental Table S7-1). This calculated dose is compared to the 25-mrem/yr DOE single pathway dose standard (DOE 1999). Doses, risk, or hazard quotients are calculated using a conservative residential scenario given the measured contaminant soil concentration.

FOODSTUFFS

Federal standards exist for radionuclides and selected non-radionuclides (e.g., mercury and polychlorinated biphenyls [PCBs]) in foodstuffs. Federal screening levels exist for selected non-radionuclides; LANL has established screening levels for radionuclides. If contaminant concentrations in foodstuffs exceed RSRLs, the concentrations are compared with screening levels. LANL has established a screening level of 1 mrem/yr for concentrations of individual radionuclides in individual foodstuffs (e.g., fish, crops, etc.), assuming a residential scenario. EPA has established screening levels for mercury (EPA 2001) and PCBs (EPA 2007) in fish.

If contaminant concentrations in foodstuffs exceed screening levels, contaminant concentrations are compared with Food and Drug Administration (FDA) standards (FDA 2000). In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured and compared with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999).

BIOTA

If contaminant concentrations in biota exceed RSRLs, the concentrations are compared with screening levels. For radionuclides in biota, screening levels were set at 10% of the standard by LANL to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no screening levels based on biota

tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL, then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (LANL 2008).

Based on the concentrations of radionuclides in biota, LANL calculates a dose and compares it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1-rad/day for terrestrial animals (DOE 2002).

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Throughout this report the US customary (English) system of measurement has generally been used because those are the units in which most data and measurements are collected or measured. 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 International System of Units (SI) units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively. Table B-1 presents conversion factors for converting US customary units into SI units.

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

Table B-3 presents abbreviations for common measurements.

DATA HANDLING OF RADIOCHEMICAL SAMPLES

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

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

Table B-1
Approximate Conversion
Factors for Selected US Customary Units

Multiply US Customary Unit	by	to Obtain SI (Metric) Unit
degrees Fahrenheit (°F)	5/9 - 32	degrees Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft ³)	0.028	cubic meters (m ³)
acres	0.4047	hectares (ha)
ounces (oz)	28.3	grams (g)
pounds (lb)	0.453	kilograms (kg)
miles (mi)	1.61	kilometers (km)
gallons (gal.)	3.785	liters (L)
feet (ft)	0.305	meters (m)
parts per million (ppm)	1	micrograms per gram (µg/g)
parts per million (ppm)	1	milligrams per liter (mg/L)
square miles (mi ²)	2.59	square kilometers (km ²)
picocuries (pCi)	37	millibecquerel (mBq)
rad	0.01	gray (Gy)
millirem (mrem)	0.01	millisievert (mSv)

Table B-2
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-3
Common Measurement Abbreviations and Measurement Symbols

Symbol or Abbreviation	Definition	Symbol or Abbreviation	Definition
aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu	British thermal unit	nCi	nanocurie
Ci	curie	nCi/dry g	nanocuries per dry gram
cm ³ /s	cubic centimeters per second	nCi/L	nanocuries per liter
cpm/L	counts per minute per liter	ng/m ³	nanograms per cubic meter
fCi/g	femtocuries per gram	pCi/dry g	picocuries per dry gram
ft	foot or feet	pCi/g	picocuries per gram
ft ³ /min	cubic feet per minute	pCi/L	picocuries per liter
ft ³ /s	cubic feet per second	pCi/m ³	picocuries per cubic meter
kg	kilogram	pCi/mL	picocuries per milliliter
kg/h	kilograms per hour	pg/g	picograms per gram
m ³ /s	cubic meters per second	pg/m ³	picograms per cubic meter
μCi/L	microcuries per liter	PM ₁₀ or PM-10	small particulate matter (less than 10 μm diameter)
μCi/mL	microcuries per milliliter	PM _{2.5} or PM-2.5	small particulate matter (less than 2.5 μm diameter)
μg/g	micrograms per gram	R	roentgen
μg/m ³	micrograms per cubic meter	s, SD, or σ	standard deviation
mL	milliliter	sq ft (ft ²)	square feet
mm	millimeter	>	greater than
μm	micrometer	<	less than
μmho/cm	micro mho per centimeter	≥	greater than or equal to
mCi	millicurie	≤	less than or equal to
mg	milligram	±	plus or minus
mR	milliroentgen	~	approximately
mrad	millirad		

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

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

where

c_i = sample i ,

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

N = number of samples in the station or group.

