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Review of Environmental Monitoring for Radionuclides in Air at the Sandia National Laboratory

Albuquerque Center for Peace and Justice

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Revised Final Report

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Executive Summary

This report describes work performed at the Institute for Energy and Environmental Research based in Heidelberg, Germany (IFEU) under contract with the Albuquerque Center for Peace and Justice. IFEU collaborated closely with the Southwest Research and Information Center (SRIC), Albuquerque that provided a summary of detailed description of sources of airborne radionuclides.

The Sandia National Laboratories (SNL) is a major laboratory of the Department of Energy (DOE) in the nuclear weapons complex. The purpose of this report is to assess the current monitoring system for radionuclides in ambient air at SNL in order to determine whether it is at par with other state-of-the-art systems. The report presents in chapter 2 a summary of data on sources of radioactive emissions into the air at SNL. In chapter 3, existing monitoring data for radionuclides in ambient air at SNL are described. Chapter 4 provides a comparison of ambient air monitoring at selected DOE facilities, and chapter 5 provides recommendations for an improved ambient air monitoring system at SNL.

The results can be summarized as follows:

- In 2004, 15 sources of releases of radioactive materials into the air were identified by SNL. The number and magnitude of releases varied from year to year. In addition to the identified sources, there are sources of potential releases such as buried radioactive materials and nuclear weapons stored at Kirtland Air Force Base (KAFB).
- SNL conducts limited monitoring of alpha and beta activity in ambient air at four onsite locations. SNL conducts no continuous monitoring for tritium in ambient air. Analytical procedures and reporting changed over time. The reported maximum concentrations exceed the levels for environmental compliance in 40CFR61 App. E, Table 2 for several radionuclides between 2000 and 2005.
- Given the uncertainties in the emission estimates and the likelihood of unidentified diffuse sources of radionuclide emissions at SNL, a detailed investigation of the raw data would be required for a more refined assessment.
- SNL excludes its operations as a source of measured radionuclide concentrations. For example, the 2004 Annual Site Environmental Report states, *"It should be noted that the radionuclides are naturally occurring or remnants, and are not emitted from sources at the SNL/NM."* This statement is not supported by the facts. Some radionuclides such as cesium-137 and uranium-238 that measured in air are also released from SNL as is evident by SNL's own emission reporting. In addition, the analysis of ambient air samples does not allow differentiating between natural background and contributions from SNL because there is no background monitoring station.
- The New Mexico Environment Department (NMED) carried out confirmatory monitoring at four locations including tritium; the results for the years 1997 to 2000 were not published by NMED until 2004.

- The comparison of SNL's ambient air monitoring with that at six other selected DOE sites[1] indicates no definitive relationship between the reported release and the number of monitoring locations. At Pantex, TX, reported tritium emissions for 2004 were a factor of 6,800 lower than at SNL, yet tritium monitoring of ambient air is carried out at a total of 27 locations onsite and at the plant perimeter.
- Similarly, ambient levels of alpha and beta particulate activity in air are measured at more locations at other DOE sites even though the reported releases were often lower than those at SNL (for alpha: LANL, LLNL, BNL and Pantex; beta: LLNL and BNL).
- Specifically, alpha and beta activity in ambient air is monitored at only four locations at SNL as compared to 46 locations at LANL, even though SNL reported larger releases of alpha activity than LANL. There is no continuous monitoring of tritium in ambient air at SNL as compared to 46 locations that are monitored at LANL. It should be self-evident that residents in the Albuquerque metropolitan area are entitled to a level of information and assurance equivalent to residents in the vicinity of other DOE facilities, especially when compared to the Los Alamos National Laboratory (see Table 4-4 on page 25 for a comparison of key data for SNL and LANL).
- A consistent and comprehensive monitoring program of for radionuclides in ambient air at and around SNL is highly recommended for a variety of reasons: (a) to demonstrate compliance with regulatory standards, (b) to be better prepared for the releases of radioactive materials in case of accidents or disasters, and (c) to establish a level of information and assurance at SNL that is equivalent to that at other DOE facilities. Isotope specific analysis for strontium-90, americium-241 and plutonium-239/240 is highly recommended.
- A minimum network of 16 stations should be placed on the plant perimeter in order to cover all wind directions. For the adequate determination of background, an additional number of four stations is recommended. Additional stations should be placed as needed as is the case at Los Alamos National Laboratory where monitoring for radioactive materials is carried out in a total of 46 stations. A precise cost estimate for the additional sampling stations is beyond the scope of this report. If an additional 20 stations for tritium and 16 alpha/beta stations with isotope-specific analysis would be installed, the additional costs are estimated to be below one million US $ per year.
- Further, the NMED monitoring program should be expanded to provide an independent verification of SNL data. NMED should provide isotope specific analysis of their data and correct tritium sampling data for absolute humidity.
- An independent audit of the SNL monitoring activities is highly recommended.
- Since reporting of different radionuclides is inconsistent (not all are reported for all years), a detailed investigation should be carried out to determine the necessary analytical procedures to identify all relevant radionuclides.
- The next step in the process should be a detailed investigation into the design of a monitoring system (function and density of stations) that is equivalent to the one at LANL and could be relied upon to demonstrate compliance with 40CFR61 Subpart 61.

[1] The six DOE sites are: Pantex, TX; Brookhaven National Laboratory, NY; Lawrence Livermore National Laboratory, CA; Los Alamos National Laboratoy, NM; Idaho National Engineering and Environmental Laboratory, ID; and Savannah River Site, SC.

.Contents

1 Introduction

The Sandia National Laboratories (SNL) is a major laboratory of the Department of Energy (DOE) in the nuclear weapons complex. Past and present operations have resulted in the contamination of air, soil, biosphere, groundwater and surface water with radioactive and other pollutants that pose a risk to human health and the environment. This report focuses on the monitoring of radioactive pollutants that are or could be present in ambient air, i.e. outside breathable air. Ambient air monitoring can be conducted either close to potential sources of emissions on the property of Sandia National Laboratory itself, on the perimeter of the plant, or in greater distance. This report provides an assessment of the current monitoring system for radionuclides in ambient air at SNL. The following issues are addressed: (a) whether monitoring at SNL is at par with state-of-the-art systems, and (b) whether it provides for detection of unmonitored and/or short-term releases from sources at the site.

Chapter 2 describes existing and potential sources for airborne radionuclides at and around SNL and presents the official estimates of radionuclide releases and resulting radiation exposures to members of the public.

Chapter 3 compares the existing monitoring system for radionuclides in air at SNL with the systems that exist at other DOE sites.

Chapter 4 evaluates the adequacy of the monitoring system with respect to detect unmonitored and/or short-term releases and the compliance with regulatory requirements.

Chapter 5 provides recommendations based on the analysis.

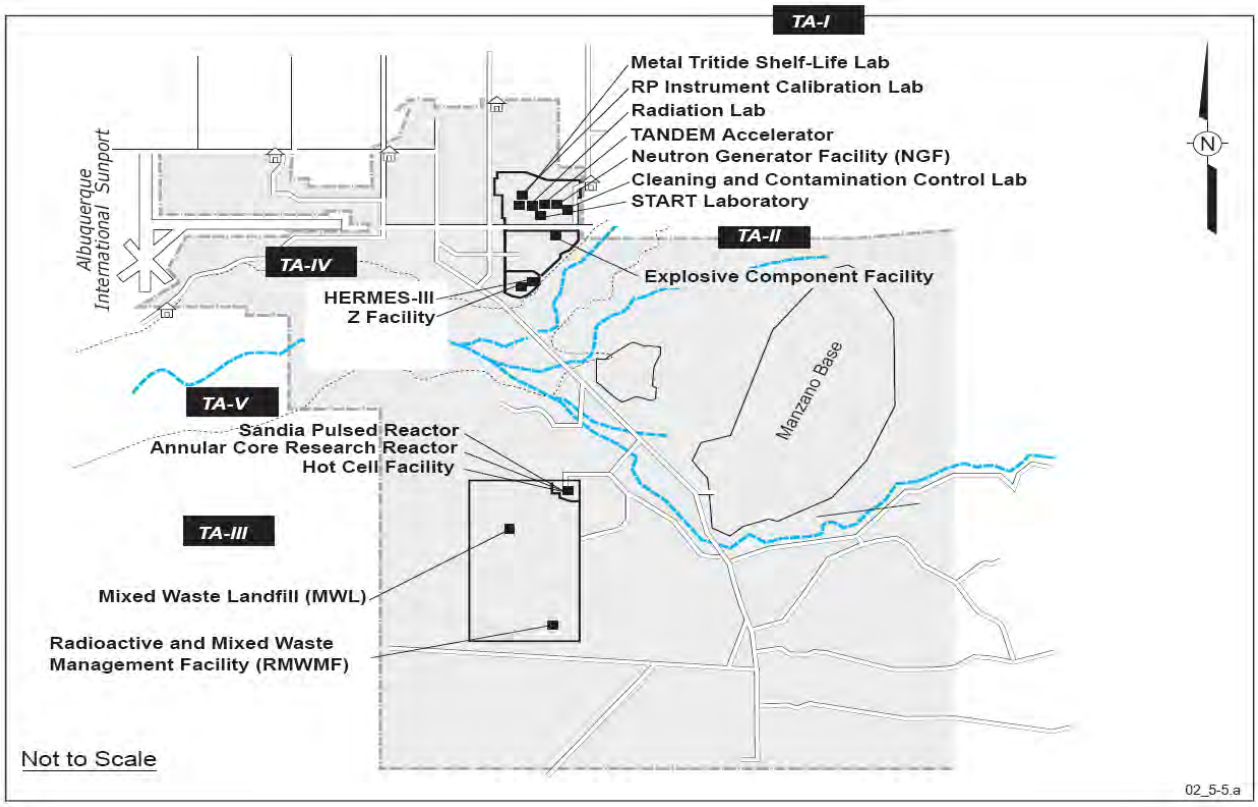
2 Sources of airborne radionuclides at SNL

A detailed description of sources of airborne radionuclides is provided in a report of the Southwest Research and Information Center – SRIC (Robinson 2006). That report was prepared for the Albuquerque Center for Peace and Justice as part of the Sandia Labs Awareness Project as well. The SRIC report includes information based on the SNL Site Environmental Report for 2005 (SNL 2006a). This chapter provides a brief summary of key information and data that was used in the review of the environmental monitoring system. The review covers officially reported releases as well potential releases that go unreported. The reference year 2004 was selected because data for other DOE facilities was available for that year as well (see chapter 4).

