LA-14469

2012 LANL Radionuclide Air Emissions Report

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U. S. Department of Energy Report

2012 LANL Radionuclide Air Emissions

Site Name:	Los Alamos National Laboratory
Location:	County of Los Alamos, New Mexico

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Compliance Assessment:

2012 Off-Site Effective Dose Equivalent: 0.58 mrem

Executive Summary

This report describes the emissions of airborne radionuclides from operations at Los Alamos National Laboratory (LANL) for calendar year 2012, and the resulting off-site dose from these emissions. This document fulfills the requirements established by the National Emissions Standards for Hazardous Air Pollutants – Emissions of Radionuclides other than Radon from Department of Energy Facilities (40 CFR 61 Subpart H, referred to as the Radionuclide NESHAP or Rad-NESHAP). Compliance with this regulation and preparation of this document is the responsibility of LANL's Rad-NESHAP compliance task, which is part of the Environmental Protection Division. The information in this report is required under the Clean Air Act and is being submitted to the U.S. Environmental Protection Agency (EPA) Region 6.

The highest effective dose equivalent (EDE) to an off-site member of the public was calculated using procedures specified by the EPA and described in this report. LANL's EDE was 0.58 mrem for 2012. The annual limit is 10 millirem per year, established by the EPA in 40 CFR 61 Subpart H. All measured air emissions are modeled to a single location, dubbed the Maximally Exposed Individual (MEI).

During calendar year 2012, LANL continuously monitored radionuclide emissions at 28 "major" release points, or stacks. The Laboratory estimates emissions from an additional 26 "minor" release points using radionuclide usage source terms in lieu of stack monitoring. Also, LANL uses a network of air samplers around the Laboratory perimeter to monitor ambient airborne levels of radionuclides. To provide data for dispersion modeling and dose assessment, LANL maintains and operates meteorological monitoring systems. From these measurement systems, a comprehensive evaluation is conducted to calculate the MEI dose for the Laboratory.

The MEI can be any member of the public at any off-site location where there is a residence, school, business, or office. In 2012, this MEI location was a business at 2201 Trinity Drive, the Los Alamos Lodge.[1] Since there are other receptors in the immediate area, all emissions were modeled to the adjacent Airnet Station 257. This station is called the Los Alamos (LA) Inn South station. The primary contributor to the off-site dose measured at this location was resuspension of legacy contamination on the hillside below the Airnet station. Overall, the MEI dose in 2012 is similar to levels in recent years, excluding the elevated releases associated with the remediation of legacy waste disposal at Materials

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[1] After a change in ownership, the Los Alamos Inn was renamed the Los Alamos Lodge. The Airnet station name of "LA Inn South" remains the same for consistency in tracking over the years.

Disposal Area B (MDA-B) in 2011, as described in that year's annual report. Doses reported to the EPA for the past 10 years are shown in Table E1.

Table E1. Ten-Year Summary of Rad-NESHAP Dose Assessment for LANL

Year	EDE (mrem)	Highest EDE Location
2003	0.65	2470 East Road ("East Gate")
2004	1.68	2470 East Road ("East Gate")
2005	6.46	2470 East Road ("East Gate")
2006	0.47	Los Alamos Airport Terminal
2007	0.52	DP Road, Airnet Station 326
2008	0.55	2470 East Road ("East Gate")
2009	0.55	2470 East Road ("East Gate")
2010	0.33	2201 Trinity Drive, Airnet Station 257
2011	3.53	278 DP Road, Airnet Station 317
2012	0.58	2201 Trinity Drive, Airnet Station 257

2012 Noteworthy Events

Several events that took place in 2012 are worth discussion in this Executive Summary. They are divided up into LANL Events, Changes to Air Sampling Program, and Operational Changes.

LANL Events

<u>Technetium-99 contamination outside of radiological controlled areas</u>. In late August 2012, there was a spread of contamination from the Lujan Neutron Scattering Center, which is part of the larger Los Alamos Neutron Science Center (LANSCE) facility. The incident involved the spread of technetium-99 (Tc-99) outside of a radiological area. Tc-99 is an emitter of low-energy beta radiation, a type of radiation which can travel through short distances of air but is generally stopped by clothing and skin. About a dozen people came into contact with the material, and some of these tracked small amounts of Tc-99 off-site. LANL and DOE personnel worked to survey, assess, and if needed, decontaminate affected personnel and property. The teams ensured that all off-site contamination was appropriately characterized and remediated.

At the time of the incident, radiological control technicians performed extensive sampling on the affected area's exhaust ventilation system and ductwork and determined that no Tc-99 was discharged to the ambient air. Similarly, LANL's Environmental Protection Division performed special measurements on the samples collected from the LANSCE facility exhaust stack sample and from nearby Airnet ambient air monitoring stations; these measurements showed no detections of Tc-99. Therefore, it was determined that this was not a general environmental issue and operations focused on remediating contaminated areas as described above. No exposures posed a health risk to members of the public or to LANL workers. Operations at the Lujan Center were curtailed or reduced for much of the 2012 operations cycle as this remediation effort took place.

Air Sampling Program Changes

Reductions in Airnet ambient air sampling program. A combination of events led to the reduction of the Laboratory's ambient air monitoring program in 2012. With the cessation of cleanup activities at Materials Disposal Area B and the delay of further work at Technical Area 21, several air sampling stations put into place specifically for these operations were not needed and sampling ceased in mid-2012. Also, with reduced budgets at the Laboratory, several air sampling stations which were not part of the regulatory compliance program were identified for shutdown.

Twelve stations were shut down effective at the end of September; these stations represent areas where there is no obvious source of radiological emissions or stations where there are other stations nearby which can provide comparable measurements. The set of stations which are used to demonstrate compliance with the Radionuclide NESHAP are not affected by this decision; these compliance stations remain in continuous operation and measured data from these stations are reported later in this document. An overall review of the Airnet station siting will be performed later in 2013. This review is intended to ensure complete Airnet coverage in light of recent years' changes in Laboratory operations and in locations of members of the public. LANL will work closely with EPA Region 6 to ensure regulatory endorsement of any changes to the compliance network.

Relocation of the air sampling location @ LA Inn South #257. One of the Airnet compliance stations, Los Alamos Inn – South station 257, is located on private property. This property went into foreclosure and power was cut to the station by local utilities in November 2012. This area is located on the rim of Los Alamos Canyon above a legacy contamination site, and Station 257 routinely measures among the highest air concentrations in the Airnet network. To continue measurement of air concentrations at this location, a new sampling location was immediately established about 75 meters east of the Station 257 site. This new location, designated Station 324, also sits on the edge of Los Alamos Canyon above and downwind of legacy contamination sites. The sampling sites are as similar as practicable for the area. A seven-month study in 2007 between the old Station 257 and new Station 324 locations showed comparable levels between the two locations. A complete description of the situation was sent to EPA Region 6 in December 2012; concurrence was received from Region 6 in January 2013.

Shutdown of Exhaust Stack-37 at TA-3 Building 29. The Chemistry and Metallurgical Research (CMR) facility at TA-3 Building 29 has fourteen monitored exhaust points. As operations are consolidated within this building and transition out to new facilities, certain exhaust fans are being shut down. The first of these to be shut down is the fan associated with Exhaust Stack-37. Radiological operations requiring ventilation are no longer being conducted in areas exhausted by this system. After the fan was shut down, the emissions sampling system was decommissioned on November 1, 2012.

LANL Operational Changes

Startup of new stack at TA-55 Building 400. In October 2012, LANL notified EPA of intent to start a new stack sampling system at TA-55 Building 400, the Radiological Laboratory / Utility / Office Building (RLUOB). This building is the first phase of the Chemistry & Metallurgy Research Replacement (CMRR) facility. A Pre-Construction notification was submitted to EPA Region 6 in June 2005 and approval to construct was received in July 2005. Construction activities at RLUOB were completed in 2012, and commissioning tests on the RLUOB stack were successfully completed in August. Effective November 15, 2012, the building is being managed as an active stack in the Rad-NESHAP program, including continuous stack sampling and routine flow measurements. Notifications of intent to start and actual start of a new emissions source were made prior to and immediately after this date in November. However, radiological operations did not commence immediately; such operations are anticipated to begin later in 2013.

Startup of new stack at TA-54 Dome 375. Also in October 2012, LANL notified EPA of intent to start a new radiological operation in late 2012 at TA-54 Dome 375. This facility is a new source, expanding LANL's radioactive waste processing and repackaging operations. Dome 375 is designed to process large "fiberglass reinforced plywood" (FRP) waste boxes and other large items that are beyond the capabilities of existing repackaging facilities at LANL's TA-50 Building 69, TA-54 Dome 231 or TA-54 Building 412. Operations were planned to commence in December; delays pushed this date back and radioactive material operations began on March 4, 2013. Appropriate notifications were provided to EPA Region 6. The stack is sampled for radiological particulate emissions with a system meeting ANSI N13.1 criteria.

Upgrade of TA-54 Dome 231 ventilation. As mentioned, waste processing and repackaging operations are accelerating to meet programmatic goals. One waste drum repackaging facility is TA-54 Dome 231. In the fall of 2012 the processing enclosure inside Dome 231 was expanded to increase drum throughput. The ventilation system capacity was increased as well; flow rates through the system increased by about 75% as part of the upgrade. Environmental Protection Division personnel had performed testing in 2011 that demonstrated that that even with the higher stack flow, the sample system still meets ANSI N13.1 design criteria. Stack emissions are continuously sampled for particulate airborne emissions.

Test Production of Molybdenum-99 at TA-53 LANSCE. Late in 2012, LANL began small-scale proof of principle tests to determine viability of producing molybdenum-99 at the accelerator facility. This experiment involves irradiation of uranium solution at LANSCE, then processing the samples at other LANL facilities (the CMR building and the TA-48 radiochemistry facility). The levels involved with initial tests in 2012 and 2013 are extremely low, and anticipated doses are well below the 0.1 millirem threshold that would require any EPA notification. To account for any possible release of irradiation and fission products generated and possible released by this irradiation process, the LANL Rad-NESHAP program expanded their standard analysis library of nuclides for charcoal sample filters. Also, the real-time radioactive gas emissions monitoring program at LANSCE was expanded to evaluate potential emissions from this type of operation. In 2012, no emissions related to Mo-99 production experiments were detected on monitored stacks at LANSCE, CMR, or TA-48.

2012 LANL Radionuclide Air Emissions Report

Abstract

The emissions of radionuclides from Department of Energy Facilities such as Los Alamos National Laboratory (LANL) are regulated by the 1990 Amendments to the Clean Air Act, National Emissions Standards for Hazardous Air Pollutants (40 CFR 61 Subpart H). These regulations established an annual dose limit of 10 mrem to the maximally exposed member of the public attributable to emissions of radionuclides from LANL. This document describes the emissions of radionuclides from LANL and the dose calculations resulting from these emissions for calendar year 2012, meeting reporting requirements established in the regulations.

Section I. Facility Information

61.94(b)(1) Name and Location of Facility

Los Alamos National Laboratory (LANL or the Laboratory) and the associated residential areas of Los Alamos and White Rock are located in Los Alamos County in north-central New Mexico, approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe. Figure 1 illustrates the Laboratory's location with respect to the nation, state, and county.

61.94(b)(2) List of Radioactive Materials Used at LANL

Since the Laboratory's inception in 1943, its primary mission has been nuclear weapons research and development. Programs include weapons development, stockpile stewardship, nonproliferation, magnetic and inertial fusion, nuclear fission, nuclear safeguards and security, isotope production, and laser isotope separation. There is also basic research in the areas of physics, chemistry, and biology.

The primary facilities involved in the emissions of radioactivity are outlined in this section. The facility locations are designated by technical area and building and shown in Figure 2. For example, the facility designation TA-3-29 is Building 29 at Technical Area (TA) 3. Potential radionuclide release points are listed in Table 1, with supporting information in later tables and in Section II of this report. Some of the sources described below are characterized as non-point (diffuse and fugitive) emissions. Off-site doses resulting from non-point emissions of radioactive particles and tritium oxide (tritiated water vapor or HTO) are measured and calculated using LANL's ambient air sampling network (Airnet).

Radioactive materials used at LANL include weapons-grade plutonium, heat-source plutonium, enriched uranium, depleted uranium, and tritium. Also, a variety of materials are generated through the process of activation; consequent emissions occur as gaseous mixed activation products (GMAP) and other particulate or vapor activation products (P/VAP).

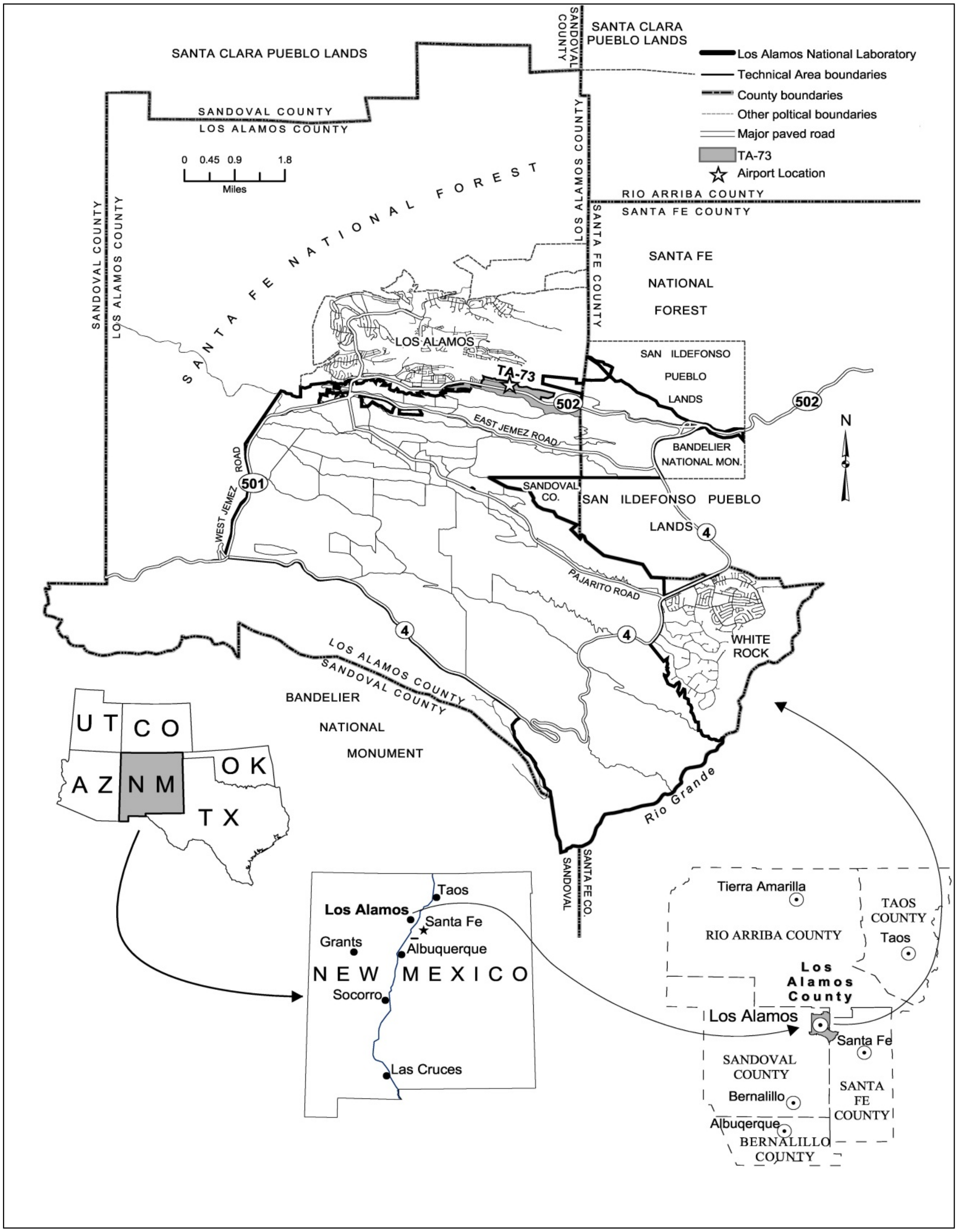

Figure 1. Location of Los Alamos National Laboratory.