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

REFERENCE

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

APPENDIX C – DESCRIPTION OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

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

Technical Area	Activities
TA-0 (Offsite Facilities)	This TA designation is assigned to structures leased by DOE that are located outside LANL's boundaries in the Los Alamos townsite and White Rock.
TA-2 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-MW nuclear research reactor, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.
TA-3 (Core Area or South Mesa Site)	This TA is LANL's core scientific and administrative area, with approximately half of LANL's employees and total floor space. It is the location of a number of the LANL's Key Facilities, including the Chemistry and Metallurgy Research Building, the Sigma Complex, the Machine Shops, the Material Sciences Laboratory, and the Nicholas C. Metropolis Center for Modeling and Simulation.
TA-5 (Beta Site)	This TA is largely undeveloped. Located between East Jemez Road and the San Ildefonso Pueblo, it contains physical support facilities, an electrical substation, and test wells.
TA-6 (Two-Mile Mesa Site)	This TA, located in the northwestern part of LANL, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and aging vacant buildings that are awaiting demolition.
TA-8 (GT-Site [Anchor Site West])	This TA, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used for the purpose of ensuring the quality of materials in items ranging from test weapons components to high-pressure dies and molds. Techniques used include radiography, radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
TA-9 (Anchor Site East)	This TA is located on the western edge of LANL. Fabrication feasibility and the physical properties of explosives are explored at this TA, and new organic compounds are investigated for possible use as explosives.
TA-11 (K-Site)	This TA is used for testing explosives components and systems, including vibration analysis and drop-testing materials and components under a variety of extreme physical environments. Facilities are arranged so that testing may be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
TA-14 (Q-Site)	This TA, located in the northwestern part of LANL, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high explosives machining, and permitted burning.
TA-15 (R-Site)	This TA, located in the central portion of LANL, is used for high explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. TA-15 is the location of two firing sites, the Dual Axis Radiographic Hydrodynamic Test Facility, which has an intense high-resolution, dual-machine radiographic capability, and Building 306, a multipurpose facility where primary diagnostics are performed.
TA-16 (S-Site)	TA-16, in the western part of LANL, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. The TA is also the location of high explosives research, development, and testing, and the High Explosives Wastewater Treatment Facility.
TA-18 (Pajarito Site)	This TA, located in Pajarito Canyon, is the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. It is the location of the Solution High-Energy Burst Assembly and is also used for teaching and training related to criticality safety and applications of radiation detection and instrumentation. All Security Category I and II materials and activities have been relocated to the Nevada Test Site.
TA-21 (DP-Site)	TA-21 is on the northern border of LANL, next to the Los Alamos townsite. In the western part of the TA is the former radioactive materials (including plutonium) processing facility that has been partially decontaminated and decommissioned. In the eastern part of the TA are the Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility. Operations from both facilities have been transferred elsewhere as of the end of 2006.
TA-22 (TD-Site)	This TA, located in the northwestern portion of LANL, houses the Los Alamos Detonator Facility. Construction of a new Detonator Production Facility began in 2003. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
TA-28 (Magazine Area A)	TA-28, located near the southern edge of LANL, was an explosives storage area. The TA contains five empty storage magazines that are being decontaminated and decommissioned.
TA-33 (HP-Site)	TA-33 is a remotely-located TA at the southeastern boundary of LANL. The TA is used for experiments that require isolation, but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located at this TA.