2.1 Reported releases of airborne radionuclides

SNL is required to file an annual report in order to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants under 40 CFR 61, Subpart H. In the year 2004, 15 facilities were identified in the assessment. Their locations are shown in Figure 2-1. The airborne releases that were reported for 2004 are listed in Table 2-1.

Figure 2-1 Locations of the 15 facilities at SNL/NM that provided radionuclide release inventories in 2004 (source: SNL, 2005a)



A major component of reported releases of radionuclides is tritium. Table 2-2 provides a summary of reported tritium emissions over time; a graphical presentation is shown in Figure 2-2. In 2001 and 2002, the main tritium emissions were reported from the Neutron Generator

Facility (NGF), from 2003 onwards, the Radioactive and Mixed Waste Management Facility (RMWMF) dominated the releases.

Table 2-1 Summary of reported releases of airborne radionuclides from sources at SNL in 2004 (SNL, 2005a)

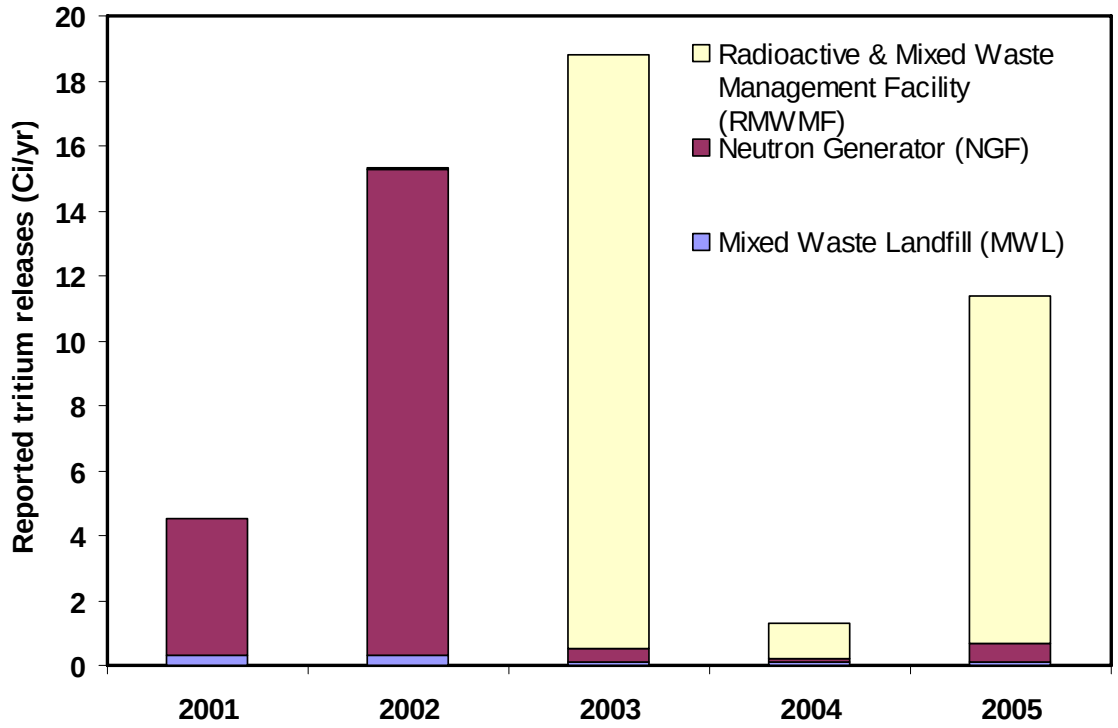
TA	Facility Name	Monitoring Method*	Used in Dose Calculation?	Radionuclide	Reported Release (Ci/yr)
I	Tomography and Radio-nuclide Transport Laboratory (START)	Calculation	No	Co-60 Cs-137	2.5E-08 5.0E-09
I	Radiation Laboratory	Calculation	No	H-3 N-13 Ar-41	1.0E-05 1.0E-06 1.0E-09
I	Calibration Laboratory	Calculation	No	H-3	6.9E-05
I	Neutron Generator (NGF)	Continuous	Yes	H-3	0.11
I	TANDEM Accelerator	Calculation	No	H-3	1.0E-05
I	Metal Tritide Shelf-Life Laboratory	Calculation	No	H-3	5.0E-09
I	Cleaning and Contamination Control Laboratory (CCCL)	Calculation	No	C-14	2.7E-04
II	Explosive Components Facility (ECF)	Calculation	No	H-3	8.4E-04
III	Mixed Waste Landfill (MWL)	Periodic	Yes	H-3	0.09
III	Radioactive & Mixed Waste Management Facility (RMWMF)	Continuous	Yes	H-3 Am-241 Sr-90 Cs-137	1.1 1.0E-05 3.9E-07 3.6E-08
IV	HERMES III	Periodic	No	N-13 O-15	1.3E-03 1.3E-04
IV	Z-Facility (Accelerator)	Calculation	No	H-3 U-238 U-234 U-235	1.6E-07 2.0E-07 9.2E-09 2.1E-09
V	Hot Cell Facility (HCF)	Periodic	Yes	N/A	N/A
V	Annular Core Research Reactor (ACRR)	Periodic	Yes	Ar-41	4.5
V	Sandia Pulsed Reactor (SPR)	Periodic	Yes	N/A	N/A

NOTE: *Monitoring Method: Periodic = Based on periodic measurements
Calculation = Calculated from known parameters
Continuous = Based on continuous air monitoring results
HERMES III = High Energy Radiation Megavolt Electron Source III
Ci/yr = curies per year
TA= Technical Area
N/A = not available

Table 2-2 Reported releases of tritium at SNL, 2001 to 2005 (Ci/yr) (Sources: SNL 2002, SNL 2003, SNL 2004, SNL 2005, and SNL 2006)

TA	Facility Name	2001	2002	2003	2004	2005
I	Tomography and Radionuclide Transport (START) Laboratory					
I	Radiation Laboratory	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
I	Calibration Laboratory (RPICL)	2.75E-04	6.60E-05	2.00E-04	6.90E-05	2.20E-05
I	Neutron Generator (NGF)	4.20E+00	1.50E+01	4.10E-01	1.10E-01	5.60E-01
I	TANDEM Accelerator	1.00E-06	1.00E-05	1.00E-05	1.00E-05	1.00E-05
I	Metal Tritide Shelf-Life Laboratory (MTSLL)	5.00E-09	5.00E-09	5.00E-09	5.00E-09	< 5.0E-09
I	Cleaning and Contamination Control Laboratory (CCCL)					
II	Explosive Components Facility (ECF)	4.65E-04	1.13E-03		8.40E-04	8.40E-04
II	Radiation Protection Sample Diagnostic Facility (RPSD)					1.20E-08
III	Mixed Waste Landfill (MWL)	2.94E-01	2.94E-01	9.00E-02	9.00E-02	9.00E-02
III	Radioactive & Mixed Waste Management Facility (RMWMF)	6.43E-03	2.50E-02	1.83E+01	1.10E+00	1.07E+01
III	Chemical Waste Landfill (CWL)	1.31E-05	9.85E-02			
III	Corrective Action Management Unit (CAMU)		8.00E-04			
IV	HERMES III					
IV	Short Pulsed High Intensity X-Radiator Facility (SPHINX)					
IV	Saturn Facility					
IV	Z-Facility (Accelerator)		9.70E-09			6.65E-03
V	Hot Cell Facility (HCF)					
V	Annular Core Research Reactor (ACRR)					
V	Sandia Pulsed Reactor (SPR)					
CTF	Shock Thermodynamic Applied Research Facility (STAR)					

Figure 2-2 Reported releases of tritium from major sources at SNL, 2001 - 2005



Reported quantities of airborne radionuclide releases varied by orders of magnitude over the years as summarized in Table 2-3. For example, the reported uranium releases for 2002 were more than seven orders of magnitude larger than for 2003. Releases of transuranics such as americium-241 or plutonium-239 were reported for all years.

Table 2-3 Reported releases of selected airborne radionuclides at SNL, 2001 to 2005 (Ci/yr) (Sources: SNL 2002, SNL 2003, SNL 2004, SNL 2005, and SNL 2006)

Facility Name	2001	2002	2003	2004	2005
Tritium (H-3)	4.50E+00	1.54E+01	1.88E+01	1.30E+00	1.14E+01
Argon-41 (Ar-41)	1.62E+01	1.06E+01	6.60E+00	4.50E+00	4.87E+00
Uranium	1.13E-06	1.43E-06	1.00E-13	4.19E-07	2.61E-10
Transuranics (americium, plutonium)	3.07E-07	2.53E-07	1.40E-05	1.00E-05	2.16E-05

2.2 Potential releases of airborne radionuclides that are not reported

In addition to the reported sources of airborne radioactive releases that were reported in the NESHAP Compliance reports, there are other potential sources at and around SNL.

Nuclear warheads at KAFB
There is no information available with respect to the tritium inventory at SNL. It is likely that large amounts of tritium are contained in the nuclear weapons at KAFB. According to Zerriffi (1996), one warhead is assumed to require a minimum of three grams of tritium but contains an average of approximately four grams of tritium. One gram of tritium is equivalent to about 10,000 curies. It was estimated that 2,450 nuclear warheads are stored at KAFB (Arkin 1998). The authors conclude:

> *"Because of a backlog of warheads awaiting dismantlement at the DOE's Pantex facility near Amarillo, TX, the Kirtland Underground Munitions Storage Complex (KUMSC) at Kirtland AFB, Albuquerque, New Mexico has emerged as number one in U.S. nuclear warheads deployed in a single location, a rise from 2nd place in 1992 and 11th place in 1985."* (Arkin 1998)

If four grams of tritium in each of the 2,450 warheads is assumed to be stored at KAFB amounts, the tritium inventory would be about 98 million curies.

Diffuse radioactivity from historic releases
For many years, the Mixed Waste Landfill (MWL) and Chemical Waste Landfill (CWL) and other facilities have been a potential source of releases of radioactive material into the air. It is likely that radioactive particles were deposited on onsite soil. There is no published inventory of such releases and the location of their deposition. They pose a potential of resuspension especially at high wind speeds.

