SEC Petition Evaluation Report
Petition SEC-00109

Report Rev #: 0 Report Submittal Date: January 22, 2009

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Site Expert(s):	N/A

Petition Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition Qualification Date	DOE/AWE Facility Name
SEC-00109	83.13	May 29, 2008	Los Alamos National Laboratory (LANL)

Petitioner Class Definition
Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.

Class Evaluated by NIOSH
Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.

NIOSH-Proposed Class(es) to be Added to the SEC
None

Related Petition Summary Information			
SEC Petition Tracking #(s)	Petition Type	DOE/AWE Facility Name	Petition Status
None			

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
SEC Petition Evaluation Report, SEC-00051	LANL
SEC Petition Evaluation Report, SEC-00061	LANL

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SEC Evaluation Approved By:	[Signature on file] *Larry Elliott*	1/22/2009 *Date*

Evaluation Report Summary: SEC-00109
Los Alamos National Laboratory (LANL)

This evaluation report by the National Institute for Occupational Safety and Health (NIOSH) addresses a class of employees proposed for addition to the Special Exposure Cohort (SEC) per the *Energy Employees Occupational Illness Compensation Program Act of 2000*, as amended, 42 U.S.C. § 7384 *et seq.* (EEOICPA) and 42 C.F.R. pt. 83, *Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000*.

Petitioner-Requested Class Definition

Petition SEC-00109, qualified on May 29, 2008, requested that NIOSH consider the following class: *Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.*

Class Evaluated by NIOSH

Based on its preliminary research, NIOSH accepted the petitioner-requested class. NIOSH evaluated the following class: Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.

NIOSH-Proposed Class(es) to be Added to the SEC

Based on its full research of the class under evaluation, NIOSH has obtained numerous documents containing monitoring results as well as LANL process and source information. LANL has provided monitoring data summaries from its employee exposure records databases, and site personnel have been interviewed. Employee-specific information provided through the EEOICPA claims process and Technical Basis Documents written by NIOSH have also been available for this evaluation. Based on its analysis of these available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.13(c)(1), NIOSH has established that it has access to sufficient information to: (1) estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class; or (2) estimate radiation doses of members of the class more precisely than an estimate of maximum dose. Information available from the site profile and additional resources is sufficient to document or estimate the maximum internal and external potential exposure to members of the proposed class under plausible circumstances during the specified period.

Health Endangerment Determination

Per EEOICPA and 42 C.F.R. § 83.13(c)(3), a health endangerment determination is not required because NIOSH has determined that it has sufficient information to estimate dose for the members of the proposed class.

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SEC Petition Evaluation Report for SEC-00109

1.0 Purpose and Scope

This report evaluates the feasibility of reconstructing doses for Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005. It provides information and analyses germane to considering a petition for adding a class of employees to the congressionally-created SEC.

This report does not make any determinations concerning the feasibility of dose reconstruction that necessarily apply to any individual energy employee who might require a dose reconstruction from NIOSH. This report also does not contain the final determination as to whether the proposed class will be added to the SEC (see Section 2.0).

This evaluation was conducted in accordance with the requirements of EEOICPA, 42 C.F.R. pt. 83, and the guidance contained in the Office of Compensation Analysis and Support's (OCAS) *Internal Procedures for the Evaluation of Special Exposure Cohort Petitions*, OCAS-PR-004.

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting that the Department of Health and Human Services (HHS) add a class of employees to the SEC. The evaluation is intended to provide a fair, science-based determination of whether it is feasible to estimate with sufficient accuracy the radiation doses of the class of employees through NIOSH dose reconstructions.[1]

42 C.F.R. § 83.13(c)(1) states: *Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, or if NIOSH has established that it has access to sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose.*

Under 42 C.F.R. § 83.13(c)(3), if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, then NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class The regulation requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring

[1] NIOSH dose reconstructions under EEOICPA are performed using the methods promulgated under 42 C.F.R. pt. 82 and the detailed implementation guidelines available at http://www.cdc.gov/niosh/ocas.

during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for at least 250 aggregated work days within the parameters established for the class or in combination with work days within the parameters established for other SEC classes (excluding aggregate work day requirements).

NIOSH is required to document its evaluation in a report, and to do so, relies upon both its own dose reconstruction expertise as well as technical support from its contractor, Oak Ridge Associated Universities (ORAU). Once completed, NIOSH provides the report to both the petitioner(s) and to the Advisory Board on Radiation and Worker Health (Board). The Board will consider the NIOSH evaluation report, together with the petition, petitioner(s) comments, and other information the Board considers appropriate, in order to make recommendations to the Secretary of HHS on whether or not to add one or more classes of employees to the SEC. Once NIOSH has received and considered the advice of the Board, the Director of NIOSH will propose a decision on behalf of HHS. The Secretary of HHS will make the final decision, taking into account the NIOSH evaluation, the advice of the Board, and the proposed decision issued by NIOSH. As part of this decision process, petitioners may seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

3.0 SEC-00109 Site Name Class Definitions

The following subsections address the evolution of the class definition for SEC-00109, Los Alamos National Laboratory (LANL). When a petition is submitted by a claimant, the requested class definition is evaluated as submitted. If the available site information and data justify a change in the petitioner's class definition, NIOSH will specify a modified class to be fully evaluated. After a complete analysis, NIOSH will determine whether to propose a class for addition to the SEC and will specify that proposed class definition.

3.1 Petitioner-Requested Class Definition and Basis

Petition SEC-00109, qualified on May 29, 2008, requested that NIOSH consider the following class for addition to the SEC: *Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.*

[2] See 42 C.F.R. pt. 83 for a full description of the procedures summarized here. Additional internal procedures are available at http://www.cdc.gov/niosh/ocas.

The petitioner provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the LANL workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00109 for evaluation:

> In the narrative attached to the petition, the petitioner points out that, when evaluating LANL petition SEC-00051 (covering 1943 through 1975), NIOSH determined "that the available monitoring records, process descriptions, and source-term data are not sufficient to complete dose reconstructions for the proposed class of employees, at a minimum, through December 31, 1975." The petitioner asserts that the evaluation report (ER) indicates that data are insufficient for dose reconstruction after 1975. The petitioner provided a large amount of documentation to support this assertion (a listing is provided in Attachment 1). In the SEC-00051 ER, NIOSH did note that "the potential for monitored and unmonitored intakes has existed throughout the history of the site." NIOSH also recognized that potential dose reconstruction issues may exist for the post-1975 period (e.g., internal dose assessment for mixed fission products). On this basis, NIOSH determined that this current petition (SEC-00109) qualifies for further evaluation. The petitioner also reported on a meeting of the Advisory Board in which NIOSH staff stated that there are "still issues on the table after 1975" and that "evaluation of the mixed fission products and a few of the other issues past 1975" would continue in order to determine if additional years need to be added to the SEC class. (Petition, 2008)
>
> The petitioner also provided ten affidavits (listed in Section 4.7). A number of these affidavits asserted that Service Support Workers with inadequate or no PPE were routinely assigned to areas in which workers were using full PPE. They also asserted that these Service Support Workers had little or no participation in the LANL urine sampling or whole-body counting program. Because this petition qualified for further evaluation based on the issues discussed in the preceding paragraph, these affidavit statements will be considered during the evaluation.

Based on its LANL research and data capture efforts, NIOSH determined that it has access to chest counts, whole-body counts, bioassay results, urinalysis results, external dosimetry data, and air monitoring data for LANL workers during the time period under evaluation. However, NIOSH also acknowledged that certain issues raised during the research for SEC-00051 remain unresolved, in particular the assessment of dose from mixed fission products. NIOSH concluded that there is sufficient documentation to support, for at least part of the proposed time period, the petition basis that radiation exposures and radiation doses were not adequately monitored at LANL, either through personal monitoring or area monitoring. The information and statements provided by the petitioner qualified the petition for further consideration by NIOSH, the Board, and HHS. The details of the petition basis are addressed in Section 7.4.

3.2 Class Evaluated by NIOSH

Based on its preliminary research, NIOSH accepted the petitioner-proposed class. Therefore, NIOSH defined the following class for further evaluation: Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.

3.3 NIOSH-Proposed Class(es) to be Added to the SEC

Based on its research, NIOSH has obtained numerous documents containing monitoring results as well as LANL process and source information. LANL has provided monitoring data summaries from its employee exposure records databases, and site personnel have been consulted. Employee-specific information provided through the EEOICPA claims process and Technical Basis Documents written by NIOSH have also been available for this evaluation.

NIOSH also addressed certain unresolved issues raised during the research for SEC-00051, in particular the assessment of dose from mixed fission products. In the SEC-00051 evaluation, NIOSH noted that whole-body counting started about 1970. The evaluation also stated that "…some radionuclide maximum intakes possibly could be inferred from the chest counting data. However, at the time of this report, an analysis of this technique has not been performed."

Furthermore, at the time of the SEC-00051 report, NOSH lacked the information or methods to support bounding at least some of the internal doses for the more "exotic" radionuclides. The term "exotics" is used to include everything other than U-234/235/238, Pu-238/239, tritium, Am-241, and Cs-137. This would include Sr-90, Th-232, Cm-244, Ac-227, Pa-231, Np-237, and others. This resulted in a recommendation to add a class to the SEC. Because SEC-00051 had the "gray" area for reconstructing internal dose from 1970-75, the decision was to recommend the class to 1975 (the petitioner's proposed end date), continue the review and evaluation efforts for the post-1975 time period, and report to the Board on the findings.

Since the SEC-00051 presentation, SEC-00109 was filed for the post-1975 period. With the subsequent capture of additional LANL documents and data, NIOSH believes that it has sufficient information to support bounding all internal doses for the SEC-00109 class, including the exotics that were the limiting factors in SEC-00051. SEC-00109 research resulted in information that clarifies the 1970-75 "gray" area, with the conclusion that available dose information now provides much stronger support for the ability to reconstruct internal dose for the 1970-75 period with sufficient accuracy. However, because a decision had already been made for the 1970-75 time period (per SEC-00051), further consideration of the reconstruction of that dose is irrelevant to the SEC-00109 evaluation.

Based on its analysis of the available resources, NIOSH found no part of the class under evaluation for which it cannot estimate radiation doses with sufficient accuracy.

4.0 Data Sources Reviewed by NIOSH to Evaluate the Class

NIOSH identified and reviewed numerous data sources to find information relevant to determining the feasibility of dose reconstruction for the class of employees under evaluation. This included determining the availability of information on personal monitoring, area monitoring, industrial processes, and radiation source materials. The following subsections summarize the data sources identified and reviewed by NIOSH.

4.1 Site Profile Technical Basis Documents (TBDs)

A Site Profile provides specific information concerning the documentation of historical practices at the specified site. Dose reconstructors can use the Site Profile to evaluate internal and external dosimetry data for monitored and unmonitored workers, and to supplement, or substitute for, individual monitoring data. A Site Profile consists of an Introduction and five Technical Basis Documents (TBDs) that provide process history information, information on personal and area monitoring, radiation source descriptions, and references to primary documents relevant to the radiological operations at the site. The Site Profile for a small site may consist of a single document. As part of NIOSH's evaluation detailed herein, it examined the following TBDs for insights into LANL operations or related topics/operations at other sites:

- *TBD for the Los Alamos National Laboratory – Introduction*, ORAUT-TKBS-0010-1; Rev. 01; October 1, 2007; SRDB Ref ID: 35193

- *TBD for the Los Alamos National Laboratory – Site Description*, ORAUT-TKBS-0010-2; Rev. 00; May 7, 2004; SRDB Ref ID: 19561

- *TBD for the Los Alamos National Laboratory – Occupational Medical Dose*, ORAUT-TKBS-0010-3; Rev. 00; December 29, 2004; SRDB Ref ID: 19562

- *TBD for the Los Alamos National Laboratory – Occupational Environmental Dose*, ORAUT-TKBS-0010-4; Rev. 00; October 8, 2004; SRDB Ref ID: 19564

- *TBD for the Los Alamos National Laboratory – Occupational Internal Dose*, ORAUT-TKBS-0010-5; Rev. 00; December 21, 2004; SRDB Ref ID: 19565

- *TBD for the Los Alamos National Laboratory – Occupational External Dose*, ORAUT-TKBS-0010-6; Rev. 01; May 30, 2007; SRDB Ref ID: 32018

4.2 ORAU Technical Information Bulletins (OTIBs) and Procedures

An ORAU Technical Information Bulletin (OTIB) is a general working document that provides guidance for preparing dose reconstructions at particular sites or categories of sites. An ORAU Procedure provides specific requirements and guidance regarding EEOICPA project-level activities, including preparation of dose reconstructions at particular sites or categories of sites. NIOSH reviewed the following OTIBs as part of its evaluation:

- *OTIB: Analysis of Coworker Bioassay Data for Internal Dose Assignment*, ORAUT-OTIB-0019, Rev. 01; October 7, 2005; SRDB Ref ID: 19438

- *OTIB: Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses*, ORAUT-OTIB-0054, Rev. 00 PC-1, November 19, 2007;SRDB Ref ID: 36235

- *OTIB: Internal Dosimetry Coworker Data for Los Alamos National Laboratory*, ORAUT-OTIB-0062, draft; SRDB Ref ID: Not currently available in the SRDB

- *OTIB: Los Alamos National Laboratory Bioassay Data Project Final Report*; ORAUT-OTIB-0063, draft; SRDB Ref ID: Not currently available in the SRDB

- *PROC*: *Occupational Onsite Ambient Dose Reconstruction for DOE Sites*, ORAUT-PROC-0060, Rev. 01; June 28, 2006; SRDB Ref ID: 29986

- *PROC*: *Occupational X-Ray Dose Reconstruction for DOE Sites*, ORAUT-PROC-0061, Rev. 02; January2, 2008; SRDB Ref ID: 39338

4.3 Facility Employees and Experts

NIOSH talked with current LANL technical staff concerning additional data capture that was subsequently performed:

- Conference call: ORAU Team and NIOSH with LANL Radiation Protection Division Personnel; August 7, 2008; SRDB Ref ID: 55742

- Conference call: ORAU Team and NIOSH with LANL Radiation Protection Division Personnel; August 28, 2008; SRDB Ref ID: 55741

- Conference call: ORAU Team and NIOSH with LANL Radiation Protection Division Personnel; September 9, 2008; SRDB Ref ID: 55744

4.4 Previous Dose Reconstructions

NIOSH reviewed its NIOSH OCAS Claims Tracking System (NOCTS) to locate EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation. Table 4-1 summarizes the results of this review. (NOCTS data available as of December 29, 2008)

Table 4-1: No. of LANL Claims Submitted Under the Dose Reconstruction Rule

Description	Totals
Total number of claims submitted for dose reconstruction	629
Total number of claims submitted for energy employees who meet the definition criteria for the class under evaluation (January 1, 1976 through December 31, 2005).	331
Number of dose reconstructions completed for energy employees who meet the definition criteria for the class under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval).	161
Number of claims for which internal dosimetry records were obtained for the identified years in the evaluated class definition	244
Number of claims for which external dosimetry records were obtained for the identified years in the evaluated class definition	308

NIOSH reviewed each claim to determine whether internal and/or external personal monitoring records could be obtained for the employee. As indicated in Table 4-1, NIOSH has been able to obtain monitoring data for many of the claims that meet the proposed class definition. Of the total number of claims submitted for energy employees who meet the class under evaluation, 244 (74%) contain internal monitoring data and 308 (93%) contain external monitoring data.