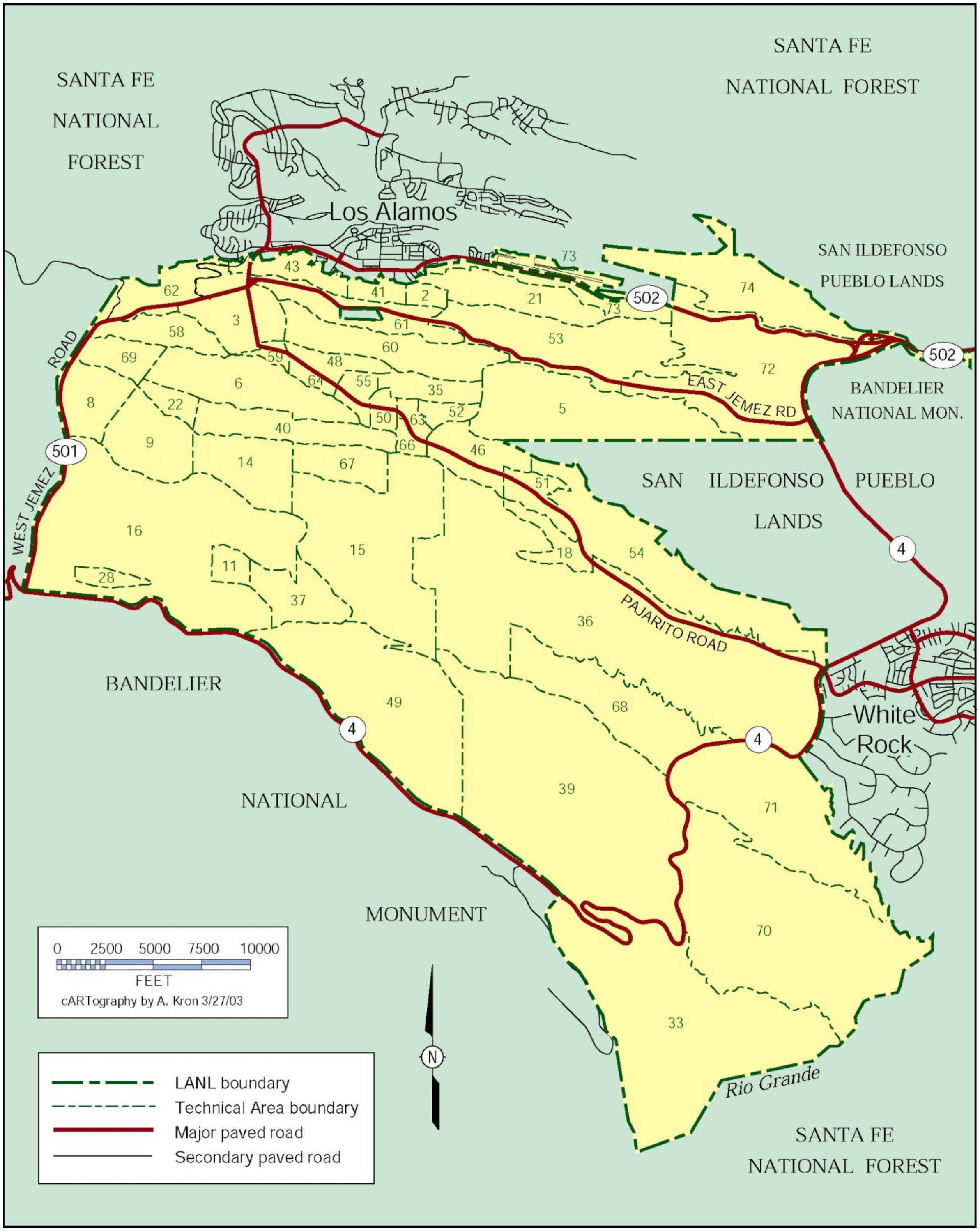

Figure 2. Los Alamos National Laboratory technical areas by number.

The radionuclides emitted from monitored point sources at LANL in calendar year 2012 are listed in Table 2. Tritium is released as either tritiated water vapor (called HTO) or elemental tritium gas (HT). Plutonium-239 can also contain Pu-240; the two isotopes are virtually indistinguishable by alpha spectroscopy, but have similar off-site dose conversions. GMAP emissions include ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O. Various radionuclides such as ^{197m}Hg, ^{68}Ge, and ^{76}Br make up the majority of the P/VAP emissions.

61.94(b)(3) Handling and Processing of Radioactive Materials at LANL Technical Areas

LANL technical areas and operations summaries are listed below. Additional descriptions of LANL technical areas can be found in the Annual Site Environmental Report for LANL.[2] More thorough descriptions of LANL operations can be found in the Annual Site-Wide Environmental Impact Statement Yearbooks, the most recent being published for 2011.[3] A complete list of non-monitored sources and activities is found in the Radioactive Materials Usage Survey (RMUS), described in the next section.

The primary facilities responsible for radiological airborne emissions are as follows.

TA-3-29: The Chemistry and Metallurgy Research (CMR) facility conducts chemical and metallurgical research. The principal radionuclides used are isotopes of plutonium and other actinides. There are a variety of activities involving plutonium and uranium, which support many LANL and other U.S. Department of Energy (DOE) programs. As mentioned in prior years' reports, work is being consolidated from six wings down to just three wings; these three wings will remain active until approximately 2019, when operations are planned for phase-out in this facility. In late 2012, one stack fan was shut down (ES-37) and the associated sampling system turned off as well.

TA-3-66: This is the Sigma facility, used for a variety of nuclear materials work. Primary materials are metallic and ceramic radionuclides, including depleted uranium. The uranium foundry is in this building. In recent years this facility has performed research and development work with low-enriched uranium (LEU) fuels used in research reactors.

TA-3-102: This machine shop is used for the metalworking of radioactive materials, primarily depleted uranium. The monitored stack at this facility (ES-22) was shut down in 2011; only minor operations are performed in this facility, and these operations do not meet requirements for a monitored stack. Planned moves of radionuclide operations from this facility to TA-3-141 (the Beryllium Test Facility) have been cancelled.

[2] Los Alamos National Laboratory, "Environmental Report 2011," LA-14461-ENV, September 2012.
[3] Los Alamos National Laboratory, "SWEIS Yearbook - 2011," LA-UR-13-20455, January 2013.

TA-3-1698: This facility is the Materials Science Laboratory. The building was designed to accommodate a wide variety of chemicals used in small amounts that are typical of many university and industrial labs conducting research in materials science. Small amounts of radioactive materials are used in experiments on materials properties (e.g., stress/strain measurements).

TA-15 and TA-36: These facilities conduct open-air explosive tests involving depleted uranium and weapons development testing. One building, TA-36-99, houses a “gas gun” focused explosive experiment that is ventilated through a non-monitored stack.

TA-15-312: This is the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility. DARHT conducts high-explosive-driven experiments to investigate weapons functions and behavior during nonnuclear tests using advanced radiography. Starting in 2007, explosive operations at DARHT are conducted in containment vessels. Use of these vessels virtually eliminates air emissions from these operations. Following explosive operations, containment vessels undergo cleanout in building 15-534 and if needed, repair in building 15-285. Both of these latter two buildings are non-monitored point sources, tracked in the RMUS.

TA-16-205 and -450: This is the Weapons Engineering Tritium Facility (WETF). Buildings 205 and 450 were specifically designed and built to process tritium safely. The operations at WETF are divided into two categories: tritium processing and activities that support tritium processing. Examples of tritium-processing operations include the repackaging of tritium into smaller quantities and the packaging of tritium and other gases to user-specified pressures. Other operations include reacting tritium with other materials to form compounds and analyzing the effects of tritium. WETF operations have historically been housed in building 205, while building 450 was built for other tritium activities. Expansion of WETF into building 450 began in 2007. As part of this expansion, exhaust ducts were reconfigured so that emissions from TA-16-205 were routed into the TA-16-450 ES-05 stack. Therefore, the TA-16-205 stack ES-04 is discontinued as a point source and TA-16-450 ES-05 will be the point source for both buildings. The older emissions sampling system for building 205 is located in the exhaust duct coming out of building 16-205, and remains operational and able to measure emissions from that building. The new stack sampling system in stack ES-05 was certified to measure emissions from building 450, whenever that portion of the complex becomes active. This system will also measure emissions from building 205 operations, but was not certified for these operations under ANSI/HPS N13.1-1999 criteria. As discussed in the 2009 emissions report, the ES-05 stack monitor experienced technical problems, and its operations were discontinued in June 2009. Reported emissions for 2012 are measured with the 16-205 duct monitor, but exhausted through and modeled from the 16-450 ES-05 stack.

TA-21: The great majority of buildings at this decommissioned radiochemistry site have been decontaminated and demolished. The tritium operations in TA-21 were relocated in 2006 to other LANL sites, primarily WETF. In 2009, demolition of office and support buildings began. Radiological process buildings were demolished in 2010. Final remediation of building foundations, subsurface structures, and legacy disposal areas will take place in coming years. The MDA-B legacy waste disposal site is also considered part of TA-21. Excavation of MDA-B was completed in 2011; removal of excavation structures was achieved in late 2012.

TA-41-4: This building was formerly used as a tritium-handling facility. The tritium sources were removed in 2002. Most of the process buildings have been demolished. Diffuse tritium emissions could result from residual tritium contamination and cleanup operations.

TA-48: The principal activities carried out in this facility are radiochemical separations and hot cell operations supporting the medical radioisotope production program, the Yucca Mountain program, nuclear chemistry experiments, and geochemical and environmental research. These separations involve nanocurie to curie amounts of radioactive materials and use a wide range of analytical chemical separation techniques, such as ion exchange, solvent extraction, mass spectroscopy, plasma emission spectroscopy, and ion chromatography. Besides the hot cell operations, the building also houses the Actinide Research Facility and includes the other radiochemical operations described above. Building 1 at TA-48 contains the majority of operations, exhausted through three monitored stacks and several non-monitored stacks. Smaller (non-monitored) operations take place in other buildings around TA-48-1.

TA-50-1: This waste management site consists of an industrial low-level radioactive liquid waste treatment facility, RLWTF. Transuranic liquid waste is also treated in this building. The building has one monitored stack (ES-2) and other smaller point sources which are not monitored. Two small cooling towers mentioned in the 2010 executive summary had been used for non-radiological purposes in the past; they operated briefly to evaporate treated effluent from RLW in 2010 but have not operated since 2010, and that practice has been discontinued. A new fuel-fired evaporator (described in the 2011 report) started radiological operations in 2011 and is being tracked as a non-monitored source.

TA-50-37: Currently there are no operations involving radioactive material in this building; long term plans for future operations that involve the use of radioactive actinides have not come to fruition. Stack sampling takes place due to legacy contamination issues. The facility is exploring the possibility of shutting down stack sampling if all criteria can be met. Starting in 2013, potentially contaminated ventilation components will be removed to eliminate sources of emissions from this building.

TA-50-69: This waste management site consists of a waste characterization, reduction, and repackaging facility. Waste drums are repackaged for on-site or off-site disposal. There is one monitored stack and three non-monitored sources at this building.

TA-53: This technical area houses the Los Alamos Neutron Science Center (LANSCE), a linear particle accelerator complex. There are two monitored stacks (on buildings TA-53-3 and TA-53-7) and several sources tracked in the non-monitored stacks program. The accelerator is used to conduct research in stockpile stewardship, radiobiology, materials science, and isotope production, among other areas. LANSCE consists of the Manuel Lujan Neutron Scattering Center, the Proton Storage Ring, the Weapons Neutron Research facilities, the Proton Radiography facility, and the high-intensity beam line (Line A). The facility accelerates protons and H- ions to energies of 800 MeV into target materials such as graphite and tungsten to produce neutrons and other subatomic particles. The design current of the accelerator is approximately 1000 microamperes, but most operations take place at beam currents of 120 microamperes or less. Airborne radioactive emissions result from proton beams and secondary particles passing through and activating air in target cells, beam stop, and surrounding areas, or activating water used in target cooling systems. The majority of the emissions are short-lived activation products such as ^{11}C, ^{13}N, and ^{15}O. Most of the activated air is vented through the main stacks; however, a fraction of the activated air becomes a fugitive emission from the target areas.

As a by-product of accelerator operations, cooling water can contain trace amounts of radionuclides. Two solar evaporative tanks were constructed and began operation in 1999 to evaporate this wastewater from the accelerator. Evaporation of water from these open-air tanks can result in a diffuse source of airborne tritium and other particulates. To support other Laboratory operations, these tanks can be used for evaporation of water from other LANL facilities.

In 2004, the Isotope Production Facility (IPF) began operations as part of the LANSCE facility. IPF uses a portion of the LANSCE beam to irradiate a variety of targets for different medical research and treatment uses. After irradiation, targets are processed at LANL hot cells at TA-48 or CMR. IPF has two stacks which are managed as part of the minor (non-monitored) source program.

TA-54: This waste management site consists of active and inactive shallow land burial sites for solid waste and is the primary storage area for mixed and transuranic radioactive waste. Waste characterization and processing operations also take place at TA-54 to prepare waste for shipment to the Waste Isolation Pilot Plant (WIPP). Shipments of transuranic waste for disposal at WIPP began in 1999. Characterization work includes analysis of headspace gases and radiography of waste drum contents; processing includes sorting, segregating, size-reduction, and repackaging of waste.

MDA G at TA-54 is also a known source of diffuse emissions of tritium vapor and direct radiation from above-ground storage of radioactive waste. Resuspension of soil contaminated with low levels of plutonium/americium has also created a diffuse source. Point sources at Area G include operations involving characterization, manipulation, or repackaging of waste containers. Two new monitored point sources came on-line in 2010, at Building 412 and Dome 231. These two new sources are waste processing facilities, preparing waste shipments for off-site disposal. As mentioned, the Dome 231 processing facility was expanded in 2012 to increase throughput capacity of the dome. At the end of 2012, a new building (Dome 375) was coming on-line to process larger waste containers; radiological operations began in March 2013.

TA-55: Building 4 of the Plutonium Facility (PF-4) provides a pit manufacturing capability and continues the role of providing the capability for research and development applications in chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides.[4] A wide range of activities (e.g., the heating, dissolution, forming, and welding of special nuclear materials) are also conducted. Additional activities include investigating the means to safely ship, receive, handle, and store nuclear materials and to manage wastes and residues from TA-55. Limited-scope tritium operations also take place in certain areas of TA-55. Building 2 of TA-55 houses associated support facilities for operations in PF-4, including the radiological sample analysis laboratory. Operations from this laboratory are tracked as part of LANL's non-monitored source program.