Storage of irradiated reactor fuel
Another potential source of radionuclide emissions into the air is reactor irradiated nuclear material including plutonium, enriched uranium and other radionuclides. The New Mexico Environment department (NMED) requested information about this issue in a March 16, 2006 letter to SNL (NMED, 2006). Pending the outcome of this investigation, it is wise to assume that additional sources of airborne radionuclide emissions exist.

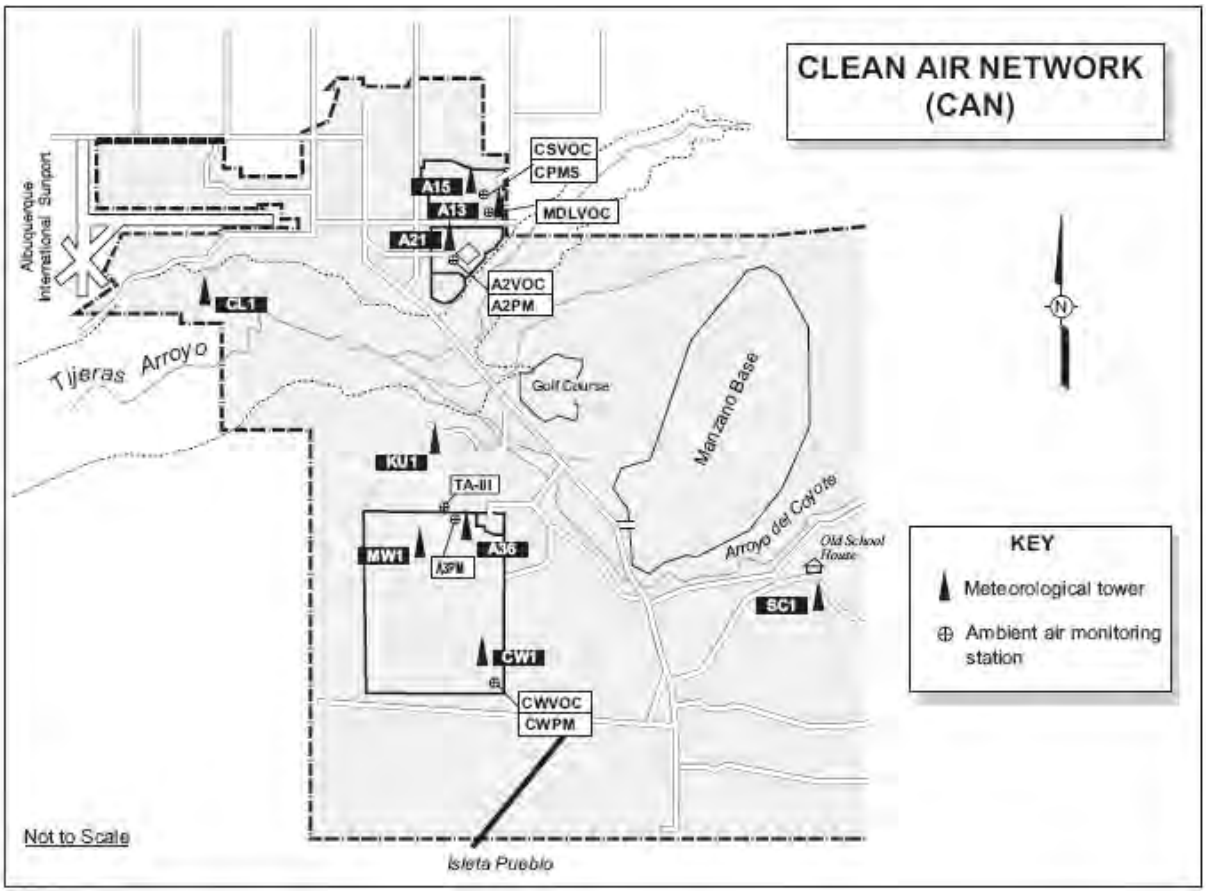
A comprehensive program of ambient air monitoring for radionuclides would allow identifying diffuse releases if they occur and provide information in case of accidents such as tritium releases from stored nuclear weapons.

3 Ambient air monitoring at SNL

3.1 Ambient air monitoring by SNL

According to the 2004 and 2005 Environmental Reports (SNL, 2005a, 2006a), Sandia National Laboratory carried out monitoring for selected radionuclides in particulate form in ambient air at four onsite locations (A2PM, CPMS, AWPM and A3PM) that are identified in Figure 3-1.

Figure 3-1 Sampling locations radionuclides in air at SNL as of 2005 (SNL, 2006a)



The results of the analysis for 2004 and 2005 are summarized in Tables 3-1 and 3-2. In order to determine compliance, measured concentrations of radionuclides in air were compared to the concentration levels for environmental compliance in 40CFR61 App. E, Table 2. The SNL Environmental Reports provide only a comparison to the less strict threshold limit values (TLV) that are based on DOE derived concentrations guideline (DCG) and "assist in the control of health hazards". For uranium-238, the TLV value is 0.1 pCi/m^3 or a factor of 12 larger than the 40CFR61 levels for environmental compliance (0.0083 pCi/m^3). The TLV value is not legally binding. The 40CFR61 levels for environmental compliance is only binding if SNL would select environmental concentration measurements to determine compliance with 40CFR61 Subpart H.

The following observations can be made for 2004:

- The maximum reported concentration of gross alpha activity is 470% of the level for environmental compliance in 40CFR61 App. E, Table 2 for americium-241 (Am-241). Am-241 was selected because it is the most hazardous alpha emitter for which releases into the air were reported by SNL in 2004.
- The maximum reported concentration of gross beta activity is 95% of the level for environmental compliance in 40CFR61 App. E, Table 2 for strontium-90 (Sr-90). Sr-90 was selected because it is the most hazardous beta emitter for which releases into the air were reported by SNL in 2004.
- The reported maximum concentrations of thorium-232 and uranium-238 exceed the levels for environmental compliance in 40CFR61 App. E, Table 2.

Table 3-1 Reported concentrations of radionuclides in air at SNL's onsite stations in 2004 (pCi/m^3) (Source: SNL 2005a); values exceeding the 40CFR61 environmental compliance criterion in **bold** *(conservative criteria used: Am-241 for gross alpha and Sr-90 for gross beta activity)*

Analyte	Monitoring location				Environmental compliance level 40CFR61 App. E, Table 2	Ratio of max. concentration to 40CFR20 compliance level
	A2PM	CPMS	CWPM	A3PM		
Gross Alpha	**0.004**	**0.009**	**0.007**	**0.004**	0.0019 [a)]	474%
Gross Beta	0.015	0.016	0.017	0.018	0.019 [b)]	95%
Beryllium-7	0.145	0.159	0.132	0.153	N/A	--
Bismuth-214	0.002	0.002	0.002	0.003	140	< 1%
Cesium-137	0.001	0.004	0.001	ND	0.019	21%
Lead-212	0.002	0.001	0.002	0.002	6.3	< 1%
Lead-214	0.002	0.001	0.002	0.001	120	< 1%
Potassium-40	0.013	0.011	0.01	0.006	N/A	--
Radium-226	0.002	0.002	0.002	0.003	0.0033	91%
Radium-228	0.002	0.002	0.004	0.002	0.0059	68%
Thorium-232	**0.002**	**0.001**	**0.002**	**0.002**	0.00062	323%
Thorium-234	0.046	0.054	0.022	0.054	2.2	2%
Uranium-238	**0.046**	**0.054**	**0.022**	**0.054**	0.0083	651%

ND = not detected, N/A = not available; a) conservatively assuming Am-241; b) conservatively assuming Sr-90

The following observations can be made for 2005:

- SNL commented on the maximum reported concentration of U-238 of 0.1906 pCi/m^3 at A2PM that exceeds the concentration level for environmental compliance by a factor of 23. According to SNL, the reported value was based on the average of four positive samples (all other samples were below the detection limit), and assuming that this value is representative for the average for the entire year. Since each sample was taken over a 6-day period, the four positive samples represent 24 days or 6.6% of the year. If there was absolute no U-238 at all in the other samples during the remainder of the year, the correct annual average would be 0.013 pCi/m^3 or 150% of the 40CFR61 concentration

levels for environmental compliance. In reality, uranium would be present even in samples below the detection limit that would have to be accounted for. Therefore, the maximum reported concentration of U-238 exceeds the levels for environmental compliance in 40CFR61 App. E, Table 2 even after the correction of the conservative averaging method.

- Likewise, reported maximum concentrations of radium-228, thorium-232 and uranium-235 exceed the levels for environmental compliance in 40CFR61 App. E, Table 2. The SNL report did not provide information on the averaging method for these radionuclides. A detailed analysis would require more information.
- The maximum reported concentrations of gross alpha and gross beta activity exceed the levels for environmental compliance in 40CFR61 App. E, Table 2 if one conservatively assumes that the concentration is due to the most hazardous radionuclide in that group that was reported to be released from SNL (Am-241 for alpha and Sr-90 for beta activity). Isotope specific analysis for Am-241, Sr-90 as well as for Pu-239/240 would be required to determine whether the levels for environmental compliance are exceeded or not.

Table 3-2 Reported concentrations of radionuclides in air at SNL's onsite stations in 2005 (pCi/m^3) (Sources: SNL 2006a); values exceeding the 40CFR61 environmental compliance criterion in **bold** *(conservative criteria used: Am-241 for gross alpha and Sr-90 for gross beta activity)*

Analyte	Monitoring location				Environmental compliance level 40CFR61 App. E, Table 2	Ratio of max. concentration to 40CFR20 compliance level
	A2PM	CPMS	CWPM	A3PM		
Gross Alpha	**0.0062**	**0.0061**	**0.0056**	**0.0047**	0.0019 [a)]	326%
Gross Beta	0.0181	**0.0204**	0.0182	**0.0197**	0.019 [b)]	107%
Actinium-228	0.0052	0.0061		0.0036	3.7	< 1%
Beryllium-7	0.1467	0.1401	0.1531	0.1367	N/A	--
Bismuth-214	ND	0.0017	0.0024	0.0024	140	< 1%
Chromium-51	ND	0.0200	ND	ND	31	< 1%
Cobalt-60	ND	0.0001	ND	0.0012	0.017	7%
Lead-212	0.0021	0.0023	0.0025	ND	6.3	< 1%
Lead-214	0.0019	ND	0.0021	0.0051	120	< 1%
Niobium-95	ND	0.0020	ND	0.0009	N/A	--
Potassium-40	0.0061	0.0083	0.0037	0.0269	N/A	--
Radium-224	0.0195	0.0103	0.0344	0.0261	N/A	--
Radium-226	ND	0.0017	0.0024	0.0024	0.0033	73%
Radium-228	0.0052	**0.0061**	ND	0.0036	0.0059	103%
Strontium-85	ND	ND	0.0003	0.0015	1.8	< 1%
Thallium-208	0.0010	0.0007	0.0015	0.0009	N/A	--
Thorium-232	**0.0021**	**0.0022**	**0.0036**	ND	0.00062	581%
Thorium-234	0.1906	0.0102	0.0327	0.0807	2.2	9%
Uranium-235	**0.0119**	ND	ND	0.0058	0.0071	168%
Uranium-238	**0.1906**	**0.0102**	**0.0327**	**0.0807**	0.0083	2296%

ND = not detected, N/A = not available; a) conservatively assuming Am-241; b) conservatively assuming Sr-90

Air monitoring data is also available for the years 2000, 2002 and 2003 (SNL 2001, SNL 2002a, SNL 2003a). Radionuclide data was not reported for 2001 "[d]ue to the lack of appropriate monthly blanks and data quality problems" (SNL 2002). The stations A2PM, CPMS, AWPM were sampled during all these years, the data is presented in Tables 3-3, Table 3-4 and Table 3-5. A fourth station sampled, labeled KUOM in 2000, was moved to KSSPM in 2002&2003 and then to A3PM in 2004.