Technical Area	Activities
TA-35 (Ten Site)	This TA, located in the north central portion of LANL, is used for nuclear safeguards research and development, primarily in the areas of lasers, physics, fusion, materials development, and biochemistry and physical chemistry research and development. The Target Fabrication Facility, located at this TA, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at TA-35 include research in reactor safety, optical science, and pulsed-power systems, as well as metallurgy, ceramic technology, and chemical plating. Additionally, there are some Biosafety Level 1 and 2 laboratories at TA-35.
TA-36 (Kappa-Site)	TA-36, a remotely-located area in the eastern portion of LANL, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
TA-37 (Magazine Area C)	This TA is used as an explosives storage area. It is located at the eastern perimeter of TA-16.
TA-39 (Ancho Canyon Site)	TA-39 is located at the bottom of Ancho Canyon. This TA is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
TA-40 (DF-Site)	TA-40, centrally located within LANL, is used for general testing of explosives or other materials and development of special detonators for initiating high explosives systems.
TA-41 (W-Site)	TA-41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
TA-43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	TA-43 is adjacent to the Los Alamos Medical Center at the northern border of LANL. Two facilities are located within this TA: the Bioscience Facilities (formerly called the Health Research Laboratory) and NNSA's local Site Office. The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at LANL. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.
TA-46 (WA-Site)	TA-46, located between Pajarito Road and the San Ildefonso Pueblo, is one of LANL's basic research sites. Activities have focused on applied photochemistry operations and have included development of technologies for laser isotope separation and laser enhancement of chemical processes. The Sanitary Wastewater Systems Plant is also located within this TA.
TA-48 (Radiochemistry Site)	TA-48, located in the north central portion of LANL, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
TA-49 (Frijoles Mesa Site)	TA-49, located near Bandelier National Monument, is used as a training area and for outdoor tests on materials and equipment components that involve generating and receiving short bursts of high-energy, broad-spectrum microwaves. A fire support building and helipad located near the entrance to the TA are operated by the U.S. Forest Service.
TA-50 (Waste Management Site)	TA-50, located near the center of LANL, is the location of waste management facilities including the Radioactive Liquid Waste Treatment Facility and the Waste Characterization, Reduction, and Repackaging Facility. The Actinide Research and Technology Instruction Center is also located in this TA.
TA-51 (Environmental Research Site)	TA-51, located on Pajarito Road in the eastern portion of LANL, is used for research and experimental studies on the long-term impacts of radioactive materials on the environment. Various types of waste storage and coverings are studied at this TA.
TA-52 (Reactor Development Site)	TA-52 is located in the north central portion of LANL. A wide variety of theoretical and computational research and development activities related to nuclear reactor performance and safety, as well as to several environmental, safety, and health activities, are carried out at this TA.
TA-53 (Los Alamos Neutron Science Center)	TA-53, located in the northern portion of LANL, includes the LANSCE. LANSCE houses one of the largest research linear accelerators in the world and supports both basic and applied research programs. Basic research includes studies of subatomic and particle physics, atomic physics, neutrinos, and the chemistry of subatomic interactions. Applied research includes materials science studies that use neutron spallation and contributes to defense programs. LANSCE has also produced medical isotopes for the past 20 years.
TA-54 (Waste Disposal Site)	TA-54, located on the eastern border of LANL, is one of the largest TAs at LANL. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage, treatment, decontamination, and disposal operations.
TA-55 (Plutonium Facility Complex Site)	TA-55, located in the center of LANL, is the location of the Plutonium Facility Complex and is the chosen location for the Chemistry and Metallurgy Research Building Replacement. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. The Chemistry and Metallurgy Research Building Replacement, currently under construction, will provide chemistry and metallurgy research, actinide chemistry, and materials characterization capabilities.