Building 400 at TA-55 is the Radiological Laboratory / Utility / Office Building (RLUOB), the first phase of the project to replace capabilities in TA-3 Building 29. A Congressionally approved line item project may eventually include a nuclear facility to replace remaining capabilities from TA-3 Building 29; design of a CMR Replacement (CMRR) nuclear facility was underway but the Administration announced its intent to delay construction for at least five years. RLUOB is designed to perform materials characterization work and actinide chemistry research. While the RLUOB stack became active in November 2012, radiological operations will not commence until summer 2013 under current plans.

[4] U. S. Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory" DOE/EIS-0380, 2009. Available on the Web at: http://www.doeal.gov/laso/NEPASWEIS.aspx

Section II. Air Emissions Data

61.94(b)(4) Point Sources

Monitored and unmonitored release points at LANL are listed in Table 1. The point sources are identified using an eight-digit identification number for each exhaust stack (StackID); the first two digits represent the LANL technical area, the next four the building, and the last two digits the stack number. Also listed in Table 1 are type, number, and efficiency of the effluent controls used on the release points. More information on effluent controls systems appear below.

In addition to the 28 monitored ("major") point sources, 57 unmonitored ("minor") release points in 42 LANL buildings are included in Table 1. Under 40 CFR 61.93(b)(4)(i), sampling of these minor release points is not required because each release point has a potential effective dose equivalent (PEDE) of less than 0.1 mrem/yr at the critical receptor. However, in order to verify that emissions from unmonitored point sources remain low, LANL conducts periodic confirmatory measurements in the form of the annual *Radioactive Materials Usage Survey for Unmonitored Point Sources*.[45] The purpose of this survey is to collect and analyze radioactive materials usage and process information for the unmonitored point sources at LANL. In alternate years, the survey is expanded to review monitored sources and ensure proper emissions monitoring is taking place at these facilities. For 2012, the 26 sources with highest potential emissions were analyzed. A full description of which sources are analyzed in each year is included in the referenced Usage Survey report.

The distance between each of the release points and the critical receptor is provided in Table 1. The critical receptor can be a residence, school, business, or office. In this report, the critical receptor is defined as the member of the public (at a fixed structure location) most impacted by a given release point. Air dispersion modeling is taken into account to determine the most critical receptor location; the nearest public receptor is not always the critical receptor if the nearest location is upwind from a source.

In compliance with Appendix D to 40 CFR 61, we have used data collected from the facilities in conjunction with engineering calculations and other methods to develop conservative emissions estimates from unmonitored point sources. Estimated PEDEs are calculated by modeling these emissions estimates using the U.S. Environmental Protection Agency (EPA)-approved CAP88 dose modeling software. A comprehensive survey of all of LANL's monitored and unmonitored point sources is conducted annually or biannually, depending on the magnitude of potential emissions. The Laboratory has established administrative requirements to evaluate all potentially new sources. These requirements are established

[5] R. Sturgeon, "2012 Radioactive Materials Usage Survey for Unmonitored Point Sources." ENV-CP memo, pending final publication at time of report development.

for the review of new Laboratory activities and projects, ensuring that air quality regulatory requirements will be met before the activity or project begins.[6]

Non-point Sources

There are a variety of non-point sources within the 111 km^2 of land (43 square miles) occupied by LANL. Non-point sources can occur as diffuse or large-area sources, or as leaks or fugitive emissions from facilities. Examples of non-point sources of airborne radionuclides include surface impoundments, evaporative tanks and basins, shallow land burial sites, open burn sites, live firing sites, outfalls, container storage areas, unvented buildings, waste treatment areas, solid waste management units, and tanks. Additionally, LANL considers a building to be a non-point source if there is no active process exhaust (e.g., no fume hood, glove box, etc.); no forced air exhaust to the environment; or is equipped with only standard heating/ventilating/air conditioning systems (e.g., occupational comfort cooling or heating).

LANL determines the potential impacts of non-point sources by measuring air concentrations of significant radionuclides at ambient air-sampling sites at locations of public receptors surrounding the Laboratory and at selected locations on Laboratory property. This network of ambient air sampling stations is called Airnet. The LANL Airnet system was approved for use in monitoring LANL's non-point radioactive air emission sources in 1996.[7] Based on the original methodology approved by EPA, additional procedures were developed to identify when new Airnet stations were required to assure continued compliance with the Radionuclide NESHAP.[8,9]

Radionuclide Emissions

Table 2 lists the radionuclides released from monitored point sources, along with the annual emissions in curies for each radionuclide. The point sources are identified using an eight-digit identification number for each exhaust stack: the first two digits represent the LANL technical area, the next four digits the building, and the last two digits the stack number. No detectable emissions are denoted as "none." Extensive notes appear at the end of the source term table. A map showing the general locations of the facilities continuously monitored for radionuclide emissions is shown in Figure 3.

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[6] Los Alamos National Laboratory Procedure, "Air Quality Reviews," P408, December 2010.
[7] U.S. Environmental Protection Agency, *Federal Register*, Vol. 60, No. 107, June 5, 1995.
[8] Los Alamos National Laboratory Procedure, "Evaluating New Diffuse Sources and New Receptors for AIRNET Coverage," ESH-17-238, R0, December 2001.
[9] Letter to Mr. George Brozowski, Radiation Program Manager, Environmental Protection Agency from Mr. Steve Fong, Office of Environment, Department of Energy, May 11, 2001.

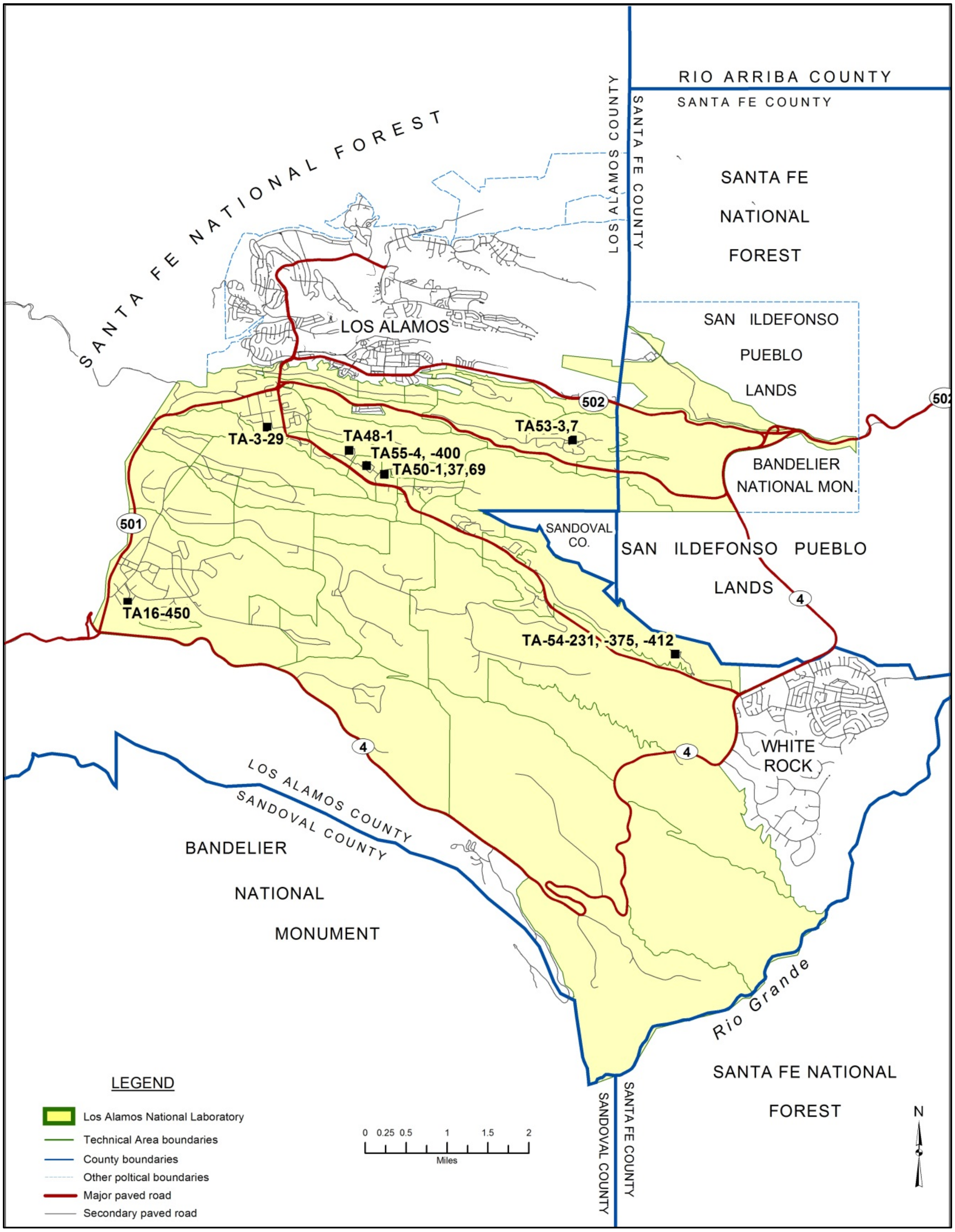

Figure 3. Location of facilities with continuously operated stack-sampling systems for airborne radionuclide emissions.

Pollution Controls

The most common type of filtration for emission control purposes at LANL is the high-efficiency particulate air (HEPA) filter, as noted in Table 1. HEPA filters are constructed of sub-micrometer glass fibers that are pressed and glued into a compact, paper-like, pleated media.

At LANL, each HEPA filter system on active operational sources is tested at least once every 12 months. The nominal performance criteria for HEPA filter systems are a maximum penetration of 5×10^{-4} for one stage (99.95% removal) and maximum penetration of 2.5×10^{-7} for two stages in series (99.999925% removal). In these quoted values, filter penetration and percent removal are defined below.

$$\text{Penetration} = (\text{downstream concentration}) / (\text{upstream concentration})$$

$$\text{Removal} = [1 - (\text{penetration})] * 100\%$$

Note that in recent years, changes to HEPA filter testing methods and equipment at LANL have resulted in limitations in the ability to certify very high levels of aerosol removal. Therefore, LANL is now only certifying all filters at the “single stage” penetration & removal criteria, regardless of the number of filter bank stages installed at the facility. Table 1 lists the number of filter banks installed at the facility and the nominal removal efficiency, not the certified tested removal efficiency.

Other types of filters used in ventilation systems are Aerosol 95; RIGA-Flow 220, 221, and 222; and FARR 30/30. These units are typically used as prefilters in HEPA filtration systems. These filters are significantly less efficient than HEPA filters and are typically used for removing gross particulate matter larger than 5 μm.

The above-mentioned filters are only effective for particles. When the contaminant of concern is in the form of a gas or vapors, activated charcoal beds can be used. Charcoal beds collect the gas contaminant through an adsorption process in which the gas comes in contact with the charcoal and adheres directly to the surface of the charcoal. The charcoal can be coated with different types of materials to make the adsorption process more efficient for specific types of contaminants. Typically, charcoal beds achieve an efficiency of 98% capture. Efficiency of a charcoal filter can vary with different chemical pollutants in the exhaust air stream.

Tritium effluent controls are generally composed of a catalytic reactor and a molecular sieve bed. Tritium-contaminated effluent is passed through a catalyst that converts gas-phase or elemental tritium (HT) into tritiated water vapor (HTO). This HTO is then collected as water on a molecular sieve bed. This process can be repeated until the tritium level is at, or below, the desired level. The effluent is then vented through the stack.

A delay system is used to reduce some of the short-lived radionuclides generated by activation at LANSCE. Emissions from a concentrated source of activated gas (the off-gas system for the 1L target cooling loops) are directed into a long transport line. The transit time through this system allows short-lived gaseous radionuclides to decay before emission from the stack. This delay system is used to provide a reduction in radionuclide emissions from the 1L target area exhausted through stack 53000702.

Compliance with Maintenance and Inspection Requirements under the Revised Rad-NESHAP

The 2003 revisions to Subpart H established several inspection and maintenance requirements for monitored stacks. These requirements are based on American National Standards Institute/Health Physics Society N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*. Annual visual inspection of particulate monitoring systems is a component of the Laboratory's program to comply with these requirements. In 2012, we performed stack inspections and/or cleaning operations on 23 monitored stacks. For the one tritium stack at TA-16, the annual in-place performance test serves as the annual inspection, per EPA alternative method approval. Three of the monitored stacks do not meet Subpart H requirements for "major" sources and did not have inspections performed on them. The new system at RLUOB (TA-55-400) was inspected prior to operation and was not inspected in 2012. This accounts for the 28 monitored stacks at LANL

Of the inspections performed in 2012, sample systems on 10 stacks showed evidence of particulate deposition in the sampler or the transport line. These systems will be addressed as part of the current year's sampler inspection cycle; some have already been cleaned at the time of this report submittal.

In 2012, no radiological material was measured on inspection or cleaning equipment. Therefore, no additions to the source term are required from this pathway for this year.

Section III. Dose Assessment

61.94(b)(7) Description of Dose Calculations

Effective dose equivalent (EDE or dose) calculations for point sources, unmonitored point sources, and non-point gaseous activation products from LANSCE were performed with the CAP88 code. Starting with the 2006 annual emissions report, LANL uses CAP88-PC version 3 to demonstrate compliance. Verification of the CAP88 code is performed by running the EPA test case before and after performing the dose calculations.

Development of Source Term

Tritium emissions

Tritium emissions from the Laboratory's tritium facilities are measured using a collection device known as a bubbler. This device enables the Laboratory to determine not only the total amount of tritium released but also if it is in the chemical form of elemental tritium (HT) or tritiated water vapor (HTO). The bubbler operates by pulling 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 is part of a water molecule (tritium oxide, or HTO). After bubbling through these three vials, essentially all the water vapor and associated HTO is removed from the air, leaving elemental tritium, or HT. The sample air stream 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 collects the newly formed HTO. The amount of HTO and HT is determined by analyzing the ethylene glycol for the presence of tritium using liquid scintillation counting. Since different chemical forms are collected in different vials, the system will discriminate HTO vapor from HT gas, allowing separate dose assessment with CAP88-PC version 3. For conservatism, however, all tritium is modeled as vapor phase HTO. Bubblers are in use to measure tritium emissions from TA-16 (WETF) and TA-55 PF-4's south stack.

Tritium emissions from LANSCE do not require monitoring under 40 CFR 61.93(b)(4)(i). The primary source for airborne tritium emissions at LANSCE is activation of water vapor in air and activation and subsequent evaporation of water in the cooling system of beam targets. Because of the low relative contribution of tritium to the off-site dose at LANSCE, formal monitoring for tritium was discontinued after July 2001. However, the tritium emissions for 2012 can be calculated based on the rate of generation measured in 2001, using representative parameters.

Very low-level tritium operations also took place from TA-55 Building 4, in the northern portion of the building exhausted through ES-15. While the southern stack ES-16 is monitored for tritium emissions, at ES-15, tritium is not a pollutant of concern. Interviews with experimenters at ES-15 areas have established an upper bound on the potential emissions and chemical form of these emissions, and they are reported in Table 2. Similarly, operators at the WCRR waste repackaging facility at TA-50-69 processed waste drums containing trace amounts of tritium; the amount reported in Table 2 from this stack represents an upper bound of emissions as estimated by facility representatives. Note that for 55000415 and 50006903, evaluation of potential emissions and potential off-site doses indicate that tritium is used at levels that do NOT require continuous monitoring from these sources.

