SEC Petition Evaluation Report
Petition SEC-00092

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Site Expert(s):	NA

Petitioner Administrative Summary			
Petition Under Evaluation			
Petition #	Petition Type	Petition A Receipt Date	DOE/AWE Facility Name
SEC-00092	83.14	June 27, 2007	Lawrence Livermore National Laboratory

Proposed Class Definition

All employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who were monitored, or should have been monitored, for internal exposure to mixed fission and/or activation product radionuclides while working at the Lawrence Livermore National Laboratory for a number of work days aggregating at least 250 work days from January 1, 1950 through December 31, 1973, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

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

Related Evaluation Report Information	
Report Title	DOE/AWE Facility Name
NONE	NONE

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Evaluation Report Summary: SEC-00092, Lawrence Livermore National Laboratory

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. 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*.

NIOSH-Proposed Class Definition

The NIOSH-proposed class includes all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who were monitored, or should have been monitored, for internal exposure to mixed fission and/or activation product radionuclides while working at the Lawrence Livermore National Laboratory for a number of work days aggregating at least 250 work days from January 1, 1950 through December 31, 1973, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

Feasibility of Dose Reconstruction

Per EEOICPA and 42 C.F.R. § 83.14(b), NIOSH has established that it does not have sufficient information to complete dose reconstructions for individual members of the class with sufficient accuracy. NIOSH lacks sufficient personal and workplace monitoring data to adequately determine the potential intake of fission and/or activation product radionuclides, making reconstruction of internal fission and/or activation product doses infeasible.

Health Endangerment Determination

The NIOSH evaluation did not identify evidence supplied by the petitioners or from other sources that would establish the class was exposed to radiation during a discrete incident likely to have involved exceptionally high-level exposures, such as nuclear criticality incidents or other events involving similarly high levels of exposure. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intakes of fission and/or activation products. Consequently, in accordance with 42 C.F.R. § 83.13(c)(3)(ii), NIOSH has determined that health may have been endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

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SEC Petition Evaluation Report for SEC-00092

1.0 Purpose and Scope

ATTRIBUTION AND ANNOTATION: This is a single-author document. All conclusions drawn from the data presented in this evaluation were made by the ORAU Team Lead Technical Evaluator: James Mahathy, Oak Ridge Associated Universities. 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.

This report evaluates the feasibility of reconstructing doses for employees who worked at specific facilities during a specified time. It provides information and analysis germane to considering a petition for adding a class of employees to the Congressionally-created Special Exposure Cohort (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, with the exception of the employee whose dose reconstruction could not be completed, and whose claim consequently led to this petition evaluation. The finding in this report is not the final determination as to whether or not the proposed class will be added to the SEC. This report will be considered by the Advisory Board on Radiation and Worker Health (the Board) and by the Secretary of Health and Human Services (HHS). The Secretary of HHS will make final decisions concerning whether or not to add one or more classes to the SEC in response to the petition addressed by this report.

This evaluation, in which NIOSH provides its findings on both the feasibility of estimating radiation doses of members of this class with sufficient accuracy and on health endangerment, was conducted in accordance with the requirements of EEOICPA and 42 C.F.R. § 83.14.

2.0 Introduction

Both EEOICPA and 42 C.F.R. pt. 83 require NIOSH to evaluate qualified petitions requesting the Department of Health and Human Services to 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 proposed class of employees through NIOSH dose reconstructions.[1]

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 petitioners and to the Advisory Board on Radiation and Worker Health. The Board will consider the NIOSH evaluation

[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.

report, together with the petition, comments of the petitioner(s) and such other information as the Board considers appropriate, 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 final decision process, the petitioner(s) may seek a review of certain types of final decisions issued by the Secretary of HHS.[2]

3.0 NIOSH-Proposed Class Definition and Petition Basis

The NIOSH-proposed class includes all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who were monitored, or should have been monitored, for internal exposure to mixed fission and/or activation product radionuclides while working at the Lawrence Livermore National Laboratory for a number of work days aggregating at least 250 work days from January 1, 1950 through December 31, 1973, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

The evaluation responds to Petition SEC-00092, which was submitted by an EEOICPA claimant whose dose reconstruction could not be completed by NIOSH due to a lack of sufficient dosimetry-related information. This claimant was employed at the Lawrence Livermore National Laboratory (LLNL) facility during the DOE operational period as an experimental physicist. NIOSH's determination that it is unable to complete a dose reconstruction for an EEOICPA claimant is a qualified basis for submitting an SEC petition pursuant to 42 C.F.R. § 83.9(b).

4.0 Radiological Operations Relevant to the Proposed Class

The following subsections summarize the radiological operations conducted at the Lawrence Livermore National Laboratory (main site located in Livermore, California and the Explosive Test Site, also known as Site 300, located near Tracy, California) from January 1, 1950 through December 31, 1973, and the information available to NIOSH to characterize particular processes and radioactive source materials. Using available sources, NIOSH has attempted to gather process and source descriptions, information regarding the identity and quantities of radionuclides of concern, and information describing the processes through which the radiation exposures of concern may have occurred and the physical environment in which they may have occurred. The information included within this evaluation report is meant only to be a summary of the available information.

4.1 LLNL Operations Description

LLNL was involved in Atomic Energy Commission (AEC) work starting in 1950. LLNL was originally known as the University of California Radiation Laboratory at Livermore and later as the

[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.

Lawrence Radiation Laboratory at Livermore. LLNL, which is still in operation under DOE direction, consists of two sites, the main Laboratory site, which is in a densely populated area in Livermore, California, and the Explosive Test Site located near Tracy, California (also known as Site 300). The original mission of LLNL was thermonuclear weapons development. By 1957, and continuing thereafter, the mission of LLNL was expanded to include diverse scientific and engineering research activities. These activities have included research, development, testing of the nuclear weapons lifecycle, strategic defense research, development of arms control and treaty verification technology, fusion research, atomic vapor laser isotope separation for defense and commercial applications, magnetic fusion, as well as other energy research in basic energy sciences, atmospheric sciences, fossil energy, and commercial nuclear waste. Activities were conducted in various buildings at both LLNL sites (DOE, 1992).

In addition to the research conducted during the development of the site profile and co-worker models, NIOSH conversed with a former LLNL employee and a current LLNL employee to help understand the diverse operations at the LLNL site. The former employee was directly involved with operations involving radioactive materials, as discussed in this report (Bihl, 2007; Chew, 2007). The current employee is knowledgeable about the database that was supplied to NIOSH (Mansfield, September 2006). Information obtained from these employees has been used in the preparation of the evaluation report.

LLNL radiological operations included the following operations involving the use of radioactive materials:

- Strategic defense,
- Nuclear propulsion research,
- Inertial confinement fusion research,
- Atomic vapor laser isotope separation research,
- Magnetic fusion, including leadership of the U.S. effort on the International Thermonuclear Experimental Reactor,
- Biological, ecological, atmospheric, and geophysical sciences relevant to weapons, energy, health, and environmental issues, and
- Charged-particle beam and free-electron laser research for defense and energy applications.

Each of the radiological operations included ancillary functions of chemistry, non-destructive testing, maintenance, and security (DOE, 1992).

LLNL staff performed a wide array of strategic defense work in the area of nuclear weapon systems. This work included weapons-systems research and design, and nuclear-weapon-systems manufacturing and assembly. Initially, LLNL focused their research and development on designing hydrogen-powered explosives that were smaller in size and yield than weapons developed at the Los

Alamos National Laboratory. The first production design that resulted from this research was a megaton-class warhead used for the Polaris missile. In the 1960s, LLNL developed warheads for the Minuteman missile, as well as the W48 warhead for use with 155-millimeter howitzer artillery. In 1973, LLNL developed the W70 warhead that was deployed on the short-range Lance missile. In 1976, LLNL was asked to modify the Lance W-70 warhead by adding an enhanced radiation capability (LLNL, 2006). Weapons assembly activities were conducted in Buildings 102, 432, 435, 491, 512, and other buildings over time (Harrach, 2003).