A comparison of reported concentrations indicates that the number of radioactive analytes increased over time (example CPWS: from 5 (in 2000), to 9 (in 2002), 12 (in 2003), 13 (in 2004), to 17 (in 2005).

Table 3-3 Reported concentrations of radionuclides in air at SNL's A2PM station, 2000 through 2005 (pCi/m^3); values exceeding the 40CFR61 environmental compliance criterion in **bold** *(conservative criteria used: Am-241 for gross alpha and Sr-90 for gross beta activity)*

Analyte	2000	2002	2003	2004	2005
Gross Alpha	**0.02085**	**0.00453**	**0.0034**	**0.004**	**0.0062**
Gross Beta	0.00995	0.01289	0.01584	0.015	0.0181
Actinium-228					0.0052
Beryllium-7	0.1097	0.10899	0.10658	0.145	0.1467
Bismuth-214		0.00139	0.00438	0.002	ND
Chromium-51					ND
Cobalt-60					ND
Cesium-137			0.00047	0.001	
Lead-212			0.00066	0.002	0.0021
Lead-214		0.00109	0.00076	0.002	0.0019
Niobium-95					ND
Potassium-40	0.02098	0.01033	0.01429		0.0061
Radium-224		0.00029		0.013	0.0195
Radium-226		0.00142	0.00241	0.002	ND
Radium-228				0.002	0.0052
Strontium-85					ND
Thallium-208		0.00128			0.001
Thorium-232			ND	**0.002**	**0.0021**
Thorium-234			0.02669		0.1906
Uranium-235				**0.046**	**0.0119**
Uranium-238			**0.0481**	**0.046**	**0.1906**
Uranium, µg/m^3	0.00002	0.00002			

For three stations A2PM, CPMS, AWPM, the time series data for gross alpha activity, gross beta activity, uranium-238, radium-226, and thorium-232 is compared in Figures 3-2 through 3-6. Uranium values in µg/m^3 were converted to pCi/m^3 of U-238 using the conversion factor for natural uranium of 0.33 pCi/µg.

Figure 3-2 Reported levels of gross alpha activity at ambient air sampling locations at SNL, 2000 through 2005

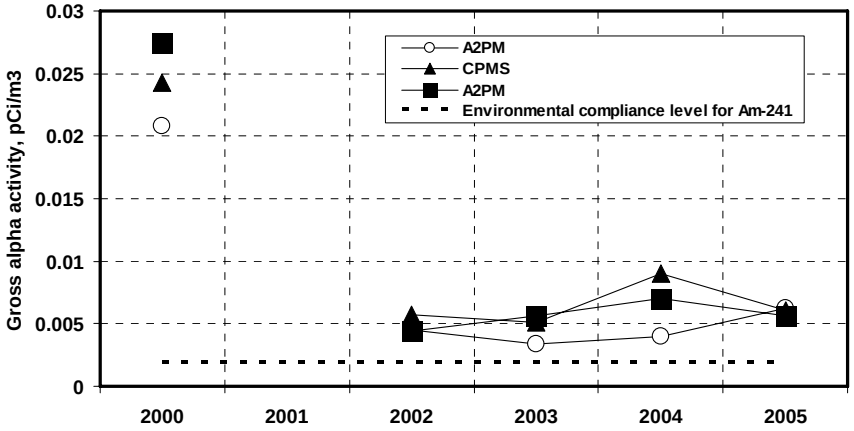


Figure 3-3 Reported levels of gross beta activity at ambient air sampling locations at SNL, 2000 through 2005

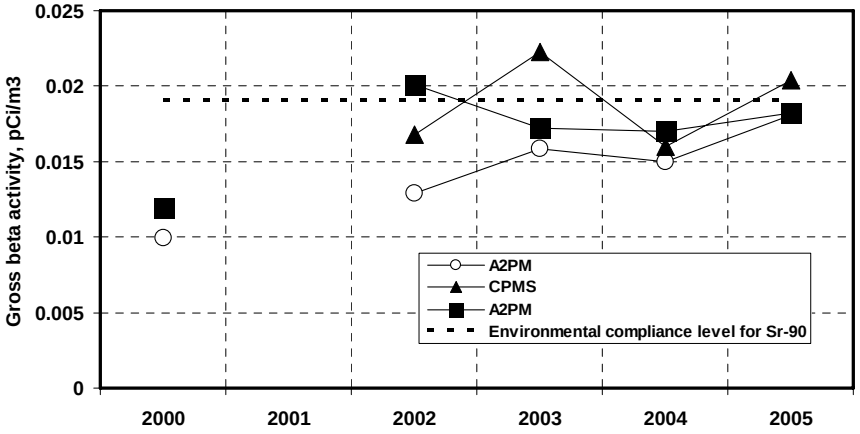


Figure 3-4 Reported levels of uranium-238 in air at ambient air sampling locations at SNL, 2000 through 2005

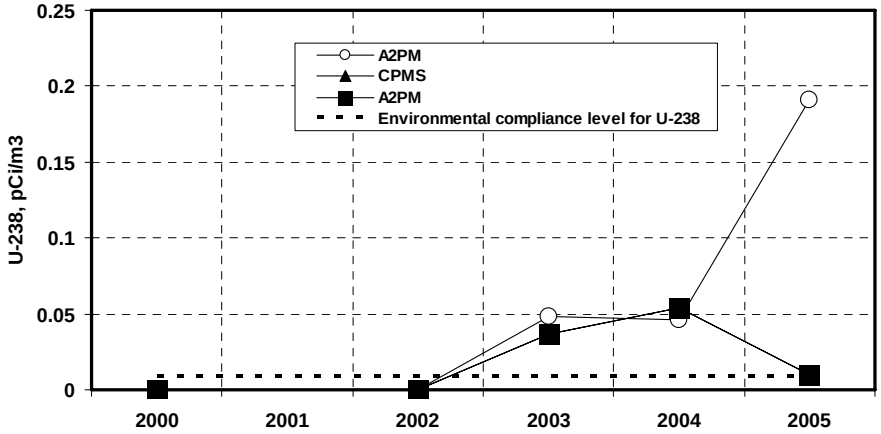


Figure 3-5 Reported levels of Ra-226 at ambient air sampling locations at SNL, 2000 through 2005

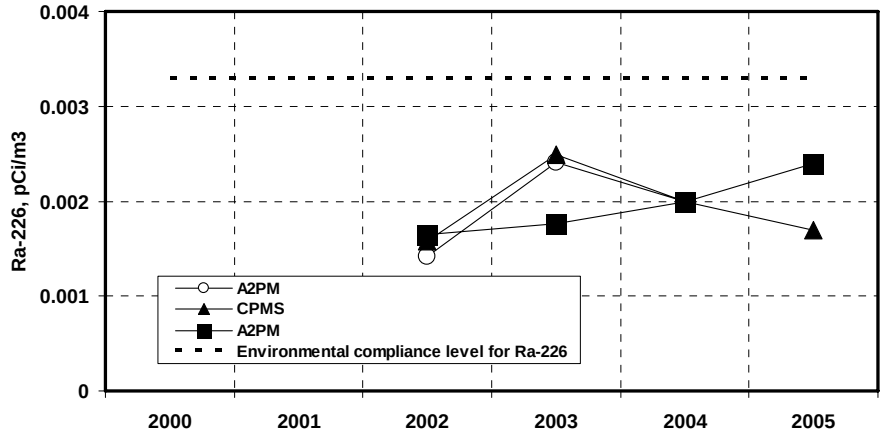
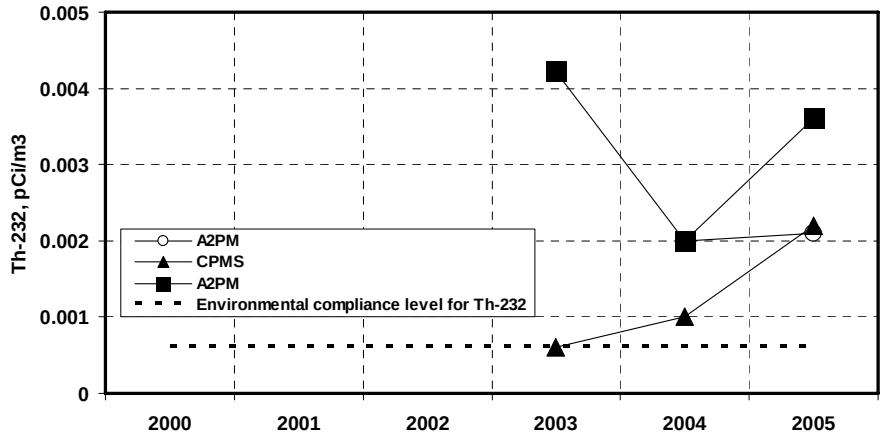


Figure 3-6 Reported levels of Th-232 at ambient air sampling locations at SNL, 2000 through 2005



The following observations can be made based on the time-series data:

- Reported levels or alpha activity in air were significantly larger in 2000 compared to 2002 through 2005. It is unclear whether this is due to changes in analytical procedures, based on natural variability or due to impacts from SNL operations. In all years, the levels exceeded the levels for environmental compliance in 40CFR61 App. E, Table 2 for americium-241.
- Reported levels or beta activity in air were significantly smaller in 2000 compared to 2002 through 2005. It is unclear whether this is due to changes in analytical procedures, based on natural variability or due to impacts from SNL operations. In 2002 and 2005, the levels exceeded the levels for environmental compliance in 40CFR61 App. E, Table 2 for strontium-90.
- Reported levels or uranium-238 were significantly smaller in 2000 and 2002 compared to 2003 through 2005. It is unclear whether this is due to changes in procedures, based on natural variability or due to impacts from SNL operations. In 2003, 2004 and 2005, the

levels exceeded the levels for environmental compliance in 40CFR61 App. E, Table 2 for uranium-238.