The telephone interviews conducted with individual LANL claimants for dose reconstruction purposes provided additional detailed information regarding work locations, hours worked, incidents, and hazards encountered. The interviews also identified conditions for which there would have been potential for either internal or external exposures.

4.5 NIOSH Site Research Database

NIOSH also examined its Site Research Database (SRDB) to locate documents supporting the evaluation of the proposed class. Two thousand one hundred six (2106) documents in this database were identified as pertaining to LANL. These documents were evaluated for their relevance to this petition. The documents include historical background on external and internal dosimetry programs and evaluations, monitoring reports, annual environmental reports, reviews and assessments of LANL, evaluations of specific buildings, site surveys, and facility and process descriptions.

4.6 Other Technical Sources

NIOSH reviewed the following technical sources in support of the evaluation of the proposed class:

- *Tritium Calculations with IMBA*, OCAS-TIB-002, Office of Compensation Analysis and Support, Technical Information Bulletin, April 22, 2003; SRBD Ref ID: 22407

- *Overview of Los Alamos National Laboratory - 1997*, LA-UR-97-4765; LANL Environment, Safety, and Health Division; 1998; SRDB Ref ID: 27224

- *Internal Dosimetry and Dose Assessment at Los Alamos National Laboratory*, Inkret, W. C., LANL; 1993; SRDB Ref ID: 14522

- *Air Monitoring and Its Evolution at the LASL Plutonium Facility*, LA-4076; LASL; 1969; SRDB Ref ID: 27223

- *History of LANL's Bioassay Program from Inception to 1993*, LA-UR-05-1942; Clark, M. J.; LANL; 2005; SRDB Ref ID: 17157

- *Brief History of Biological Monitoring and Dose Assessment for Tritium at Los Alamos*, LANL, 1987; SRDB Ref ID: 14512

- *Compendium of Reports on Various Nuclides, Work Groups and Operations, Circa 1945*, LASL; 1946; SRDB Ref ID: 14878

- *Evaluation of Polonium-210 Exposure for Termination Reports*, LANL, 1979. SRDB Ref ID: 14519

- *Interim Report of the Los Alamos Historical Document Retrieval and Assessment (LAHDRA) Project*, ChemRisk et al.; Version 3B; July 27, 2004; SRDB RefID: 27260

- *Evaluation of Continuous Air Monitor Placement in a Plutonium Facility*, J. J. Whicker, J. C. Rodgers, C. I. Fairchild, R. C. Scripsick, and R. C. Lopez; Health Physics, Volume 72, pp. 734–743; 1997; SRDB Ref ID: 13095

- *Relationship of Air Sample Measurements to Internal Dose: A Review*, J. J. Whicker; Health Physics Society Midyear Topical Meeting; 2004; SRDB Ref ID: 13096

- *In Vivo Assessment of Whole Body Radioisotope Burdens at the Los Alamos National Laboratory*, D. G. Vasilik and I. C. Aikin; LA-9858-MS, Los Alamos National Laboratory; 1983: SRDB Ref ID: 925

- Internal memorandum, *Health Protection of Maintenance Personnel Working in Contaminated Areas*, J. F. Tribby; Los Alamos Scientific Laboratory; May 14, 1946; SRDB Ref ID: 27980

- *Los Alamos National Laboratory (LANL) Bioassay Data Project Final Report*, J. M. O'Brien; Shonka, Inc.; Atlanta, Georgia; June, 2006; SRDB Ref ID: 49287

- *Identifying Uranium Intakes from Bioassay Data in the Presence of Environmental Background*, T. T. Little, G. Miller, and R. Guilmette; Proceedings of the 49th Annual Radiobioassay & Radiochemical Measurements Conference; 2003; http://www.bioassay.org/2003; SRDB Ref ID: 12939

- *Health Physics Checklist*, http://eshdb.lanl.gov/~esh12/new_eshdb/Matrices, accessed April 30, 2004; SRDB Ref ID: 12969

- *Tiger Team Assessment of the Los Alamos National Laboratory*, U.S. Department of Energy; November 1991; SRDB Ref ID: 23620

- E-mail correspondence, *LANL Lab Notebooks*, J. Buddenbaum; ENSR|AECOM; Westford, Massachusetts; September 1, 2006; SRDB Ref ID: 27995

- *Conference Call Minutes, Final*, J. Buddenbaum; ENSR|AECOM; Westford, Massachusetts; February 13, 2006; SRDB Ref ID: 27992

- *Los Alamos National Laboratory Radiological Dose Assessment – Tritium Internal Dosimetry*, W. C. Inkret, D. Lewis, G. Miller, and M. E. Schillaci; LA-UR-99-838; Los Alamos National Laboratory; 1999; SRDB Ref ID: 12899

- *Los Alamos National Laboratory Radiological Dose Assessment – Tritium Internal Dosimetry and Bioassay Programs*, Inkret, W. C., D. Lewis, T. T. Little, G. Miller, and M. E. Schillaci, LA-UR-99-832; Los Alamos National Laboratory; 1998; SRDB Ref ID: 13485

- *Los Alamos National Laboratory Radiological Dose Assessment – Americium Internal Dosimetry and Bioassay Program*, W. C. Inkret, D. Lewis, G. Miller, and M. E. Schillaci; LA-UR-99-836; Los Alamos National Laboratory; 1998; SRDB Ref ID: 13488

4.7 Documentation and/or Affidavits Provided by Petitioners

In qualifying and evaluating the petition, NIOSH reviewed a large number of documents submitted by the petitioners. These documents are in the file of supporting documents submitted with the SEC-00109 Petition (OSA Ref ID: 105765); the document titles and/or descriptions are listed in Attachment 1. This same file also contains the following ten affidavits from workers or survivors:

- *Affidavit from* D&D Laborer, February 13, 2008; pdf pp. 213-214

- *Affidavit from* Security Officer, March 24, 2008; pdf pp. 173-175

- *Affidavit from* Assembly Technician, April 12, 2005; pdf pp. 204-208

- *Affidavit from* Laborer (unspecified), June 6, 2006; pdf pp. 211-212

- *Affidavit from* Survivor of Uncle who worked as Chemical Plant Operator, Prototype Machinist, and Plant Engineering Technician; February 28, 2007; pdf pp. 215-216

- *Affidavit from* Engineer-Operator, March 18, 2008; pdf pp. 186-199
- *Affidavit from* Electrician, June 21, 2006; pdf p. 176
- *Affidavit from* Custodial Worker, February 12, 2008; pdf pp. 209-210
- *Affidavit from* current staff member of the Office of Nuclear Worker Advocacy (State of New Mexico) and former LANL administrative worker; also documenting work history of deceased father who worked as a Truck Driver; March 21, 2008; pdf pp. 177-181
- *Affidavit from* Radiation Technician, April 12, 2005; pdf pp. 200-203

5.0 Radiological Operations Relevant to the Class Evaluated by NIOSH

The following subsections summarize both radiological operations at the LANL from January 1, 1976 through December 31, 2005 and the information available to NIOSH to characterize particular processes and radioactive source materials. From available sources NIOSH has gathered process and source descriptions, information regarding radionuclides of concern, and information describing processes through which radiation exposures may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is intended only to be a summary of the available information.

5.1 LANL Plant and Process Descriptions

ATTRIBUTION: Section 5.1 was completed by Chris Miles, Quantaflux, LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

NOTE: The LANL Evaluation Report for Petition SEC-00051 (covering 1943 through 1975) provides a detailed historical description of the LANL site. Additional information can also be found in the Site Description TBD of the Site Profile, ORAUT-TKBS-0010-2. The following discussion focuses on the time period currently under evaluation (1976 through 2005).

Nuclear weapons-related activities have been the primary function of LANL since the laboratory was established in 1943. Since that time until 2006, including the entire period covered by this evaluation, the laboratory was managed by the University of California. Work with radioactive materials in the very early years involved primarily plutonium, enriched uranium, and fission products. Since those early years through the present time, the site has been performing a variety of activities involving a wide array of radioactive materials, nuclear reactors, accelerators, and other machines that generate ionizing radiation.

To accomplish its mission, LANL was divided into a number of physically separate Technical Areas (TAs) which spread in time over a relatively large area. These TAs and locations, along with their significant radiation sources, are briefly described in Table 5-1 of the Evaluation Report for Petition SEC-00051.

The LANL site's main functional areas include:

- Weapons Development and Testing
- Critical Assemblies, Reactors, and Reactor Development
- Accelerators, X-ray Equipment, and Radiography Sources
- Biomedical Research
- Project Sherwood and Fusion Research
- Waste Treatment and Disposal

Overviews of each of these functional areas are presented in Section 5.2 of the SEC-00051 Evaluation Report. More detailed information on TAs and functional areas is also available in ORAUT-TKBS-0010-2.

5.2 Radiological Exposure Sources from LANL Operations

The following subsections provide an overview of the internal and external exposure sources for the LANL class under evaluation.

5.2.1 Internal Radiological Exposure Sources from LANL Operations

ATTRIBUTION: Section 5.2.1 and its related subsections were completed by Chris Miles, Quantaflux, LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

In the SEC-00051 Petition Evaluation Report, data deficiencies for mixed fission and mixed activation products, Am-241 (separated from plutonium), Th-232, Th-230, Ac-227, Pa-231, Np-237, and Cm-244 were identified for the 1970 through 1975 time period. NIOSH subsequently recognized that these internal dose reconstruction issues may also exist for the post-1975 period. On this basis, NIOSH determined that this current petition (SEC-00109) qualified for evaluation. Potential intakes of these "exotic" radionuclides are therefore a focus of this evaluation report. The primary exposure sources (tritium, uranium, and plutonium) are also included for completeness and because, as will be seen later in this report, intakes of the primary sources can sometimes be used to bound intakes of the exotic radionuclides.

Many of the radioactive source materials handled at LANL were alpha-particle emitters. Although alpha particles do not present an external exposure hazard, prevention of internal exposures to alpha-emitters was recognized from the onset of site operations as the most significant radiological hazard protection challenge.

There were also a variety of beta and beta-gamma-emitting radionuclides that represented potential internal dose hazards at LANL. Table 5-1 provides a summary of radionuclides that are recognized as potentially contributing to internal dose to LANL workers. This list is not all-inclusive, but it includes all of the more significant sources of internal radiation dose. Radionuclides that emit both alpha and beta(-gamma) are simply listed as alpha-emitters, since the alpha emission will be the predominant component of the internal dose. Likewise, beta-gamma emitters are simply listed as beta emitters. Specific TAs where various radionuclides may have been present are provided in Table 5-1 of the SEC-00051 Evaluation Report.

Table 5-1: Potential Contributors to LANL Internal Dose and Their Primary Modes of Decay

Radionuclide	Primary Mode of Decay
H-3	Beta
Sr-90/Y-90	Beta
Mixed Fission Products (MFP)	Beta
Mixed Activation Products (MAP)	Beta
Ac-227	Alpha (progeny)
Th-230	Alpha
Th-232	Alpha
Pa-231	Alpha
uranium	Alpha
Np-237	Alpha
plutonium	Alpha
Am-241	Alpha
Cm-244	Alpha

5.2.1.1 Plutonium

Freshly-separated weapons-grade plutonium is comprised of nominally 93% by weight Pu-239, 6% Pu-240, and less than 1% (combined) of Pu-238, Pu-241, and Pu-242. With time, Am-241 begins to "grow in" to the mix as Pu-241 decays. Kilogram quantities of weapons-grade plutonium have been handled at LANL throughout its history.

Beginning in 1968, heat sources (radioisotope thermoelectric generators) containing primarily Pu-238 were developed at LANL for space electric-power applications and for powering artificial organs. Such programs involving the use of Pu-238 have been on-going for the duration of this evaluation period.

5.2.1.2 Hydrogen-3 (Tritium)

Tritium is a primary component of thermonuclear weapons and was used extensively at LANL throughout the time period under evaluation. Megacurie quantities of H-3 have been handled at LANL. Tritium at LANL has taken several forms, including water (HTO), organically-bound tritium (OBT), metal tritide (MT), and gaseous hydrogen (T2 or HT). Gaseous tritium could have been contained as a pressurized gas or adsorbed onto various metals (e.g., uranium or palladium).

5.2.1.3 Uranium

Depleted and natural uranium compounds were commonly used in kilogram quantities at LANL. Enriched uranium and U-233 were used in critical assemblies. The U-233 contained U-232 as an unavoidable contaminant.