Planning and conducting weapons tests were critical work components of the strategic defense mission. Starting in 1953, LLNL conducted above-ground (atmospheric) and underground tests at both the Pacific Proving Ground and at the Nevada Test Site (NTS). Although tests were conducted offsite, test planning and preparation were done at LLNL. The first nuclear test conducted by LLNL explored a new design for fission devices that offered hope for smaller, more efficient bombs and provided information about certain thermonuclear reactions; however, that test failed. LLNL performed eleven nuclear tests during 1953, all at NTS. The first thermonuclear test, conducted by LLNL staff, was performed in 1954 at the Pacific Proving Ground (DOE, 2000). Another test, KOON, conducted during 1954, had a predicted yield of 1 megaton but the actual yield was only 110 kiloton (LLNL, 2006). In September 1957, in a tunnel at the Nevada Test Site, LLNL detonated the first contained underground nuclear explosion (DOE, 2000). Beginning in 1959, in the midst of a nuclear testing moratorium, LLNL conducted mock testing of nuclear designs and hydrodynamic studies using depleted uranium, thorium, and other radioactive materials at Site 300 (LLNL, 1985; Williams, 1977; LLNL, 2006); however, tests conducted at Site 300 did not use fissile materials. By 1969, only natural uranium, depleted uranium, and natural thorium were allowed for testing with high explosives (LRL, January 3, 1969-December 31, 1969).

In 1962, the United States resumed nuclear weapons testing using fissile materials; LLNL staff co-led Operation Dominic, the largest nuclear test ever conducted at the Pacific Proving Ground. In 1971, LLNL managed the CANNIKIN test event at Amchitka Island, Alaska. That operation was a massive undertaking that involved hundreds of LLNL employees and nearly five years of effort (LLNL, no date; DOE, 1992). The total number of tests sanctioned by LLNL is shown by year and by type in Table 4-1 (DOE, 2000).

Table 4-1: LLNL Sanctioned Tests
This table spans two pages.

Year	Number of Underground Tests	Number of Atmospheric Tests
1953	-	3
1954	-	1
1955	-	3
1956	-	8
1957	1	12
1958	7	27
1961	4	-
1962	33	20
1963	23	-
1964	30	-
1965	22	1
1966	25	-
1967	23	-

Table 4-1: LLNL Sanctioned Tests *This table spans two pages.*		
Year	**Number of Underground Tests**	**Number of Atmospheric Tests**
1968	36	7
1969	34	-
1970	38	-
1971	14	-
1972	17	-
1973	14	-
1974	14	-
1975	14	-
1976	12	-
1977	9	-
1978	12	-
1979	7	-
1980	9	-
1981	8	-
1982	10	-
1983	11	-
1984	9	-
1985	10	-
1986	8	-
1987	9	-
1988	9	-
1989	10	-
1990	4	-
1991	6	-
1992	4	-

Notes:
- indicates no tests were performed

None of the fissionable tests were conducted within the boundaries of the main LLNL site or Site 300. However, samples, referred to as "shot" samples, were taken from blast media (soil, water, air) by LLNL staff and transported to LLNL for physical and chemical analyses. These samples were handled in several buildings at LLNL including 117, 132, 171, 222, 172, 221, 241, 251 and 419. Shot sample remnants were secured in Building 155 (Chew, 2007) and were processed by waste management at Buildings 514 and 612 (Harrach, 2003).

In 1955, LLNL initiated work on nuclear propulsion. For this work, nuclear reactors were built and tested at LLNL (LLNL, 2006). In 1957, LLNL conducted Project Pluto in an effort to develop a nuclear ramjet engine to be used in low-flying, supersonic cruise missiles. The project presented a severe technical challenge (LLNL, no date). Scientists had to devise mass-producible ceramic fuel elements that could meet stressing operating conditions. From the late 1950s through 1964, LLNL built and successfully tested six versions of the Tory reactor (fissionable tests were conducted at the Nevada Test Site). The last version of the Tory reactor generated 600 megawatts (LLNL, 2006). LLNL also operated a pool-type reactor on the main Livermore site from 1957 through 1980 (LLNL, 2006; DOE, 1992).

LLNL conducted research applying nuclear and isotope sciences to a wide range of problems including stockpile stewardship, nonproliferation, safeguard technologies, forensic science, and waste characterization and analysis. LLNL performed research using linear accelerators for a variety of defense and energy applications, and for activation product production. Accelerators used included a 10-MeV tandem accelerator, a 100-MeV linear accelerator (LINAC), and a Cockcroft Walton accelerator. LLNL also housed a 90-inch cyclotron used to conduct experiments with uranium, plutonium, and tritium.

Accelerator type devices and related services were housed in Buildings 192, 194, 210, 212, 241, 298, 327, 341, 421, and 435. At Site 300, LLNL operated linear accelerators and radiography devices, including flash X-ray equipment (DOE, 1992; LLNL, no date). The XR2 accelerator was moved to LLNL from the Nevada Test Site in the 1950s. A new linear accelerator, know as the Astron LINAC, greatly exceeded the capabilities of the XR2 machine. The Astron machine required the invention of a new kind of electron accelerator that would produce an intense circulating electron beam to magnetically confine and heat a plasma matrix. The Astron concept was tested at Site 300 (LLNL, 2006). Operations using flash generation and accelerators at Site 300 were conducted in Buildings 801, 851 Firing Table, and open areas. Secondary radionuclides expected from the operation of linear accelerators at LLNL included activation products such as carbon-11, nitrogen-13, oxygen-15, nitrogen-16, argon-41, zinc-65, and zirconium-95 (Williams, 1975-1977; Myers, 1988).

LLNL performed extensive work with tritium compounds at the Hydrogen Research Facility (Building 331) where various projects using tritium were conducted. Most of the tritium used at the facility was in the elemental form or in the form of metal hydride compounds capable of being turned into elemental form by heating. Although some tritiated water was formed in the tritium cleanup systems during the removal of tritium from glovebox atmospheres, there was no programmatic use of tritiated water in the building (DOE 1992). A small amount of tritium was used at LLNL for labeling compounds or synthesizing lithium hydride (DOE, 1992). Tritium triggers were tested at Site 300 (DOE, 1992).

LLNL performed research and testing of plutonium-bearing engineering assemblies, developed and demonstrated improved plutonium fabrication techniques, and performed fundamental and applied research in plutonium metallurgy. This work was conducted in Building 332 (Harrach, 2003). There is some evidence that fission products were also used in Building 332 at some period in the 1960s.

LLNL also fabricated metals using both depleted uranium and enriched uranium (some of which contained plutonium). Fabrication operations included milling, machining, and shaping (DOE, 1992). Transuranic radionuclide research was conducted in Building 251.

LLNL performed research in the field of genetics and biomedical sciences using radioactive materials. These activities were conducted in Buildings 361, 362, 363, 364, 365, 366, 367, and 412. With some of the research, carbon-14 and sulfur-35 were injected into animals and the animals were studied over time. Other research projects used radiological tracers in genetic studies (Harrach, 2003). Radiological inventory records show that the following radionuclides were handled within the biomedical program: americium-241, americium-243, carbon-14, cadmium-109, cobalt-57, cobalt-60, cesium-134, cesium-137, neptunium-237, neptunium-239, tritium, phosphorus-32, sulfur-35, strontium-85, and several isotopes of plutonium and uranium (Harrach, 2003).

As LLNL had to deal with radioactive wastes, studies on the handling and treatment of wastes were performed. Waste processing and optimizing were studied in Building 513. Among the radionuclides recorded in a LLNL inventory for Building 513 were americium-241, barium-133, carbon-14, cesium-134, cesium-137, tritium, iodine-125, iodine-131, phosphorus-32, plutonium-238, plutonium-239, plutonium-240, plutonium-241, plutonium-242, and thorium-232. Consolidation, evaporation, and waste filtration were studied and implemented at Building 514. A wide range of radionuclides have been observed from monitoring in Building 514. Liquid radioactive wastes were either treated and or stored at Buildings 513 and 514, while dry or solid wastes were normally handled at Buildings 612 or 614. Waste materials were received at Building 625 (Harrach, 2003).