Technical Area	Activities
TA-57 (Fenton Hill Site)	TA-57 is located about 20 miles (32 kilometers) west of LANL on land administered by the U.S. Forest Service. The primary purpose of the TA is observation of astronomical events. TA-57 houses the Milagro Gamma Ray Observatory and a suite of optical telescopes. Drilling technology research is also performed in this TA.
TA-58 (Twomile North Site)	TA-58, located near LANL's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to TA-3. The TA houses a few LANL-owned storage trailers and a temporary storage area.
TA-59 (Occupational Health Site)	This TA is located on the south side of Pajarito Road adjacent to TA-3. This is the location of staff who provide support services in health physics, risk management, industrial hygiene and safety, policy and program analysis, air quality, water quality and hydrology, hazardous and solid waste analysis, and radiation protection. The Medical Facility at TA-59 includes a clinical laboratory and provides bioassay sample analytical support.
TA-60 (Sigma Mesa)	TA-60 is located southeast of TA-3. The TA is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located here. Due to the moratorium on testing, these buildings have been placed in indefinite safe shutdown mode.
TA-61 (East Jemez Site)	TA-61, located in the northern portion of LANL, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County and sewer pump stations.
TA-62 (Northwest Site)	TA-62, located next to TA-3 and West Jemez Road in the northwest corner of LANL, serves as a forested buffer zone. This TA is reserved for future use.
TA-63 (Pajarito Service Area)	TA-63, located in the north central portion of LANL, contains physical support and infrastructure facilities. The facilities at this TA serve as localized storage and office space.
TA-64 (Central Guard Site)	This TA is located in the north central portion of LANL and provides offices and storage space.
TA-66 (Central Technical Support Site)	TA-66 is located on the southeast side of Pajarito Road in the center of LANL. The Advanced Technology Assessment Center, the only facility at this TA, provides office and technical space for technology transfer and other industrial partnership activities.
TA-67 (Pajarito Mesa Site)	TA-67 is a forested buffer zone located in the north central portion of LANL. No operations or facilities are currently located at the TA.
TA-68 (Water Canyon Site)	TA-68, located in the southern portion of LANL, is a testing area for dynamic experiments that also contains environmental study areas.
TA-69 (Anchor North Site)	TA-69, located in the northwestern corner of LANL, serves as a forested buffer area. The new Emergency Operations Center, completed in 2003, is located here.
TA-70 (Rio Grande Site)	TA-70 is located on the southeastern boundary of LANL and borders the Santa Fe National Forest. It is a forested TA that serves as a buffer zone.
TA-71 (Southeast Site)	TA-71 is located on the southeastern boundary of LANL and is adjacent to White Rock to the northeast. It is an undeveloped TA that serves as a buffer zone for the High Explosives Test Area.
TA-72 (East Entry Site)	TA-72, located along East Jemez Road on the northeastern boundary of LANL, is used by protective force personnel for required firearms training and practice purposes.
TA-73 (Airport Site)	TA-73 is located along the northern boundary of LANL, adjacent to Highway 502. The County of Los Alamos manages, operates, and maintains the community airport under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA-74 (Otowi Tract)	TA-74 is a forested area in the northeastern corner of LANL. A large portion of this TA has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo of San Ildefonso and is no longer part of LANL.

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

Current environmental report and supplemental data tables	http://www.intellusnmdata.com/
Current and past environmental reports	http://www.lanl.gov/community-environment/environmental-stewardship/environmental-report.php
Los Alamos National Laboratory website	http://www.lanl.gov/
US Department of Energy/National Nuclear Security Administration Los Alamos Site Office website	http://www.doeal.gov/laso/default.aspx
US Department of Energy website	http://www.energy.gov/
LANL's air quality pages	http://www.lanl.gov/environment/air/index.shtml
LANL's water quality pages	http://www.lanl.gov/environment/h2o/index.shtml
LANL's waste pages	http://www.lanl.gov/environment/waste/index.shtml
LANL's biological resources pages	http://www.lanl.gov/environment/bio/index.shtml
LANL's risk reduction pages	http://www.lanl.gov/environment/risk/index.shtml
LANL's cleanup pages	http://www.lanl.gov/environment/cleanup/index.shtml
LANL's environmental database	http://www.intellusnmdata.com/

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.
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.
AOC	Area of concern
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
biota	The types of animal and plant life found in an area.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.
CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the Federal Register.
contamination	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Ci	Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DCG	Derived Concentration Guides. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure (DCG values are presented in DOE Order 5400.5).
DOE	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. Los Alamos National Laboratory is managed by the NNSA, an agency within the DOE.
dose	A term denoting the quantity of radiation energy absorbed.
absorbed dose	The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

TEDE	Total 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.
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).
effluent	A liquid waste discharged to the environment.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.
environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.
environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.

EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), 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) regulations set strict controls on the management of hazardous wastes.
hazardous waste constituent	The specific substance in a hazardous waste that makes it constituent hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.
long-lived isotope	A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
short-lived isotope	A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).
LANL	Los Alamos National Security. The limited liability corporation that took over management of LANL in June 2006.
LASO	Los Alamos Site Office. The Los Alamos office of the DOE's NNSA.
LLW	Low-level radioactive waste. Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the <i>Atomic Energy Act of 1954</i> , as amended), or naturally occurring radioactive material.
MCL	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.
MDA	Material disposal area.