5.2.1.4 Mixed Fission and Activation Products

Mixed fission and products (MFP) and mixed activation products (MAP) are generally beta and/or gamma-emitters. MFP is common in reactor areas. MFP includes Cs-137, Sr-90, radioactive noble gases, and others. MAP is common in accelerator and reactor areas. MAP includes C-11, N-13, O-15, Ar-41, Be-7, Na-22, Na-24, Co-58, Co-57, Mn-54, Mn-52, V-48, and others.

5.2.1.5 Strontium-90/Yttrium-90

Sr-90/Y-90 is a common component of MFP. It is also listed separately here because it is a residual contaminant from the radioactive lanthanum (RaLa) program, in which case it could be present in some areas in the absence of other mixed fission products. The RaLa program ended in 1963 (Bayo, 1963). Residual Sr-90 contamination from the RaLa program was still present in some areas after 1975. H-1 Health Physics Quarterly Progress Reports for October-December 1979 and January-March 1980 discuss decommissioning activities at Ten Site involving an estimated 0.021 Ci of Sr-90 in 260 m^3 of waste debris (Quarterly, 1979; Quarterly, 1980). A Radiological Work Permit from 1995 addresses an asbestos removal operation involving Sr-90 contamination (RWP, 1995).

5.2.1.6 Thorium-230

In the 1950s, an effort was underway within the AEC complex to build a production capacity for Th-230 (also called "ionium") as a potential heat source. It appears that LANL may have had some involvement with this effort since there were a number of bioassays conducted for Th-230 in the year 1958. There is no evidence of its use since that time.

5.2.1.7 Thorium-232

According to the LANL Occupational Internal Dose TBD, casting, machining, and powder metallurgy were conducted with Th-232 at LANL (ORAUT-TKBS-0010-5). There is evidence of operations involving Th-232 beginning in the mid-1940s (Steele, 1998; SCA-TR-TASK1-0011). There are also indications that operations involving Th-232 continued into later years, as evidenced from an Office Memorandum from H-1 Division, dated October 29, 1976, titled *Health Physics Aspects of Thorium*. (Buckland, 1976). This memo compares Th-232 with depleted uranium with respect to specific activities. It also compares Th-232 to Pu-238 from an internal dose perspective, pointing out the tremendous difference between Th-232 and Pu-238 in terms of specific activity. Special Work Permits (SWPs) for Radiation Work from 1992 discuss operations involving Th-232 contamination (SWP, 1992).

5.2.1.8 Americium-241

As mentioned in Section 5.2.1.1, Am-241 is a component that is always present in aged weapons-grade plutonium. There is also evidence that operations involving purified Am-241 took place at LANL during the time period under evaluation (post-1975). For example, a 1982 memorandum that discusses the criteria for routine Am-241 urine sampling states: "However, in the plutonium recovery process Am-241 concentrates in the residues (which contain little plutonium) such that the weight percent of Am-241 is much larger than initial values. These high Am-241 content residues may be recycled for more efficient plutonium recovery, further processed to recover the

Am-241 specifically, or prepared for recoverable storage. Personnel involved in these operations would be americium workers." (Criteria, 1982).

5.2.1.9 Neptunium-237

Neptunium-237 was not a commonly-used radionuclide at LANL. There is, however, evidence of periodic operations involving Np-237 prior to 1975 and continuing to at least 2002. Approximately seven kg of Np-237 metal were used for a criticality experiment conducted in 2002 (Mosteller, 2003). A TA-55 "Radiological and Hazardous Work Permit," dated August 30, 1994, addresses radiological issues for work involving Np-237 contamination (TA-55 RWP). The SEC-00109 petitioner also describes use of 100-gram quantities of neptunium powders (Neptunium, 2005).

5.2.1.10 Actinium-227

There is no indication that Ac-227 was frequently used post-1975. LANL research operations with Ac-227 were focused on its possible use as a "substitute" radionuclide to replace Po-210, which had a short half-life (DOE, 1993). The "substitute material" program was cancelled in 1955 (DOE, 1993).

For the time period under evaluation (post-1975), only residual material would have formed a potential for a presumptive exposure. For example, decommissioning and decontamination of Filter Building 153 in 1978 (Harper, 1981) is likely to have resulted in potential exposures to Ac-227.

5.2.1.11 Protactinium-231

In a survey conducted by the Mound site in 1970, LANL projected its future needs for Pa-231 for the years 1979, 1980, and 1981, as 0.1 g, 30.1 g, and 11.0 g, respectively (Eppley, 1979). Another Mound site reference states that the semi-works operated at Mound from 1974 through 1979, and that during this time, 0.890 g of Pa-231 were produced (DOE, 1993). The end of Pa-231 processing in the semi-works precludes delivery of the material to LANL after 1979. Although NIOSH has been unable to find specific evidence of Pa-231 use at LANL, the topic is included in this section because it was identified in the SEC-00051 Evaluation Report as being a radionuclide for which internal dose reconstruction issues may exist after 1975.

5.2.1.12 Curium-244

There is evidence that operations involving Cm-244 took place at LANL in the 1950s (and perhaps into the 1960s). In an external "Radiation Exposure Follow-up" report, dated 1985, there is mention of a weld encapsulation operation of highly-radioactive materials, including Cm-244 (Follow-up, 1985).

A special dose assessment for Cm-244 was performed in 2003 because an individual's security badge triggered an alarm and was found to be contaminated with Cm-244 (Little, 2003). The source of the contamination was one of many uncharacterized items that site personnel had packed into a cooler and shipped to TA-59 for pre-disposal characterization. These were legacy items that had been placed inside two stainless steel boxes and stored inside a shielded pit in the hot cell area of TA-48. TA-48 personnel were engaged in an effort to identify and dispose of unnecessary material so that the hazard category of the facility could be reduced. Quoting the Occurrence Report (ORPS, 2003), these items had been stored for "tens of years (at least one sample was dated 1970's). The owner (as indicated by labeling on the boxes) has been retired from the laboratory for some time. When contacted by TA-48 personnel, he did not remember what might be in the boxes." Through a series of administrative oversights, the individual's badge, smock, and radiological van became contaminated by Cm-244 when she repackaged items in the van. The presence of this legacy material supports the notion that operations involving Cm-244 took place at some point during the site's history.

5.2.2 External Radiological Exposure Sources from LANL Operations

ATTRIBUTION: Section 5.2.2 and its related subsections were completed by Chris Miles, Quantaflux, LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

Given the broad scope of activities involving ionizing radiation at LANL, workers were potentially exposed to external photon, beta and/or neutron radiation from a variety of sources. Potential sources included numerous radioactive materials, nuclear reactors, particle accelerators, and miscellaneous X-ray-generating equipment.

5.2.2.1 Photon

Many LANL radiological operations involved gamma and X-ray photon radiation fields. Potential photon exposure sources to workers would have been associated with the following:

- Gamma-emitting fission and/or activation products resulting from reactor and accelerator operations.
- Uranium and associated decay progeny.
- Bremsstrahlung radiation from various beta-emitting radionuclides.
- X-ray-generating machines.
- Plutonium and associated decay progeny
- Calibration sources of americium, thorium, radium, cobalt, cesium, and other miscellaneous radionuclides.

5.2.2.2 Beta

LANL facilities during the period under evaluation involved diverse activities with an extensive beta particle-emitting source term. Beta radiation over a broad range of energies could have been encountered from: certain plutonium isotopes; uranium progeny; thorium progeny; tritium; activation and fission products from reactor and accelerator operations; and other radionuclides such as those used as calibration sources.

Whether a beta source is considered an internal hazard or both an internal and external hazard depends on the maximum energy of the beta emission continuum for a given radionuclide, the shielding employed, and the use of protective clothing. Higher-energy beta emitters present both an external hazard (to the skin) and an internal hazard. In many cases, beta-emitting radionuclides also emit characteristic photons.

5.2.2.3 Neutron

There were several sources of potential neutron radiation exposure associated with LANL operations. Neutron exposures could have resulted from LANL weapons development operations, neutron-generating sources, criticality experiments, and operating reactors and accelerators. The source of the neutron emissions from these activities and potential worker exposure would have been associated with the following:

- Spontaneous fission
- Alpha-neutron (α,n) reactions particularly with low-atomic-number elements
- Operating reactors
- Criticality experiments with plutonium or enriched uranium
- Accelerators
- Neutron-generating sources, either via the α,n reaction (PuBe, RaBe, PoBe) or via spontaneous fission sources (Cf-252)

The broad scope of LANL neutron-generating activities resulted in a correspondingly extensive neutron energy spectrum. The spectrum ranged from the thermal energy region of 0.025 eV through the fission spectrum of 0.1 to 6.0 MeV (predominant energy of 0.7 to 1.0 MeV), and included high-energy, accelerator-produced neutrons up to 20 MeV. Estimated neutron energy spectra for various LANL operations are in SEC-00051, Table 5-4. More detailed information is available in ORAUT-TKBS-0010-6.

5.2.3 Incidents

ATTRIBUTION: Section 5.3 was completed by Chris Miles, Quantaflux, LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

After researching the historical monitoring programs and their records disposition, the LANL staff has provided the following accounting of incident-related records that are available:

Hardcopy Historical Incident Files (1944 – 1991), including:

- Miscellaneous event-related and monitoring records
- Type A/B/C investigation reports (also available through DOE/HSS)
- Radiation Occurrence Reports (RORs) (1974 – 1991)
  - Record inventory summaries for each year
  - Datatrieve entry forms for each ROR
  - Datatrieve printouts
  - Details of events and personnel involved
  - Indications whether special bioassay was performed
- Radiological Incident Reports related to significant ROR events

Radiological Incident Reports (RIRs) / Radiation Protection Observations (RPOs):

- Includes details of events and personnel involved
- Name changed to RPO in 2005
- Hardcopy for 1989-2000 in LANL archives
- Hardcopy RIRs archived in:
  - Late 1980s to early 1990s: FRC (Denver)
  - Late 1980s to early 1990s: NSSB (LANL, accessible)
  - Mid 1990s-2000: TA-35 (LANL, inaccessible – in transit to NSSB
  - 2001-present: database, TA-59

ORPS Reports (1990-present):

- DOE-maintained database includes details of events, but no personal information

Hardcopy Dose Assessment Reports (1998-present):

- Includes methods, data, and results of special dose assessments

Hardcopy Personnel Radiological Files (1944-present):

- Includes any dose-related information incremental to routine dosimetry

Electronic Bioassay Data Repository (1944-present):

- Includes all bioassay results (routine, special, *in vitro*, *in vivo*)

Internal Dosimetry Database (1944-present):

- Includes bioassay and dose assessment results from Pu-238, Pu-239, Am-241, and H-3 intakes

Personnel Dose Records (1944-present):

- Internal doses for applicable individuals

There was an attempt to comprehensively review LANL incidents in the past. In 1999, the Centers for Disease Control and Prevention (CDC) began the Los Alamos Historical Document Retrieval and Assessment (LAHDRA) project. The purpose of the LAHDRA project was to identify information available concerning past releases of radionuclides and chemicals at the LANL site. Millions of documents were reviewed; however, issues regarding access to classified information prevented access to all files. As a result, a large but still partial chronology of incidents was compiled. The following incidents are examples of incident types that occurred during the time period under evaluation. These incidents are drawn from Appendix L of the *2007 Interim Report of CDC's LAHDRA Project* (LAHDRA, 2007).

- January 1, 1976: Air release – Approximately 3271 Ci of tritium was released into the environment.

- July 15, 1976: Air Release – Tritium release of 22,000 Ci from TA-3-34.

- January 1, 1977: Air Release – Approximately 6417 Ci of tritium was released into the environment.

- October 6, 1977: Air Release – Tritium release of 33, 800 Ci from TA-33-86.

- November 11, 1977: Fire – At the TA-54 Burial Pit, seven bales of suspect low-level radioactive contaminated combustible waste auto-ignited.
- May 4, 1979: Air Release – Tritium release of approximately 3000 Ci from SM-34.
- August 22, 1979 – Air Release – Approximately 200 grams of UF-6 was released at Building 23 TA-18 Parajito Site.
- February, 1981: Contamination Events – A total of eleven minor radiation accidents were reported internally.
- October 14, 1981: Contamination Event – Plutonium contamination incident at TA-3, SM-29.
- November, 1981: Contamination Events – A total of ten minor radiation releases were reported internally.
- November 2, 1982: Liquid Release – Approximately 50-100 liters of waste liquid escaped from a tank vent at TA-21-257, contaminating the roof, walls, and surrounding area with plutonium, americium, and uranium.
- June 1, 1983: Air Release - High airborne plutonium levels were detected in Room 429 at TA-55 Building PF-4.
- February 17, 1984: Fire – Filter bags were ignited in the TA-50 Building 1 ventilation exhaust plenum.
- September 12, 1985: Fire – A fire in a glove box at TA55-4-429 resulted in high airborne activity and area contamination.
- October 30, 1986: Air Release – An estimated 633 Ci of tritium were released at TA-33, mostly in the form of tritiated water.
- February 27, 1990: Liquid Release – Cooling water overflowed into the exhaust system of TA-55-4.
- March 1, 2000: Air Release - Eight workers at TA-55 were exposed to airborne plutonium.
- May, 2000: Fire – A wild fire was ignited that ultimately burned nearly 50,000 acres in and around Los Alamos. This incident was cited by the petitioner (see Section 7.4.1)
- July, 2005: Contamination Event - Am-241 contamination occurred at the Sigma Facility due to repeated handling of highly-contaminated components with no radiological controls in place. This incident was cited by the petitioner (see Section 7.4.1)

6.0 Summary of Available Monitoring Data for the Class Evaluated by NIOSH

The following subsections provide an overview of the state of the available internal and external monitoring data for the LANL class under evaluation.