LLNL performed extensive chemical and biological research, sampling, and analyses in support of all other operations. This work included bench-scale synthesis and testing of chemical compounds, development of bench-scale polymers and composites, as well as collection, analyses, and monitoring of personnel, process, environmental, and waste samples (DOE, 1992). An example of these operations is the preparation of aqueous samples containing radioactive tracers for use with stable isotopic studies (Harrach, 2003). Radioactive materials, some of which were low-level tracers, were used with these latter operations in Buildings 132, 151, 167, 168, 169, 171, 173, 174, 175, 176, 217, 222, 241, 253, 254, 255, 334, 377, and 378.

4.2 Radiation Exposure Potential from Operations

The potential for external radiation dose existed at all locations where radioactive materials were handled or stored, where materials were tested by explosive or radiographic means, and from exposures resulting from accelerators, nuclear reactors, and cyclotrons. Based on LLNL operations outlined in Section 4.1, sources of potential external exposures included primarily beta and photon radiations. The beta and photon (X-ray and gamma) energy ranges and geometries varied across operations. The potential for exposure to neutrons existed in several operations; the energy range has been considered to be 0.1 – 2.0 MeV (ORAUT-TKBS-00035-6, page 11).

There were numerous sources of potential internal radiation exposures at LLNL during the proposed class timeframe of January 1, 1950 through December 31, 1973. During that time, internal exposures to alpha radiation potentially resulted from releases and subsequent re-suspension of uranium, plutonium, thorium, and transuranic radionuclides in areas where weapons-related work, fuel fabrication and clean-up, reactor utilization, and waste disposal occurred. There were also sources of potential internal exposure to beta and gamma emitters resulting from shot sample analyses, high explosive testing, biomedical research, safeguards research, laboratory analyses, and waste management tasks, as well as from the use of particle accelerators at the Livermore and Site 300 campuses.

Processing of the nuclear test shot samples represented a frequent and long-term radiation exposure hazard at LLNL. LLNL analyzed samples from most of the tests presented in Table 4-1. With respect to shot samples obtained from above ground (atmospheric) testing, sample filters were sent to LLNL for analyses (Chew, 2007). The average dose rate upon receipt was about one (1) rad/hour at one foot. Samples were divided in a ventilated hood within one-half hour after receipt. These samples were then dissolved during the morning of receipt to further reduce the beta dose rate. Exposure rates to the skin during the sample splitting and dissolution processes averaged about 100 mrad/hour. With respect to the underground tests conducted at NTS, tests were normally conducted on Thursday and samples were pulled over the subsequent weekend from an average depth of between 750 to 1000 feet. The samples retrieved from NTS were taken from within the core of the weapon blast, which represented the highest radiation dose. The samples were retrieved within hours after detonation and were split for duplicate analyses, with halves being sent to LLNL and Los Alamos National Laboratory for analysis (Chew, 2007). The average NTS sample, which consisted of glassy or melted dirt, had the following exposure rates upon receipt at LLNL (Chew, 2007):

- 100 mrad/hour beta at 6 inches
- 10 to 20 mr/hour gamma at 1 foot

With respect to samples obtained from the surface crater of test shots, the average dose rate was about one (1) rad/hour at the surface of the sample. The dose rate initially declined due to decay of short-lived fission products.

Upon arrival at LLNL, all types of shot samples were dried, assayed, split, and analyzed in one or more laboratories depending on the information sought from the test. Analyses were conducted in fume hoods. After analyses were completed, the remaining portions of samples were stored in a vault in the basement of Building 155 until the dose rate decayed to less than ten mrad/hour (Chew, 2007).

While shot sample handling was normally performed in fume hood environments, the potential existed for external unshielded electron and photon dose and for internal exposures from accidental loss of containment during sample handling. Given the high activity levels that would be associated with the observed sample dose rates, any such releases during sample handling would have constituted substantial internal exposure hazards. Radionuclides detected in the weapons samples included rare isotopes of tungsten (W-181/185/188) (Bihl, 2007). NESHAP reports (2000, 2002) reported fission products found in waste materials that were attributed to shot samples.

Depleted uranium and uranium isotopes were used with high explosive materials at Site 300. Thorium was also used in some lab processes and in some research and development activities at Site 300. Accelerators and flash x-ray equipment were routinely used at Site 300 in conjunction with both indoor and outdoor testing. The use of such equipment generated air and metal activation products which resulted in potential exposures for Site 300 workers.

Tritium was a major byproduct of reactor, accelerator, and other operations and research conducted at LLNL. Forms of tritium that existed at LLNL included hydrides, tritium oxide, and tritium gas.

The potential for exposure to mixed fission and activation products existed from operations performed at LLNL, as indicated by the site monitoring for mixed fission product exposures using gross activity methods (LLNL, 1961-1962). LLNL also maintained administrative limits to control exposures to mixed fission products. Potential for fission product exposures existed with accelerator and reactor operations, handling and analyses of weapon testing shot samples, biomedical research, research and development activities, safeguards and security programs, miscellaneous laboratory analyses, and from waste management research operations. Most research projects performed at LLNL were conducted in small groups consisting of only a few workers and the Hazard Control staff assigned to monitor a particular project (Bihl, 2007). Different labs in a common building were sometimes associated with unique source terms, including fission products (Bihl, 2007).

While no specific operations or buildings were identified, *Internal Ionizing Radiation Exposure Standards, Procedure 202* listed maximum permissible concentrations in air for cobalt-60, cesium-137, and strontium-90 (Unknown author, 1961). Another LLNL document further lists twenty-nine buildings as approved for handling fission products and other radionuclides (Balanda, 1962). An examination of bioassay data for the period from 1972 through 1980 showed that employees in thirty-six LLNL buildings/locations were monitored for exposures to mixed fission products (ORAUT, 2007a). NIOSH has also found mixed fission product air monitoring data for seven of those thirty-six buildings from 1959 through 1967, further indicating site concern for fission product exposures. The buildings for which fission product bioassay and/or monitoring data were found include Buildings 222, 251, 281, 332, 412, 419, and Site 300 (LLNL, 1965-1967; LLNL, 1960-1970; LRL, August 1964-December 1964; LRL, January 1963-January 1964; LRL, January 1964-October 1964; LRL, January 1965-December 1965).

NIOSH research indicates that fission and activation products were either used or generated in the buildings listed in Table 4-2.

Table 4-2: Buildings Involved with Fission and Activation Products

Current Building Number	Operations/Activities
101, 125, 132, 151, 162, 165, 166, 167, 168, 169, 171, 173, 174, 175, 176, 182, 217, 221, 222, 223, 224, 243, 253, 254, 255, 334	Chemistry, nuclear and radiochemical analyses/tests, lab services, and radiological calibrations, isotope sciences, tracer and dissolution studies , research
192, 194, 210, 212, 241, 298, 327, 341, 421, 435	Accelerators studies
281	Reactor
361, 362, 363, 364, 365, 366, 377, 378, 412	Biomedical studies
241, 412, 513, 514, 612, 614 Yard, 625	Waste operations
Site 300 (All buildings and areas)	Linear accelerators, radiography, Plowshare programs

Sources: ORAUT, 2007a; LLNL, 2005; LLNL, 1965-1967; AACG, 1959; ORAUT-TKBS-0035-2, pages 9-19

A list of fission and activation products encountered in these buildings is listed in ORAUT-TKBS-0035-2, pages 11-13. While NIOSH has access to documents that describe some of the activities and radionuclides specific to certain buildings, NIOSH does not have sufficient data to document the quantities and types of most fission products and activation products. NIOSH also does not have sufficient information to rule out the use of fission and activation products in other buildings where radioactive material was handled and stored. However, NIOSH has no indication that exposures to mixed fission products and activation products would have been a concern in administrative areas outside of radiological areas (e.g., cafeterias, libraries, and office areas outside of radiological areas)

4.3 Time Period Associated with Radiological Operations

Mixed fission products and/or activation products were potentially produced, generated, used, handled, and/or stored with all operations and tasks conducted at LLNL from January 1, 1950 through December 31, 1973. Several LLNL operations produced, generated, used, handled, and/or stored mixed fission products and/or activation products beyond December 31, 1973 and continue to do so today. However, NIOSH has the *in vitro* and *in vivo* bioassay monitoring data needed to reconstruct with sufficient accuracy, the potential internal doses that may have been received from exposures to fission and activation products after December 31, 1973 (see Sections 5.1 and 6.1). Therefore, the time period associated with this evaluation report for mixed fission product exposures at LLNL is January 1, 1950 through December 31, 1973.