Radioactive particulate emissions

Emissions of radioactive particulate matter, generated by operations at facilities such as the CMR facility (TA-3-29) and the Plutonium Facility (TA-55), are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through the filter, where small particles of radioactive material are captured. These samples are analyzed weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, LANL composites these stack samples for subsequent analysis at an off-site laboratory. These composite samples are analyzed to determine the total activity of materials such as ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, and ^{241}Am. These semiannual composite data are then combined with estimates of sampling losses and stack and sample flows to calculate emissions. Short-lived progeny are assumed to be emitted in secular equilibrium with their long-lived parent nuclides. For example, we measure for the presence of ^{90}Sr and assume that an equal amount of the progeny ^{90}Y is emitted as well.

Vapor form emissions

Vapor emissions, generated by LANSCE operations and by hot-cell activities at TA-3-29 and TA-48, are sampled using an activated charcoal filter or canister. A continuous sample of stack air is pulled through a charcoal filter upon which vaporous emissions of radionuclides are adsorbed. The amount and identity of the radionuclide(s) present on the filter are determined through the use of gamma spectroscopy. These analytical results are used in conjunction with facility information to calculate emissions. Examples of radionuclides of this type include ^{68}Ge and ^{76}Br.

Gaseous mixed activation products (GMAP)

GMAP emissions resulting from activities at LANSCE are measured using real-time monitoring data. A continuously-operating air flow-through ionization chamber is operated in series with a high-purity germanium (HPGe) detector and data acquisition system. A sample of stack air is pulled through the ionization chamber to measure the total amount of radioactivity in the sample, while specific radioisotopes are identified through the use of gamma spectroscopy and decay curve analysis with the HPGe system. This information is then used to calculate emissions. Radionuclides of this type include ^{11}C, ^{13}N, and ^{15}O.

Summary of Input Parameters

EDE to potential receptors was calculated for all radioactive air emissions from sampled LANL point sources. The radionuclide releases for the point sources monitored in 2012 are provided in Table 2. Input parameters for these point sources are provided in Table 3. The geographic locations of the release points, given in New Mexico State Plane coordinates, are provided in Table 4. The relationship of the highest receptor location to the individual release points are provided in Table 5. Other site-specific parameters and the sources of these data are provided in Table 6.

LANL operates an on-site network of meteorological monitoring towers. Data gathered by the towers are summarized and formatted for input to the CAP88 program. For 2012, data from three different towers were used for the air-dispersion modeling; the tower data that are most representative of the release point are applied. Copies of the meteorological data files used for the annual 2012 dose assessments are provided in Table 7. Note that due to the extent of the data in Table 7, that table has been moved to Appendix 1. There are three files included in Table 7, detailing wind speed and direction information from TA-6, TA-53, and TA-54 meteorology towers.

The Laboratory also enters population array data to the CAP88 program. The data file represents a 16-sector polar-type array, with 20 radial distances for each sector. Population arrays are developed for each release point using U.S. Census data, and the population files used at LANL were updated in late 2012 using 2010 census data[10], Different population files are used depending on where the dominant LANL source is located in a given year. For 2012, LANL's dominant emitter was in Los Alamos Canyon, so the LANL "line source" array is used for population dose assessment. This array appears in Table 8. For agricultural array input, LANL is currently using the default values in CAP88.

Public Receptors

Compliance with the annual dose standard is determined by calculating the highest EDE to any member of the public at any off-site point where there is a residence, school, business, or office. The Laboratory routinely evaluates public areas to assure that any new residence, school, business, or office is identified for the EDE calculation. As per EPA guidance,[11] personnel that work in leased space within the boundaries of the Laboratory are not considered members of the public for the EDE determination.

[10] M. McNaughton and B. Brock, "Population Files for use with CAP88 at Los Alamos. LA-UR-12-22801. January 2012.

[11] Frank Marcinowski, Acting Director, Radiation Protection Division, "Criteria to Determine Whether a Leased Facility at Department of Energy (DOE) is Subject to Subpart H," Office of Radiation and Indoor Air, U. S. Environmental Protection Agency, March 26, 2001.

Personnel of this type are considered to be subcontractors to DOE, similar to security guards and maintenance workers.

Point Source Emissions Modeling

The CAP88 version 3 program was used to calculate doses from both the monitored and unmonitored point sources at LANL. The CAP88 program uses on-site meteorological data to calculate atmospheric dispersion and transport of the radioactive effluents. CAP88 version 3 includes all radionuclides for which there are dose conversion factors in the EPA's Federal Guidance Reports.[12,13,14] In 2012, only three monitored radionuclides were not included in CAP88 for the monitored stacks source term: ^{10}C, ^{14}O, and ^{16}N. These nuclides are all very short-lived accelerator activation & spallation products. For ^{10}C and ^{14}O, ^{11}C was used as a surrogate, as described in the Laboratory procedure ENV-EAQ-512.[15] CAP88 was used to calculate the ^{11}C dose, which was then adjusted for the number of curies emitted, the gamma energy emitted per decay, and the half life of the radionuclides. For ^{16}N, ^{28}Al was used as the surrogate nuclide and the resulting dose was adjusted accordingly. The maximum dose from emissions of radionuclides not included in the CAP88 library was 8.94E-08 mrem (see Tables 12 and 13). This dose contribution is well below the criteria for individual nuclide monitoring, which is 10% of a source's PEDE. Updates of "non-CAP88 nuclides" for monitored and non-monitored point sources will have been described in previous memos to EPA Region 6, most recently in a 2011 memo[16].

[12] K. F. Eckerman, A. B. Wolbarst, and A. C. B. Richardson, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., 1988.

[13] K. F. Eckerman and J. C. Ryman, Federal Guidance Report No. 12, "External Exposures to Radionuclides in Air, Water, and Soil Exposure-to-Dose Coefficients for General Application," U.S. Environmental Protection Agency, Washington, D.C., 1993

[14] K. F. Eckerman, R. W. Leggett, C. B. Nelson, J. S. Puskin, and A. C. B. Richardson, Federal Guidance Report No. 13, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," U.S. Environmental Protection Agency, Washington, D.C., 1999

[15] Los Alamos National Laboratory Procedure, "Dose Factors for Non-CAP88 Radionuclides," ENV-EAQ-512, November 2009.

[16] M. McNaughton memo to G. Brozowski, "Documentation of Dose Calculation Methods for Radionuclides Not Included in CAP88 Version 3." Memo WES-EDA-11-0023, December 21, 2011.

LANSCE Diffuse / Fugitive Emission Modeling

Some of the GMAP created at the accelerator target cells or at other accelerator beam line locations migrate into room air and into the environment. These diffuse or fugitive sources are continuously monitored throughout the beam-operating period. In 2012, approximately 14 Ci of ^{11}C and 0.6 Ci of ^{41}Ar were released from LANSCE as fugitive emissions.[17] These sources were modeled as area sources using CAP88, and the specific input parameters are provided in Table 9.

Environmental Data Used for Non-point Source Emission Estimation

The net annual average ambient concentration of airborne radionuclides measured at 23 air sampling stations (Figure 4) is calculated by subtracting an appropriate background concentration value.[18] The net concentration at each air sampler is converted to the annual EDE using Table 2 of Appendix E of 40 CFR 61 and applying the valid assumption that each Table 2 value is equivalent to 10 mrem/yr from all appropriate exposure pathways (100% occupancy assumed at the respective location).[19] Dose assessment results from each air sampler are given in Table 10. The operational performance and analytical completeness of each air sampler is provided in Table 11.

Note that for 2012, some stations not designated as historical compliance stations did not have tritium (H-3) measured at that location. For these stations, it is known that tritium is not a pollutant of concern for these locations. These stations have the notation "n/a" in the tritium dose or analytical completeness column. More discussion on tritium at MDA-B can be found in the 2011 annual report.

[17] Los Alamos National Laboratory, "2012 Annual Source Term for Radionuclide Air Emissions," ENV-ES:13-0115, May 21, 2012.

[18] Los Alamos National Laboratory Procedure, "Air Pathway Dose Assessment," ENV-ES-QP-502.4, November 2011

[19] U.S. Environmental Protection Agency, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Title 40, Part 61.90, Subpart H, 1989.

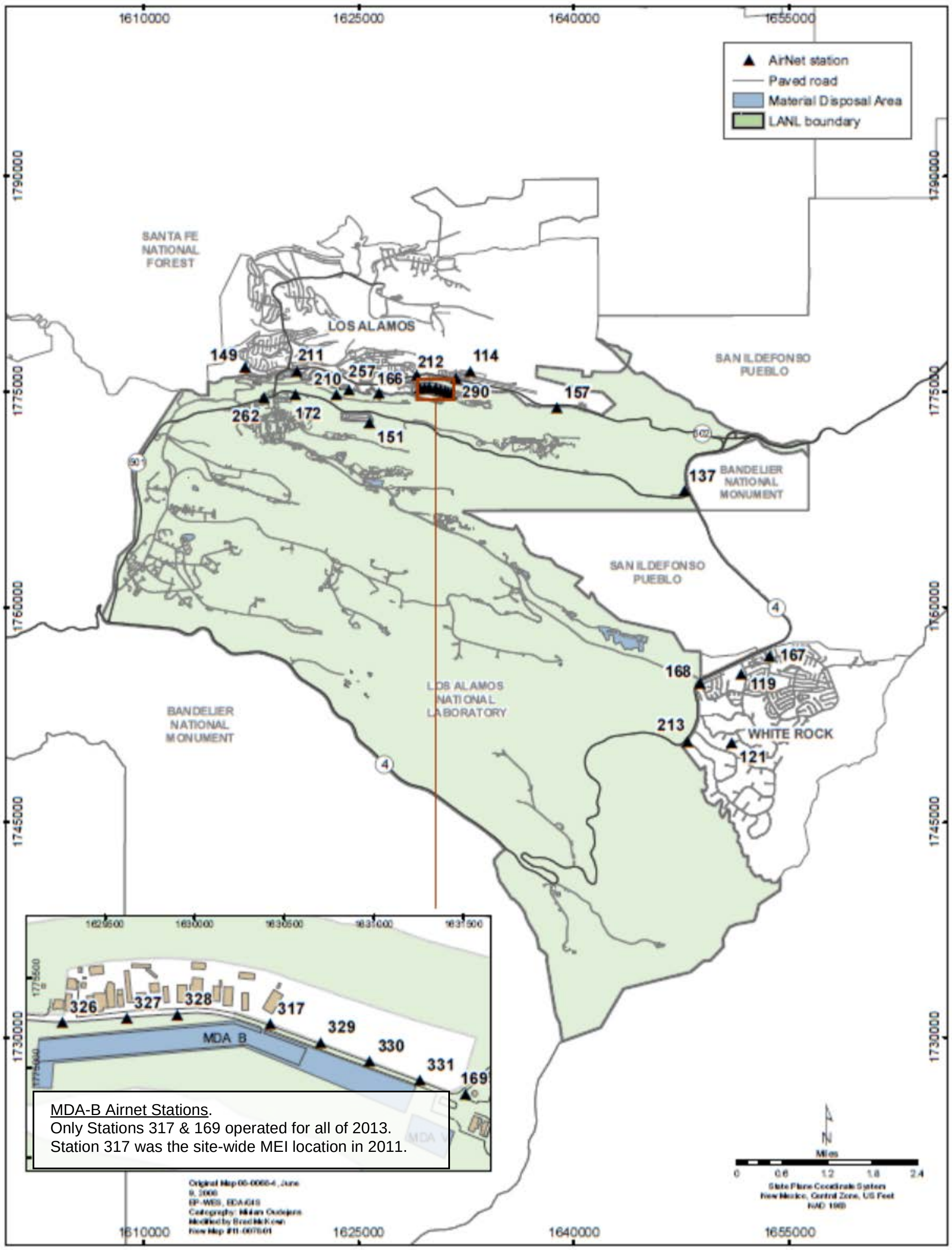

Figure 4. Locations of air sampling stations used for non-point source emissions compliance.

LANSCE Monthly Assessments

The Laboratory evaluates and reports the dose from short-lived radioactive gases released from LANSCE exhaust stack 53000702 on a monthly basis. This is so we can track and trend the emissions and identify any issues that need addressing throughout the year. The monthly dose values are calculated using actual meteorology for the month and the resulting doses are shown in Table 12. For 2012 the Laboratory also evaluated this stack's total gaseous emissions for the year in a single CAP88 run and compared the results to the monthly values summed for the calendar year. When evaluated to the LANSCE facility critical receptor, the sum of monthly doses is a dose of 0.0183 mrem, and the annual total single analysis result is also 0.0183 millirem. This same comparison, when emissions are modeled to the LANL site-wide MEI for 2012, results in a sum of monthly analyses equal to 0.00106 millirem and a single annual analysis equal to 0.000795 millirem. This difference, about 29%, is likely due to the annual meteorological file including the windy spring season, while the monthly files do not include this season (see Table 12 for details). The effect of meteorological parameters on the more distant receptor at 2201 Trinity Drive is much more pronounced than at East Gate (the facility critical receptor), due to the longer airborne mixing time. This issue is made moot by using the maximum value of either the annual evaluation or the sum of the monthly doses for EPA reported doses.

Aside from these monthly GMAP runs from 53000702, all other CAP88 assessments are performed using annual source term and annual meteorological inputs. This decision reflects the year-round sampling for PVAP nuclides, while GMAP is only measured during beam operations. The summary of off-site dose analyses from the LANSCE facility is contained in Table 12.

Highest EDE Determination

For most of the past decade, the maximally exposed individual (MEI) location has been at 2470 East Road, usually referred to as "East Gate." The dose was mostly a result of LANSCE emissions. Emissions reduction efforts in place at LANSCE since 2005 have resulted in very low off-site doses from TA-53 stacks. Emissions were further reduced by improvements made in the new beam Target/Moderator/Reflector System (TMRS) that was installed in early 2010. Because the LANSCE emissions are 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, modeled with CAP88 to determine dose at each location. Recall that the MEI location must be a school, business, residence, or office.

In 2012, measured ambient air dose at station 257 was much higher than other station measurements, and much higher than expected off-site doses from LANSCE stacks. Therefore, it was readily apparent that the MEI location would be 2201 Trinity Drive, the Los Alamos Lodge location, similar to 2010. This site is located above hillsides in Los Alamos Canyon which have known plutonium contamination. Station 257 routinely measures among the higher air concentrations of the network, and the measured air concentration is entirely dependent on wind speed, vegetation cover, and dryness of the soil & its readiness for resuspension. Current LANL operations have minimal effect on Station 257 measurements; measured air concentrations at this location are almost entirely due to legacy contamination from Manhattan Project-era operations.

To get the total MEI dose at this location, we start with the Airnet measured dose at Station 257 and then add (1) the doses modeled by CAP88 dose from all LANL monitored stacks and LANSCE diffuse sources to this MEI location and (2) the sum of all non-monitored stack potential emissions as modeled by CAP88 to the individual facility receptors for these non-monitored stacks. Details are in the next section and in Table 13.