- Reporting of radium-226 levels started in 2002. The reported concentrations were well below the levels for environmental compliance in 40CFR61 App. E, Table 2 for radium-226.
- Reporting of thorium-232 levels started in 2003. Levels at station A2PM was significantly larger than those reported for the other stations. With the exception of the 2003 level at the CPMS station, all reported values exceeded the levels for environmental compliance in 40CFR61 App. E, Table 2 for thorium-232.

Table 3-4 Reported concentrations of radionuclides in air at SNL's CPMS station, 2000 through 2005 (pCi/m^3); values exceeding the 40CFR61 environmental compliance criterion in **bold** *(conservative criteria used: Am-241 for gross alpha and Sr-90 for gross beta activity)*

Analyte	2000	2002	2003	2004	2005
Gross Alpha	**0.02429**	**0.00568**	**0.00514**	**0.009**	**0.0061**
Gross Beta	0.01193	0.01679	**0.02223**	0.016	**0.0204**
Actinium-228					0.0061
Beryllium-7	0.08831	0.09856	0.13001	0.159	0.1401
Bismuth-214		0.00324	0.00095		0.0017
Chromium-51					0.02
Cobalt-60					0.0001
Cesium-137			0.00076	0.004	
Lead-212			0.00062	0.001	0.0023
Lead-214		0.00131	0.00176	0.001	ND
Niobium-95					0.002
Potassium-40	0.01879	0.00838	0.00837	0.011	0.0083
Radium-224					0.0103
Radium-226		0.00158	0.00249	0.002	0.0017
Radium-228				0.002	**0.0061**
Strontium-85					ND
Thallium-208		0.0009			0.0007
Thorium-232			0.00061	**0.001**	**0.0022**
Thorium-234			0.04718	0.054	0.0102
Uranium-235					ND
Uranium-238			**0.03693**	**0.054**	**0.0102**
Uranium, $\mu g/m^3$	0.00002	0.00003			

Table 3-5 Reported concentrations of radionuclides in air at SNL's CWPM station, 2000 through 2005 (pCi/m^3); values exceeding the 40CFR61 environmental compliance criterion in **bold** *(conservative criteria used: Am-241 for gross alpha and Sr-90 for gross beta activity)*

Analyte	2000	2002	2003	2004	2005
Gross Alpha	**0.0275**	**0.00446**	**0.00561**	**0.007**	**0.0056**
Gross Beta	0.01193	**0.02011**	0.0172	0.017	0.0182
Actinium-228					
Beryllium-7	0.06119	0.08204	0.11831	0.132	0.1531
Bismuth-214		0.00097	0.00131	0.002	0.0024
Chromium-51					ND
Cobalt-60					ND
Cesium-137		0.01113	ND	0.001	
Lead-212			ND	0.002	0.0025
Lead-214			0.00301	0.002	0.0021
Niobium-95					ND
Potassium-40	0.01386	0.004	0.0061	0.01	0.0037
Radium-224					0.0344
Radium-226		0.00165	0.00176	0.002	0.0024
Radium-228		0.00055		0.004	ND
Strontium-85					0.0003
Thallium-208		0.00089			0.0015
Thorium-232			**0.00423**	**0.002**	**0.0036**
Thorium-234			0.01616	0.022	0.0327
Uranium-235					ND
Uranium-238			**0.0206**	**0.022**	**0.0327**
Uranium, µg/m^3	0.00002	0.00001			

Table 3-6 Years in which reported concentrations of identified radiocnuclides in ambient air exceeded 40CFR61 environmental compliance levels

Radionuclide	Years in which concentrations in ambient air reported by SNL exceeded **40CFR61 environmental compliance levels at least in one location**
Uranium-238	2002, 2004, 2005
Radium-226	none
Thorium-232	2003, 2004, 2005

SNL excludes its operations as a source of measured radionuclide concentrations. For example, the 2004 Site Environmental Report states, "It should be noted that the radionuclides are naturally occurring or remnants, and are not emitted from sources at the SNL/NM." (SNL 2005a, p.5-8). This is statement is not supported by the facts. Some radionuclides such as cesium-137

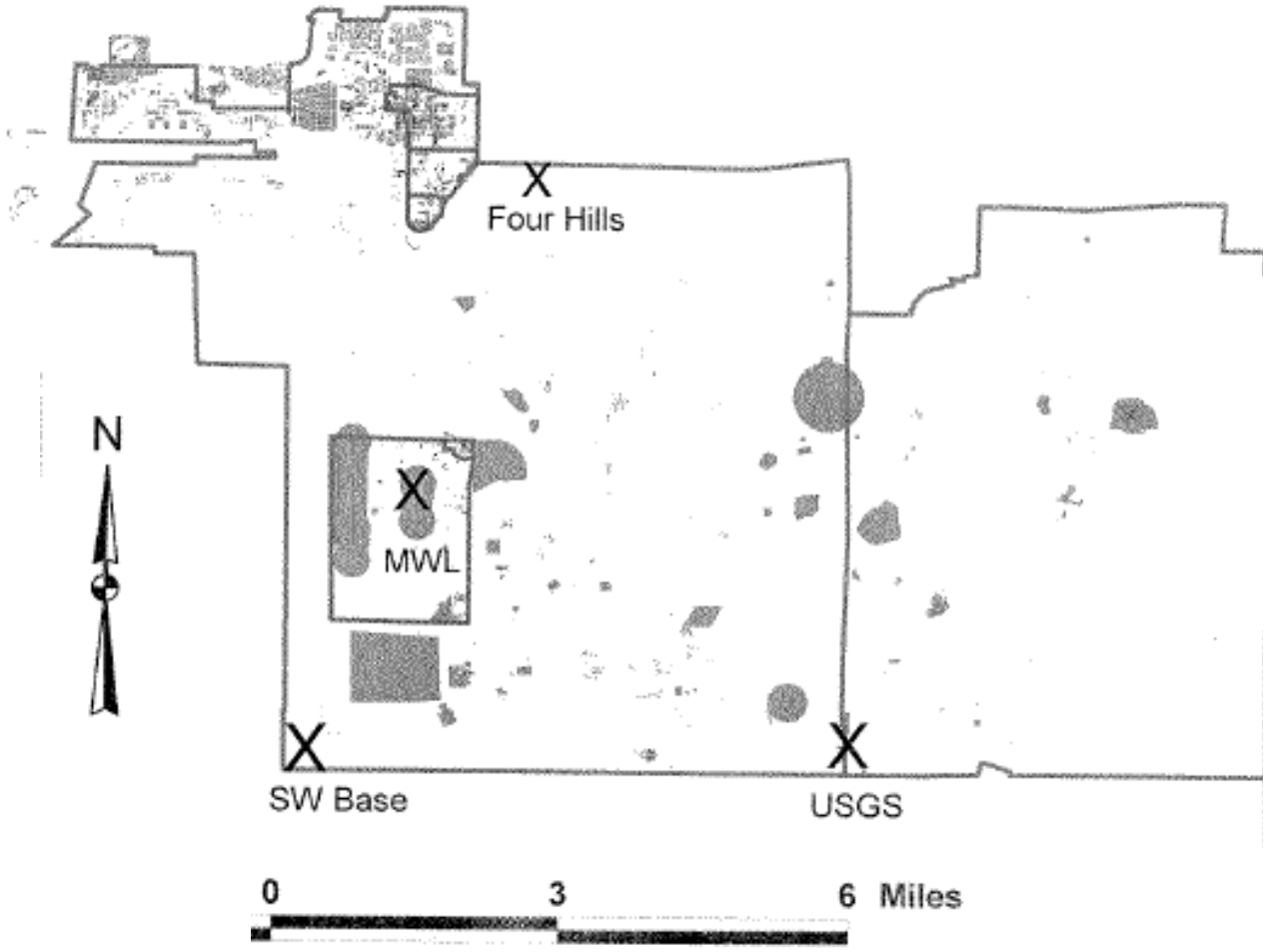
and uranium-238 that measured in air are also released from SNLs as is evident by their own emission reporting (see Table 2-1). The analysis of ambient air samples does not allow differentiating between natural background and contributions from SNL.

Given the uncertainties in the emission estimates and the likelihood of unidentified diffuse sources of radionuclide emissions at SNL, a detailed investigation of the raw data would be required for a more refined assessment. Isotope specific analysis for Am-241 and Sr-90 would be required to determine whether the levels for environmental compliance for these radionuclides were exceeded or not. It would be appropriate to perform isotope specific analysis on other transuranic isotopes such as plutonium as well since plutonium releases were reported for 2005 (SNL 2006a).

3.2 Ambient air monitoring by NMED

Confirmatory monitoring was carried out by the New Mexico Environment Department DOE Oversight Bureau. Results for the years 1997 to 2000 were published in 2004 (NMED 2004). Monitoring took place at three perimeter stations (Four Hills, United States Geological Service - USGS, KAFB Fire Station #4 at Southwest Base – SW Base) and a background station (University of New Mexico - UNM). As of 2002, the UNM background station was moved to SNL's Mixed Waste Landfill (NMED; 2004a), four stations were still in operation in 2003 (NMED, 2005).

Figure 3-7 NMED air sampling locations at SNL as of 2002



According to NMED, air samplers were continuously operated to collect airborne particulate matter on a glass fiber filter and water vapor into a silica gel filled cartridge. Quarterly, the filters are analyzed for gross radioactivity, isotopic radioactivity, gamma spectroscopy and the silica gels are analyzed for tritium in water vapor. As of 2002, uranium and plutonium analysis was

performed on particulates collected at the SW Base and Mixed Waste Landfill station. The results of isotope specific analysis other than tritium are not available through the website (http://www.nmenv.state.nm.us/DOE_Oversight/pubs.htm) and cannot be found in any published NMED report. The results of gross alpha/beta and tritium activity for the years 1997 to 2000 were published in the year 2004 and are summarized in Table 3-6.