4.4 Site Locations Associated with Radiological Operations

While NIOSH does have access to some information that details which radionuclides were handled in particular areas, NIOSH does not have adequate data to determine if exposures to particular radionuclides were limited to the buildings where the radionuclides were known to be handled. Given the extensive list of site areas involved with mixed fission product operations, as presented in Table 4-2, and NIOSH's inability to rule out the use or storage of mixed fission products and activation products within other buildings where radioactive material was stored or used, this evaluation report includes all buildings and work locations where radioactive materials were handled, processed, tested, or stored.

4.5 Job Descriptions Impacted by Radiological Operations

NIOSH has limited documentation associating job titles and/or job assignments with specific radiological operations or work locations. Without additional specific information that links known worker job descriptions with specific work locations, it is not feasible to narrow listed job descriptions to only those workers with potential exposures to radiological operations. Therefore, it is not possible to determine that any specific work group who worked in areas where fission and activation products were used or stored was not potentially exposed to the mixed fission product exposures defined in this report, nor is it possible to use job descriptions to define the proposed class. As previously indicated, NIOSH feels that workers whose job kept them in administrative facilities (e.g. library, cafeteria, offices) outside of radiological areas should not be included in the class..

5.0 Summary of Available Monitoring Data for the Proposed Class

The primary data used for determining internal exposures are derived from personal monitoring data, such as urinalyses, fecal samples, and whole-body counting results. If these are unavailable, the air monitoring data from breathing zone and general area monitoring are used to estimate the potential internal exposure. If personal monitoring and breathing zone area monitoring are unavailable, internal exposures can sometimes be estimated by using more general area monitoring, process information, and information characterizing and quantifying the source term.

This same hierarchy is used for determining the external exposures to the cancer site. Personal monitoring data from film badges or thermoluminescent dosimeters (TLDs) comprise the primary data used to determine such external exposures. If there are no personal monitoring data, exposure rate surveys, process knowledge, and source term modeling can sometimes be used to reconstruct the potential exposure.

A more detailed discussion of the information required for dose reconstruction can be found in OCAS-IG-001, *External Dose Reconstruction Implementation Guideline,* and OCAS-IG-002, *Internal Dose Reconstruction Implementation Guideline*. These documents are available at: http://www.cdc.gov/niosh/ocas/ocasdose.html.

NIOSH searched available DOE data to find source term, workplace monitoring, and personnel monitoring information pertaining to LLNL. NIOSH has obtained internal and external monitoring data for LLNL workers, documentation that describes the processes and radiological source term associated with LLNL operations, and information regarding buildings and locations where work was performed. A sampling of the NIOSH claimant database (using a sampling confidence level of 95% and confidence interval of 10% for claims received through July 6, 2007) indicates that DOE has supplied external monitoring data, including occupational medical X-ray data, for 88% of LLNL claimants and internal monitoring data for 53% of LLNL claimants.

5.1 LLNL Internal Monitoring Data

NIOSH has obtained about 35,000 laboratory-reported bioassay results in electronic format (ORAUT, 2007a; Mansfield, May 2006). These data were supplied by LLNL in the MAPPER (Maintaining and Preparing Executive Reports) database, a data storage system developed for LLNL by the Sperry Corporation. The LLNL MAPPER database only contains *in vitro* monitoring data, primarily from urinalysis analyzed for uranium, plutonium, gross alpha, gross beta, gross gamma, and mixed fission products. The following NIOSH summary of the MAPPER data reflects the number of LLNL entries found in the database, without NIOSH assessment of possible duplicate entries or unusable data points. NIOSH has found the reported MAPPER data to contain (ORAUT, 2007a; Mansfield, May 2006; Mansfield, September 2006):

- approximately 16,750 uranium urinalysis results dating back to 1958 and continuing through 1996;
- approximately 7,700 results for plutonium-239 analyses from 1957 through 1996;
- 312 results for specific analyses of transuranic radionuclides with sample dates ranging from February 27, 1964 through May 13, 1996;
- about 5,000 gross alpha results with sample dates ranging from March 18, 1956 through August 15, 1996;
- 4,226 gross beta and gross gamma results representing sampling for fission and/or activation products with sample dates ranging from September 27, 1957 through September 11, 1996 with 325 gross beta results having sample dates prior to 1974 (results denoted as mixed fission product or MFP are included here as gross beta results because they employed the same radiochemical analysis);
- 19 results reported for specific radionuclides such as cobalt-60 and iodine-131; and

- approximately 800 mixed fission product results with sample dates ranging from January 13, 1974 through October 1, 1989; and

NIOSH has found that the MAPPER data do not include any *in vivo* analysis results. NIOSH has obtained logbooks for two whole-body counter systems used at LLNL (Anderson, 1966; LLNL, 1964-1966; LLNL, 1966-1971; Anderson, 1964-1965; LLNL, 1967-1969; LLNL, 1969-1970; LLNL, 1970-1971; LLNL, 1971; LLNL, 1971-1972; LLNL, 1972; LLNL, 1972-1973; LLNL, 1973-1974; LLNL, 1974-1975; LLNL, 1975-1976; LLNL, 1976-1979; and LLNL, 1980-1981). Logbook entries indicate the following:

- approximately 50 to 200 *in vivo* counts were performed each year beginning in 1965;

- logbooks recorded the names of thirty-four employees counted in 1965 and 1966, some with multiple counts (additional workers were counted in 1965 and 1966 but no names or other specifics were provided);

- fifteen analyses had results that were noted as "normal spectrum," with no further specifics;

- notations were listed for sixteen cyclotron workers in 1965 and 1966, indicating zinc-65 activity;

- a note indicates that one worker was used for calibration of zinc analysis methods on November 24, 1965;

- a person with a suspected intake of plutonium was counted;

- at least one person involved with setting up the whole-body counter was analyzed as experimental;

- entries made to the logbooks starting in 1967 contained some names along with dates of counting, but made no indication of results;

- by 1970, logbooks only recorded the number of people counted on a particular date; and

- much of the information in the whole-body counter logbooks dealt with setup, calibration, and experimentation information.

Although 325 gross beta results were reported by LLNL in the MAPPER data for the period from 1957 through 1973, these gross results were not identified as a particular fission product radionuclide by LLNL (ORAUT, 2007a). Further, units of activity used for gross beta results varied from dpm (disintegrations per minute), dpm/L, cpm (counts per minute), cpm/L, and μCi, or μCi/L. NIOSH lacks adequate documentation needed to convert counts per minute to intake. In addition, gross beta measurement results would be at least partially dependent on the radionuclides and material forms to which an employee was exposed. While the efficiencies of gross beta results were based on strontium-90 measurements, the LLNL Hazards Control group indicated that gross beta results could not be precisely interpreted in terms of internal dose or body burden (Miller, 1979). While internally detected activities of Zinc-65 were given for sixteen workers, indications are that the implementation and testing of the whole body counter was in a state of evolution at the time, and NIOSH lacks the information necessary to validate the calibration and radionuclide efficiencies associated with the zinc *in vivo* analyses.

With the exception of the 325 gross beta results reported by LLNL, NIOSH does not have *in vitro* bioassay results for exposures to mixed fission products through 1973. NIOSH reviewed mixed fission product *in vitro* results recorded by LLNL through 1980. As presented in Table 5-1, the number of mixed fission product analyses increased in 1974, peaking in 1978.