MEI	Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.
mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
mrem	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
NEPA	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.
NESHAP	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
NNSA	National Nuclear Security Agency. An agency within the DOE that is responsible for national security through the military application of nuclear energy.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
NPDES	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.
nuclide	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
outfall	The location where wastewater is released from a point source into a receiving body of water.

PCB	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.
PDL	Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).
PE Curie	One PE curie is the quantity of transuranic material that has the same radiation inhalation hazard as one curie of Pu-239. The PE curie is described in Appendix B of http://www.wipp.energy.gov/library/wac/CH-WAC.pdf .
perched groundwater	A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.
person-rem	A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive.
pH	A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
pollution	Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).
point source	An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.
ppb	Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as $\mu\text{g/L}$ or ng/mL . Also used to express the weight/weight ratio as ng/g or $\mu\text{g/kg}$.
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 $\mu\text{g/g}$ or mg/kg .
QA	Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC	Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.
rad	<p>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.</p> $1 \text{ rad} = 1,000 \text{ millirad (mrad)}$
radionuclide	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
release	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.
rem	<p>Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation.</p> $\text{rem} = \text{rad} \times \text{quality factor}$ $1 \text{ rem} = 1,000 \text{ millirem (mrem)}$
SAL	Screening Action Level. A defined contaminant level that if exceeded in a sample requires further action.
SARA	Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.
saturated zone	Rock or soil where the pores are completely filled with water, and no air is present.

SWMU	Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).
terrestrial radiation	Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.
TLD	Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.
TRU	Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.
TSCA	Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this act for controlling substances found to be detrimental to human health or to the environment.
tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.
vadose zone	The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.

water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

ACA	accelerated corrective action
ADESH	Associate Directorate for Environment, Safety and Health
AIRNET	ambient air monitoring network
ALARA	as low as reasonably achievable
AOC	area of concern
AQA	Analytical Quality Associates, Inc.
AR	Abiquiu Reservoir
ARRA	American Recovery and Reinvestment Act
ARSL	American Radiation Services, Inc.
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
AST	aboveground storage tank
BCG	biota concentration guide
BDD	Buckman Direct Diversion Project
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BMI	benthic macroinvertebrate
BMP	Best Management Practice
BOD	biological oxygen demand
BSRL	baseline statistical reference level
C&T	(Land) Conveyance and Transfer Project
CAA	Clean Air Act
CD	Critical Decision
CEM	Certified Energy Manager
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGP	Construction General Permit
CME	corrective measures evaluation
CMi	corrective measures implementation
CMR	Chemistry and Metallurgy Research (Facility)
CMRR	Chemistry and Metallurgy Research Replacement (Facility)
CO	monoxide
CO ₂	carbon dioxide

COE	United States Army Corps of Engineers
Consent Order	Compliance Order on Consent
COPC	chemical of potential concern
CR	Cochiti Reservoir
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DAC	derived air concentration
DARHT	Dual Axis Radiographic Hydrodynamic Test (Facility)
DB	detention basin
DCG	derived concentration guide
DMCC	DOE Meteorological Coordinating Council
DOE	US Department of Energy
DOECAP	DOE Contract Analytical Program
DPA	Data Package Assessment
DRO	diesel-range organic compound
DPRNET	Direct Penetrating Radiation Monitoring Network
DU	depleted uranium
EDE	effective dose equivalent
EIS	Environmental Impact Statement
ELG	Effluent Limitation Guideline
EMS	Environmental Management System
EO	Executive Order
EP	Environmental Programs (Directorate)
EPA	US Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPRR	Electronic Public Reading Room
ES&H	environment, safety, and health
ESH&Q	Environment, Safety, Health, and Quality Directorate
ESL	ecological screening level
ESPC	Energy Savings Performance Contract
EU	enriched uranium