6.1 Available LANL Internal Monitoring Data

ATTRIBUTION: Section 6.1 was completed by Chris Miles, Quantaflux, LLC; and Rowena Argall, MJW Corporation. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

In vivo counting equipment and techniques were developed in the late 1950s and have been in routine use for measuring X-ray and gamma-ray-emitting radionuclides since June 1969 (Internal Dosimetry, 2007). There are indications that some of the counts recorded between 1955 (program onset) and the 1960s were performed for program development rather than actual suspected intakes. NIOSH has been unable to locate any records of these early *in vivo* measurements. A detailed discussion of the early years of *in vivo* counting is provided in the ER for petition SEC-00051.

In 1970, an *in vivo* counter capable of measuring four separate regions of the body began operation (Vasilik, 1983). Twin Phoswich (CsI and NaI) detectors were placed over the lungs. The two layers of the detector were capable of simultaneously, yet separately, monitoring chest burdens for 10- to 250-keV photons (NaI), and 200- to 2,000-keV photons (CsI) for a qualitative assessment of a variety of fission and activation nuclides. A planar High Purity Germanium (HPGe) detector monitored the region between 10 and 250 keV with excellent energy resolution and could be positioned over the liver or thyroid as needed. Finally, an HPGe (previously a GeLi) detector was positioned under the prone subject. This detector was primarily for whole-body assessment. This system could both identify radionuclides and quantify the body burden. Pu-239 and Am-241 were a routine part of the *in vivo* analysis library for all individuals receiving lung counts. In recent years, U-235 and Th-234 (as U-238) were added to the routine library. Other nuclides would be identified at their corresponding MDA levels if they appeared in the gamma spectrum. MDAs for whole-body counting and lung counting by historical period are provided in Tables 5-17 and 5-19 in ORAUT-TKBS-0010-5.

Table 6-1 summarizes the records in the *in vivo* database for the post-1975 period, including non-positive results.

Table 6-1: Number of Records in the LANL *in vivo* Database

Analyte	Number of Records (1976 forward)
Am-241	40,966
As-72	12
Be-7	963
Bi-214	12
Br-76	61
Br-77	64
C-11/N-13	1,461
Cd-109	81
Ce-141	61
Cf-249	14
Cm-244	1
Co-56	7
Co-57	18
Co-57/Co-58	2
Co-58	7
Co-60	211
Cr-51	7
Cs-134	189
Cs-137	440
Cu-64	7
Cu-67	8
Eu-152	507
Fe-59	8
"Fission Prods"	1
Ge-67/Ga-67	1
Ge-68/Ga-68	2
Hf-173	4
Hg-195m	61
Hg-197	85
Hg-197m	61
Hg-203	73
I-125	314
I-131	12
I-132	2
"Mixed Activation Products"	0
"Mixed Fission Products"	0
Mn-54	928
Na-22	1,321
Na-24	25
Nd-147	61
Os-185	61
P-32	0
Pb-212	2
Pu-238	6
Pu-239	40,100
Ra-226	0
Rb-83	62

Table 6-1: Number of Records in the LANL *in vivo* Database

Analyte	**Number of Records (1976 forward)**
Rb-84	61
Sb-124	61
Sc-46	18
Se-72/As-72	1
Se-75	72
Sm-145	61
Ta-179	69
Te-132	1
Th-234	2,971
Tl-201	61
Tl-202	62
"Tungsten"	2
U-235	2,974
U-237	8
U-238	127
"Unidentified"	2
V-48	9
Zn-65	10
Zr-95	4
Zr-95/Nb-95	7

Table 6-2 below shows that bioassay results are available for the development of co-worker studies for use in dose reconstructions. Data values for H-3, U-235, and U-238 for Jan-Jun 91 are absent from the static data subsets the ORAU Team derived from the LANL bioassay database. There appears to have been a change in record-keeping practices during that period with a modern database coming on line in mid-1991. In addition, there was a shift in analytical technique from Uranium Neutron Activation Analysis (UNAA) to Radiometric Alpha Spectroscopy (RAS).

Although not readily available for the purpose of generating the table below, data for the year 2005 do exist at LANL and have been requested. Details regarding the various analyses used and the associated minimum detectable activities are presented in the Technical Basis Document for the Los Alamos National Laboratory - Occupational Internal Dose (ORAUT-TKBS-0010-5).

Table 6-2: Number of LANL Urinalysis Samples, 1976-2004									
Year	**Am-241**	**H-3**	**Pu-238**	**Pu-239**	**Pu-240**	**U***	**U-234**	**U-235**	**U-238**
1976		963	2714	2757		1738			
1977		815	3043	3070		1780			
1978		756	2434	2441		2653			
1979		1390	2703	2713		2724			
1980		1589	2689	2711		2951			
1981		1282	3297	3328		2972			
1982		1063	2192	2211		1874			
1983		930	1998	1990		1342			
1984		1361	2172	2170		1189			
1985		1566	2086	2087		925			
1986		1492	1983	1983		822			
1987		1666	1973	1970		768			
1988		1611	1931	1927		954			
1989		1870	2197	2201				272***	604***
1990		2197	2218	2219				394***	953***
Jan-Jun 91			1256	1256					
Jul-Dec 91	30	1247	1099	1099			538	538	538
1992	38	2307	2254	2254			1360	1360	1360
1993	28	1974	2584	2584			1431	1431	1431
1994	47	1691	2390	2390			1602	1602	1602
1995	57	1955	1991	1991			1651	1651	1651
1996	12	1647	1937	1948			1026	1026	1026
1997	85	1681	1928	2434	138**		825	825	825
1998	122	1691	2343	2668	117		829	829	829
1999	123	1673	2085	2455	62		740	740	740
2000	114	1623	2299	2565	67		905	905	905
2001	133	1471	2092	2771	186		1272	1272	1272
2002	142	1406	2206	3292	213		748	748	748
2003	107	1427	2342	3949	1189		772	772	772
2004	161	1260	2147	3772	1625		1109	1109	1109

* Reported uranium samples for 1976-1988 are for non-isotopic-specific urinalysis.
** The introduction of TIMS analysis in 1997 made the separation of Pu-240 possible.
*** 1989 through June 1991 comprises a transition period to a new analytical technique for uranium. The uranium results for U-235 and U-238 for 1989 and 1990 correspond to EU and DU.

6.2 Available LANL External Monitoring Data

ATTRIBUTION: Section 6.2 was completed by Chris Miles, Quantaflux, LLC; and Bob Burns, NGTS, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

NOTE: The following discussion focuses on the time period for the class under evaluation (1976 through 2005). For a historical summary of the LANL external monitoring program as it developed from the onset of operations in 1943, see the LANL Occupational External Dose TBD (ORAUT-TKBS-0010-6). That document discusses the evolution of dosimetric technology, analytical techniques, MDAs, calibration procedures, and methods for estimating missed dose.

Historically, LANL had an extensive radiation safety monitoring program using portable radiation instruments, contamination surveys, zone controls, and personnel dosimeters for measuring exposure in the workplace. This program was conducted directly by, or under the guidance of, a specially-trained group of radiation monitors or radiation protection technologists. The relevant types of personnel dosimetry technology in use during the time period under evaluation are listed below.

- The Cycolac film badge was adopted in 1962 and used until 1978. The multi-element Cycolac used several filters and two film packets: a DuPont 543 packet that contained DuPont 502 dental film and an Eastman Kodak Type B packet that contained an NTA fast neutron film. In addition, it contained indium, gold, and sulfur foils for accident dosimetry. The Cycolac badge was improved relative to earlier LANL dosimeters and was considered to have the advantages of relative gamma and X-ray energy independence (within 30%) from about 30 keV to 1,400 keV, the ability to evaluate thermal neutrons in the presence of X- and gamma radiations below 400 keV, and improved directional independence.

- Beginning in 1978, LANL began conversion to the Model 7776 thermoluminescent dosimeter (TLD). The TLD had cadmium (for use in neutron radiation fields) and non-cadmium versions. It incorporated copper, Cycolac plastic, and cadmium filters and used three TLD-700 chips (one covered with copper, one with thin Cycolac plastic, and the third with thicker plastic) and one TLD-600 chip (enriched in ^{6}Li). In the cadmium badge, the third TLD-700 chip and the TLD-600 chip were shielded by cadmium pockets, as opposed to plastic covers in the non-cadmium badge. The changeover from film dosimeters to TLDs as the dosimeter of record was completed on January 1, 1980. The Model 7776 dosimeter was not designed to meet the DOELAP performance criteria for those categories involving low-energy beta particles or mixtures of beta and low-energy photons (Hoffman, 1999, pdf p. 4).

  Neutron dose determination with the Model 7776 dosimeter relied on the use of site- and operation-specific neutron correction factors (NCFs) to improve accuracy of the assigned neutron dose. TLD albedo dosimeters are sensitive to intermediate and lower-energy neutrons that other dosimetry methods could not detect, but their net neutron signal was highly energy-dependent and required the use of workplace-specific NCFs to convert the response to dose. NCFs could vary by more than an order of magnitude. As a consequence, NCFs that were assigned had conservative values; therefore, neutron doses were typically overestimated by factors of two to three (Blackstock, 1978). A detachable holder for NTA film was included in the Model 7776 TLD badge design to improve fast neutron measurement (Mallett, 1990).

- In 1995, LANL began using the Model 8823 TLD and a Track-Etch Dosimeter (TED or PN3), that is sensitive only to neutron radiation and employed for special field conditions. The Model 8823 is an improved TLD design that contains two TLD cards containing a total of 8 TLD sensitive elements. The TED component contains three dosimetry-grade CR-39 track-etch plastic foils (Hoffman, 1999, pdf p. 30). The foils are placed in a hemispherically-shaped ABS plastic case on the sides of a triangular polystyrene pyramid to minimize angular dependence of the TED. (Hoffman, 1999, pdf p. 30). The Model 8823 became the dosimeter of record for LANL on April 1, 1998. It satisfies DOELAP performance criteria in all categories and continues in use until the present.

Due to historical changes in dosimetric technology and analytical methodology, workers exposures have been recorded in different data types. Table 6-3 summarizes the dose data types that have been recorded in LANL worker exposure records over time. Interpretations of these data types for dose reconstruction are detailed in ORAUT-TKBS-0010-6, Attachment A.

Table 6-3: Dose Data Types Recorded Over Time

Period	Dose Data Types Recorded in Personnel Exposure Records
1960–1979	Gamma dose (rem) Beta dose (rad) Thermal neutron dose (rem) Fast neutron dose (rem)
1980–1997	"Non-penetrating Rad" "Penetrating-rem" "Neutron-rem" "Total-rem"
1998–present	Beta shallow DE (mrem) Beta eye DE (mrem) Gamma shallow DE (mrem) Gamma deep DE (mrem) Gamma eye DE (mrem) Neutron deep DE (mrem) Total shallow DE (mrem) Total deep DE (mrem) Total eye DE (mrem) Total deep neutron DE (mrem)

Sources: LASL, 1977; LASL, 1979; LANL, 1986; LANL, 1989; LANL, 1996; LANL, 2001; LANL, 2003

LANL has always implemented a policy of monitoring individuals with the highest potential for exposure. When monitoring for external radiation exposures began in 1943, PICs were assigned to "a few persons thought to have the highest potential for receiving exposures at or above the 'tolerance' limit" (LANL, 1986, 10/6/81 Questionnaire). By 1945, when film badges were in use by a number of LANL groups, only workers with the "higher exposure potentials" were issued dosimeter badges (LANL, 1986, 10/6/81 Questionnaire). As of 1960, film badges were worn by about half of University of California employees, all of the Security Force, and 75% of Zia employees (LASL, 1969). Between 1943 and late 1981, the number of persons monitored for external exposures increased from less than 100/yr to more than 5,000/yr, but personnel monitoring for external radiation still had not been extended to all LANL workers (LANL, 1996). In the 1970s, LANL initiated an Employee Health Physics Checklist (LANL, 2004a). This checklist allowed the evaluation of each individual for potential internal and external exposure. Individuals were placed on the appropriate monitoring schedule based on this checklist. During the first quarter of 1976, 50 such checklists were completed, as evidenced by the Group H-1 Health Physics Quarterly Progress Report, January – March, 1976 (Quarterly, 1976). The checklist is still used and was computerized in 1998 as the Dosimetry Enrollment System.

Table 6-4 lists the reported numbers of workers monitored by LANL from 1976 to 2003 along with total and average doses calculated from those data (LANL, 2004b). Estimates of the total number of workers employed at LANL each year are also presented. The estimated number of LANL workers for each year was obtained from a number of LANL sources; these values are quite uncertain for some years. Consequently, for some years the number of total workers supplied by LANL is smaller than the number of people who received dosimeters. Sources of workforce data for Table 6-4 included staff from LANL Human Resources - Workforce Data & Analysis, and Los Alamos publication LASL-77-25. The major source of uncertainty appears to stem from variability in the worker types included in the worker count each year. Worker categories include full-time regular, part-time, limited-term, students, subcontractors, and visitors. More recent data have worker type information recorded, but older data might not.

In Table 6-4, "Average total dose" for each year is calculated as the total dose (person-rem) divided by the number of workers monitored (i.e., Column 2 divided by Column 3). The data have not been corrected for potential missed doses.

Table 6-4: Annual External Radiation Doses (1976-2005)				
Year	**Total Dose* (person-rem)**	**No. of Workers**		**Average Total Dose (rem)**
		Monitored	**Total**	
1976	393.26	5,254	6,224	0.07
1977	432.81	5,624	6,519	0.08
1978	364.53	7,045	7,162	0.05
1979	320.88	7,549	7,398	0.04
1980	375.54	7,638	5,317	0.05
1981	588.55	7,966	8,028	0.07
1982	672.83	7,997	7,639	0.08
1983	673.33	8,144	7,912	0.08
1984	798.77	8,622	8,467	0.09
1985	715.19	9,487	9,025	0.08
1986	531.67	9,612	9,265	0.06
1987	400.48	9,202	9,075	0.04
1988	391.98	9,469	9,128	0.04
1989	326.93	10,605	9,665	0.03
1990	228.85	10,796	10,806	0.02
1991	163.25	11,284	11,037	0.01
1992	132.49	11,560	11,377	0.01
1993	141.81	11,772	11,371	0.01
1994	178.44	11,783	11,386	0.02
1995	234.93	12,448	11,382	0.02
1996	188.70	10,958	11,603	0.02
1997	182.02	10,860	12,146	0.02
1998	158.21	11,167	12,829	0.01
1999	128.89	11,212	13,294	0.01
2000	87.45	10,456	12,987	0.01
2001	114.28	10,443	13,284	0.01
2002	160.06	10,871	14,332	0.01
2003	218.83	10,660	10,015	0.02
2004	113.29	10,192	13,652	0.01
2005	149.06	10,826	13,194	0.01

* Total Dose = deep dose + neutron dose
** Annual dose summaries are available for all years after 2005.