Table 5-1: Mixed Fission Product *In Vitro* Bioassay Analyses

Year	# of Individuals	# of Results	# of Known Locations	Location(s)
1972	2	2	2	Radiochemistry, Waste Disposal
1973	16	16	4*	Biomedical, Hazards Control, Pool Reactor, Radiochemistry
1974	35	42	9*	Assay Lab, Biomedical, Chemistry, Diagnostic Chemistry, Metallurgical Chemistry, Pool Reactor, Safeguards and Engineering, Waste Disposal
1975	39	79	14*	Assay Lab, Assembly and Test, Biomedical, Chemistry, Classified Storage, Hazardous Wastes, Hazards Control, Lab Services, Mechanical Engineering, Pool Reactor, Safeguards and Engineering, R&D, Radiochemistry, Waste Disposal
1976	34	70	13*	Assay Lab, Assembly and Test, Biomedical, Chemistry, Classified Storage, Hazards Control, Lab Services, Mechanical Engineering, Pool Reactor, R&D, Radiochemistry, Safeguards and Engineering, Waste Disposal, 1575, 2506
1977	45	96	10*	Assay Lab, Biomedical, Diagnostic Chemistry, Dry Waste, Metallurgical Chemistry, Pool Reactor, R&D, Radiochemistry, Storage, Waste Disposal
1978	68	100	13*	Assay Lab, Diagnostic Chemistry, Dry Waste, Engineering, Hazards Control, Heavy Element Facility, Metallurgical Chemistry, Pool Reactor, Radiochemistry, Refractory Materials, Site 300, Storage, Waste Disposal
1979	40	73	7*	Accelerators, Assay Lab, Dry Waste, Metallurgical Chemistry, Pool Reactor, Radiochemistry, Waste Disposal
1980	26	30	7*	Assay Lab, Biomedical, Dry Waste, Hazards Control, Pool Reactor, Radiochemistry, Waste Disposal

Note:
*** indicates that the location could not be determined for some worker bioassay results**

NIOSH has identified a LLNL bioassay procedure pertinent to 1966; the procedure does require bioassay of personnel involved with nuclear samples and other operations, but there was no specific requirement to check for fission products (Balanda, 1966).

NIOSH has also reviewed bioassay data cards obtained from Lawrence Berkeley National Laboratory (LBNL); these cards appeared to be a potential source of bioassay data for LLNL workers. Some LBNL data cards noted the word "Livermore" for many gross alpha results (LLNL & LBNL, January1960-August 1962; LLNL & LBNL, 1960-1968). There were some separate results for fission products, which accompanied the gross alpha "Livermore" results; in some cases specific radionuclides were mentioned. NIOSH examined the LBNL data to determine if LBNL had performed analyses of bioassay samples for LLNL employees. NIOSH used bioassay rosters of LBNL workers (Grill, 1965; Soule, 1962) to determine that the data with the notation "Livermore" were often reported for LBNL workers. Indications are that the word "Livermore" was often used to refer to the gross alpha procedure used at LBNL (LLNL, 1967, page 3). LBNL also referred to a gross beta procedure as "Los Alamos." Further, LLNL actually analyzed bioassay samples of LBNL workers until 1961 (Howe, 1961; Browne, 1952). In summary, NIOSH has insufficient worker information to associate data reported on LBNL data cards with LLNL workers involved in work at the LLNL main site or Site 300; the "Livermore" notations on the LBNL cards do not appear to indicate that the analysis is necessarily associated with a LLNL worker.

NIOSH has obtained tritium results from LLNL in an electronic format suitable for statistical analysis. The file contained 47,472 tritium results with sample dates ranging from May 3, 1955 through September 13, 1995 (ORAUT, 2007b).

NIOSH has identified about 1,000 personal lapel monitoring records for the periods of 1960 and 1961 (LLNL, December 12, 1960-August 31, 1961). Each record contains gross alpha and gross beta results. Almost all of the lapel samples were taken in Building 125 (Assay Lab). A majority of the gross alpha and gross beta results were reported as "background." NIOSH lacks adequate documentation as to what processes were being conducted, and therefore is unable to determine if all potentially exposed workers in that building were monitored with the lapel samplers, or if the lapel sample results represent the exposures of the highest exposed individuals in the building.

5.2 LLNL External Monitoring Data

NIOSH has identified personnel external monitoring data going back to 1952, as well as documentation describing LLNL monitoring programs. This documentation includes dialogue regarding the rationale for monitoring (ORAUT-TKBS-0035-6, pages 8-11). The data include extensive external results, including neutron exposure data; these external monitoring results are available for reconstructing external doses. NIOSH has obtained documentation necessary to define the geometry and energy ranges experienced with each process.

5.3 LLNL Workplace Monitoring Data

LLNL monitored the workplace in an attempt to identify any increasing potential for intakes. NIOSH has identified air monitoring data dating back to 1953 for many buildings at LLNL and Site 300. NIOSH has access to thousands of results, mostly total or net alpha and total or net beta results

(LLNL, 1961-1962; LLNL, 1960-1961; LLNL, 1960-1962; LRL, 1967). For some results, reported analytes were listed on the result sheet in terms of element (plutonium, uranium, or thorium), but no nuclide specific information was provided. NIOSH has also found mixed fission product air monitoring data linked to seven buildings/areas for the time periods ranging from 1959 through 1967. The buildings for which fission product monitoring data (gross beta) were found include Buildings 222, 251, 281, 332, 412, 419, and Site 300 (LRL, January 1963-December 1963; LRL, 1966). NIOSH has air monitoring results for Site 300 for 1964, 1965, 1966; for Building 101 (Chemistry) from 1963 through 1966; and for Building 121 (Biomedical) for 1959 and 1962 through 1967. However, NIOSH lacks sufficient information to ensure that the results represent the breathing zones of the exposed workers. NIOSH is therefore unable to use the gross beta results for dose determination in any specific building.

Included in the air monitoring data are monitoring results for the pool reactor (Building 281) for portions of each year from 1961 through 1973; however, there are only partial data for some years (LRL, April 2, 1965-January 3, 1966; LRL, August 30, 1965-November 29, 1965; LLNL, January 14, 1971-January 11, 1973; LRL, 1966; LRL, April 7, 1965-March 9, 1966; LRL, January 7, 1965- April 12, 1965; LRL, August 1964-December 1964; LLNL, January 9, 1969-January 11, 1971; LRL, November 4, 1963-December 17, 1964; LRL, January 4, 1963-December 30, 1963; LRL, January 3, 1962-January 2, 1963; LLNL, March 1, 1967-January 5, 1968; LRL, February 1, 1962-January 2, 1963; LRL, January 2, 1963-May 6, 1963; LRL, January 1964-August 1964; LRL, May 10, 1963-December 31, 1963; LRL, January 2, 1968-January 3, 1969). While some assumptions can be professionally made about the pool reactor operations, NIOSH lacks more specific documentation on maintenance activities that could have impacted airborne concentrations during those operations. Further, NIOSH lacks documentation that indicates how representative the results were of the actual worker environments.

Although air monitoring data do exist, NIOSH has insufficient information to link specific air monitoring results to the high-risk work areas. Considering the episodic and dynamic high-activity work that was associated with laboratory analysis of various nuclear test samples at LLNL, the general area air sample results available to NIOSH cannot be used to adequately bound the potential air concentrations that may have existed in the breathing zones of laboratory personnel.

Starting in 1961, LLNL used environmental air monitoring at two site perimeter stations and at nine stations beyond the site boundary (ORAUT-TKBS-0035-4, page 7). In 1971, LLNL established a network of permanent outdoor stations to collect air samples to determine airborne radiological levels both within the site and at its perimeters (Gallegos, 1992). These air samples were analyzed for gross alpha and beta radiations, tritium, plutonium-239, plutonium-240, uranium-235, and uranium-238 (Gallegos, 1992).

5.4 Radiological Source Term Data

NIOSH has obtained documentation that defines some of the radioactive source term encountered at LLNL; some data are building specific. Predominant radionuclides in the source term were plutonium, uranium, and tritium; these are well documented. However, fission and activation products were also part of the total source term. Fission and activation products were generated as a result of weapons research, shot sample analysis and handling, development and testing, nuclear fuel fabrication, reactor operations, materials research, biological research, nuclear jet research, fuel testing, reactor operations, linear accelerator operations, and chemical separations. Activation/fission product radionuclides resulting from these operations are documented in ORAUT-TKBS-0035-2, pages 11-13.