Table 3-6 Results of NMED monitoring of ambient air around SNL, 1997 to 2000 (pCi/m^3) (Sources: NMED 2004)

Year	*Location*			
	Four Hills	**USGS**	**SW Base**	**UNM**
	Gross alpha activity			
1997	0.00635	0.00438	0.00427	0.00578
1998	0.00424	0.00400	0.00424	0.00435
1999	0.00295	0.00362	0.00432	0.00367
2000	0.00332	0.00462	0.00443	0.00267
	Gross beta activity			
1997	0.0121	0.0122	0.0115	0.0125
1998	0.0144	0.0110	0.0152	0.0151
1999	0.0176	0.0195	0.0172	0.0156
2000	0.0144	0.0145	0.0163	0.0130
	Tritium activity			
1997	11	10.5	11.7	13.2
1998	2.27	4.69	5.43	2.63
1999	3.33	1.62	1.93	1.83
2000	5.10	4.54	10.5	5.03

The NMED summary report concludes:

> *"The Oversight Bureau's tritium based dose values ranged approximately 14 to 56 times greater than Sandia's modeled dose values at the same locations using the CAP-88 computer code for a variety of radionuclides. Even at UNM, which is the background station, indicated a greater dose value based on tritium in relation to Sandia's highest modeled dose values. However, all measured dose values were approximately 1,200 to 18,000 less than the applicable regulatory criteria."*

From the above, it appears that NMED's conclusion is limited to measured levels of tritium and does not consider the contribution of alpha and beta emitters. In order to determine compliance, measured concentrations of radionuclides in air should be compared to the levels for environmental compliance in 40CFR61 App. E, Table 2. The results if the comparison are summarized in Table 3-7.

The NMED 2004 report provided only data for gross alpha and gross beta activity. Therefore, one does not know which specific radionuclides were responsible for the measured

concentration. In such a case, it is prudent to use as reference the critical radionuclide, i.e. the radionuclide with the lowest value for environmental compliance of those alpha and beta emitters for which releases into the air were reported for the year 2004 (see Table 2-1).

Table 3-7 Comparison of maximum annual levels of gross alpha, gross beta and tritium in ambient air with the compliance level for the critical radionuclide

Type	(A): Highest measured concentration (Table 3-1)	(B): Environmental compliance level for critical radionuclide identified in Table 2-1	Ratio (A / B)
Gross alpha activity	0.00635 pCi/m^3	0.0019 pCi/m^3 (Am-241)	334 %
Gross beta activity	0.0195 pCi/m^3	0.019 pCi/m^3 (Sr-90)	103 %
Tritium activity	13.2 pCi/m^3	1,500 pCi/m^3	0.9%

A comparison of SNL and NMED data is presented in Figures 3-8 for alpha activity and in Figure 3-9 for beta activity. In general, the level for alpha activity reported by NMED are lower than those values reported by SNL. In 2000, the only year for which data was available from both sources, the average alpha activity reported by SNL were a factor of 6.4 larger than those reported by NMED whereas the average beta activity reported by SNL was 23% smaller than that reported by NMED.

Figure 3-8 Comparison of reported data for gross alpha activity in air at locations sampled by SNL (A2PM, CPMS, A2PM) with those sampled by NMED (Four Hills, USGS, SW Base, UNM); the 40CFR61 level for environmental compliance for Am-241 is indicated with a dotted line.

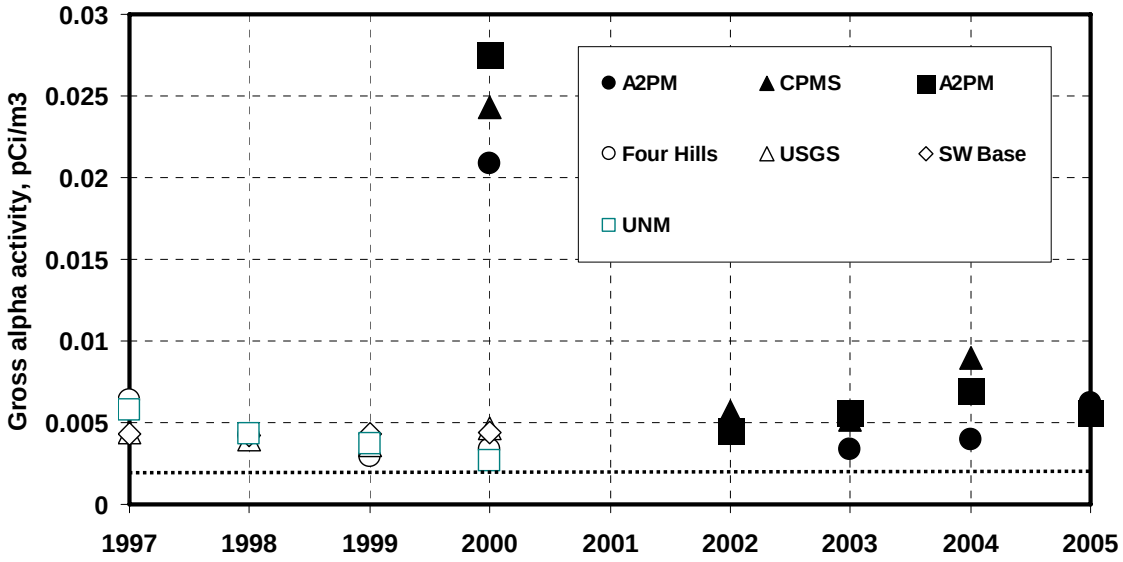
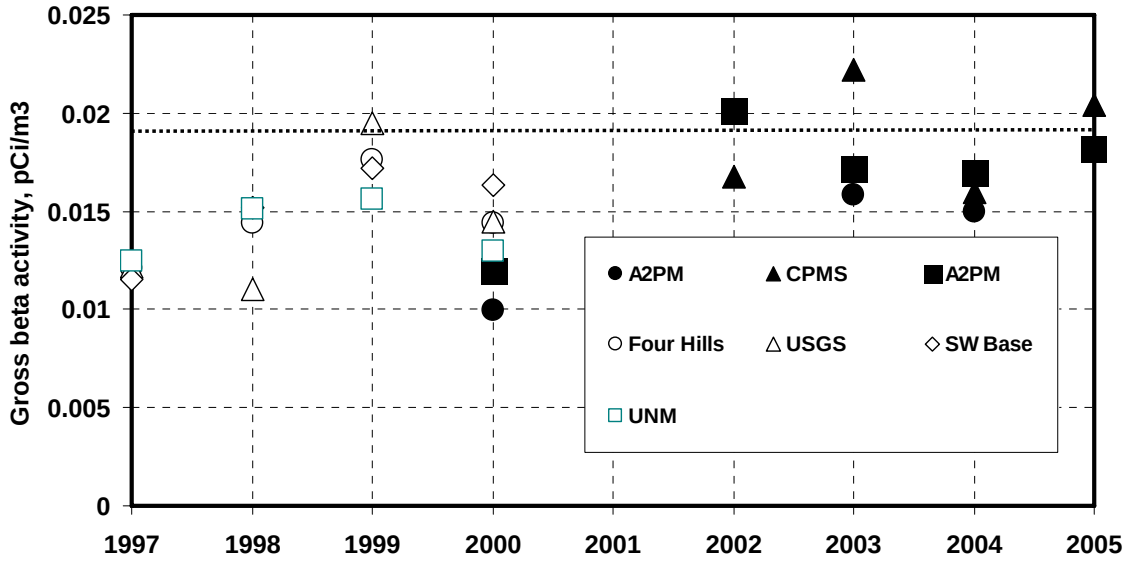


Figure 3-9 Comparison of reported data for gross beta activity in air at locations sampled by SNL (A2PM, CPMS, A2PM) with those sampled by NMED (Four Hills, USGS, SW Base, UNM); the 40CFR61 level for environmental compliance for Am-241 is indicated with a dotted line.



For tritium in air, the highest measured annual average concentration in air (13.2 pCi/m^3 at UNM in the year 1997) represents about 0.9% of the compliance level, or a factor of 111 below the compliance level (not a factor of 1,200 to 18,000 as was calculated by NMED. Further, the reported tritium concentrations are likely to be biased on the low side due to the poor efficiency of silica gel to capture water at low humidity.

At Los Alamos National Laboratories the amount of water collected in the dry season was less than a quarter of the amount expected from measured humidity levels (Eberhardt 1999). Therefore, the reported data had to be adjusted by a factor of ~4. The NMED tritium sampling data was not corrected for absolute humidity (Skibitski, 2006) and are therefore likely to be too low. Given the lower humidity levels in Albuquerque, the adjustment factor may even have to be larger than ~4.

The highest measured annual average concentration of alpha activity in air (0.00635 pCi/m^3 at Four Hills in the year 1997) is a factor of 3.3 times the compliance level for Am-241. The highest measured annual average concentration of beta activity in air (0.0195 pCi/m^3 at USGS in the year 1999) is roughly equivalent to the compliance level for Sr-90. Therefore, the NMED monitoring program cannot serve as proof of compliance with 40CFR61 dose limit in the absence of isotope-specific data.

4 Comparison of monitoring for radionuclides at DOE sites

A suitable way to evaluate the environmental monitoring system at SNL is to compare it to monitoring systems at other DOE facilities. In the following, this is done separately for monitoring of tritium, as well as for monitoring of alpha and beta activity in particles. The following DOE facilities were selected because the environmental reports were readily availability:

- Pantex, TX (Pantex 2005)
- Brookhaven National Laboratory, NY (BNL 2004)
- Lawrence Livermore National Laboratory, CA (LLNL 2005)
- Los Alamos National Laboratory, NM (LANL 2005)
- Idaho National Engineering and Environmental Laboratory, ID (INEEL 2005)
- Savannah River Site, SC (SRS 2005)

Table 4-1 contains the summary data for SNL as well as for six other facilities for which tritium emissions in 2004 were reported, ranging from 0.00019 curies (Pantex) to 61,300 curies (Savannah River Site). The number of ambient air monitoring stations for tritium of non-SNL facilities ranged from 7 to 46.