Tables 6-5, 6-6, and 6-7 below summarize the mean and maximum doses values for LANL workers with reported gamma, shallow, and neutron doses $\geq$ 50 mrem for the years 1976 through 2004 (partial). These data can be used to estimate unmonitored doses and to bound dose for the class. They can also be used to estimate reasonable values of unrecorded doses for which no records exist. The data upon which these tables are based do not include the potential missed dose.

Table 6-5: LANL Recorded Gamma Dose ≥ 50 mrem

	No. of Workers w/Reported Gamma Dose ≥ 50 mrem	Dose (mrem)	
		Mean	Maximum
1976	952	358	3,290
1977	921	422	4,460
1978	938	333	3,680
1979	779	270	1,870
1980	666	269	1,850
1981	832	271	2,400
1982	821	325	2,270
1983	1,017	296	2,160
1984	1,513	232	2,470
1985	733	354	1,880
1986	527	321	1,710
1987	420	314	2,740
1988	428	297	1,710
1989	436	256	1,470
1990	340	241	2,280
1991	298	187	1,860
1992	221	138	565
1993	224	140	946
1994	215	147	689
1995	193	126	285
1996	267	174	600
1997	327	200	1,210
1998	313	192	1,090
1999	253	158	641
2000	215	120	596
2001	281	169	2,130
2002	380	186	1,370
2003	453	250	2,350
2004	282	155	1,230
2005	339	157	1,266

* Parameters can be obtained for all years after 2005.

Table 6-6: LANL Recorded Shallow Dose ≥ 50 mrem			
	No. of Workers w/Reported Shallow Dose ≥ 50 mrem	Dose (mrem)	
		Mean	Maximum
1976	1,231	411	3,920
1977	1,211	476	5,470
1978	1,183	387	3,990
1979	1,036	283	2,330
1980	1,087	228	2,350
1981	1,275	253	2,930
1982	1,191	302	2,810
1983	1,414	274	2,750
1984	2,269	205	2,840
1985	1,299	263	1,970
1986	651	303	1,820
1987	501	314	8,890
1988	497	290	1,820
1989	518	249	1,470
1990	431	237	2,550
1991	398	188	2,042
1992	323	144	630
1993	349	141	962
1994	343	143	734
1995	345	182	657
1996	335	174	618
1997	466	186	1,342
1998	390	190	1,126
1999	311	162	1,572
2000	250	130	611
2001	353	165	2,133
2002	470	179	1,381
2003	548	236	2,352
2004	332	156	1,230
2005	383	164	1,291

* Parameters can be obtained for all years after 2005.

Table 6-7: LANL Recorded Neutron Dose ≥ 50 mrem			
	No. of Workers w/Reported Neutron Dose ≥ 50 mrem	Dose (mrem)	
		Mean	Maximum
1976	221	118	800
1977	162	160	990
1978	221	125	1,370
1979	418	198	1,380
1980	659	242	3,390
1981	723	415	3,970
1982	691	519	3,700
1983	586	555	3,790
1984	692	517	3,930
1985	779	538	3,390
1986	648	524	2,920
1987	616	409	2,270
1988	604	408	2,450
1989	602	326	1,510
1990	519	249	1,690
1991	369	248	1,523
1992	386	212	1,569
1993	408	217	1,651
1994	465	248	1,515
1995	592	265	1,705
1996	562	206	1,465
1997	412	206	1,374
1998	354	198	1,370
1999	333	207	1,451
2000	258	158	831
2001	272	177	1,474
2002	331	196	1,731
2003	411	190	1,564
2004	314	146	842
2005	382	165	1,584

* Parameters can be obtained for all years after 2005.

Details regarding the various analyses used and the associated minimum detectable activities are presented in the Technical Basis Document for the Los Alamos National Laboratory - Occupational External Dose (ORAUT-TKBS-0010-6).

7.0 Feasibility of Dose Reconstruction for the Class Evaluated by NIOSH

The feasibility determination for the class of employees under evaluation in this report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(1). Under that Act and rule, NIOSH must establish whether or not it has access to sufficient information either to estimate the maximum radiation dose for every type of cancer for which radiation doses are reconstructed that could have been incurred under plausible circumstances by any member of the class, or to estimate the radiation doses to members of the class more precisely than a maximum dose estimate. If NIOSH has access to sufficient information for either case, NIOSH would then determine that it would be feasible to conduct dose reconstructions.

In determining feasibility, NIOSH begins by evaluating whether current or completed NIOSH dose reconstructions demonstrate the feasibility of estimating with sufficient accuracy the potential radiation exposures of the class. If the conclusion is one of infeasibility, NIOSH systematically evaluates the sufficiency of different types of monitoring data, process and source or source term data, which together or individually might assure that NIOSH can estimate either the maximum doses that members of the class might have incurred, or more precise quantities that reflect the variability of exposures experienced by groups or individual members of the class as summarized in Section 7.6. This approach is discussed in OCAS's SEC Petition Evaluation Internal Procedures which are available at http://www.cdc.gov/niosh/ocas. The next four major subsections of this Evaluation Report examine:

- The sufficiency and reliability of the available data. (Section 7.1)
- The feasibility of reconstructing internal radiation doses. (Section 7.2)
- The feasibility of reconstructing external radiation doses. (Section 7.3)
- The bases for petition SEC-00109 as submitted by the petitioner. (Section 7.4)

7.1 Pedigree of LANL Data

This subsection answers questions that need to be asked before performing a feasibility evaluation. Data Pedigree addresses the background, history, and origin of the data. It requires looking at site methodologies that may have changed over time; primary versus secondary data sources and whether they match; and whether data are internally consistent. All these issues form the bedrock of the researcher's confidence and later conclusions about the data's quality, credibility, reliability, representativeness, and sufficiency for determining the feasibility of dose reconstruction. The feasibility evaluation presupposes that data pedigree issues have been settled.

7.1.1 Internal Monitoring Data Pedigree Review

ATTRIBUTION: Section 7.1.1 was completed by Bob Burns, NGTS, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

Beginning in 2004, LANL and NIOSH representatives began a collaborative effort to retrieve and evaluate LANL's historical bioassay data and capture it in an active database for on-going use. The master database is hosted and maintained by LANL. The ORAU Team has three static subsets of this database on its network: *in vivo* data for the period 1960-2004, *in vitro* data prior to 1991, and *in vitro* data for 1991-2004. These subsets result from queries of the master database designed to provide data for use in individual dose reconstructions and co-worker studies. The queries were performed in 2004, but subsequent data are available from the master database. These datasets provide a readily-available source of bioassay results for the radionuclides considered the principal sources of internal radiation dose prior to, and during, the class period under evaluation.

Based on a reconnaissance of the various databases and datasets that existed at LANL, it was decided to create the master bioassay database by modifying LANL's existing Bioassay Enrollment, Scheduling, and Tracking (BEST) system, which already contained bioassay data from 1990 to the present. Modification and adaptation of the BEST system was an iterative process carried out in parallel with the retrieval and evaluation of historical bioassay data. Beyond the data already in the BEST system, the additional data incorporated into the database were derived from three principal sources:

- *In vivo* data from existing and historical databases
- *In vitro* data for americium and plutonium from a standalone database
- *In vitro* data for tritium, uranium, and polonium (TUPo) extracted from an obsolete electronic archive format

Table 6-1 presents the *in vivo* analytes present in the database for the period 1976-2004; Table 6-2 presents the same information for urinalyses. There are no records for bioassay for polonium in the database after 1965.

Because the *in vivo* data and later *in vitro* data had primarily been recorded electronically (and automatically), validation of the historical information incorporated into the database focused on the earlier *in vitro* records (i.e., TUPo data). The electronically-archived TUPo data had been entered from laboratory notebooks, which were the formal records for such information prior to about 1980. Thus, the fraction of the *in vitro* data obtained from lab notebooks was relatively small for the time period under evaluation in this report (1976-2005). Most of the *in vitro* data for the period were obtained (recorded) automatically. The LANL bioassay master database provides a readily-available set of bioassay results for the radionuclides considered the principal sources of internal radiation dose for the class period under evaluation.

7.1.2 External Monitoring Data Pedigree Review

ATTRIBUTION: Section 7.1.2 was completed by Bob Burns, NGTS, Inc. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

NIOSH has found that LANL's policies for the collection and maintenance of employee external radiation monitoring data are sufficient to provide estimates of employee gamma, beta, and neutron dose. Radiological instrument and dosimeter measurement methods used for external exposures made during the evaluated timeframe were consistent with prevailing industry standards. With the exception of neutron exposure data obtained from NTA film (see Section 7.3), the data obtained from the evaluated class timeframe are sufficient in quality and quantity to be used to evaluate external doses. Section 7.3.4 describes a method to bound potential neutron exposures.

Records of radiation doses to individual workers from personnel dosimeters worn by workers and co-workers are available for LANL operations beginning in 1943. Doses from these dosimeters were recorded at the time of measurement and routinely reviewed by operations and radiation safety personnel for compliance with radiation control limits. Administrative practices are described in the *Photodosimetry Evaluation Book* (LASL 1959a, 1969, and 1977a, 1979; LANL 1986, 1989, 1996, 2001, and 2003) and LANL technical reports. Detailed information for each worker is in the NIOSH claim documentation. The claim documentation provides specific information to be evaluated on the recorded dose of record. There do not appear to have been significant administrative practices that jeopardized the integrity of the dose of record (ORAUT-TKBS-0010-6). Furthermore, data recording became more automated with time.

7.2 Evaluation of Bounding Internal Radiation Doses at LANL

ATTRIBUTION: Section 7.2 and its related subsections were completed by Chris Miles, Quantaflux, LLC; Rowena Argall, MJW Corporation; and Elizabeth Brackett, MJW Corporation. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The principal sources of internal radiation doses for members of the class under evaluation were the variety of site processes and incidents involving plutonium, americium, tritium, and uranium (ORAUT-TKBS-0010-5). The following subsections address the ability to bound internal doses, methods for bounding doses, and the feasibility of internal dose reconstruction.

7.2.1 Evaluation of Bounding Process-Related Internal Doses

The following subsections summarize the extent and limitations of information available for reconstructing the process-related internal doses of members of the class under evaluation.

The primary sources of internal radiation doses for members of the proposed class were inhalation of plutonium isotopes, tritium, uranium isotopes, and mixed fission and activation products (MFP/MAP). The LANL internal dosimetry database contains bioassay data for U-234/235/238, Pu-238/239, tritium, Po-210, and Cs-137. Uranium, plutonium, and tritium were the primary contributors to the collective internal dose at LANL during the time period under evaluation. Po-210, widely used during the 1940s and 1950s, was not a significant nuclide for this time period. Am-241 was also a significant source of internal dose, primarily due to its association with weapons-grade plutonium, although it was not always associated with plutonium. There is an abundance of bioassay data for Am-241. Data for Cs-137 are available due to ease of detection using gamma spectroscopy systems. For the purpose of this discussion, the term "exotics" is used to include everything other than U-234/235/238, Pu-238/239, tritium, Am-241, and Cs-137 (i.e., radionuclides for which there are limited or no internal dosimetry data). This would include Sr-90, Th-232, Cm-244, Ac-227, Pa-231, Np-237, and others. Although not primary contributors to the collective dose at LANL, it is possible that for some individuals, one or more of these exotic radionuclides were the primary source of internal dose. LANL clearly possessed capabilities to conduct bioassay measurements for these exotic radionuclides (LANL, 2008); however, specific data for such measurements are very sparse and generally unavailable.

Multiple data capture efforts have taken place to support this evaluation. These efforts have included trips to LANL as well as the National Archives in Denver. It is clear from these efforts that comprehensive health physics programs were in effect at LANL during the 1976-2005 time period. Hundreds of boxes of health physics records have been found pertaining to this time period. Records include: exposure reports, air monitoring reports, radiation incident reports, radiation work permits, special operating procedures, radioactive material handling, stack air monitoring, contamination surveys, nasal smears, whole body counting, urinalysis reports, CAM reports, ALARA reports, and employee checklists (Records, 2008)

These health physics records indicate that exotic radionuclides were handled, controlled, and monitored in a similar manner as the primary nuclides. For example, many alpha-emitting exotics were handled in a manner similar to handling plutonium: using glove-boxes, monitoring airborne concentrations, using personal protective equipment (PPE) such as respirators, performing surface contamination surveys, and covering jobs with radiation protection technicians. Although the vast majority of these documents were associated with the primary radionuclides, several documents pertaining to exotics were located. Some examples are listed below:

- A Special Work Permit (SWP) for Radiation Work, dated July 31,1992, addressed an operation described as "disconnect thoria duct, stack, and fan." Th-232 is identified as the radiological hazard associated with this operation. The PPE called for included double anti-contamination suits (anti-Cs) with taped openings and a full-face respirator. It also called for nose wipes and stated that urine samples were required, as requested (SWP, 1992).

- An SWP, dated July 28, 1992, addressed an operation described as "remove service connections, wiring, and plumbing for Th contaminated hood." Th-232 and U-238 are identified as the radiological hazards associated with this operation. The PPE called for included anti-Cs with taped openings and a full-face respirator, as requested. It also called for nose wipes (SWP, 1992).