6.0 Feasibility of Dose Reconstruction for the Proposed Class

42 C.F.R. § 83.14(b) states that HHS will consider a NIOSH determination that there was insufficient information to complete a dose reconstruction, as indicated in this present case, to be sufficient, without further consideration, to conclude that it is not feasible to estimate the levels of radiation doses of individual members of the class with sufficient accuracy.

In the case of a petition submitted to NIOSH under 42 C.F.R. § 83.9(b), NIOSH has already determined that a dose reconstruction cannot be completed for an employee at the DOE or AWE facility. This determination by NIOSH provides the basis for the petition by the affected claimant. Per § 83.14(a), the NIOSH-proposed class defines those employees who, based on completed research, are similarly affected and for whom, as a class, dose reconstruction is similarly not feasible.

In accordance with § 83.14(a), NIOSH may establish a second class of co-workers at the facility for whom NIOSH believes that dose reconstruction is similarly infeasible, but for whom additional research and analysis is required. If so identified, NIOSH would address this second class in a separate SEC evaluation rather than delay consideration of the claim currently under evaluation (see Section 10.0). This would allow NIOSH, the Board, and HHS to complete, without delay, their consideration of the class that includes a claimant for whom NIOSH has already determined a dose reconstruction cannot be completed, and for which the only possible remedy under EEOICPA is the addition of a class of employees to the SEC.

This section of the report summarizes research findings by which NIOSH determined that it lacked sufficient information to complete the relevant dose reconstruction and on which basis it has defined the class of employees for which dose reconstruction is not feasible. NIOSH's determination relies on the same statutory and regulatory criteria that govern consideration of all SEC petitions.

6.1 Feasibility of Estimating Internal Exposures

NIOSH has located thousands of bioassay monitoring results for LLNL employees (ORAUT, 2007a; ORAUT, 2007b). In addition to the MAPPER data supplied by LLNL, NIOSH has access to individual results reported for 617 claimants using data stored in the NIOSH OCAS Claims Tracking System. As of July 23, 2007, 88 % of claims have external data and 53 % have internal data; however, records for less than 5% of the claims contain bioassay results for mixed fission products. Using the MAPPER bioassay data, NIOSH has developed co-worker intakes for uranium, starting in 1958 and mixed fission products, starting in 1974 (ORAUT-OTIB-0065). These derived co-worker intakes can be used to reconstruct doses for those radionuclides and time periods for all LLNL workers and all LLNL locations (ORAUT-OTIB-0065-Draft, pages 17-19).

NIOSH has access to only limited fission product bioassay data for the period prior to 1974, consisting of data available in NOCTS for less than 30 claimants, 325 gross beta results from MAPPER, and zinc-65 *in vivo* data for 1965 and 1966 for sixteen cyclotron workers. NIOSH has been unable to obtain additional *in vivo* counting results adequate for dose reconstruction for the period prior to 1974. The *in vivo* logbooks examined by NIOSH further indicate that LLNL staff members were routinely modifying the design of the *in vivo* facility during this timeframe, often operating it from a testing scheme rather than from a programmatic bioassay scheme. For reasons stated in Section 5.1 above, NIOSH finds these limited pre-1974 bioassay data insufficient for development of sufficiently accurate co-worker fission product intake models.

While NIOSH has access to some fixed and personal airborne monitoring data that indicate the presence of fission and activation product radionuclides, those data cannot be used to bound or reconstruct doses with sufficient accuracy. Breathing zone results are available for only one building and for portions of 1960 and 1961 only. Considering the high-activity work that was associated with laboratory analysis of various nuclear test samples at LLNL, and the unknown characteristics of biomedical, research, and waste management activities, the general area air sample results available to NIOSH cannot be used to adequately bound the potential air concentrations that may have existed in the breathing zones of LLNL staff.

Further, while some of the fission and activation product source term information is known (ORAUT-TKBS-0035-2, pages 11-13), NIOSH does not have information to sufficiently quantify the activity levels for the wide array of fission product radionuclides encountered across the LLNL site.

While pre-1974 air monitoring and source term information available to NIOSH are not adequate for sufficiently accurate dose reconstruction, these data do show that fission product radionuclides were either used or exposure to them was expected in a wide array of buildings across the site. Therefore, due to a lack of sufficient bioassay, air monitoring, and source term data, NIOSH finds that it is not feasible to reconstruct with sufficient accuracy, the internal doses from intakes of fission and activation products potentially received at LLNL during the period from January 1, 1950 through December 31, 1973.

Some limited documentation may be available to match radiological workers to specific locations; however, many of these workers were likely assigned to multiple locations, and as such, the proposed class cannot be restricted to a specific job title or occupation. Further, NIOSH does not have workplace monitoring documentation to demonstrate that fission and activation products were not used or stored in other areas of LLNL involved in radiological activities. NIOSH does not have information to definitively limit the generation, use, processing, or spread of fission product radionuclides to specific LLNL locations within the buildings where radioactive material was handled or stored; thus, the NIOSH proposed class definition includes all known LLNL locations that handled or stored radioactive material. However, NIOSH has no indication that exposures to mixed fission products and activation products would have been a concern in administrative areas outside of radiological areas (e.g., cafeterias, libraries, and office areas outside of radiological areas).

6.2 Feasibility of Estimating External Exposures

Beta and photon doses received from exposure to uranium, plutonium, fission products, and other sources can be reconstructed for LLNL workers for the entire covered period using available monitoring data that were provided by DOE and obtained by NIOSH during on-site data captures for LLNL. NIOSH also considers the reconstruction of neutron doses to be possible for workers who were potentially exposed to neutrons. Neutron doses can be reconstructed using DOE-supplied personal neutron monitoring data and LLNL process documentation (the latter is presented in ORAUT-TKBS-0035-6, pages 8-11). NIOSH considers reconstruction of external dose possible by using individual dosimetry records, claimant-favorable assumptions, and the relevant protocols specified in various complex-wide Technical Information Bulletins.

NIOSH considers reconstruction of medical dose for LLNL workers feasible because medical records are available for most claimants. NIOSH can also use claimant-favorable assumptions and protocols specified in ORAUT-OTIB-0006 to adequately reconstruct potential LLNL medical dose.

7.0 Summary of Feasibility Findings for Petition SEC-00092

This report evaluates the feasibility for estimating dose, with sufficient accuracy, for all employees of the DOE, its predecessor agencies, and DOE contractors or subcontractors who were monitored, or should have been monitored, for exposure to mixed fission and/or activation product radionuclides while working at the Lawrence Livermore National Laboratory for a number of work days aggregating at least 250 work days from January 1, 1950 through December 31, 1973. NIOSH determined that it lacks sufficient fission product bioassay, source term data, and workplace monitoring data to adequately reconstruct radiation doses resulting from potential internal exposures to fission and activation products received by members of this class of employees. Consequently, NIOSH finds that it is not feasible to estimate, with sufficient accuracy, the total radiation dose received by members of this class of employees.

NIOSH has documented herein that it cannot complete the dose reconstructions related to this petition for doses resulting from exposure to mixed fission and/or activation products. The basis of this finding, specified in this report, demonstrates that NIOSH does not have access to sufficient information to estimate, with sufficient accuracy, either the maximum radiation dose incurred by any member of the class or to estimate such radiation doses more precisely than a maximum dose estimate. Members of this class may have received unmonitored internal radiological exposures from mixed fission product radionuclides resulting from work conducted at LLNL. NIOSH lacks sufficient information, which includes sufficient personnel and workplace monitoring data and radiological source term information, to allow it to estimate the potential total internal exposures to which the proposed class may have been exposed.

8.0 Evaluation of Health Endangerment for Petition SEC-00092

The health endangerment determination for the class of employees covered by this evaluation report is governed by EEOICPA and 42 C.F.R. § 83.14(b) and § 83.13(c)(3). Pursuant to these requirements, if it is not feasible to estimate with sufficient accuracy radiation doses for members of the class, NIOSH must determine that there is a reasonable likelihood that such radiation doses may have endangered the health of members of the class. The regulations require 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.