Table 4-1 Ambient air monitoring for tritium at selected DOE facilities in 2004

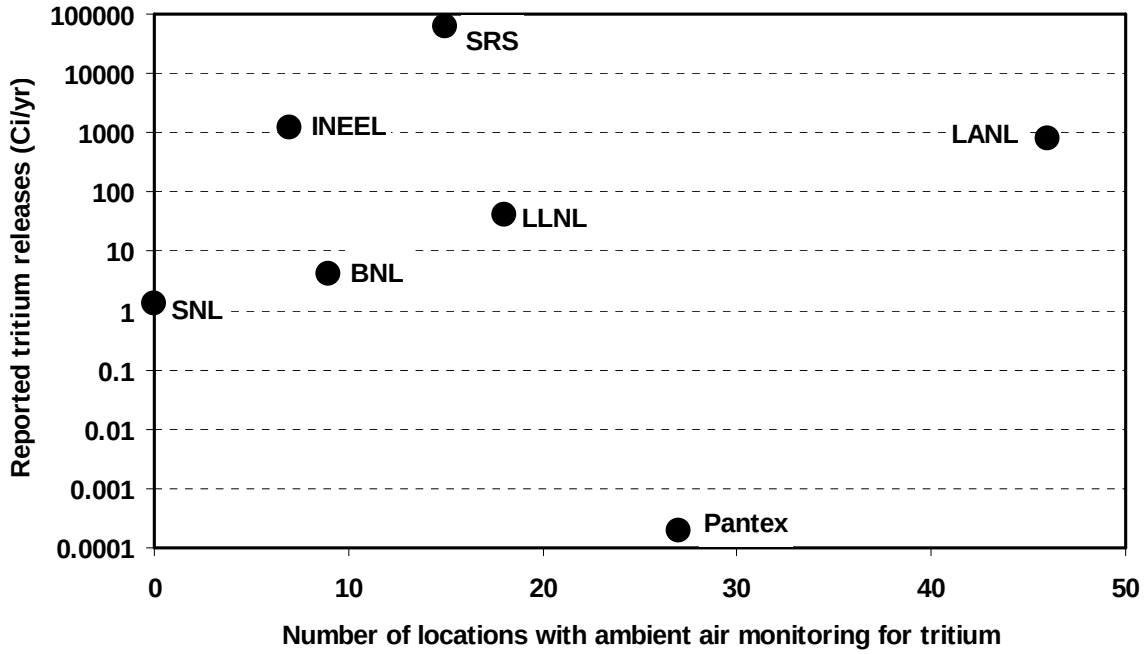
Facility	**Reported tritium release (Ci)[a)]**	**Number of ambient air stations sampling tritium [a)]**	**Population in 50 mile radius [b)]**
Pantex, TX	0.00019	27 (5 onsite, 22 perimeter)	260,000
Sandia National Laboratories, NM	1.3	0	500,000
Brookhaven National Laboratory, NY	4.1	9 (7 onsite, 2 perimeter)	5,200,000
Lawrence Livermore National Laboratory, CA	40.4	18 (12 onsite, 6 offsite)	5,300,000
Los Alamos National Laboratory, NM	789	46 (15 onsite; 24 perimeter; 7 offsite)	160,000
Idaho National Engineering and Environmental Laboratory, ID	1,210	7 (2 onsite; 5 offsite)	103,000
Savannah River Site, SC	61,300	15 (1 onsite; 10 perimeter 4 offsite)	550,000

a) Based on environmental reports for the respective facility
b) Based on data in CAP88-PC

Figure 4-1 illustrates that there is no definitive relationship between the tritium release and the number of sampling locations. The lack of ambient tritium monitoring at SNL does not meet the de facto standard established at other DOE facilities. The prime example is the Pantex site where the reported tritium emissions for 2004 were a factor of 6,800 lower than at SNL, yet tritium monitoring of ambient air is carried out at 27 stations at Pantex.

At SNL, tritium emissions are expected to increase over the next few years due to an increase in use of the neutron generator facility for tritium target loading associated with fabrication of nuclear weapons (Robinson 2006).

Figure 4-1 Number of locations at selected DOE facilities with ambient air monitoring for tritium as a function of the reported releases of airborne tritium



Similarly, the relationship between reported releases of airborne alpha particulates and the monitoring of alpha particulate activity in ambient air is presented in Table 4-2 and Figure 4-2. Whereas SNL reported alpha activity releases of 1.1E-05 curie in the year 2004 and carried out ambient air monitoring at only four locations, ambient air monitoring is carried out at four DOE facilities that reported lower or no releases of particulate alpha activity (LANL, LLNL, BNL and Pantex). The most extensive network exists at Los Alamos National Laboratory with a total of 46 locations while having smaller reported emissions of alpha activity compared to SNL.

The relationship between reported releases of airborne beta particulates and the monitoring of beta particulate activity in ambient air is presented in Table 4-3 and Figure 4-3. Whereas SNL reported emissions of beta particle activity of 8.1E-07 curie in the year 2004 and carried out ambient air monitoring at only four locations, ambient air monitoring was carried out at two DOE facilities that reported lower or no releases of particulate beta activity (LLNL and BNL). The most

extensive network exists at Los Alamos National Laboratory with a total of 46 locations for which reported emissions of beta activity are a factor of 10,000 larger compared to SNL.

As the result of the comparison, there is obviously no linear relationship between the reported releases of radioactive materials into the air and the extent of environmental monitoring carried out. While there are only four ambient air monitoring stations at Sandia National Laboratories in Albuquerque, a much larger number of locations (up to 11 times) are monitored at other DOE facilities.

A comparison of key data for SNL and LANL is provided in Table 4-4.

Table 4-2 Ambient air monitoring for alpha activity in particulates at selected DOE facilities in 2004

Facility	**Reported alpha particulate emissions (Ci)**	**Reported radionuclides from monitored facilities**	**Number of ambient air monitoring stations**	**Reported radionuclides in air**
Pantex, TX	2.20E-09	Th-232 U-233/234 U-238 Pu-239/240	27 (5 onsite, 22 perimeter)	Th-232 U-233/234 U-238 Pu-239/240
Sandia National Laboratories, NM	1.10E-05	U-234 U-235 U-238 Am-241	4 (all onsite)	U-234/235/238 Th.232
Brookhaven National Laboratory, NY	0	N/A	6	gross alpha
Lawrence Livermore National Laboratory, CA	5.14E-09	gross alpha gross beta	24 (15 onsite, 9 offsite)	gross alpha Pu-239/240 U-234/238
Los Alamos National Laboratory, NM	6.60E-06	Am-241 Isotopes of U Pu Th	46	gross alpha Pu-238 U-234/238 Pu-239/240 Am-241
Idaho National Engineering and Environmental Laboratory, ID	8.96E-03	Isotopes of Am, Cf, Cm, Pu, U, Ra, Th	29 (15 onsite; 8 perimeter 6 offsite)	gross alpha Pu-239/240 U-234/238
Savannah River Site, SC	3.01E-04	U-234 U-235 U-238 Pu-238 Pu-239 Am-241 Cm-244	15 (1 onsite; 10 perimeter 4 offsite)	gross alpha U-234/238 Am-241 Cm-244

Figure 4-2 Number of locations at selected DOE facilities with ambient air monitoring for alpha particulate activity as a function of the reported releases of airborne alpha particulate activity

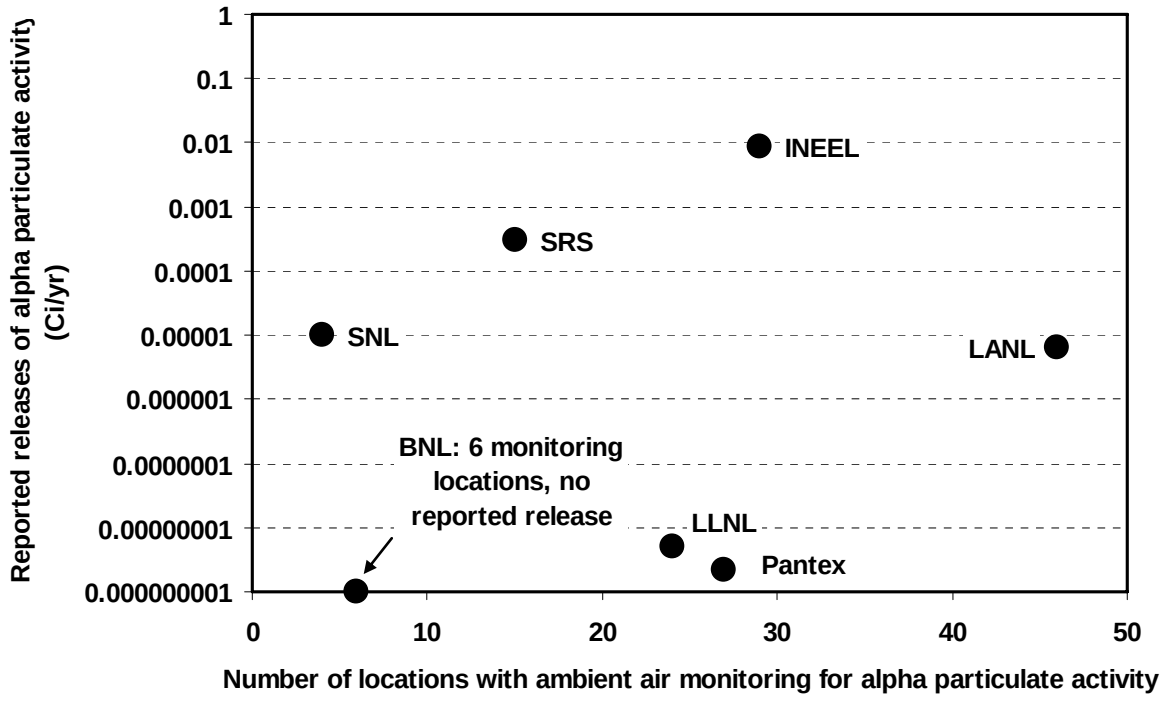


Table 4-3 Ambient air monitoring for beta activity in particulates at selected DOE facilities in 2004

Facility	Reported beta particulate emissions (Ci)	Reported radionuclides from monitored facilities	Number of ambient air monitoring stations	Type of analysis
Pantex, TX	0	N/A	0	N/A
Sandia National Laboratories, NM	8.10E-07	Cs-137 Co-60 Sr-90	4 (all onsite)	gross beta gamma spectroscopy
Brookhaven National Laboratory, NY	1.98E-08	Cs-137 Co-60 Ge-68 Eu-152	6	gross beta
Lawrence Livermore National Laboratory, CA	4.32E-08	gross beta	24	gross beta gamma spectroscopy
Los Alamos National Laboratory, NM	8.21E-03	P/VAP[2]	46	gross beta; gamma spectroscopy
Idaho National Engineering and Environmental Laboratory, ID	1.88E+00	37 different radionuclides[3]	29 (15 onsite; 8 perimeter 6 offsite)	gross beta; gamma spectroscopy Sr-90
Savannah River Site, SC	2.18E-03	gross beta	15 (1 onsite; 10 perimeter 4 offsite)	gross beta; gamma spectroscopy Sr-90

[2] Reported P/VAP–Particulate/vapor activation products (with measured radionuclides and short-lived radioactive progeny). The emissions of the only identified beta emitter (Sr-90) was reported to be 0.0E+00 curie.