- A Radiological and Hazardous Work Permit, dated August 30, 1994, addresses work involving Np-237 contamination. It calls for a continuous air monitor (CAM) to be used, with "settings changed to threshold 4.15, and window 1.5." It also required Level 1 PPE with full-face respirator and continuous health physics tech (HPT) coverage (TA-55 RWP).

- LANL report entitled, *The Decommissioning of TA-21-153, Ac-227 Contaminated Old Filter Building*, dated November 1981, includes a discussion about health physics controls used for this operation. The work was performed by experienced radiation workers who had received formal health physics training. Decommissioning work was not permitted without the presence of a health physics surveyor. All workers participated in a full-face respirator, fitting, testing, and training program. Air samplers and continuous air monitors (CAMs) were used with the maximum air concentration detected being 2.5 dis/s/m^3. All workers wore gamma and neutron film badges (TA-21-153, 1981).

- *Radiological Safety Procedures in P-Division*, dated January 1977, contain a set of procedures prepared by the Radiation Safety Committee which describe various health physics practices designed to minimize exposure to radioactive materials (P-Division, 1977).

- A memorandum, *Standard Operating Procedures for the Handling of Actinide Elements*, dated October 15, 1973 and reviewed and updated on April 20, 1976, states: "All manipulations of americium or curium are carried out in enclosed gloved-boxes or vacuum systems, maintained at a negative pressure with respect to laboratory air. Neoprene gloves, a minimum of 10-gauge thickness and tested for leaks before use are installed on these boxes. In addition, the operator uses surgeon's gloves. Protective clothing and a full face mask respirator are supplied. Respirators are used whenever material from a 'hot' gloved-box is transferred out, or between boxes." (SOPs, 1973).

- An office memorandum entitled *Radiation Protection Procedures*, dated September 17, 1976, lists 40 Standard Operating Procedures that pertain to radiation protection that were reviewed and found to be adequate and up-to-date (SOPs, 1976).

The above is small sampling from hundreds of boxes of health physics-related records that are archived at LANL.

NOTE: The LANL Evaluation Report for Petition SEC-00051 (covering 1943 through 1975) has a detailed description of the monitoring methods employed since the creation of the site. The following discussion focuses on the time period of the class currently under evaluation (1976 through 2005).

In the 1970s, LANL initiated an Employee Health Physics Checklist. This checklist allowed the evaluation of each individual for potential internal and external exposure, the purpose being the identification of those individuals with significant potential for radiation exposure. Individuals were placed on a monitoring schedule based on this checklist. The checklist is still used and was computerized in 1998 as the Dosimetry Enrollment System (Checklist, 1985; Checklist, 1990; Checklist, 2000). Sampling protocols for various radionuclides are discussed in the LANL Internal Dose TBD (ORAUT-TKBS-0010-5).

7.2.1.1 Urinalysis Information and Available Data

Excreta bioassay methods for determining internal exposures were developed in late 1944 for plutonium (fully implemented in April 1945); for uranium and americium in 1949; and tritium in 1950. Methodologies for interpreting these resulting bioassay data over the years are presented in the LANL Internal Dose TBD. Although the number of monitored individuals increased over the years, not all individuals working at LANL were monitored. The Employee Health Physics Checklist was used to ensure that workers with the highest exposure potential were monitored. These checklists were completed for LANL employees, contractor employees, students, and visitors (Checklist, 1977). Workers involved in radiological incidents were also often monitored, as evidenced by the historical incident files maintained by LANL (see Section 5.2.3 for a summary of the incident-related records that are available). Nasal swipes and wound counts have also been used extensively at LANL to identify the need for bioassay.

Plutonium

The largest intakes at LANL have involved isotopes of plutonium. Current and historical bioassay results are stored with the plutonium results in the LANL bioassay database. There are over 70,000 urine sample results for Pu-239 and over 60,000 results for Pu-238 in the LANL database, from 1976 through 2005. The optimum source of data to estimate doses to unmonitored workers is co-worker data analyzed per ORAUT-OTIB-0019. This analysis has been performed and documented in ORAUT-OTIB-0062 (draft). In 1997, the TIMS analysis (which could separate Pu-239 and Pu-240) became available. There are over 3500 urine sample results for Pu-240, beginning in 1997.

Many of the Service Support Workers, as defined in the petitioner-proposed class definition, were Zia Company employees. The Zia Company was the service workers' contractor for many years. Zia employees participated in a plutonium bioassay program that required annual urine samples. In 1976, a program was used for Zia employees that restricted access to plutonium areas if participation in the plutonium bioassay program was not recorded within 425 calendar days.

Table 7-1 contains a list of criteria and exempt job categories (LASL, 1978a). In more recent years, other service contractors have participated in site activities and would be subject to these criteria.

Table 7-1: Zia Employee Access to Plutonium Areas

Area	Urine Sample Within 425 Days of Entry	Exempt
Job requiring respiratory protection	X	
Modifications or repairs on dry boxes or other highly contaminated equipment.	X	
Replacement of plutonium-contaminated filters at all sites.	X	
Janitorial (long-term) work in plutonium operation areas	X	
Long-term operations (weeks) in areas of low levels of plutonium contamination (>1,000 dpm-60 cm^2 and <10,000 dpm-60 cm^2)	X	
Decontamination of plutonium spills with >10,000 dpm-60 cm^2	X	
Work in burial pits at TA-54 when personnel contamination potential is moderate to high	X	
Short-term jobs (2-3 d) when sizable quantities of plutonium (grams of Pu-238 or kilograms of Pu-239) are present in dry boxes (even when work is being done outside dry box)	X	
Supervisory personnel (base urine sample on record)		X
Short-term jobs (2-3 d) in areas of CMR Building, Ten Site, TA-50, TA-55, TA-54, TA-18, TA-48, or TA-21, where there is little plutonium contamination (<1,000 dpm-60 cm^2)		X
Jobs in other minimum exposure potential areas when respiratory protection is not required and possibility of plutonium contamination is minimal.		X

Americium

At LANL, Am-241 is usually encountered as a trace contaminant in plutonium; however, there is potential for exposure to pure Am-241, as seen in the 2005 Am-241 contamination incident discussed by the petitioner. The americium bioassay program began in 1954, although a procedure for determining Am-241 in urine was in development in 1948. Also, laboratory notebook pages dated 1950 through 1957 list approximately 950 urinalyses for Am-241; many of these results were pre-1954 (Kirkham, 2006). Current and historical bioassay results are stored with the plutonium results in the Los Alamos Bioassay Data Repository database. There are over 1200 urine sample results for Am-241 in the LANL database, from 1991 through 2005.

Tritium

Tritium was encountered in several forms: tritiated water (HTO), tritiated gas (HT), organically-bound tritium (OBT), and metal tritide (MT). Each form has unique characteristics. From 1950 until the present, an average of 100 individuals per year has been monitored for tritium intakes at LANL. The form generally encountered was HTO. There are no records of tritium monitoring prior to 1950. Urinalysis for tritium began on January 1, 1950; data are available in the Los Alamos Bioassay Data Repository database. There are over 40,000 urine sample results for tritium in the LANL database, from 1976 through 2005. The tritium bioassay data were sufficient to derive a co-worker model to estimate tritium doses after 1950 (ORAUT-OTIB-62, draft).

Uranium

Monitoring for uranium consisted of routine urinalysis, starting in 1949, for employees identified as being at risk for exposure (ORAUT-TKBS-0010-5, Table 5A-14, *Routine Sampling Procedure*). Nasal swipes with more than 50 cpm indicated the need for follow-up bioassay. Internal monitoring data are available in the Los Alamos Bioassay Data Repository database and doses due to intakes of uranium can be reconstructed for the period after 1949. There are over 40,000 urine sample results for uranium in the LANL database, from 1976 through 2005. The co-worker data were sufficient to derive intake estimates for unmonitored workers for uranium after January 1, 1950 (ORAUT-OTIB-62, draft).

Strontium-90

Records of routine or special Sr-90 urinalyses are very sparse for the post-1975 time period. Conversations in 2004 with current bioassay personnel indicate that possibly 200 Sr-90 analyses have been performed throughout the history of the site. In 1979, four urine samples were analyzed in association with a decommissioning operation at Ten Site, in an area that had been contaminated with Sr-90 due to the RaLa program prior to 1963 (Quarterly, 1980). Results are also available for three Sr-90 analyses performed in 1997 (Targeted Sr-90).

7.2.1.2 Lung and Whole Body Counting Information and Available Data

In vivo counting equipment and techniques were developed in the late 1950s and have been in routine use for measuring X-ray and gamma-ray-emitting radionuclides at LANL since 1970. Descriptions of the counting equipment in use over the years at LANL are included in the LANL Internal Dose TBD (ORAUT-TKBS-0010-5).

Prior to the recent consolidation efforts by LANL and NIOSH (see Section 7.1.1 and ORAUT-OTIB-0063, draft), *in vivo* counting data from 1960-2003 were maintained in a legacy system called "OMNIS7". Table 6-1 summarizes the numbers of *in vivo* records, by analyte, that are available in the LANL database during the post-1975 time period. Methodologies for interpreting these resulting bioassay data over the years are are presented in the LANL Internal Dose TBD (ORAUT-TKBS-0010-5). Validation of these data sources is described in Section 7.1.1.

7.2.1.3 Other Types of Intake Monitoring

Wound Counts

In August 1959, the H-6 Group acquired a probe to be used to monitor wounds contaminated with plutonium. This probe was capable of detecting soft plutonium X-rays. The sensitivity of this probe was 1×10^{-9} Ci of plutonium unshielded. This was equivalent to detection of one-tenth of a permissible body burden of plutonium embedded in tissue to a depth of 1 cm (LASL 1959a). In 1977, a new NaI detector (12 mm x 2 mm) was being evaluated. This produced an MDA of 0.07 nCi based on weapons-grade plutonium (LASL 1977c). No other information on instrumentation or sensitivities is available (ORAUT-TKBS-0010-5).

Wound counting was used primarily as a tool for surgeons to locate plutonium in the wound, and results were not used to calculate internal dose. Wound monitoring continues to be performed. In most cases, intake and dose will not be assessed directly from the wound count but rather from the resultant *in vitro* (urine and fecal samples) bioassay data. Follow-up studies of wounds found that, in the majority of incidents, plutonium does not readily migrate away from the wound site. Wound count results are added to a worker's case file, and although they are not used specifically to reconstruct dose, may indicate that a potential uptake occurred that should be accounted for during dose reconstruction.

7.2.2 Evaluation of Bounding Ambient Environmental Internal Doses

An ambient air-monitoring program at LANL began as early as 1954. Historical results of the AIRNET monitoring network through 2000 are available on the LANL website (LANL, 2003); annual environmental surveillance reports summarize yearly results. Emissions data are also available. These data are described in detail in ORAUT-TKBS-0010-4 and are used to evaluate airborne environmental intakes for application to individual dose reconstructions. Table 4-31 in ORAUT-TKBS-0010-4 provides site-wide maximum ambient intakes for the entire class period under evaluation. Although available post-1975 data enable dose reconstruction, in this evaluation, workers are assumed to be maximally exposed to conditions that potentially existed in operational areas. Ambient environmental dose is bounded by the assignment of this operations-related dose.

7.2.3 Methods for Bounding Internal Dose at LANL

7.2.3.1 Methods for Bounding Operational Period Internal Dose

Application of Available Bioassay Data for Monitored Workers

Intakes to monitored workers may be estimated using the available *in vitro* and/or *in vivo* data for the specific radionuclides that were analyzed. These intake estimates may then be used to bound organ doses from those radionuclides, for those monitored individuals, using the methodologies described in the LANL Internal Dose TBD (ORAUT-TKBS-0010-5).

Application of Co-Worker Data for Internal Dose Reconstruction

A draft technical information bulletin (ORAUT-OTIB-0062, draft) has been developed for dose reconstruction, for unmonitored individuals, using co-worker data for Pu-239, Pu-238, uranium, tritium, and Cs-137. The intake rates provided in the OTIB cover the class period under evaluation:

In Section 7.2.1, it was demonstrated through various health physics records that exotic radionuclides were handled, controlled, and monitored in a similar manner as the primary nuclides. The applicable guidelines for controlling airborne concentrations and surface contamination levels for all radioactive materials are defined in units of activity (e.g., $\mu Ci/m^3$ and $dpm/100cm^2$). The guidelines for many of the exotic alpha-emitters were the same as, or more restrictive than, the guidelines established for Pu-238 and Pu-239. For this reason, in the absence of specific internal dosimetry data, it is possible to bound intakes of many of the exotic alpha-emitting radionuclides using co-worker data for Pu-238 and/or Pu-239. Co-worker data for LANL are given in draft ORAUT-OTIB-0062. Daily intake rates for Pu-239 taken from ORAUT-OTIB-0062, in units of pCi/d, may be assigned separately for each alpha-emitting exotic radionuclide that would have required similar controls: Ac-227, Pa-231, Np-237, and Th-230. To process an individual claim, on a case-by-case basis, the nuclide that results in the highest dose to the organ of interest for the energy employee could be used as the bounding intake. Since the properties of Cm-244 are more similar to Pu-238, daily intake rates for Pu-238 could be used for Cm-244. Since the radiological properties and health physics controls for natural thorium are comparable to uranium, co-worker data for uranium could similarly be used to bound intakes of natural thorium.

Incidents

Incidents often resulted in requests for special bioassays (see Section 5.2.3 for a summary of the incident-related records that will be available for data capture by NIOSH in early 2009).). In such cases, these bioassay results may be used to support bounding intake estimates for the exposure situations/conditions associated with the incidents.

7.2.3.2 Bounding Methods by Radionuclide

Plutonium

The LANL bioassay programs for plutonium were extensive. Monitored worker intakes were determined by chest counting and through urine bioassay. These data are readily available to bound dose from plutonium isotopes for monitored workers.