The petitioner did not provide, and NIOSH has not obtained, any information to indicate that members of the class were exposed to radiation during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents. However, the evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through unmonitored exposure to fission products. LLNL generated or processed unknown quantities of mixed fission products during the proposed class period as part of work conducted for DOE. Consequently, NIOSH is specifying that health may have been endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

9.0 NIOSH Proposed Class for Petition SEC-00092

The evaluation defines a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. This class includes all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who were monitored, or should have been monitored, for internal exposure to mixed fission and/or activation product radionuclides while working at the Lawrence Livermore National Laboratory for a number of work days aggregating at least 250 work days from January 1, 1950 through December 31, 1973, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.

10.0 Evaluation of Second Similar Class

In accordance with § 83.14(a), NIOSH may establish a second class of co-workers at the facility, similar to the class defined in Section 9.0, for whom NIOSH believes that dose reconstruction may not be feasible, and for whom additional research and analyses is required. Such a class would be addressed in a separate SEC evaluation rather than delay consideration of the current claim. At this time, NIOSH has not located information suggesting that there is likely to be a second, similar class of employees at LLNL for whom dose reconstruction may not be feasible.

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11.0 References

42 C.F.R. pt. 81, *Guidelines for Determining the Probability of Causation Under the Energy Employees Occupational Illness Compensation Program Act of 2000;* Final Rule, Federal Register/Vol. 67, No. 85/Thursday, p 22296; May 2, 2002; SRDB Ref ID: 19391

42 C.F.R. pt. 82, *Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program Act of 2000*; Final Rule; May 2, 2002; SRDB Ref ID: 19392

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*; Final Rule; May 28, 2004; SRDB Ref ID: 22001

42 U.S.C. §§ 7384-7385 [EEOICPA], *Energy Employees Occupational Illness Compensation Program Act of 2000*; as amended; OCAS website

OCAS-IG-001, *External Dose Reconstruction Implementation Guideline*, Rev. 1; Office of Compensation Analysis and Support (OCAS); Cincinnati, Ohio; August 2002; SRDB Ref ID: 22401

OCAS-IG-002, *Internal Dose Reconstruction Implementation Guideline*, Rev. 0; Office of Compensation Analysis and Support (OCAS); Cincinnati, Ohio; August 2002; SRDB Ref ID: 22402

ORAUT-OTIB-0006, *Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, Rev. 03 PC-1; Oak Ridge Associated Universities (ORAU); Oak Ridge, Tennessee; December 21, 2005; SRDB Ref ID: 20220

ORAUT-OTIB-0065, DRAFT *Internal Dosimetry Coworker Data for Lawrence Livermore National Laboratory,* Rev. 00-1A, Oak Ridge Associated Universities; SRDB Ref ID: not currently in the SRDB—Draft document

ORAUT-TKBS-00035-2, *Lawrence Livermore National Laboratory – Site Description*, Rev. 00 PC-1; Oak Ridge Associated Universities (ORAU); Oak Ridge, Tennessee; October 26, 2005; SRDB Ref ID: 19553

ORAUT-TKBS-00035-4, *Lawrence Livermore National Laboratory – Occupational Environmental Dose*, Rev. 00; Oak Ridge Associated Universities (ORAU); Oak Ridge, Tennessee; November 18, 2005; SRDB Ref ID: 19557

ORAUT-TKBS-00035-5, DRAFT *Lawrence Livermore National Laboratory – Occupational Internal Dose*; Rev. 01C; July 9, 2007; SRDB Ref ID: not currently in the SRDB—Draft document

ORAUT-TKBS-00035-6, *Lawrence Livermore National Laboratory – Occupational External Dose*, Rev. 01; Oak Ridge Associated Universities (ORAU); Oak Ridge, Tennessee; April 26, 2007; SRDB Ref ID: 31423

AACG, 1959, *Report of Airborne Activity for Various Facilities*; Airborne Activity Control Group (AACG); January 7, 1959; SRDB Ref ID: 35033

Anderson, 1964-1965, *Logbook of Arthur L. Anderson with Various Dates Between 1964 and 1965*; Arthur L. Anderson; 1964 through 1965; SRDB Ref ID: 35019

Anderson, 1966, *Personal Logbook*; A. L. Anderson; 1966; SRDB Ref ID: 14074

Balanda, 1962, *Workplaces for Radionuclides*, Procedure 701-H. C. Manual Part I; John J. Balanda; October 19, 1961, revised March 28, 1962; SRDB Ref ID: 15697

Balanda, 1966, *Personnel Monitoring-Routine Monitoring for Internal Radiation*, Procedure 1003-H. C. Manual Part I; John Balanda; August 25, 1966; SRDB Ref ID: 14029

Bihl, 2006, *Recommended Interpretation for Gross Beta Results from LLNL*, email correspondence from Don Bihl; Don E. Bihl; November 3, 2006; SRDB Ref ID: 31381

Bihl, 2007, *Documented Communication*; communication with Melton Chew; Donald Bihl; April 23, 2007; SRDB Ref ID: 31425

Browne, 1952, *Notes on Gloved Box Installation Relative to Architectural Details for Lab Design*, correspondence to Al Wilson; Howard Browne; January 31, 1952; SRDB Ref ID: 21271

Chew, 2007, *Dose Rate of Shot Test Samples at LLNL*, discussion with Mel Chew; Mel Chew, Bryce Rich, Don Morris, and Mike Mahathy; November 14, 2007; SRDB Ref ID: 36393

DOE, 1992, *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*, DOE/EIS-0157; U.S. Department of Energy (DOE); August 1992; SRDB Ref ID: 24749

DOE, 2000, *United States Nuclear Tests—July 1945 through September 1992*, DOE/NV--209-Rev 15; Department of Energy (DOE); December 2000; SRDB Ref ID: 2433

Gallegos, 1992, *Environmental Monitoring Plan*; Gretchen M. Gallegos, Kris A. Surano, Kenneth C. Lamson, Paula J. Tate, Brian K. Balke, Arthur H. Biermann, William G. Hoppes, Barbara C. Fields, Frank J. Gouveia, Robert L. Berger, Fred S. Miller, Duane W. Rueppel, and John M. Sims; April 1992; SRDB Ref ID: 23047

Gallegos, 2001, *LLNL NESHAPs 2000 Annual Report*, UCRL-ID-113867-01; Gretchen M. Gallegos, Robert J. Harrach, Robert L. Berger, Nicholas A. Bertoldo, Paula J. Tate, and Sylvie-Ring Peterson; June 2001; SRDB Ref ID: 23049

Grill, 1965, *Bioassay List*, memo to Dr. M. R. Powell and Dr. L. R. Scheer; R. P. Grill; December 29, 1965; SRDB Ref ID: 20781

Harrach, 2003, *LLNL NESHAPs 2002 Annual Report*, UCRL-ID-113867-03; Robert J. Harrach, Gretchen M. Gallegos, Sylvie-Ring Peterson, Paula J. Tate, Nicholas A. Bertoldo, Kent R. Wilson, Paris E. Althouse, and Jennifer M. Larson; June 1, 2003; SRDB Ref ID: 23051

Howe, 1961, *Bioassay Program*, PWH-248-61-memo to W. B. Reynolds; P. W. Howe; March 17, 1961; SRDB Ref ID: 20569

LLNL, no date, *Fifty Years of Accomplishments*, 1952 through 2002; Lawrence Livermore National Laboratory (LLNL); no date; SRDB Ref ID: 23405

LLNL, 1960-1961, *Routine Air Monitoring Data Sheets, November 1960 to August 1961*; Lawrence Livermore National Laboratory (LLNL); November 1960 through August 1961; SRDB Ref ID: 35122

LLNL, 1960-1962, *Routine Air Monitoring Data Sheets, 1960 to April 1962*; Lawrence Livermore National Laboratory (LLNL); 1960 through April 1962; SRDB Ref ID: 35076

LLNL, 1960-1970, *Soil and Air Samples*, Site 300; Lawrence Livermore National Laboratory (LLNL); 1960 through 1970; SRDB Ref ID: 35058

LLNL, December 12, 1960-August 31, 1961, *Lapel Samples*, Building 125; Lawrence Livermore National Laboratory (LLNL); December 12, 1960 through August 31, 1961; SRDB Ref ID: 35120