[3] Ag-110; Ag-110m; Ba-133; Ba-133; Ba-14Ce-1444; Cl-36; Co-57; Co-58; Co-6Cr-51; Cs-134; Cs-137; Cs-138; Eu-151; Eu-154; Eu-155; Fe-55; Fe-59; Hf-181; Hg-203; I-129; I-131; I-132; I-133; I-134; I-135; In-1113m; Ir-192; K-4Mn-54; Mo-99; Na-24; Nb-93m; Nb-94; Nb-95; Ni-59; Ni-63; Pm-147; Rb-89; Ru-103; Ru-106; Sb-124; Sb-125; Sc-46; Sm-151; Sn-113; Sn-123; Sr-89; Sr-9Tc-99; Tc-99M; W-187; Y-91m; Zn-65; Zr-95

Figure 4-3 Number of locations at selected DOE facilities with ambient air monitoring for beta particulate activity as a function of the reported releases of airborne beta particulate activity

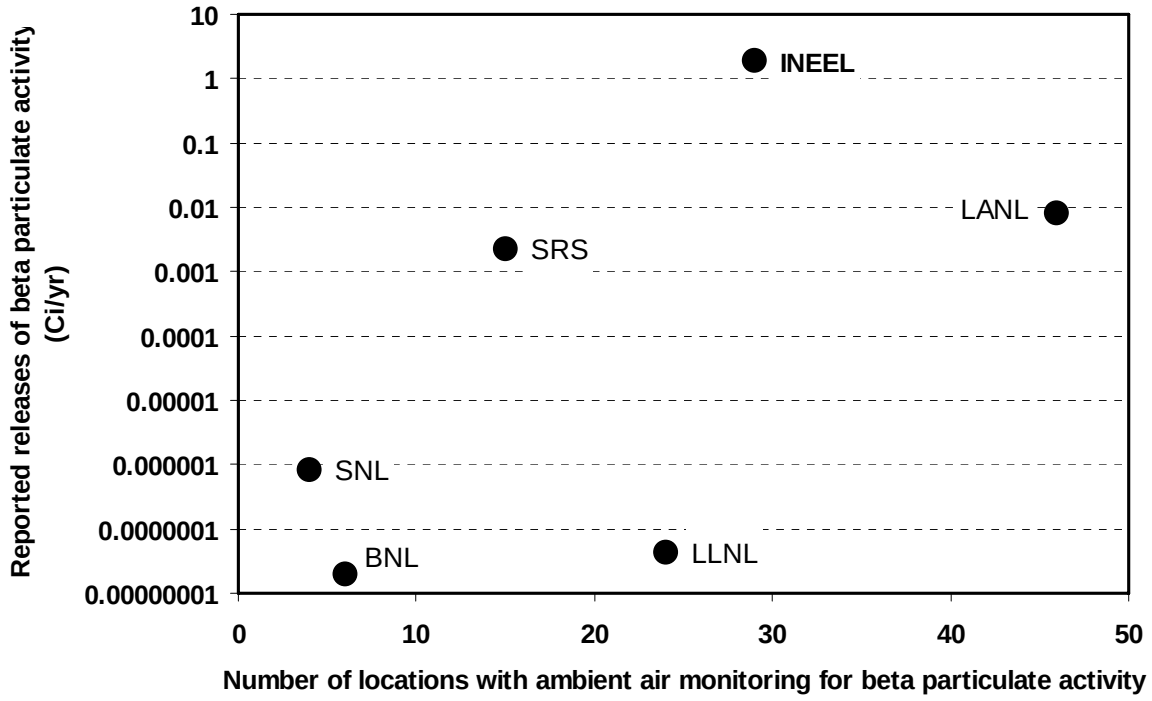


Table 4-4 Key data for comparison of the ambient air monitoring system for radionuclides at SNL and LANL in the year 2004

Parameter	SNL	LANL
Population in 50 mile radius	about 500,000	about 160,000
Tritium		
Reported release into air	1.3 Ci	789 Ci
Number stations with ambient air monitoring	0	46
Alpha particulate activity		
Reported release into air	11 µCi	6.6 µCi
Number stations with ambient air monitoring	4	46
Beta particulate activity		
Reported release into air	0.81 µCi	8,210 µCi
Number stations with ambient air monitoring	4	46

5 The need for improved ambient air monitoring at SNL

There are many reasons to improve the ambient air monitoring system at SNL:

- Like any other Department of Energy Facility, SNL has to comply with Subpart H of the National Emission Standards for Hazardous Air Pollutants (40CFR61). Ambient air monitoring is the preferred method to demonstrate compliance in the case of diffuse source emissions.
- For point sources, compliance with 40CFR61 Subpart H can be established with computer models such as CAP88 (for details see CAP88-PC 2006). In such a case, ambient air monitoring will provide supplemental verification because monitoring results can be compared with model predictions.
- Ambient air monitoring can provide a precautionary measure for the event of accidental releases of radioactivity.
- Ambient air monitoring can improve public relations with surrounding communities.

5.1 Compliance with regulatory requirements

With respect to releases of radioactive materials at SNL, compliance with the regulatory requirement in 40CFR61 Subpart H has to be ensured. For sources, this can be done on the basis of measured or conservatively estimated release data and modeling with CAP-88. SNL has selected that method in its compliance reporting (SNL 2002, SNL 2003, SNL 2004, SNL 2005 and SNL 2006).

This method requires, of course, that the emissions of all point and diffuse sources are well characterized. If that is not the case, or if measurements at the source are unfeasible, 40CFR61.93(5) allows that *"[e] nvironmental measurements of radionuclide air concentrations at critical receptor locations may be used as an alternative to air dispersion calculations in demonstrating compliance with the standard.*"

As explained in chapter 2, SNL has potential diffuse sources of radioactive materials (the Mixed Waste Landfill, resuspended activity from historical releases, and potentially unidentified sources). The application of the precautionary principle suggests ambient air monitoring that would allow identifying all radionuclides in air no matter where they originated. Thus, the presence (or absence) of diffuse sources could be confirmed well as compared to the current situation where no monitoring is carried out at all.

5.2 Precautionary monitoring because of possible accidental releases of radioactive materials

There is no publicly available inventory of radioactive materials at SNL that would allow determining the possibility of accidental releases of radionuclides into the air. The presence of nuclear warheads at KAFB was confirmed at least for the year 1998 (Arkin 1998). A comprehensive ambient air monitoring system would be of benefit in case of accidental releases.

5.3 Establish a level of information and assurance at SNL that is equivalent to that at other DOE facilities

It was demonstrated in Chapter 4 that SNL carried out ambient air monitoring for radionuclides at far less locations compared to other DOE facilities. Tritium in ambient air is not monitored by SNL although it is monitored by all other DOE facilities that were reviewed, including those that reported less tritium emissions than SNL. Alpha activity in air is monitored at only four locations as compared to 46 locations at the LANL, even though SNL reported larger releases of alpha activity than LANL. It should be self-evident that residents in the Albuquerque metropolitan area are entitled to a level of information and assurance equivalent to residents in the vicinity of other DOE facilities, especially when compared to the Los Alamos National Laboratory (see Table 4-4 on page 25 for a comparison of key data for SNL and LANL) .

In addition to the monitoring of radionuclides in ambient air, a NEWNET (Neighborhood Environmental Watch Network) system is established near Los Alamos National Laboratory as well as along transportation routes for nuclear waste. NEWNET is a network of environmental monitoring stations with public access to the data through the Internet (http://newnet.lanl.gov). Most stations have sensors for monitoring wind speed and direction, ambient air temperature, barometric pressure, relative humidity and ionizing gamma radiation. Such a system would be beneficial for SNL as well.

5.4 Recommendation

Based on the foregoing, it is highly recommended to install a comprehensive monitoring system of radioactive materials in ambient air at and around SNL. The system should be based on the following principles:

- Ambient air monitors should be placed in a dense network at the plant perimeters covering all wind directions;
- Tritium should be sampled as well as particulate activity in air on a weekly basis (supplemented by monthly or quarterly isotopic analysis of alpha and beta activity);
- The data should be rapidly made public on SNL's website and be subject to independent quality assurance;
- SNL should involve the local community in the planning process;
- Ambient air monitoring at SNL should be coordinated with efforts to establish a NEWNET system in the vicinity of SNL;
- The NMED monitoring program should be expanded to provide verification of SNL data;
- NMED should provide isotope specific analysis of their data and correct tritium sampling data for absolute humidity;
- An independent audit of SNL monitoring activities is highly recommended.

A minimum network of 16 stations should be placed on the plant perimeter in order to cover all wind directions. For the adequate determination of background, an additional number of four stations is recommended. Additional stations should be placed as needed as is the case at Los

Alamos National Laboratory where monitoring for radioactive materials is carried out in a total of 46 stations.

Since reporting of different radionuclides is inconsistent (not all are reported for all years), a detailed investigation should be carried out to determine the necessary analytical procedures to identify all relevant radionuclides.

A precise cost estimate for the additional sampling stations is beyond the scope of this report. If an additional 20 stations for tritium and 16 alpha/beta stations with isotope-specific analysis would be installed, the additional costs are estimated to be below one million US $ per year. This estimate is based on the assumption of $50,000 annual operating and write-off costs per station.

The next step in the process should be a detailed investigation into the design of a monitoring system (function and density of stations) that is equivalent to the one at LANL and could be relied upon to demonstrate compliance with 40CFR61 Subpart 61.

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