61.92 Compliance Assessment

The highest EDE to any member of the public at any off-site point where there is a residence, school, or business was 0.58 mrem for radionuclides released by LANL in 2012. This dose was calculated by adding up (1) the dose contributions for each of the point sources at LANL, modeled to the MEI location; (2) the diffuse/fugitive gaseous activation products from LANSCE modeled to this MEI location; (3) the dose measured by the ambient air sampler in the vicinity of the public receptor location; and (4) the potential dose contribution of 0.0757 mrem from unmonitored stacks. Because the emissions estimates from unmonitored stacks do not account for pollution control systems, the actual dose from these minor sources is significantly less than the reported potential dose value. Table 13 of this report provides the compliance assessment summary, broken down by stack.

The location of the off-site point of highest EDE for 2012 is a business at 2201 Trinity Drive, the Los Alamos Lodge.

Section IV. Construction and Modifications

61.94(b)(8) Constructions, Modifications, and 61.96 Activity Relocations

A brief description of construction and modifications that were completed in 2012 for which the requirement to apply for approval to construct or modify was waived under section 61.96 is given below:

Surrogate Fuel Pellet Fabrication at TA-35-455

Surrogate fuel pellet fabrication and characterization work currently being performed in TA-3-32 was expanded into TA-35-455 in February 2012. This work includes mixing, milling, and pressing of fuel pellets and sintering of powders. Initial emissions estimates were based on maximum operating scope, particulate reduction factor of 1E-3, and assuming a release height of 20 ft above ground level. Based on these conservative assumptions, CAP88 calculated a worst-case off-site dose of 1E-3 mrem/yr. Based on the actual amount of radioactive material used in 2012, the potential off-site dose was 1.28E-04 mrem. This work will continue in 2013. Radioactive air emissions from this source will continue to be tracked in RMUS.

Uranium Extraction Research

Sample preparation and analysis work with natural uranium ores took place at TA-48-1. Sample prep work included coring, sorting, crushing, and grinding of rock which contains natural uranium ore. Analytical work included High Performance Liquid Chromatography, Inductively Coupled Mass Spectography, X-ray diffraction, X-ray Fluorescence, and Scanning Electron Microscope/Energy Dispersive X-ray Analysis. Initial emissions estimates were based on maximum operating scope and particulate reduction factor of 1E-3. Based on these assumptions, CAP88 calculated an off-site dose of less than 3.1E-6 mrem/yr. Actual work in 2012 ramped up to these planned levels by the end of the year. This work is planned to continue in 2013. Radioactive air emissions from this source will continue to be tracked in RMUS.

Fe-55 Analysis at TA-48-1

Sample preparation and analysis of a sample of Fe-55 took place at TA-48-1 in June of 2012. Common laboratory procedures and existing equipment were used for this work, but it was the first time Fe-55 was used at this location. The area where this work took place is vented to an unmonitored stack, so emissions were tracked through RMUS. Initial emissions estimates were based on the maximum operating scope and the liquid/particulate reduction factor of 1E-3. Using the predicted throughput levels for planned operations, CAP88 calculated a worst-case off-site dose of 5E-6 mrem from this operation; the overall stack off-site dose is still less than 0.1 mrem. Actual 2012 usage was close to the predicted levels, and the calculated dose from this process in 2012 was 4.5E-06 mrem. Operations will continue in future years, and the work will be tracked as part of RMUS.

Mo-99 Production Capability Testing at TA-53. As discussed in the Executive Summary, experiments were initiated in 2012 to explore the viability of producing molybdenum-99 using accelerator processes. Planned operational levels in 2012 predicted emissions well below 0.1 millirem. Irradiation operations started late in 2012. Operations were vented to a monitored exhaust stack (53000702), and Environmental Protection Division personnel updated analytical libraries for stack sample media and also expanded the number of nuclides of interest in the real-time gamma acquisition processes to look for specific nuclides that may be generated in these irradiations. No emissions from these irradiations were measured in 2012. The work continued in early 2013 and is expected to continue in future years. Samples from these irradiation operations are transported to other LANL facilities for processing, and emissions may result at monitored stacks (e.g., CMR Wing 9 stacks) and some non-monitored stacks (e.g., TA-48-1 stacks), depending on the type of analysis performed. Measured emissions will be reported as part of the routine source term from monitored stacks, and calculated emissions tracked and reported as part of the RMUS.

Section V. Additional Information

This section is provided pursuant to DOE guidance and is not required by Subpart H reporting requirements.

Unplanned Releases

During 2012, there were no instances of unplanned releases from the Laboratory via the airborne pathway. The August 2012 Technetium-99 contamination spread was described in the Executive Summary earlier, but did not represent an airborne release subject to the Radionuclide NESHAP.

Environmental Monitoring

In addition to the Airnet monitors identified in this report, additional environmental monitoring stations are operated at LANL and include several environmental monitoring stations located near the LANSCE boundary inhabited by the public. Measurement systems at these stations include thermoluminescent dosimeters, continuously operated air samplers, and in-situ high-pressure ion chambers. The combination of these measurement systems allows for monitoring of radionuclide air concentrations and the radiation exposure rate. Results for air sampling associated with NESHAP compliance are included in this document, while results for all monitoring data are published in the Annual Site Environmental Report for compliance with DOE Orders.

Other Supplemental Information

The following information is included for completeness, but not directly required under 40 CFR 61 Subpart H regulations.

- 80-km collective effective (population) dose for 2012 airborne releases: **0.272 person-rem**.
- Compliance with Subparts Q and T of 40 CFR 61—Radon-222 Emissions.
  These regulations apply to ^{222}Rn emissions from DOE storage/disposal facilities that contain by-product material. "By-product material" is the tailings or wastes produced by the extraction or concentration of uranium from ore. Although this regulation targets uranium mills, LANL has likely stored small amounts of by-product material used in experiments in the TA-54 low-level waste facility, MDA G; this practice makes the Laboratory subject to this regulation. Subject facilities cannot exceed an emissions rate of 20 pCi/m^2 s of ^{222}Rn. In 1993 and 1994, LANL conducted a study to characterize emissions from the MDA G disposal site.[20] This study showed an average emission rate of 0.14 pCi/m^2 s for MDA G. The performance assessment for MDA G has determined that there will not be a significant increase in ^{222}Rn emissions in the future.[21]
- Potential to exceed 0.1 mrem from LANL sources of ^{222}Rn or ^{220}Rn emissions: not applicable at LANL.
- Status of compliance with EPA effluent monitoring requirements as of June 3, 1996: LANL is in compliance with these requirements.

[20] Bart Eklund, "Measurements of Emission Fluxes from Technical Area 54, Areas G and L," Radian Corporation report, Austin, Texas, 1995

[21] Los Alamos National Laboratory, "Performance Assessment and Composite Analysis for Los Alamos National Laboratory Materials Disposal Area G," LA-UR-97-85, 1997.

Table 1. 40-61.94(b)(4-5) Release Point Data

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls*	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
03001600	TA-03-16	None	0	0%		968	N
03002913	TA-03-29-1	unknown	0	0%		859	NNE
03002914	TA-03-29-2	HEPA	2*	99.95% each*	X	733	NE
03002915	TA-03-29-2	HEPA	2*	99.95% each*	X	734	NE
03002919	TA-03-29-3	Aerosol 95	1	80%	X	838	NNE
03002920	TA-03-29-3	Aerosol 95	1	80%	X	837	NNE
03002923	TA-03-29-4	FARR 30/30	1	20%	X	618	NNW
03002924	TA-03-29-4	FARR 30/30	1	20%	X	618	NNW
03002928	TA-03-29-5	HEPA	2*	99.95% each*	X	938	NE
03002929	TA-03-29-5	HEPA	2*	99.95% each*	X	939	NE
03002932	TA-03-29-7	HEPA	2*	99.95% each*	X	858	NNE
03002933	TA-03-29-7	HEPA	2*	99.95% each*	X	857	NNE
03002937	TA-03-29-V	HEPA	2*	99.95% each*	X	872	NE
03002944	TA-03-29-9	RIGA-Flow	1	80%	X	939	NNE
03002945	TA-03-29-9	RIGA-Flow	1	80%	X	941	NNE
03002946	TA-03-29-9	RIGA-Flow	1	80%	X	940	NNE
03003299	TA-03-32	unknown	0	0%		641	NNE
03003400	TA-03-34	none	0	0%		668	NNE
03003501	TA-03-35	HEPA	1	99.95%		683	NNE
03006601	TA-03-66	none	0	0%		695	N
03006602	TA-03-66	none	0	0%		709	N
03006603	TA-03-66	none	0	0%		708	N
03006604	TA-03-66	none	0	0%		708	N
03006605	TA-03-66	none	0	0%		714	N
03006606	TA-03-66	none	0	0%		670	N
03006626	TA-03-66	HEPA	1	99.95%		618	N
03006654	TA-03-66	HEPA	1	99.95%		665	N
03006699	TA-03-66	none	0	0%		669	N
03010225	TA-03-102	HEPA	1	99.95%		772	N
03169800	TA-03-1698	none	0	0%		717	NNE
09002103	TA-09-21	none	0	0%		3044	NE
09003499	TA-09-34	none	0	0%		2879	NE

(Table continued next page)

Table 1 (continued)

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
15028599	TA-15-285	HEPA	1	99.95%		3719	NNE
15053401	TA-15-534	HEPA	1	99.95%		3282	NNE
16020299	TA-16-202	none	0	0%		1185	S
16020599	TA-16-205	none	0	0%		752	SSW
16045005	TA-16-450	none	0	0%	X	772	S
35000200	TA-35-2	none	0	0%		1294	NNW
35021305	TA-35-213	none	0	0%		1010	N
35045599	TA-35-455	Unknown	0	0%		1055	N
36000104	TA-36-1	unknown	0	0%		5379	SE
39006999	TA-39-69	unknown	0	0%		3071	ENE
43000100	TA-43-1	none	0	0%		122	NNE
46002499	TA-46-24	none	0	0%		2887	N
46003100	TA-46-31	none	0	0%		2792	N
46004106	TA-46-41	none	0	0%		2890	N
46015405	TA-46-154	none	0	0%		2769	N
46015899	TA-46-158	none	0	0%		3053	N
46020099	TA-46-200	none	0	0%		2743	N
48000107	TA-48-1	HEPA/Charco	2*	99.95% each*	X	754	NNE
48000111	TA-48-1	none	0	0%		874	NNE
48000115	TA-48-1	none	0	0%		764	NNE
48000135	TA-48-1	none	0	0%		797	NNE
48000145	TA-48-1	none	0	0%		893	NNE
48000154	TA-48-1	HEPA	2*	99.95% each*	X	756	NNE
48000160	TA-48-1	HEPA	1	99.95%	X	769	NNE
48000166	TA-48-1	HEPA	2*	99.95% each*		867	NNE
48000167	TA-48-1	HEPA	2*	99.95% each*		897	NNE
48000168	TA-48-1	none	0	0%		874	NNE
48004500	TA-48-45	none	0	0%		742	N

(Table continued next page)

Table 1 (Continued)

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
50000102	TA-50-1	HEPA	1	99.95% each*	X	1185	N
50000299	TA-50-2	none	0	0%		1215	N
50003701	TA-50-37	HEPA	2*	99.95% each*	X	1171	N
50006901	TA-50-69	HEPA	1	99.95%		1199	N
50006902	TA-50-69	HEPA	1	99.95%		1188	N
50006903	TA-50-69	HEPA	2*	99.95% each*	X	1187	N
50006999	TA-50-69	unknown	0	0%		1190	N
50025799	TA-50-257	none	0	0%		1201	N
53000116	TA-53-1	unknown	0	0%		1443	ENE
53000303	TA-53-3	HEPA	1	99.95%	X	806	NNE
53000702	TA-53-7	HEPA	1	99.95%	X	957	NNE
53001599	TA-53-15	none	0	0%		1096	NNE
53001899	TA-53-18	none	0	0%		1019	NNE
53098401	TA-53-984	none	0	0%		1049	NE
53109099	TA-53-1090	none	0	0%		1009	NNE
54003399	TA-54-33	None	0	0%		2058	ESE
54023199	TA-54-231	HEPA	1	99.95%	X	1480	SE
54028101	TA-54-281	HEPA	1	99.95%		1922	ESE
54037599	TA-54-375	HEPA	1	99.95%	X (started ops March 2013)	1783	SE
54041299	TA-54-412	HEPA	1	99.95%	X	1660	SE
54100199	TA-54-1001	None	0	0%		4999	ESE
54100999	TA-54-1009	None	0	0%		4781	ESE
55000201	TA-55-2	None	0	0%		1111	NNE
55000415	TA-55-4	HEPA	4*	99.95% each*	X	1018	NNE
55000416	TA-55-4	HEPA	4*	99.95% each*	X	1091	NNE
55040099	TA-55-400	HEPA	1	99.95%	X	1302	N

Notes: * As described in the main text, LANL only tests HEPA filter banks down to 0.0005 penetration & 99.95% removal.
This table reports the actual number of installed HEPA bank stages and nominal/design removal efficiencies, not tested efficiencies.