FCRS	Flood Control Retention Structure
FDA	Food and Drug Administration
FFCA	Federal Facility Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLUTe	Flexible Liner Underground Technologies
FOD	Facility Operations Directorate
FSOC	Federal Species of Concern.
FY	fiscal year
GAC	granular activated carbon
GEL	General Environmental Laboratory
GHG	greenhouse gas
GMAP	gaseous mixed air activation products
GP	Guiding Principle
GSAF	Generator Set-Aside Fee
GSA	General Services Administration
HAP	hazardous air pollutant
HE	high explosives
HEP	High Explosives Processing
HET	High Explosives Testing
HEWTF	High Explosive Wastewater Treatment Facility
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HPRR	Hardcopy Public Reading Room
HPSB	High Performance Sustainable Building
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
Interim Plan	Interim Facility-Wide Groundwater Monitoring Plan
IP	Individual Permit
ISL	industrial screening level

ISM	Integrated Safety Management
ISO	International Organization for Standardization
IT	information technology
JIT	just in time
LAC	Los Alamos County
LACW	Los Alamos Canyon Weir
LANL	Los Alamos National Laboratory (or the Laboratory)
LANS	Los Alamos National Security, LLC
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
LCS	laboratory control sample
LDCC	Laboratory Data Communications Center
LEED	Leadership in Energy and Environmental Design
LLW	low-level waste
MAP	Mitigation Action Plan
MAPAR	Mitigation Action Plan Annual Report
MAPEP	Mixed-Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MDA	material disposal area
MDCN	Mortandad Canyon
MDL	method detection limit
MEI	maximally exposed individual
MLLW	mixed low-level waste
MOU	memorandum of understanding
MOV	management observation and verification
μR/h	microrentgen/hour
MS	matrix spike
MSGP	Multi-Sector General Permit
MSL	Materials Science Laboratory
MTRU	mixed transuranic

NCOM	North Community
NCRP	National Council on Radiation Protection
ND	nondetect
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NHPA	National Historic Preservation Act
NISC	Nonproliferation and International Security Center
NM	New Mexico
NMAC	New Mexico Administrative Code
NME	New Mexico Endangered
NMED	New Mexico Environment Department
NMED-HWB	New Mexico Environment Department - Hazardous Waste Bureau
NMEIB	New Mexico Environmental Improvement Board
NMS	New Mexico Sensitive
NMT	New Mexico Threatened
NMWQCC	New Mexico Water Quality Control Commission
NNSA	National Nuclear Security Administration
NNSS	Nevada Nuclear Security Site
NOV	Notice of Violation
NO _x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRDA	natural resources damage assessment
NSSB	National Security Sciences Building
NSR	New Source Review
NTS	Nevada Test Site
NTU	nephelometric turbidity units
ODS	ozone-depleting substances
ORP	oxidation-reduction potential
OS	overstory
OSRP	Off-Site Source Recovery Project

P2	Pollution Prevention Program
PA/CA	performance assessment/composite analysis
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCFRS	Pajarito Canyon Flood Retention Structure
PE	performance evaluation
PM	particulate matter
PMR	periodic monitoring report
ppb	parts per billion
PQL	practical quantitation limit
PRB	permeable reactive barrier
PRS	potential release site
PSI	Pueblo de San Ildefonso
PSTB	Petroleum Storage Tank Bureau
PV	photovoltaic
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
Rad-NESHAP	National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides Other than Radon
RAMP	Roof Assessment Management Program
RAP	Radiological Assistance Program
RBG	regional background
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
REC	Renewable Energy Certificate
RESRAD	residual radioactivity (computer model)
RG @ LAC	Rio Grande at Los Alamos Canyon
RG @ SI	Rio Grande at San Ildefonso
RLUOB	Radiological Laboratory/Utility/Office Building

RLWTF	Radioactive Liquid Waste Treatment Facility
ROD	Record of Decision
RP-2	Health Physics Measurements Group (LANL)
RSL	residential screening level
RSRL	regional statistical reference level
RWMB	Radioactive Waste Management Basis
SAL	screening action level
SDPPP	Site Discharge Pollution Prevention Plan
SDWA	Safe Drinking Water Act
SERF	Sanitary Effluent Reclamation Facility
SFB	soil, foodstuffs, and biota
SI	International System of Units
SL	screening level
SMA	Site Monitoring Area
SMO	Sample Management Office
SODAR	sonic detection and ranging
SOP	standard operating procedure
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SSL	soil screening level
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
STP	Site Treatment Plan
SV	screening value
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWEIS	Site-Wide Environmental Impact Statement
SWPPP	Storm Water Pollution Prevention Plan
SWMU	solid waste management unit
SWSC	Sanitary Wastewater Systems Consolidation
SWWS	Sanitary Wastewater Systems (Plant)