Unmonitored worker intakes may be bound using monitored co-worker data. Internal dosimetry co-worker data for LANL are presented in ORAUT-OTIB-0062 (draft).

Hydrogen-3 (Tritium)

The tritium bioassay program at LANL was extensive. Monitored worker doses were determined through urine bioassay. These data are readily available to bound tritium dose to monitored workers.

Unmonitored worker intakes may be bound using monitored co-worker data. Unmonitored worker intakes may be bound using monitored co-worker data. Internal dosimetry co-worker data for LANL are presented in ORAUT-OTIB-0062 (draft).

Exposures to tritiated water and/or vapor (HTO) and gaseous tritium (HT) were the most prevalent forms of tritium exposure at LANL. Organically bound tritium (OBT) would have been encountered only in locations where biological research with labeled compounds was conducted. Exposures to the stable metal tritide (SMT) form of tritium may have been encountered as the result of the storage of tritium adsorbed on rare metals. Exposure to these compounds is a specialized circumstance (Inkret, 1999b). On a case-by-case basis, intakes of OBT and SMT compounds may be bounded using the methodologies outlined in ORAUT-OTIB-0066.

Uranium

The LANL bioassay programs for uranium were extensive. Monitored worker intakes were determined by chest counting and through urine bioassay. These data are readily available to bound dose to uranium isotopes for monitored workers.

Internal dosimetry co-worker data for LANL are presented in ORAUT-OTIB-0062 (draft).

Mixed Fission and Activation Products

By 1976, *in vivo* counting methods were well-established and available for bounding intakes of MFP and MAP. ORAUT-OTIB-0054 discusses MFAP ratios and the calculation of intakes based on a single nuclide (e.g., Cs-137 co-worker data). For unmonitored workers, Cs-137 co-worker data are available in the draft co-worker study ORAUT-OTIB-0062. For bounding intakes to unmonitored workers, Cs-137 co-worker data in the draft co-worker study (ORAUT-OTIB-0062) may be used.

Strontium-90/Yttrium-90

Sr-90/Y-90 is often associated with other mixed fission products. In such cases, bounding intakes may be estimated by assessing intakes of Cs-137, another fission product with a similar fission yield and similar physical half-life as Sr-90. Intakes of Cs-137 can be readily determined by *in vivo* counting. Intakes of Sr-90/Y-90 for workers exposed to MFP who were monitored for Cs-137 can therefore be estimated from Cs-137 intake assessments (assuming that the Sr-90/Y-90 is a component of MFP). The details of this method are described in ORAUT-OTIB-0054.

Urine bioassay methods for Sr-90/Y-90 were well-established by 1976. Due to a lack of necessity, routine Sr-90/Y-90 bioassay was uncommon. As described previously, the only activity at LANL known to have involved Sr-90 contamination (other than as a component of MFP) was the RaLa program. Although this program ended in 1963, residual Sr-90 contamination remained in specific associated areas long after the program ended. The available health physics records provide information supporting that operations in affected areas were sufficiently controlled from a radiological exposure control perspective. After the RaLa program ended, NIOSH found no indication of work that could result in significant exposures (or disturbance of the residual Sr-90 contamination) until the commencement of decommissioning activities at the associated locations. The decommissioning operation at Ten Site during the late 1979 and early 1980 time period involved hundreds of air tests, continuous air monitoring (CAM) during all operations, hundreds of routine and special air tests, hundreds of nose swipes and four urine bioassay samples (Quarterly, 1979). RWPs from the 1990s are available for the decommissioning work conducted in TA-35 where Sr-90 contamination was known to have been present (RWP, 1995). These operations were conducted by trained radiation workers and involved the use of CAMs, other air monitoring, radiological technician coverage, level 1 PPE, nasal swipes, etc. Workers with significant potential for Sr-90 intakes during these decommissioning activities would have been monitored via urine bioassay; the resulting data would be included in their personnel records.

Following a NIOSH request, LANL staff has provided evidence of targeted urine bioassay for Sr-90 involving three workers performed in 1997 (Targeted Sr-90, 1997).

Thorium-230

NIOSH has not found any evidence of work with separated Th-230 at LANL since the late 1950s. Urine bioassay methods for Th-230 were established in the 1950s, as there were a number of bioassays conducted for Th-230 in 1958 (ORAUT-TKBS-0010-5). In the absence of bioassay data, intakes of Th-230 from residual contamination could be bound using co-worker data for Pu-239, as described earlier in this section.

Thorium-232

There is evidence of small-scale operations involving Th-232 extending into the 1990s (DOE, 1991). Due to a lack of necessity, routine Th-232 bioassays were uncommon; however, LANL maintained the ability to perform targeted bioassay for the duration of the evaluation period (post-1975). Targeted dosimetry was indicated for an international traveler in 1999 (Targeted Th-232, 2000). LANL maintains a DOELAP-accredited *in vitro* bioassay program for Th-230 and Th-232. In the absence of bioassay data, Th-232 intakes could be bound using co-worker data approach for uranium, as described earlier in this section.

Americium-241

For intakes of Am-241 as a component of weapons-grade plutonium, plutonium bioassay data may be used to bound intakes of Am-241. Since 1970, LANL has maintained *in vivo* capability for Am-241. These data are readily available to bound intakes of Am-241 for monitored workers. Although bioassay data for Am-241 are abundant, unmonitored intakes could be bound using co-worker data approach for Pu-239, as described earlier in this section.

Neptunium-237

Neptunium-237 was not a commonly-used radionuclide at LANL. There is, however, evidence of periodic operations involving its use prior to 1975 and continuing to at least 2002. Although LANL maintains the ready ability for targeted *in vitro* measurements (LANL, 2008), bioassay data are generally unavailable. In the absence of bioassay data, intakes of Np-237 could be bound using co-worker data approach for Pu-239, as described earlier in this section.

Actinium-227

Actinium is unlikely to have been a significant radiological hazard in the post-1975 period at LANL. The available literature suggests that work with this radionuclide was substantially complete by 1955 (DOE, 1993). Residues of this material may exist in waste streams, including filter buildings and environmental disposal sites.

Potential doses to affected workers from the 1978 decontamination and decommissioning of the Old Filter Building, TA-21-153 may be bounded using job-coverage data from the decommissioning report (Harper, 1981) when a realistic exposure scenario can be inferred from case-specific information. During this decommissioning project, workers wore respiratory protection, air monitoring was conducted throughout the project (air monitoring data are available), and the maximally exposed individuals received bioassay via whole-body counting. No measureable intakes were found (Harper, 1981). This is an example of "targeted dosimetry" as described by current LANL Radiation Protection Division staff (LANL, 2008). In the absence of bioassay data, intakes of Ac-227 could be bound using co-worker data approach for Pu-239, as described earlier in this section.

Protactinium-231

No LANL workers are on a routine Pa-231 bioassay program, although LANL has the ability to detect this nuclide through targeted *in vivo* measurements (LANL, 2008). In the absence of bioassay data, intakes of Pa-231 could be bound using co-worker data approach for Pu-239, as described earlier in this section.

Curium-244

LANL has the ability to detect Cm-244 through targeted *in vitro* measurements, if warranted, with sample analysis conducted at Oak Ridge (LANL, 2008). An example case of targeted bioassay was provided by LANL for a presumptive intake occurring in 2003 (Little, 2003b). In the absence of bioassay data, intakes of Cm-244 could be bound using co-worker data for Pu-238, as described earlier in this section.

7.2.3.3 Methods for Bounding Ambient Environmental Internal Dose

The LANL Environmental Occupational Dose TBD lists relevant monitoring or other data pertinent to estimating environmental internal dose (ORAUT-TKBS-0010-4). Although available post-1975 data enable dose reconstruction, in this evaluation, workers are assumed to be maximally exposed to conditions that potentially existed in operational areas. Ambient environmental dose is bounded by the assignment of this operations-related dose.

7.2.4 Internal Dose Reconstruction Feasibility Conclusion

This evaluation concludes that internal dose reconstruction for members of the proposed class is feasible, based on: (1) using *in vitro* and *in vivo* bioassay data for monitored workers; and (2) using co-worker data to bound intakes to unmonitored workers, based on the co-worker study described in ORAUT-OTIB-62 (draft) and as described within this section of this evaluation report.

7.3 Evaluation of Bounding External Radiation Doses at LANL

ATTRIBUTION: Section 7.3 and its related subsections were completed by Bob Burns, NGTS, Inc.; and John Fix, Dade Moeller & Associates. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The principal source of external radiation exposure for members of the class under evaluation was photon radiation, with the expectation that members of the class may have been exposed to beta and neutron radiation associated with: nuclear weapon development; reactor and accelerator operations; criticality experimentation; handling of radioactive materials in production or research activities; radiation-producing devices; or radioactive waste facilities or handling operations. For some workers, neutron radiation accounted for a large fraction of the occupational external radiation dose. The principal sources of neutron dose over the time period under evaluation were accelerator and plutonium-handling operations.

The following subsections address the ability to bound external doses, methods for bounding doses, and the feasibility of external dose reconstruction.

7.3.1 Evaluation of Bounding Process-Related External Doses

The following subsections summarize the extent and limitations of information available for reconstructing the process-related external doses of members of the class under evaluation.

LANL historical documentation shows knowledge of potential workplace external radiation hazards, applicable radiation exposure guidelines, methods of limiting worker exposure, and an on-going pursuit of improved radiation instrumentation and dosimetry capabilities. Table 6-2 of the LANL External Dose TBD shows monitoring for a substantial fraction of the total workers for all years after 1945 and certainly over the time period under evaluation (1976 through 2005) (ORAUT-TKBS-0010-6). The values for 1976 through 2005 are shown in Table 6-4 of this evaluation. The dosimeters employed were state-of-the-art and included design features to provide sensitivity in the workplace radiation environments encountered by LANL workers. LANL made efforts to characterize the response of its personnel dosimeters to workplace radiation fields. For the period 1976 through 1979, the dosimeter of record for beta, gamma, and thermal-to-intermediate-energy neutron dose was the multi-element "Cycolac" film badge. In 1978, some workers began receiving thermoluminescent dosimeters (TLDs) which incorporated a new and improved technology. TLDs have been the dosimeter of record since 1980. For fast-neutron monitoring, NTA film was used in conjunction with the Cycolac film or TLD personnel dosimeters until 1995, when it was replaced with track-etch dosimeters (TEDs).

LANL has recorded gamma (penetrating), beta (non-penetrating), and neutron dose (or dose equivalent) for monitored workers over the time period under evaluation. Prior to 1980, fast and thermal neutron dose were recorded separately; total neutron dose (i.e., that from all neutron energies) has been recorded thereafter (ORAUT-TKBS-0010-6).

Data from LANL dosimetry systems and workplace instrument measurements such as multi-sphere and rem-meter workplace measurements of neutron dose and spectra, and recent LANL Rotating Neutron Spectrometer workplace measurements provide a basis for determining an upper-bound neutron dose for the corresponding periods of dosimeter use (ORAUT-TKBS-0010-6).

Photon

The personnel dosimeters assigned to LANL workers over the time period under evaluation were capable of measuring photon doses in the workplace with sufficient accuracy to permit the calculation of bounding photon doses. The majority of workers were routinely monitored with state-of-the-art dosimeters and the measured photon doses are considered to be reasonably accurate based on laboratory-measured response characteristics of these dosimeters, and complete based on the worker dose records (ORAUT-TKBS-0010-6). These data have been used in several health effect studies of LANL workers. Potential missed dose is assigned using OCAS-IG-001 guidance. The Occupational External Dose TBD includes documentation of measures taken by LANL staff to characterize the response of their personnel dosimeters to the low-energy photon fields associated with plutonium-handling operations (ORAUT-TKBS-0010-6, Section 6.2.3.4).

Table A-2 in the External Dose TBD gives gamma dose rate statistics for LANL dosimeter results (gamma dose $\geq$ 50 mrem) for all years of operation through 2003 and into 2004. These data include the mean, maximum., median, and 95th percentile values, and the corresponding geometric standard deviation. If these data are adjusted for missed dose and uncertainty, as applicable, they represent a reasonable means of bounding photon dose for all members of the class under evaluation. The External Dose TBD contains sufficient information with which to adjust the Table A-2 data for missed dose and uncertainty (ORAUT-TKBS-0010-6).

Beta

Beta in association with photon radiation monitoring instrumentation was commonly used to evaluate workplace beta radiation fields. The personnel dosimeters assigned to LANL workers during the time period under evaluation had the capability to measure doses from significant beta radiation sources. Non-penetrating, beta, or shallow (depending upon terminology used at different times) doses were routinely recorded along with the photon dose. These data provide information to permit the calculation of bounding doses for members of the class. LANL shallow doses were based on uranium calibration (ORAUT-TKBS-0010-6). Mixed photon and beta radiation fields typically result in substantial overestimation of the shallow dose. Lower-energy beta radiation was not generally a significant source of dose at LANL (ORAUT-TKBS-0010-6). There is sufficient LANL documentation to allow bounding of beta dose for members of the class under evaluation.

Neutron

Neutron radiation monitoring instrumentation was commonly used to evaluate workplace neutron radiation fields. Prior to 1980, the NTA personnel neutron dosimeter was used to measure and record personnel neutron dose. Since NTA film-based dosimeters do not respond to neutrons with energies less than approximately 500 keV, the use of neutron-to-photon dose ratios is necessary to bound neutron dose prior to 1980 (ORAUT-TKBS-0010-6). After 1980, recorded neutron doses are considered to be sufficiently accurate based on a combination of albedo TLD (for low- and intermediate-energy neutrons) and NTA film (for high-energy neutrons).