Table 2. 40-61.94(b)(7) User Supplied Data—Radionuclide Emissions

StackID	Nuclide	Annual Emission (Ci)
03002914	Pu-238	3.33E-09
03002914	U-234	8.10E-08
03002914	U-238	3.30E-08
03002914	Pa-234m (p)	3.30E-08
03002914	Th-234 (p)	3.30E-08
03002915	Pu-238	1.79E-09
03002915	Th-228	9.61E-09
03002915	U-234	1.86E-08
03002919	Am-241	4.14E-07
03002919	Pu-238	4.56E-07
03002919	Pu-239	1.84E-06
03002919	Sr-90	2.84E-08
03002919	Y-90 (p)	2.84E-08
03002919	U-234	5.30E-08
03002919	U-238	3.80E-08
03002919	Pa-234m (p)	3.80E-08
03002919	Th-234 (p)	3.80E-08
03002920	Am-241	5.55E-08
03002920	Pu-238	2.73E-08
03002920	Pu-239	1.18E-07
03002920	Sr-90	5.14E-08
03002920	Y-90 (p)	5.14E-08
03002920	U-234	1.72E-07
03002920	U-238	1.10E-07
03002920	Pa-234m (p)	1.10E-07
03002920	Th-234 (p)	1.10E-07
03002923	Pu-238	2.29E-09
03002923	Pu-239	2.04E-09
03002923	Sr-90	1.85E-08
03002923	Y-90 (p)	1.85E-08
03002923	Th-230	6.04E-08
03002923	U-234	7.63E-07
03002923	U-235	2.22E-08
03002923	U-238	1.23E-07
03002923	Pa-234m (p)	1.23E-07
03002923	Th-234 (p)	1.23E-07
03002924	Pu-238	1.06E-06
03002924	Pu-239	3.31E-08
03002924	Sr-90	4.77E-08
03002924	Y-90 (p)	4.77E-08
03002924	Th-228	8.94E-08
03002924	U-234	2.07E-06
03002924	U-238	7.75E-08
03002924	Pa-234m (p)	7.75E-08
03002924	Th-234 (p)	7.75E-08
03002928	Pu-238	2.46E-08
03002928	Pu-239	4.11E-09
03002929	Pu-238	8.05E-09
03002929	Th-232	1.11E-08
03002932	Pu-239	5.72E-09
03002932	Th-232	3.55E-08
03002932	U-234	1.19E-07
03002932	U-238	7.28E-08
03002932	Pa-234m (p)	7.28E-08
03002932	Th-234 (p)	7.28E-08
03002933	Th-228	2.81E-08
03002933	Th-230	1.15E-07
03002933	U-234	5.44E-08
03002933	U-238	4.73E-08
03002933	Pa-234m (p)	4.73E-08
03002933	Th-234 (p)	4.73E-08
03002937	Sr-90	5.87E-10
03002937	Y-90 (p)	5.87E-10
03002937	Th-232	1.68E-10
03002937	U-238	3.88E-10
03002937	Pa-234m (p)	3.88E-10
03002937	Th-234 (p)	3.88E-10
03002944	Am-241	1.47E-08
03002944	Ge-68	7.96E-05
03002944	Ga-68 (p)	7.96E-05
03002944	Pu-238	6.30E-09
03002944	Sr-90	4.11E-08
03002944	Y-90 (p)	4.11E-08
03002944	Th-228	2.55E-08
03002944	Th-232	1.21E-08
03002944	U-234	1.34E-07
03002945	Th-228	4.04E-08
03002945	Th-232	1.08E-08
03002945	U-234	7.52E-08

(Table continued next page)

Table 2 (continued)

StackID	Nuclide	Annual Emission (Ci)
03002945	U-238	4.65E-08
03002945	Pa-234m (p)	4.65E-08
03002945	Th-234 (p)	4.65E-08
03002946	Th-228	2.04E-08
03002946	Th-230	8.60E-08
03002946	Th-232	1.49E-08
03002946	U-234	6.44E-08
03002946	U-238	1.41E-07
03002946	Pa-234m (p)	1.41E-07
03002946	Th-234 (p)	1.41E-07
16045005	H-3(Gas)	8.56E+00
16045005	H-3(HTO)	6.65E+01
48000107	As-74	3.58E-06
48000107	Br-77	1.00E-05
48000107	Ge-68	1.06E-02
48000107	Ga-68 (p)	1.06E-02
48000107	Se-75	8.96E-05
48000154	U-234	4.65E-09
48000154	U-238	1.01E-08
48000154	Pa-234m (p)	1.01E-08
48000154	Th-234 (p)	1.01E-08
48000160	Ge-68	1.13E-06
48000160	Ga-68 (p)	1.13E-06
48000160	Se-75	1.61E-05
50000102	Pu-238	6.34E-09
50000102	Sr-90	5.61E-08
50000102	Y-90 (p)	5.61E-08
50000102	U-238	1.79E-07
50000102	Pa-234m (p)	1.79E-07
50000102	Th-234 (p)	1.79E-07
50003701	Th-228	4.45E-09
50003701	Th-230	5.52E-09
50003701	U-234	1.28E-08
50003701	U-238	7.21E-09
50003701	Pa-234m (p)	7.21E-09
50003701	Th-234 (p)	7.21E-09
50006903	H-3(HTO)	1.50E+00
50006903	Pu-238	1.95E-10
50006903	Sr-90	8.71E-10
50006903	Y-90 (p)	8.71E-10
50006903	Th-228	3.99E-10

StackID	Nuclide	Annual Emission (Ci)
50006903	U-234	1.17E-09
50006903	U-238	7.86E-10
50006903	Pa-234m (p)	7.86E-10
50006903	Th-234 (p)	7.86E-10
53000303	Ar-41	1.79E+00
53000303	Be-7	4.82E-05
53000303	Br-76	2.96E-06
53000303	Br-77	4.30E-06
53000303	Br-82	1.03E-04
53000303	C-11	4.29E+01
53000303	H-3(HTO)	1.53E+01
53000303	Na-24	2.93E-06
53000303	Os-191	8.21E-08
53000702	Ar-41	5.73E+00
53000702	As-73	1.14E-05
53000702	Be-7	2.78E-06
53000702	Br-76	1.49E-04
53000702	Br-82	9.39E-04
53000702	C-10	1.32E-01
53000702	C-11	3.77E+01
53000702	H-3(HTO)	1.62E+00
53000702	Hg-197m	2.83E-04
53000702	Hg-197 (p)	2.83E-04
53000702	N-13	1.21E+01
53000702	N-16	2.79E-01
53000702	Na-24	3.31E-06
53000702	O-14	2.03E-01
53000702	O-15	1.81E+01
53000702	Os-191	3.38E-06
54023199	Pu-239	2.23E-10
54023199	Sr-90	1.79E-09
54023199	Y-90 (p)	1.79E-09
54023199	Th-228	8.20E-10
54023199	Th-232	7.08E-10
54023199	U-234	2.01E-09
54023199	U-238	4.50E-09
54023199	Pa-234m (p)	4.50E-09
54023199	Th-234 (p)	4.50E-09
54041299	Th-232	2.43E-10
54041299	U-234	4.84E-09

(Table continued next page)

Table 2 (continued)

StackID	Nuclide	Annual Emission (Ci)
55000415	H-3(HTO)	5.00E-01
55000415	Pu-241	2.24E-09
55000415	Th-228	9.22E-09
55000415	Th-232	3.40E-09
55000415	U-234	3.72E-08
55000415	U-238	3.29E-08
55000415	Pa-234m (p)	3.29E-08
55000415	Th-234 (p)	3.29E-08
55000416	H-3(Gas)	1.19E+00
55000416	H-3(HTO)	3.01E+00
55000416	Pu-239	1.44E-09
55000416	Th-228	9.25E-09
55000416	Th-232	3.59E-09
55000416	U-234	4.76E-08
55000416	U-238	3.65E-08
55000416	Pa-234m (p)	3.65E-08
55000416	Th-234 (p)	3.65E-08
55040099	None	0.00E+00

Non-Point (Diffuse) Sources		
StackID	**Nuclide**	**Annual Emission (Ci)**
53DIF1LS	Ar-41	1.87E-01
53DIF1LS	C-11	4.48E+00
53DIF3SY	Ar-41	2.06E-01
53DIF3SY	C-11	4.94E+00

Table 2 Notes: Stacks at the Chemistry & Metallurgy Research (CMR) facility identified as 03002914 through 03002933 are recorded in the RADAIR database as N3002914 through N3002933, to indicate measurements made with the New sampling systems, effective 2001.

Starting in 2006, particulate emissions from TA-55 stacks 55000415 and 55000416 are measured from new sample systems, which consist of four independent sample systems on each stack. The four samplers are identified as 5500415A, -B, -C, and -D; and 5500416A, -B, -C, and -D. Stack emissions data reported in this table represent average emission values measured from these four samplers. In the RADAIR database, these average emissions are given the stack ID 5500415X and 5500416X, with the "X" indicating the calculated average value from the four samples. The emissions of tritium (H-3, both HT and HTO forms) from the ES-16 stack use a different sample system, and references remain unchanged in the database.

Radionuclides with the designator "(p)" are short-lived progeny in secular equilibrium with their parent radionuclide; e.g., Ga-68 (progeny) is in equilibrium with Ge-68 (parent).

The term "None" in the Nuclide column indicates that there were no detectable emissions from this source this calendar year.

Non-point emissions sources 53DIF3SY and 53DIF1LS are separated from the main source term table because they are addressed in different sections of the annual emissions report.

Stack 16045005 (ES-5) exhausts buildings TA-16-450 and TA-16-205. The ES-5 stack sampler was not operational, so reported emissions are measured by the sampler in the exhaust duct from 16-205, designated 16020504. That sampler captures all emissions from the facility, as 16-450 operations have not commenced.

Emissions of H-3 from 55000415 and 50006903 represent potential emissions, based on user estimation. These stacks are not monitored for tritium due to the very low contribution of tritium to off-site dose from this stack.

Table 3. 40-61.94(b)(7) User-Supplied Data—Monitored Stack Parameters

StackID	Height (m)	Diameter (m)	Exit Velocity (m/s)	Nearest Meteorological Tower
03002914	15.9	1.07	17.4	TA-6
03002915	15.9	1.05	9.3	TA-6
03002919	15.9	1.07	19.5	TA-6
03002920	15.9	1.07	5.3	TA-6
03002923	15.9	1.07	17.6	TA-6
03002924	15.9	1.06	6.0	TA-6
03002928	15.9	1.05	17.6	TA-6
03002929	15.9	1.07	21.0	TA-6
03002932	15.9	1.07	14.2	TA-6
03002933	15.9	1.06	16.2	TA-6
03002937	16.8	0.20	3.4	TA-6
03002944	16.5	1.52	5.7	TA-6
03002945	16.5	1.52	6.9	TA-6
03002946	16.5	1.88	7.4	TA-6
16045005	18.3	1.18	15.7	TA-6
48000107	13.4	0.30	19.7	TA-6
48000154	13.1	0.91	5.5	TA-6
48000160	12.4	0.38	7.5	TA-6
50000102	15.5	1.82	9.7	TA-6
50003701	12.4	0.91	5.7	TA-6
50006903	10.5	0.31	6.5	TA-6
53000303	33.5	0.91	10.5	TA-53
53000702	13.1	0.91	8.0	TA-53
54023199	0.61	0.61	0 vertical 9.3 horizontal	TA-54
54041299	0.61	0.61	0 vertical 4.5 horizontal	TA-54
55000415	9.5	0.93	7.3	TA-6
55000416	9.5	0.94	9.9	TA-6
55040099	26.0	1.88	12.3	TA-6

**Table 4. 61.94(b)(7) User-Supplied Data—Monitored Stack Parameters—
NM State Plane Coordinates (NAD '83)**

StackID	Easting	Northing
03002914	1,619,176	1,772,806
03002915	1,619,171	1,772,805
03002919	1,619,252	1,772,350
03002920	1,619,257	1,772,352
03002923	1,618,691	1,772,719
03002924	1,618,686	1,772,718
03002928	1,618,774	1,772,265
03002929	1,618,767	1,772,265
03002932	1,619,268	1,772,267
03002933	1,619,272	1,772,269
03002937	1,618,966	1,772,397
03002944	1,618,987	1,772,121
03002945	1,618,977	1,772,120
03002946	1,618,982	1,772,121
16045005	1,609,426	1,760,910
48000107	1,623,591	1,770,693
48000154	1,623,744	1,770,650
48000160	1,623,613	1,770,638
50000102	1,626,157	1,769,086
50003701	1,625,757	1,769,111
50006903	1,625,579	1,769,065
53000303	1,638,133	1,771,546
53000702	1,638,057	1,771,054
54023199	1,644,758	1,757,255
54041299	1,644,568	1,757,946
55000415	1,624,870	1,769,742
55000416	1,624,675	1,769,550
55040099	1,624,983	1,768,754

Table 5. 40-61.94(b)(7) User-Supplied Data—Highest Off-Site Dose Location for Monitored Release Points

StackID	Associated Meteorological Tower	Distance to LANL Highest Dose Location (m)	Direction to LANL Highest Dose Location
03002914	TA-06	1718	ENE
03002915	TA-06	1719	ENE
03002919	TA-06	1759	ENE
03002920	TA-06	1757	ENE
03002923	TA-06	1864	ENE
03002924	TA-06	1866	ENE
03002928	TA-06	1900	ENE
03002929	TA-06	1902	ENE
03002932	TA-06	1767	ENE
03002933	TA-06	1765	ENE
03002937	TA-06	1829	ENE
03002944	TA-06	1863	ENE
03002945	TA-06	1866	ENE
03002946	TA-06	1865	ENE
16045005	TA-06	6272	NE
48000107	TA-06	1363	N
48000154	TA-06	1369	N
48000160	TA-06	1379	N
50000102	TA-06	1918	NNW
50003701	TA-06	1878	NNW
50006903	TA-06	1880	NNW
53000303	TA-53	4347	WNW
53000702	TA-53	4365	WNW
54023199	TA-54	8270	NW
54041299	TA-54	8089	NW
55000415	TA-06	1643	N
55000416	TA-06	1697	N
55040099	TA-06	1965	N

Table 6. 40-61.94(b)(7) User-Supplied Data—Other Input Parameters

Description	Value	Units	CAP88 Variable Name (source code/V0 identifiers)
Annual rainfall rate	45	cm/y	RR
Lid height	1600	m	LIPO
Annual ambient temperature	9	deg C	TA
Absolute humidity	5.5	g/m^3	
E-vertical temperature gradient	0.02	K/m	TG
F-vertical temperature gradient	0.035	K/m	TG
G-vertical temperature gradient	0.035	K/m	TG
Food supply fraction - local vegetables	1		F1V
Food supply fraction - vegetable regional	0		F2V
Food supply fraction - vegetable imported	0		F3V
Food supply fraction - meat local	1		F1B
Food supply fraction - meat regional	0		F2B
Food supply fraction - meat imported	0		F3B
Food supply fraction - milk local	1		F1M
Food supply fraction - milk regional	0		F2M
Food supply fraction - milk imported	0		F3M
Ground surface roughness factor	0.5		GSCFAC

Table 7: 40-61.94(b)(7) User-Supplied Data—Wind Frequency Array

Due to the extent of data reported in Table 7, this table has been moved to Appendix 1.