TA	technical area
TAL	target action level (under the Individual Permit)
TAL	target analyte list
TCDD	tetrachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TDS	total dissolved solids
TEDE	total effective dose equivalent
TEQ	toxicity equivalent quotient
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TOC	total organic carbon
TRC	total residual chlorine
TRU	transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility
TSS	total suspended solids
UI	Utilities and Infrastructure Facilities
US	Understory
US	United States
USFS	US Forest Service
USGS	US Geological Survey
UTL	upper threshold limit
VOC	volatile organic compound
WETF	Weapons Engineering Tritium Facility
WIPP	Waste Isolation Pilot Project
WMO	World Meteorological Organization
WWTP	wastewater treatment plant
WY	water year
ZLD	Zero Liquid Discharge
ZVI	zero-valent iron

APPENDIX G – ELEMENTAL AND CHEMICAL NOMENCLATURE

Actinium	Ac	Erbium	Er
Aluminum	Al	Europium	Eu
Americium	Am	Fermium	Fm
Argon	Ar	Fluorine	F
Antimony	Sb	Francium	Fr
Arsenic	As	Gadolinium	Gd
Astatine	At	Gallium	Ga
Barium	Ba	Germanium	Ge
Berkelium	Bk	Gold	Au
Beryllium	Be	Hafnium	Hf
Bicarbonate	HCO ₃	Helium	He
Bismuth	Bi	Holmium	Ho
Boron	B	Hydrogen	H
Bromine	Br	Hydrogen oxide	H ₂ O
Cadmium	Cd	Indium	In
Calcium	Ca	Iodine	I
Californium	Cf	Iridium	Ir
Carbon	C	Iron	Fe
Cerium	Ce	Krypton	Kr
Cesium	Cs	Lanthanum	La
Chlorine	Cl	Lawrencium	Lr (Lw)
Chromium	Cr	Lead	Pb
Cobalt	Co	Lithium	Li
Copper	Cu	Lithium fluoride	LiF
Curium	Cm	Lutetium	Lu
Cyanide	CN	Magnesium	Mg
Carbonate	CO ₃	Manganese	Mn
Dysprosium	Dy	Mendelevium	Md
Einsteinium	Es	Mercury	Hg

Molybdenum	Mo	Samarium	Sm
Neodymium	Nd	Scandium	Sc
Neon	Ne	Selenium	Se
Neptunium	Np	Silicon	Si
Nickel	Ni	Silver	Ag
Niobium	Nb	Sodium	Na
Nitrate (as Nitrogen)	NO ₃ -N	Strontium	Sr
Nitrite (as Nitrogen)	NO ₂ -N	Sulfate	SO ₄
Nitrogen	N	Sulfite	SO ₃
Nitrogen dioxide	NO ₂	Sulfur	S
Nobelium	No	Tantalum	Ta
Osmium	Os	Technetium	Tc
Oxygen	O	Tellurium	Te
Palladium	Pd	Terbium	Tb
Phosphorus	P	Thallium	Tl
Phosphate (as Phosphorus)	PO ₄ -P	Thorium	Th
Platinum	Pt	Thulium	Tm
Plutonium	Pu	Tin	Sn
Polonium	Po	Titanium	Ti
Potassium	K	Tritiated water	HTO
Praseodymium	Pr	Tritium	³ H
Promethium	Pm	Tungsten	W
Protactinium	Pa	Uranium	U
Radium	Ra	Vanadium	V
Radon	Rn	Xenon	Xe
Rhenium	Re	Ytterbium	Yb
Rhodium	Rh	Yttrium	Y
Rubidium	Rb	Zinc	Zn
Ruthenium	Ru	Zirconium	Zr



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