Characterization of workplace neutron spectra at LANL showed that the neutron energies associated with plutonium-handling operations were consistent with those from well-moderated sources. Measurements performed in plutonium processing areas in 1978 indicated an average neutron energy of 200 keV. Neutron spectrometry data collected in these areas in 1993 showed that approximately 90% of the neutron flux was from neutrons having energy of 1.2 MeV or less. Characterization of neutron spectra at TA-53 showed neutron energy spectra could vary widely, and included areas where the dominant contribution to neutron dose equivalent came from neutrons having energy greater than 10 MeV. These measurements included evaluation of NTA and TLD measured neutron doses. (ORAUT-TKBS-0010-6).

The External Dose TBD contains sufficient information to allow bounding of neutron dose using, as necessary, neutron-to-photon dose ratios in LANL areas where personnel neutron exposures occurred. It also contains sufficient information to allow assessment of missed dose and uncertainties associated with reported neutron dose after 1979, as well as reported neutron dose for the entire time period under evaluation. The combination of bounding neutron-to-photon dose ratios and the photon (i.e., gamma) dose information given in Table A-2 of ORAUT-TKBS-0010-6 therefore provides a means for bounding neutron dose for all members of the class for the period prior to 1980 when NTA film was still the principal means of neutron monitoring. The same approach could be extended to the post-1979 period; alternatively, an approach akin to that described above for bounding photon exposures could be used. Either way, sufficient information is available to allow bounding of neutron dose for all members of the class for the entire time period under evaluation.

7.3.2 Evaluation of Bounding Ambient Environmental External Doses

LANL had a comprehensive program for monitoring ambient radiation exposure within its boundaries and in the surrounding area. This program and the data it generated are described in detail in ORAUT-TKBS-0010-4, which provides a thorough evaluation of ambient environmental dose as applicable to performing individual dose reconstructions. Table 4-25 in ORAUT-TKBS-0010-4 provides site-wide maximum ambient dose data for the entire class period under evaluation. This information should be sufficient to allow bounding of ambient environmental external dose for all members of the class.

7.3.3 LANL Occupational X-Ray Examinations

The information given in the Occupational Medical Dose TBD is sufficient to allow bounding of radiation dose associated with occupationally-related X-ray examinations received by members of the class under evaluation. The examination protocols and equipment used during the relevant time period are documented sufficiently to allow assessments of organ dose that may be considered bounding (ORAUT-TKBS-0010-3).

7.3.5 External Dose Reconstruction Feasibility Conclusion

During the period of this evaluation, the majority of LANL workers were monitored as illustrated in Table 6-4. Information describing workplace radiation fields at LANL, performance of personnel dosimetry systems in those fields, and the monitoring data produced by LANL's personnel dosimetry program have been reviewed as they pertain to bounding of radiation dose from external sources of photon, beta, and neutron radiation for members of the class under evaluation. Information describing dose from ambient sources of radiation and from occupationally-related X-ray examinations have also been reviewed. The available information has been found adequate to allow bounding of external radiation doses with sufficient accuracy for members of the class under evaluation.

7.4 Evaluation of Petition Basis for SEC-00109

ATTRIBUTION: Section 7.4 and its related subsections were completed by Ray Clark, Oak Ridge Assiciated Universities (ORAU); and Chris Miles, Quantaflux, LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

The following subsections evaluate the assertions made on behalf of petition SEC-00109 for the LANL site.

7.4.1 Cerro Grande Fire

SEC-00109: The petitioner identified the "Cerro Grande Fire" in 2000 as an unmonitored, unrecorded, or inadequately monitored exposure incident.

A study performed soon after the Cerro Grande fire included two dose calculations: (1) the hypothetical maximally-exposed firemen or volunteer who was working actively in the Los Alamos area throughout the worst of the burn duration; and (2) the maximally-exposed member of the public outside Los Alamos. Those calculations are updated in *Updated Calculations of the Inhalation Dose from the Cerro Grande Fire Based on Final Air Data* (Cerro Grande, 2001). In addition, a third calculation is added: a fireman or other worker in the vicinity of AIRNET (LANL's ambient air monitoring network) Station #23 in Mortandad Canyon where elevated levels of LANL-derived airborne uranium occurred during the peak of the fire. The incident information was reviewed by NIOSH and these data can be used to bound the dose for any Service Support Worker who might have been exposed during the fire.

7.4.2 Sigma Americium Contamination Incident

SEC-00109: The petitioner identified the "Sigma Americium Contamination Incident" in 2005 as an unmonitored, unrecorded, or inadequately monitored exposure incident.

The Type B Accident Investigation report on the July 14, 2005 americium contamination accident at the LANL Sigma Facility states that the maximum dose to Worker 1 (the maximally-exposed individual) was 500 mrem CEDE. Based on this assessment and its review by NIOSH, a maximum intake may be estimated, which could then be used to bound the dose for service workers (Investigation, 2006).

7.4.3 Neptunium Special Hazards

SEC-00109: *The process hazards analysis, HCPs, and work instructions for actinide fuels work do not adequately define or analyze the special hazards posed by the use of 100-gram quantities of neptunium powders by NMT-11 workers.*

NIOSH recognizes that there was a potential for unmonitored intakes of Np-237 at LANL. A methodology for bounding intakes of Np-237 to unmonitored workers is described in Section 7.2.3 of this report.

7.4.4 LANL 7776 TLDS and Neutron Correction Factors

SEC-00109: *"NCFs can vary by more than an order of magnitude at LANL facilities." Considering that Support Service workers could work at several facilities during a day, dose reconstruction using the data from the LANL 7776 type TLD cannot be done.*

Area-specific neutron correction factors (NCFs) are used at LANL to improve the accuracy of the neutron dose based on workplace instrument measurements (ORAUT-TKBS-0010-6). If workers frequented multiple facilities, or if the facilities frequented are unknown, NIOSH can bound neutron doses by applying the highest NCF for any of the buildings the worker may have entered.

7.4.5 LANL Contamination Surveys, Postings, and Control

SEC-00109: The Tiger Team Assessment Report (submitted by the petitioner) made a number of observations about the LANL site that are pertinent to the potential for unmonitored intakes (DOE, 1991). In summary, the report observed that: (1) radiation surveys sometimes did not conform to LANL policies and documented schedules; (2) contamination control programs did not ensure complete control of the spread of contamination; (3) there were instances in which barriers had been removed or signage was inappropriate or missing; (4) posting was inconsistent throughout the site; (5) the frequency of surveys mandated by procedures was not consistently followed; (6) signs and labels throughout the plutonium and uranium facilities did not indicate radiological conditions, were not accurate, or had other problems that could lead to unsafe practices; (7) documentation of smear surveys was not consistently performed; (8) the use of open-front hoods led to an increased frequency of radioactive material contamination incidents; (9) cracked glovebox gloves were observed; (10) removable and fixed surface contamination limits for tritium and pure gamma-emitting nuclides were not in compliance with DOE Order 5480.11; (11) calibration and response-checking of fixed instruments and tritium monitors did not reflect the same level of attention and commitment given to portable instrumentation; (12) out-of-calibration instruments, such as glovebox hand and foot monitors and tritium monitors, were not placed out of service; (13) placement of air monitoring instruments at the DU sites was not based on studies of flow patterns; (14) facility air monitor alarm points, used per DOE Order 5480.11 to warn workers that airborne radioactive material contamination levels had exceeded an action level, were not always set at a uniform level, with the set points varying from monitor to monitor even in the same building; and (15) training programs had not been established to ensure that routine dose rate and contamination surveys were conducted in a consistent manner.

None of the numerous Tiger Team findings and observations pertains to the adequacy of the internal or external personnel monitoring programs; therefore, they do not compromise NIOSH's ability to conduct dose reconstruction with sufficient accuracy. Dose reconstructions for LANL employees are based upon internal and external monitoring data. These data are also employed in co-worker studies to estimate unmonitored worker intakes.

7.5 Other Potential SEC Issues Relevant to the Petition Identified During the Evaluation

ATTRIBUTION: Section 7.5 was completed by Ray Clark, Oak Ridge Associated Universities (ORAU); and Chris Miles, Quantaflux. LLC. These conclusions were peer-reviewed by the individuals listed on the cover page. The rationales for all conclusions in this document are explained in the associated text.

During the feasibility evaluation for SEC-00109, a number of issues were identified in the LANL ER for Petition SEC-00051 that needed further analysis and resolution. The issues and their current status are:

- ISSUE: SEC-00051, Sect. 7.2.1.1: *There are no data available that permit internal dose contributions from Sr-90 to be reconstructed with sufficient accuracy.*

  RESPONSE: During the time period covered by the SEC-00051 evaluation (at least until about 1970), *in vivo* counting was not effectively used at LANL to monitor for mixed fission products, of which Sr-90 is most commonly associated. Also, prior to the termination of the RaLa program, the potential for exposure to Sr-90 was much greater and controls were much less robust. Methods for bounding intakes to Sr-90 during the post-1975 period are described in Section 7.2.3.2.

- ISSUE: SEC-00051, Section 7.2.1.1: *After 1970, with the onset of chest counting and improved analytical capabilities, LANL possessed the ability to monitor for all ROCs with the exception of Ac-227, Cm-244, and Pa-231. Ac-227 and Pa-231 possibly could be quantified by the chest count procedure. However, no information has been found that would indicate an attempt at this process or that any such data are available. Inventory records to establish the significance of the source term of these "exotic" radionuclides is limited. Most available information is limited to waste activity reports.*

  Few bioassay data are available for Ac-227, Cm-244, or Pa-231. Health physics records are available for the post-1975 time period which indicate that controls and protective measures applied when these nuclides were being used were similar to the controls applied when working with plutonium. A methodology to bound intakes of these nuclides by unmonitored workers using plutonium co-worker data is described in Section 7.2.3 of this report.

- ISSUE: SEC-00051, Section 7.2.1.2: *Data for Pu-238, Pu-239, Am-241, and Cs-137 are available. Few data for other radionuclides are available prior to the 1980s when the use of germanium detectors became more common.*

  A significant amount of additional data has been captured from LANL since the SEC-00051 Evaluation Report was written. Using these additional data, methodologies for bounding intakes to unmonitored LANL workers of the less-frequently-encountered radionuclides have been developed. These are described in Section 7.2.3 of this report.

7.6 Summary of Feasibility Findings for Petition SEC-00109

This report evaluates the feasibility for completing dose reconstructions for employees at LANL from January 1, 1976 through December 31, 2005. NIOSH found that the available monitoring records, process descriptions and source term data available are sufficient to complete dose reconstructions for the evaluated class of employees.

Table 7-2 summarizes the results of the feasibility findings at LANL for each exposure source during the time period January 1, 1976 through December 31, 2005.

Table 7-2: Summary of Feasibility Findings for SEC-00109

January 1, 1976 through December 31, 2005

Source of Exposure	Reconstruction Feasible	Reconstruction Not Feasible
Internal[1]	**X**	
- Pu	X	
- H-3	X	
- U	X	
- MFP and MAP	X	
- Sr-90/Y-90	X	
- Th-230 and Th-232	X	
- Am-241	X	
- Np-237	X	
- Ac-227	X	
- Pa-231	X	
- Cm-244	X	
External	**X**	
- Gamma	X	
- Beta	X	
- Neutron	X	
- Occupational Medical X-ray	X	

[1] Internal includes an evaluation of urinalysis (in vitro), airborne dust, and lung/whole body count (in vivo) data

As of December 29, 2008, a total of 331 claims have been submitted to NIOSH for individuals who worked at LANL and are covered by the class definition evaluated in this report. Dose reconstructions have been completed for 161 individuals (~49%).

8.0 Evaluation of Health Endangerment for Petition SEC-00109

The health endangerment determination for the class of employees covered by this evaluation report is governed by both EEOICPA and 42 C.F.R. § 83.13(c)(3). Under these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must also determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. Section 83.13 requires NIOSH to assume that any duration of unprotected exposure may have endangered the health of members of a class when it has been established that the class may have been exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. If the occurrence of such an exceptionally high-level exposure has not been established, then NIOSH is required to specify that health was endangered for those workers who were employed for a number of work days aggregating at least 250 work days within the parameters established for the class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

NIOSH has obtained numerous documents containing monitoring results as well as LANL process and source information. LANL has provided monitoring data summaries from its employee exposure records databases. NIOSH's evaluation determined that it is feasible to estimate radiation dose for members of the proposed class with sufficient accuracy based on the sum of information available from available resources. Modification of the class definition regarding health endangerment and minimum required employment periods, therefore, is not required.

9.0 NIOSH-Proposed Class for Petition SEC-00109

Based on its research, NIOSH accepted the NIOSH-evaluated class to define a single class of employees for which NIOSH can estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1976 through December 31, 2005.

NIOSH has carefully reviewed all material sent in by the petitioner, including the specific assertions stated in the petition, and has responded herein (see Section 7.4). NIOSH has also reviewed available technical resources and many other references, including the Site Research Database (SRDB), for information relevant to SEC-00109. In addition, NIOSH reviewed its NOCTS dose reconstruction database to identify EEOICPA-related dose reconstructions that might provide information relevant to the petition evaluation.

These actions are based on existing, approved NIOSH processes used in dose reconstruction for claims under EEOICPA. NIOSH's guiding principle in conducting these dose reconstructions is to ensure that the assumptions used are fair, consistent, and well-grounded in the best available science. Simultaneously, uncertainties in the science and data must be handled to the advantage, rather than to the detriment, of the petitioners. When adequate personal dose monitoring information is not available, or is very limited, NIOSH may use the highest reasonably possible radiation dose, based on reliable science, documented experience, and relevant data to determine the feasibility of reconstructing the dose of an SEC petition class. NIOSH concludes that it has complied with these standards of performance in determining that it would be feasible to reconstruct the dose for the class proposed in this petition.

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10.0 References

10 C.F.R. pt. 835, App. C, *Occupational Radiation Protection,* Appendix C: *Derived Air Concentrations (DAC) for Controlling Radiation Exposure to Workers at DOE Facilities*, accessed via the Internet on August 27, 2008; http://www.hss.energy.gov/HealthSafety/WSHP/Radiation/10cfr835/finalfedregjune82007.pdf

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Attachment 1: Documentation Provided by Petitioner

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