Table 8. 40-61.94(b)(7) User-Supplied Data—Population Array

Estimated 2010 Population within 80 km of Los Alamos National Laboratory (revised 2012)

	Distances from Los Alamos Canyon Line Source												
Direction (sector)	250	750	1500	2500	3500	4500	7500	15000	25000	35000	45000	55000	70000
N	26	79	313	506	326	0	0	16	103	1077	0	945	641
NNW	26	99	284	423	442	0	0	7	22	291	0	0	528
NW	51	24	260	372	447	343	106	2	27	56	821	0	1153
WNW	24	117	205	321	359	348	407	0	35	41	0	0	3305
W	0	0	134	156	150	181	106	14	119	575	0	135	257
WSW	0	0	0	0	0	0	2	14	1	696	0	4673	0
SW	0	0	0	0	0	0	5	5	0	0	0	3965	0
SSW	0	0	0	0	0	0	36	6	1766	2392	5674	4591	100236
S	0	0	0	0	0	0	20	9	31	274	0	0	6060
SSE	0	0	0	0	0	0	765	51	406	6811	3328	0	0
SE	0	0	0	0	0	0	5764	1	1318	88346	9870	218	6
ESE	0	0	0	0	0	0	36	14	868	10461	0	803	2430
E	0	0	134	156	150	181	106	1915	5002	511	588	1	598
ENE	24	117	205	321	359	348	407	2600	5419	4317	194	1128	1752
NE	51	24	260	372	447	343	106	1314	17067	2878	1604	1597	3527
NNE	26	99	284	423	442	0	0	15	2739	479	3483	0	58

Table 9. 40-61.94(b)(7) User-Supplied Data

Modeling Parameters

for LANL Non-Point Sources

Non-Point Source	Area of Source (m^2)	Radionuclide	Emission (Ci)
TA-53 Beam Switchyard StackID = 53DIF3SY	484	^{41}Ar ^{11}C	2.06-01 4.94E+00
TA-53-1L Service Area Stack ID = 53DIF1LS	1.0	^{41}Ar ^{11}C	1.87E-01 4.48+00

Non-Point Source	Distance to Nearest Receptor Location [Critical receptor] (meters)	Direction to Nearest Receptor Location [Critical Receptor]
TA-53 Beam Switchyard StackID = 53DIF3SY	774	NNE
TA-53-1L Service Area Stack ID = 53DIF1LS	943	NNE

Non-Point Source	Distance to LANL Maximum Dose Location (m)	Direction to LANL Maximum Dose Location
TA-53 Beam Switchyard StackID = 53DIF3SY	4299	WNW
TA-53-1L Service Area Stack ID = 53DIF1LS	4351	WNW

Table 10. Environmental Data—Compliance Stations

2012 Effective Dose Equivalent measured at air sampling locations around LANL (net millirem)									
Site	**Site Name**	**H-3**	**Am-241**	**Pu-238**	**Pu-239**	**U-234**	**U-235**	**U-238**	**Total (mrem)**
114	Los Alamos Airport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
119	Rocket Park	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
121	Pajarito Acres	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
133	Bandelier Fire Lookout	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	**0.00**
137	Well PM-1	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	**0.00**
149	48th Street	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	**0.00**
151	Royal Crest Trailer Court	0.00	0.00	0.00	0.00	0.01	0.00	0.01	**0.01**
157	Eastgate	0.00	0.00	-0.01	0.00	0.01	0.00	0.01	**0.01**
166	McDonalds	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	**0.01**
167	White Rock Fire Station	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
168	White Rock Nazarene Church	0.01	-0.01	0.00	0.01	0.00	0.00	0.00	**0.02**
169	TA-21 Area B	0.00	0.00	0.00	0.05	0.01	0.00	0.01	**0.08**
172	Los Alamos County Landfill	0.00	0.00	0.00	0.00	0.03	0.00	0.03	**0.07**
206	Eastgate – Backup	0.00	0.00	0.00	0.00	0.01	0.00	0.01	**0.02**
210	LA Canyon	0.00	0.00	0.00	0.01	0.01	0.00	0.01	**0.02**
211	LA Hospital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
212	Crossroads Bible Church	0.00	0.00	0.00	0.00	0.02	0.00	0.02	**0.06**
213	Monte Rey South	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	**0.00**
257 / 324	Los Alamos Inn – South / Hillside 138*	0.00	0.00	0.00	0.48	0.01	0.00	0.01	**0.49**
262	TA-3 Research Park	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
290	Los Alamos Airport Road	0.00	0.00	0.00	0.01	0.00	0.00	0.00	**0.02**
307	TA-16 / S-Site Cafeteria	0.01	0.00	0.00	0.00	0.01	0.00	0.00	**0.02**
317	A15- West End	n/a	0.00	0.00	0.10	0.02	0.00	0.01	**0.13**

* As discussed in the Executive Summary, Station 324 replaced Station 257 as a compliance measurement point in November 2012.

22 "compliance" stations; +1 station 317 for inter-year comparison.

Table 11. Environmental Data—Compliance Stations

2012 Sampler Operational Completeness and Analytical Completeness									
Site #	**Site Name**	**Station % Run Time**	**Am-241**	**H-3**	**Pu-238**	**Pu-239**	**U-234**	**U-235**	**U-238**
114	Los Alamos Airport	99.82	100.0	100.0	100.0	100.0	100.0	100.0	100.0
119	Rocket Park	98.52	100.0	100.0	100.0	100.0	100.0	100.0	100.0
121	Pajarito Acres	98.98	100.0	100.0	100.0	100.0	100.0	100.0	100.0
133	Bandelier Fire Lookout	99.84	100.0	100.0	100.0	100.0	100.0	100.0	100.0
137	Well PM-1 (E. Jemez Road)	99.92	100.0	100.0	100.0	100.0	100.0	100.0	100.0
149	48th Street (Twin Tanks Complex)	99.73	100.0	100.0	100.0	100.0	100.0	100.0	100.0
151	Royal Crest Trailer Court	99.90	100.0	100.0	100.0	100.0	100.0	100.0	100.0
157	Eastgate	99.65	100.0	96.3	100.0	100.0	100.0	100.0	100.0
166	McDonalds	99.81	100.0	100.0	100.0	100.0	100.0	100.0	100.0
167	White Rock Fire Station	99.86	100.0	100.0	100.0	100.0	100.0	100.0	100.0
168	White Rock Nazarene Church	99.63	100.0	100.0	100.0	100.0	100.0	100.0	100.0
169	TA-21 Area B	99.18	100.0	100.0	100.0	100.0	100.0	100.0	100.0
172	Los Alamos County Landfill	99.77	100.0	100.0	100.0	100.0	100.0	100.0	100.0
206	Eastgate – Backup	99.65	100.0	100.0	100.0	100.0	100.0	100.0	100.0
210	LA Canyon	99.86	100.0	100.0	100.0	100.0	100.0	100.0	100.0
211	LA Hospital	99.84	100.0	100.0	100.0	100.0	100.0	100.0	100.0
212	Crossroads Bible Church	99.81	100.0	100.0	100.0	100.0	100.0	100.0	100.0
213	Monte Rey South	97.69	100.0	100.0	100.0	100.0	100.0	100.0	100.0
257 / 324	Los Alamos Inn – South / Hillside 138*	99.00	100.0	96.3	100.0	100.0	100.0	100.0	100.0
262	TA-3 Research Park	99.79	100.0	96.3	100.0	100.0	100.0	100.0	100.0
290	Los Alamos Airport Road	98.55	100.0	96.3	100.0	100.0	100.0	100.0	100.0
307	TA-16 Near S-Site Cafeteria	99.85	100.0	100.0	100.0	100.0	100.0	100.0	100.0
317	A15 West End	99.82	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Average:	**99.48**	**100.0**	**99.33**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* As discussed in the Executive Summary, Station 324 replaced Station 257 as a compliance measurement point in November 2012.

Table 12. LANSCE Monthly Assessments, Comparison with Annual Analyses, and Facility Dose Summary

Description	StackID	Dose at East Gate Receptor (mrem)	Dose at Trinity Drive receptor (mrem)
LANSCE stack January GMAP	53000702	5.26E-03	4.01E-04
LANSCE stack February GMAP	53000702	8.11E-03	4.21E-04
LANSCE stack March GMAP	53000702	None	None
LANSCE stack April GMAP	53000702	None	None
LANSCE stack May GMAP	53000702	None	None
LANSCE stack June GMAP	53000702	None	None
LANSCE stack July GMAP	53000702	None	None
LANSCE stack August GMAP	53000702	1.81E-03	4.30E-05
LANSCE stack September GMAP	53000702	7.17E-04	2.87E-05
LANSCE stack October GMAP	53000702	7.60E-04	4.01E-05
LANSCE stack November GMAP	53000702	6.28E-04	2.97E-05
LANSCE stack December GMAP	53000702	9.87E-04	9.23E-05
Sum of monthly GMAP runs for this stack	53000702	1.83E-02	1.06E-03
GMAP single annual analysis for this stack	53000702	1.83E-02	7.95E-04
Difference, sum of monthly vs. annual analyses:		*0.0%*	*28.6%*

To be conservative, the **maximum value** of the two above methods will be used for all further reporting of GMAP emissions from the main LANSCE stack 53000702. Values are highlighted above for each receptor location.

SUMMARY OF LANSCE FACILITY DOSE		Dose at East Gate Receptor (mrem)	Dose at Trinity Drive receptor (mrem)
LANSCE stack GMAP	53000303	6.63E-03	4.31E-04
LANSCE stack PVAP	53000303	8.68E-03	2.72E-04
LANSCE Non-CAP88 Radionuclides	53000303	None	None
LANSCE stack GMAP (see above)	53000702	1.83E-02	1.06E-03
LANSCE stack PVAP	53000702	2.04E-03	4.28E-05
LANSCE Non-CAP88 Radionuclides	53000702	7.19E-06	8.94E-08
LANSCE Diffuse/Fugitive Emissions – Beam Switchyard	53DIF3SY	3.73E-03	8.89E-05
LANSCE Diffuse/Fugitive Emissions – 1L Service Area	53DIF1LS	2.35E-03	7.92E-05
2012 LANSCE facility summary:		6.48E-02	1.97E-03

GMAP = Gaseous Mixed Activation products; short-lived radioactive gases (e.g., C-11, O-15, Ar-41).

PVAP = Particulate & Vapor Activation Products (e.g., Na-24, Br-76).

Note: All CAP88 analyses above are annual assessments, with the exception of the monthly GMAP analyses for stack 53000702, as described.

Note: For completeness, the "Summary" portion of this table is reproduced in Table 13, next page, for both the East Gate receptor and the LA Inn South receptor.

Table 13. 40-61.92 Highest Effective Dose Equivalent Summary All LANL Sources

Description	StackID	Dose for Release Site Receptor (mrem)	Dose at Trinity Drive receptor (mrem)
CMR Stack – Wing 2	03002914	7.98E-07	4.18E-07
CMR Stack – Wing 2	03002915	1.03E-06	5.25E-07
CMR Stack – Wing 3	03002919	2.10E-04	9.74E-05
CMR Stack – Wing 3	03002920	2.21E-05	1.11E-05
CMR Stack – Wing 4	03002923	8.56E-06	3.15E-06
CMR Stack – Wing 4	03002924	1.52E-04	6.15E-05
CMR Stack – Wing 5	03002928	1.68E-06	9.71E-07
CMR Stack – Wing 5	03002929	7.33E-07	4.23E-07
CMR Stack – Wing 7	03002932	2.97E-06	1.51E-06
CMR Stack – Wing 7	03002933	4.88E-06	2.44E-06
CMR Stack	03002937	0.00E+00	0.00E+00
CMR Stack – Wing 9	03002944	4.26E-05	6.48E-05
CMR Stack – Wing 9	03002945	3.59E-06	1.97E-06
CMR Stack – Wing 9	03002946	5.06E-06	2.42E-06
WETF Stack – new	16045005	3.11E-02	2.78E-03
Radiochemistry Stack	48000107	7.85E-03	1.03E-02
Radiochemistry /non-CAP88 nuclides	48000107	None	None
Radiochemistry Stack	48000154	1.24E-07	5.06E-08
Radiochemistry Stack	48000160	8.32E-06	3.45E-06
Waste Management Stack	50000102	9.19E-07	3.21E-07
Waste Management Stack	50003701	4.57E-07	1.56E-07
Waste Management Stack	50006903	1.25E-03	2.09E-04
LANSCE-Stack – GMAP	53000303	6.63E-03	4.31E-04
LANSCE- Annual – Partic/Vapor	53000303	8.68E-03	2.72E-04
LANSCE Non-CAP88 radionuclides	53000303	None	None
LANSCE-Stack – GMAP (See Note below)	53000702	1.83E-02	1.06E-03
LANSCE- Annual – Partic/Vapor	53000702	2.04E-03	4.28E-05
LANSCE Non-CAP88 radionuclides	53000702	7.19E-06	8.94E-08
LANSCE Fugitive - Beam Switch Yard	53DIF3SY	3.73E-03	8.89E-05
LANSCE Fugitive - 1L Service Area	53DIF1LS	2.35E-03	7.92E-05
Waste Processing Stack	54023199	4.95E-08	2.55E-10
Waste Processing Stack	54041299	3.43E-08	2.23E-10
Plutonium Facility Stack	55000415	5.52E-04	1.16E-04
Plutonium Facility Stack	55000416	3.38E-03	7.59E-04
Radiological Lab/Utility/Office Bldg	55040099	0.00E+00	0.00E+00
Unmonitored Stacks - No credit for controls	99000000	7.57E-02	7.57E-02
Air Sampler Net Dose @ this location	99000010	N/A (Various Locations)	4.90E-01
Total maximally exposed individual dose (mrem)			**5.82E-01 = 0.58 mrem (report value)**

Note 1: As described in Table 12, the reporting value for GMAP emissions from 53000702 is the maximum value of either the annual GMAP dose assessment or the sum of monthly GMAP dose assessments. Data for TA-53 stacks here is reproduced from Table 12.

61.94(b)(9) Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Signature: *<signature on file>* Date: *17 June 2013*

Owner: Geoffrey L. Beausoleil
Manager (Acting)
Los Alamos Field Office, NA-00-LA
National Nuclear Security Administration
U. S. Department of Energy

Signature: *<signature on file>* Date: *13 June 2013*

Operator: Michael T. Brandt
Associate Director
Environment, Safety, and Health
Los Alamos National Security, LLC
Los Alamos National Laboratory

Appendix 1 – Meteorology Data

Due to the extent of data reported in Table 7, that table has been moved to this appendix.

Table 7: 40-61.94(b)(7) User-Supplied Data—Wind Frequency Arrays

Table 7a: CAP88 Input Data for 2012 TA-6 Meteorological Tower (99.68% Data Completeness)

N	A	0.001110.000340.000000.000000.000000.00000
NNE	A	0.001340.000540.000000.000000.000000.00000
NE	A	0.002310.000660.000000.000000.000000.00000
ENE	A	0.004000.001370.000000.000000.000000.00000
E	A	0.004310.002280.000000.000000.000000.00000
ESE	A	0.003430.002060.000000.000000.000000.00000
SE	A	0.002600.002460.000000.000000.000000.00000
SSE	A	0.002460.002660.000000.000000.000000.00000
S	A	0.001630.001510.000000.000000.000000.00000
SSW	A	0.000800.000890.000000.000000.000000.00000
SW	A	0.000740.000490.000000.000000.000000.00000
WSW	A	0.000830.000290.000000.000000.000000.00000
W	A	0.000660.000310.000060.000000.000000.00000
WNW	A	0.000460.000230.000030.000000.000000.00000
NW	A	0.000510.000290.000000.000000.000000.00000
NNW	A	0.000710.000090.000000.000000.000000.00000
N	B	0.000290.000370.000030.000000.000000.00000
NNE	B	0.000510.000690.000000.000000.000000.00000
NE	B	0.000660.001110.000000.000000.000000.00000
ENE	B	0.000970.001860.000000.000000.000000.00000
E	B	0.001030.002310.000000.000000.000000.00000
ESE	B	0.001110.002860.000000.000000.000000.00000
SE	B	0.001030.003230.000000.000000.000000.00000
SSE	B	0.000630.003110.000030.000000.000000.00000
S	B	0.000310.001770.000030.000000.000000.00000
SSW	B	0.000260.000830.000060.000000.000000.00000
SW	B	0.000030.000430.000090.000000.000000.00000
WSW	B	0.000110.000400.000000.000000.000000.00000
W	B	0.000090.000310.000000.000000.000000.00000
WNW	B	0.000110.000340.000110.000000.000000.00000
NW	B	0.000140.000290.000030.000000.000000.00000
NNW	B	0.000110.000260.000030.000000.000000.00000
N	C	0.000400.000910.000170.000000.000000.00000
NNE	C	0.000890.001540.000110.000000.000000.00000
NE	C	0.000890.003600.000290.000000.000000.00000
ENE	C	0.002000.005110.000110.000000.000000.00000
E	C	0.002030.005940.000030.000000.000000.00000
ESE	C	0.001400.006340.000090.000000.000000.00000
SE	C	0.001060.007600.000710.000000.000000.00000
SSE	C	0.000770.010850.001880.000000.000000.00000
S	C	0.000600.005940.003080.000030.000000.00000

(Table continued next page)

Table 7a (continued)

SSW	C	0.000340.002030.001710.000000.000000.00000
SW	C	0.000200.001140.000740.000000.000000.00000
WSW	C	0.000110.000630.000310.000000.000000.00000
W	C	0.000140.000770.000890.000000.000000.00000
WNW	C	0.000170.000890.000940.000110.000000.00000
NW	C	0.000090.000970.001060.000030.000000.00000
NNW	C	0.000090.000660.000370.000000.000000.00000
N	D	0.004230.007420.003140.000740.000030.00000
NNE	D	0.003770.011190.007680.002400.000090.00000
NE	D	0.003600.009220.005400.000310.000000.00000
ENE	D	0.003850.006250.001630.000060.000000.00000
E	D	0.004080.006650.000460.000030.000000.00000
ESE	D	0.003630.007850.001630.000090.000000.00000
SE	D	0.003830.009420.004370.000230.000000.00000
SSE	D	0.003970.017420.020670.002540.000030.00000
S	D	0.004370.023700.036320.008370.000690.00006
SSW	D	0.004600.016450.023590.006540.001430.00017
SW	D	0.003540.008880.016450.006220.000830.00006
WSW	D	0.004630.007480.012710.009650.001830.00014
W	D	0.003850.007000.015330.009510.002280.00037
WNW	D	0.003830.006680.015680.010710.004140.00089
NW	D	0.004230.009220.013880.006680.000740.00006
NNW	D	0.005740.007480.004340.000970.000030.00000
N	E	0.002830.005970.002370.000000.000000.00000
NNE	E	0.001710.004080.002200.000000.000000.00000
NE	E	0.001460.001710.000310.000000.000000.00000
ENE	E	0.001280.000970.000090.000000.000000.00000
E	E	0.000940.000890.000000.000000.000000.00000
ESE	E	0.001200.000770.000030.000000.000000.00000
SE	E	0.000800.001090.000090.000000.000000.00000
SSE	E	0.001540.002170.000090.000000.000000.00000
S	E	0.001510.007710.001090.000000.000000.00000
SSW	E	0.002200.015330.002740.000000.000000.00000
SW	E	0.002460.012160.008220.000000.000000.00000
WSW	E	0.002340.004800.003770.000000.000000.00000
W	E	0.002400.004310.003310.000000.000000.00000
WNW	E	0.002630.005510.004430.000000.000000.00000
NW	E	0.002230.009080.005800.000000.000000.00000
NNW	E	0.002660.005740.001600.000000.000000.00000
N	F	0.006570.007420.000710.000000.000000.00000
NNE	F	0.003740.002430.000090.000000.000000.00000
NE	F	0.001630.000630.000000.000000.000000.00000
ENE	F	0.001260.000230.000000.000000.000000.00000
E	F	0.000970.000110.000000.000000.000000.00000
ESE	F	0.000800.000340.000000.000000.000000.00000
SE	F	0.001310.000340.000000.000000.000000.00000
SSE	F	0.001680.000060.000000.000000.000000.00000
S	F	0.002060.000830.000000.000000.000000.00000
SSW	F	0.003910.003710.000000.000000.000000.00000
SW	F	0.005570.013990.001260.000000.000000.00000
WSW	F	0.006340.027210.004400.000000.000000.00000
W	F	0.006940.022810.001880.000000.000000.00000
WNW	F	0.006510.017270.001770.000000.000000.00000
NW	F	0.007250.024160.000540.000000.000000.00000
NNW	F	0.007170.013880.000290.000000.000000.00000

Table 7 (continued)

Table 7b: CAP88 Input Data for 2012 TA-53 Meteorological Tower (99.96% Data Completeness)

N	A	0.001000.000340.000000.000000.000000.00000
NNE	A	0.002080.000630.000000.000000.000000.00000
NE	A	0.003330.001280.000000.000000.000000.00000
ENE	A	0.004130.002990.000000.000000.000000.00000
E	A	0.003390.002310.000000.000000.000000.00000
ESE	A	0.002730.002790.000030.000000.000000.00000
SE	A	0.002900.002190.000000.000000.000000.00000
SSE	A	0.002140.001880.000000.000000.000000.00000
S	A	0.001110.001540.000030.000000.000000.00000
SSW	A	0.000600.000800.000000.000000.000000.00000
SW	A	0.000630.000480.000000.000000.000000.00000
WSW	A	0.000510.000340.000000.000000.000000.00000
W	A	0.000260.000310.000000.000000.000000.00000
WNW	A	0.000430.000260.000000.000000.000000.00000
NW	A	0.000400.000260.000000.000000.000000.00000
NNW	A	0.000480.000460.000000.000000.000000.00000
N	B	0.000140.000310.000000.000000.000000.00000
NNE	B	0.000650.000770.000000.000000.000000.00000
NE	B	0.000710.001310.000000.000000.000000.00000
ENE	B	0.001400.002930.000030.000000.000000.00000
E	B	0.000970.003190.000000.000000.000000.00000
ESE	B	0.001000.003100.000030.000000.000000.00000
SE	B	0.000800.002140.000000.000000.000000.00000
SSE	B	0.000630.001990.000000.000000.000000.00000
S	B	0.000400.001820.000000.000000.000000.00000
SSW	B	0.000230.000510.000000.000000.000000.00000
SW	B	0.000110.000340.000030.000000.000000.00000
WSW	B	0.000060.000170.000000.000000.000000.00000
W	B	0.000060.000260.000030.000000.000000.00000
WNW	B	0.000030.000340.000000.000000.000000.00000
NW	B	0.000140.000090.000060.000000.000000.00000
NNW	B	0.000110.000280.000030.000000.000000.00000
N	C	0.000200.000830.000430.000000.000000.00000
NNE	C	0.000770.002250.000370.000030.000000.00000
NE	C	0.001080.004300.000510.000000.000000.00000
ENE	C	0.001480.006720.000230.000000.000000.00000
E	C	0.001480.006860.000260.000000.000000.00000
ESE	C	0.001280.005870.000110.000000.000000.00000
SE	C	0.000830.005040.000280.000000.000000.00000
SSE	C	0.000850.007150.000630.000000.000000.00000
S	C	0.000570.005240.000910.000000.000000.00000
SSW	C	0.000200.002250.000540.000000.000000.00000
SW	C	0.000140.001170.000430.000030.000000.00000
WSW	C	0.000110.000570.000600.000000.000000.00000
W	C	0.000140.000710.000680.000000.000000.00000
WNW	C	0.000060.000770.000680.000000.000000.00000
NW	C	0.000030.000280.000310.000000.000000.00000
NNW	C	0.000310.000480.000260.000000.000000.00000

(Table continued next page)

Table 7b (continued)

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  N D 0.006090.009710.009480.003300.000200.00000
NNE D 0.006580.011560.010360.004560.000650.00003
 NE D 0.005750.009880.006430.001080.000060.00000
ENE D 0.004730.010140.002990.000200.000000.00000
  E D 0.003390.009650.001940.000060.000000.00000
ESE D 0.003360.005610.001540.000170.000000.00000
 SE D 0.002650.006350.002250.000370.000000.00000
SSE D 0.001990.011650.014120.005270.000680.00006
  S D 0.002760.014750.037300.019050.001110.00040
SSW D 0.002420.011300.036930.023290.002330.00125
 SW D 0.002160.009450.020900.009910.000970.00009
WSW D 0.001740.006180.012700.009850.002530.00034
  W D 0.001680.005520.014720.008600.001910.00011
WNW D 0.002050.004700.008880.007000.002140.00006
 NW D 0.002900.003700.005180.004070.000510.00026
NNW D 0.004440.005670.005150.001910.000400.00006
  N E 0.004470.010220.001540.000000.000000.00000
NNE E 0.004380.007630.002160.000000.000000.00000
 NE E 0.002930.006060.001050.000000.000000.00000
ENE E 0.001990.002960.000460.000000.000000.00000
  E E 0.001590.001940.000170.000000.000000.00000
ESE E 0.000910.001710.000110.000000.000000.00000
 SE E 0.000830.000940.000090.000000.000000.00000
SSE E 0.001000.001960.000970.000000.000000.00000
  S E 0.001280.005380.007400.000000.000000.00000
SSW E 0.001170.010820.027670.000000.000000.00000
 SW E 0.001710.020840.015230.000000.000000.00000
WSW E 0.001510.008230.010340.000000.000000.00000
  W E 0.001820.009420.009480.000000.000000.00000
WNW E 0.002050.006720.004870.000000.000000.00000
 NW E 0.002510.005210.002510.000000.000000.00000
NNW E 0.003730.007920.003900.000000.000000.00000
  N F 0.006210.002360.000000.000000.000000.00000
NNE F 0.006090.001990.000170.000000.000000.00000
 NE F 0.005470.002220.000000.000000.000000.00000
ENE F 0.004640.001000.000000.000000.000000.00000
  E F 0.003360.000570.000000.000000.000000.00000
ESE F 0.003100.000370.000000.000000.000000.00000
 SE F 0.003160.001170.000000.000000.000000.00000
SSE F 0.002820.001340.000060.000000.000000.00000
  S F 0.002990.002960.000030.000000.000000.00000
SSW F 0.003700.007400.001400.000000.000000.00000
 SW F 0.003840.004750.000340.000000.000000.00000
WSW F 0.003270.007740.003330.000000.000000.00000
  W F 0.003050.009110.004670.000000.000000.00000
WNW F 0.004610.006490.000260.000000.000000.00000
 NW F 0.004610.003730.000540.000000.000000.00000
NNW F 0.005470.003500.000570.000000.000000.00000
```

Table 7 (continued)

Table 7c: CAP88 Input Data for 2012 TA-54 Meteorological Tower (99.95% Data Completeness)

```
  N A 0.000570.000280.000000.000030.000000.00000
NNE A 0.001080.000650.000000.000000.000000.00000
 NE A 0.001710.001420.000000.000000.000000.00000
ENE A 0.003500.002450.000000.000000.000000.00000
  E A 0.005980.004100.000000.000000.000000.00000
ESE A 0.005180.003080.000000.000000.000000.00000
 SE A 0.003530.002140.000000.000000.000000.00000
SSE A 0.002310.002160.000000.000000.000000.00000
  S A 0.000850.001650.000000.000000.000000.00000
SSW A 0.000830.000880.000000.000000.000000.00000
 SW A 0.000650.000510.000000.000000.000000.00000
WSW A 0.000310.000430.000000.000000.000000.00000
  W A 0.000230.000370.000000.000000.000000.00000
WNW A 0.000370.000280.000000.000000.000000.00000
 NW A 0.000400.000310.000000.000000.000000.00000
NNW A 0.000340.000370.000030.000000.000000.00000
  N B 0.000090.000400.000030.000000.000000.00000
NNE B 0.000170.000600.000030.000000.000000.00000
 NE B 0.000310.001540.000030.000000.000000.00000
ENE B 0.000850.002650.000000.000000.000000.00000
  E B 0.001110.003050.000000.000000.000000.00000
ESE B 0.001080.002530.000000.000000.000000.00000
 SE B 0.000650.002160.000000.000000.000000.00000
SSE B 0.000510.001880.000000.000000.000000.00000
  S B 0.000280.001820.000110.000000.000000.00000
SSW B 0.000090.001080.000060.000000.000000.00000
 SW B 0.000110.000340.000030.000000.000000.00000
WSW B 0.000060.000310.000000.000000.000000.00000
  W B 0.000000.000280.000090.000000.000000.00000
WNW B 0.000060.000260.000030.000000.000000.00000
 NW B 0.000060.000140.000000.000000.000000.00000
NNW B 0.000030.000200.000000.000000.000000.00000
  N C 0.000170.000340.000260.000000.000000.00000
NNE C 0.000140.001450.000340.000000.000000.00000
 NE C 0.000570.004210.000230.000000.000000.00000
ENE C 0.000970.007200.000280.000000.000000.00000
  E C 0.001050.006440.000140.000000.000000.00000
ESE C 0.000850.004640.000030.000000.000000.00000
 SE C 0.000570.003500.000060.000000.000000.00000
SSE C 0.000480.003590.000400.000000.000000.00000
  S C 0.000370.004900.001030.000000.000000.00000
SSW C 0.000480.002960.000850.000000.000000.00000
 SW C 0.000170.001400.000460.000000.000000.00000
WSW C 0.000060.000540.000680.000030.000000.00000
  W C 0.000060.000400.001450.000090.000000.00000
WNW C 0.000090.000480.000910.000000.000000.00000
 NW C 0.000060.000510.000280.000000.000000.00000
NNW C 0.000000.000340.000090.000000.000000.00000
```

(Table continued next page)

Table 7c (continued)

N	D	0.003590.004870.003250.002360.000170.00000
NNE	D	0.004610.009480.012070.005780.001280.00006
NE	D	0.004410.016120.012360.001400.000140.00003
ENE	D	0.004360.010540.002360.000230.000000.00000
E	D	0.002560.005580.001110.000060.000030.00000
ESE	D	0.001790.002930.000680.000060.000000.00000
SE	D	0.001310.003250.001960.000370.000000.00000
SSE	D	0.001250.005040.006860.004930.001220.00028
S	D	0.001420.009940.024200.020960.005270.00020
SSW	D	0.001480.012590.036620.039270.006690.00271
SW	D	0.002110.009540.019250.012240.001650.00031
WSW	D	0.002510.006610.008570.007260.001250.00006
W	D	0.003100.005780.009820.004580.000200.00000
WNW	D	0.003530.004270.008170.003250.000570.00000
NW	D	0.004160.005810.004810.002990.000280.00000
NNW	D	0.003840.004840.002620.001370.000200.00000
N	E	0.002420.004560.003640.000000.000000.00000
NNE	E	0.001850.004360.003450.000000.000000.00000
NE	E	0.001540.002650.001480.000000.000000.00000
ENE	E	0.000850.001510.000460.000000.000000.00000
E	E	0.000770.000940.000060.000000.000000.00000
ESE	E	0.000770.000140.000060.000000.000000.00000
SE	E	0.000570.000430.000090.000000.000000.00000
SSE	E	0.000400.000910.000770.000000.000000.00000
S	E	0.000650.002650.004470.000000.000000.00000
SSW	E	0.000880.005270.013150.000000.000000.00000
SW	E	0.001280.008340.016260.000000.000000.00000
WSW	E	0.001400.005980.003390.000000.000000.00000
W	E	0.002080.007800.003190.000000.000000.00000
WNW	E	0.003020.009600.003500.000000.000000.00000
NW	E	0.002900.008230.002450.000000.000000.00000
NNW	E	0.002930.005520.001620.000000.000000.00000
N	F	0.008400.014070.001540.000000.000000.00000
NNE	F	0.006830.009820.000800.000000.000000.00000
NE	F	0.003220.003190.000200.000000.000000.00000
ENE	F	0.001850.001250.000000.000000.000000.00000
E	F	0.001480.000310.000000.000000.000000.00000
ESE	F	0.001140.000090.000000.000000.000000.00000
SE	F	0.000710.000200.000000.000000.000000.00000
SSE	F	0.000940.000630.000030.000000.000000.00000
S	F	0.001080.001450.000060.000000.000000.00000
SSW	F	0.001590.005300.001080.000000.000000.00000
SW	F	0.002360.014180.006950.000000.000000.00000
WSW	F	0.003050.020470.006380.000000.000000.00000
W	F	0.006320.022670.004730.000000.000000.00000
WNW	F	0.007800.020240.000830.000000.000000.00000
NW	F	0.011280.040210.001540.000000.000000.00000
NNW	F	0.009990.021180.002990.000000.000000.00000

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