LLNL, 1961-1962; *Routine Air Monitoring Data Sheets, September 1961 to May 1962*; Lawrence Livermore National Laboratory (LLNL); September 1961 through May 1962; SRDB Ref ID: 35121

LLNL, 1964-1966, W*hole-Body Counter Logbook #1, September 18, 1964 to December 14, 1966*; Lawrence Livermore National Laboratory (LLNL); September 18, 1964 through December 14, 1966; SRDB Ref ID: 35017

LLNL, 1965-1967, *Environmental Sample Record*, *Air Filters (composite) for Site 300*; Lawrence Livermore National Laboratory (LLNL); various dates between 1965 and 1976; SRDB Ref ID: 35049

LLNL, 1966-1971, W*hole-Body Counter Logbook #2, December 16, 1966 to August 23, 1971*; Lawrence Livermore National Laboratory (LLNL); December 16, 1966 through August 23, 1971; SRDB Ref ID: 35018

LLNL, 1967, *88-Inch Cyclotron Operation*, misc. radiation files; Lawrence Livermore National Laboratory (LLNL); 1967; SRDB Ref ID: 21523

LLNL, 1967-1969, W*hole-Body Counter #2 Logbook #1, September 18, 1967 to July 29, 1969*; Lawrence Livermore National Laboratory (LLNL); September 18, 1967 through July 29, 1969; SRDB Ref ID: 35020

LLNL, March 1, 1967-January 5, 1968, *Radioactivity Sampling Record*, Building 193 and 281; Lawrence Livermore National Laboratory (LLNL); March 1, 1967 through January 5, 1968; SRDB Ref ID: 36061

LLNL, 1969-1970, W*hole-Body Counter #2 Logbook #2, July 30, 1969 to September 9, 1970*; Lawrence Livermore National Laboratory (LLNL); July 30, 1969 through September 9, 1970; SRDB Ref ID: 35021

LLNL, January 9, 1969-January 11, 1971, *Air Monitoring*, multiple buildings; Lawrence Livermore National Laboratory (LLNL); January 9, 1969 through January 11, 1971; SRDB Ref ID: 36014

LLNL, 1970-1971, W*hole-Body Counter #2 Logbook #3, September 10, 1970 to January 19, 1971*; Lawrence Livermore National Laboratory (LLNL); September 10, 1970 through January 19, 1971; SRDB Ref ID: 35022

LLNL, 1971, W*hole-Body Counter #2 Logbook #4, January 10, 1971 to September 1, 1971*; Lawrence Livermore National Laboratory (LLNL); January 10, 1971 through September 1, 1971; SRDB Ref ID: 35023

LLNL, 1971-1972, W*hole-Body Counter #2 Logbook #5, September 2, 1971 to April 6, 1972*; Lawrence Livermore National Laboratory (LLNL); September 2, 1971 through April 6, 1972; SRDB Ref ID: 35024

LLNL, January 14, 1971-January 11, 1973, *Air Monitoring*, Building 281; Lawrence Livermore National Laboratory (LLNL); January 14, 1971 through January 11, 1973; SRDB Ref ID: 35131

LLNL, 1972, W*hole-Body Counter #2 Logbook #6, April 7, 1972 to October 31, 1972*; Lawrence Livermore National Laboratory (LLNL); April 7, 1972 through October 31, 1972; SRDB Ref ID: 35025

LLNL, 1972-1973, W*hole-Body Counter #2 Logbook, October 31, 1972 to November 15, 1973*; Lawrence Livermore National Laboratory (LLNL); October 31, 1972 through November 15, 1973; SRDB Ref ID: 35026

LLNL, 1973-1974, W*hole-Body Counter #2 Logbook #8, November 19, 1973 to December 14, 1974*; Lawrence Livermore National Laboratory (LLNL); November 19, 1973 through December 14, 1974; SRDB Ref ID: 35027

LLNL, 1974-1975, W*hole-Body Counter #2 Logbook #9, December 14, 1974 to December 3, 1975*; Lawrence Livermore National Laboratory (LLNL); December 14, 1974 through December 3, 1975; SRDB Ref ID: 35028

LLNL, 1975-1976, W*hole-Body Counter #2 Logbook #10, December 9, 1975 to October 5, 1976*; Lawrence Livermore National Laboratory (LLNL); December 9, 1975 through October 5, 1976; SRDB Ref ID: 35029

LLNL, 1976-1979, W*hole-Body Counter #2 Logbook #11, October 6, 1976 to December 12, 1979*; Lawrence Livermore National Laboratory (LLNL); October 6, 1976 through December 12, 1979; SRDB Ref ID: 35030

LLNL, 1980-1981, W*hole-Body Counter #2 Logbook #12, January 14, 1980 to February 3, 1981*; Lawrence Livermore National Laboratory (LLNL); January 14, 1980 through February 3, 1981; SRDB Ref ID: 35031

LLNL, 1985, *Health and Safety Discipline Program-Site 300*, discipline action plan; Lawrence Livermore National Laboratory (LLNL); 1985; SRDB Ref ID: 16007

LLNL, 2005, *LLNL Building Index: Pre 1966 and Post 1966*, facsimile to J.J. Maisler (Integrated Environmental Management, Inc.), Livermore, California; February 15, 2005; SRDB Ref ID: 16948

LLNL, 2006, *Lawrence Livermore Timeline*; Lawrence Livermore National Laboratory (LLNL); May 2, 2006; located at http://www.llnl.gov/timeline

LLNL & LBNL, 1960-1968, *Bioassay Cards*; Lawrence Livermore National Laboratory (LLNL) and Lawrence Berkley National Laboratory (LBNL); 1960 through 1968; SRDB Ref ID: 32379

LLNL & LBNL, January1960-August 1962, *Bioassay Cards*, cards #1-407; Lawrence Livermore National Laboratory (LLNL) and Lawrence Berkley National Laboratory (LBNL); January 1960 through August 1962; SRDB Ref ID: 32378

LRL, January 3, 1962-January 2, 1963, *Hazards Control Radioactivity Sampling Records*, Air Monitoring for Building 193; January 3, 1962 through January 2, 1963; SRDB Ref ID: 36055

LRL, February 1, 1962-January 2, 1963, Hazar*ds Control Radioactivity Sampling Records*, Air Monitoring for Building 193; February 1, 1962 through January 2, 1963; SRDB Ref ID: 36192

LRL, January 1963-December 1963, *Hazards Control Radioactivity Sampling Records*, Building 125 air sample cards; Lawrence Radiation Laboratory (LRL); January 2, 1963 through December 31, 1963; SRDB Ref ID: 35141

LRL, January 1963-January 1964, *Computation of Radioactivity Results*, Building 121 Air monitoring; Lawrence Radiation Laboratory (LRL); January 1963 through January 1964; SRDB Ref ID: 36068

LRL, January 2, 1963-May 6, 1963, *Hazards Control Radioactivity Sampling Records*, Air Monitoring for Building 193; January 2, 1963 through May 6, 1963; SRDB Ref ID: 36198

LRL, January 4, 1963-December 30, 1963; *Computation of Radioactivity Results*, Building 193; January 4, 1963 through December 30, 1963; SRDB Ref ID: 36051

LRL, May 10, 1963-December 31, 1963, *Hazards Control Radioactivity Sampling Records*, Air Monitoring for Building 193; Lawrence Radiation Laboratory (LRL); May 10, 1963 through December 31, 1963; SRDB Ref ID: 36230

LRL, November 4, 1963-December 17, 1964, *Computation of Radioactivity Results*, Building 193; Lawrence Radiation Laboratory (LRL); November 4, 1963 through December 17, 1964; SRDB Ref ID: 36048

LRL, 1964-1967, *Hazards Control Radioactivity Sampling Records*, 300 Area; Lawrence Radiation Laboratory (LRL); 1964 through 1967; SRDB Ref ID: 35090

LRL, January 1964-August 1964, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); January 1964 through August 1964; SRDB Ref ID: 36225

LRL, January 1964-October 1964, *Hazards Control Radioactivity Sampling Records*, Building 101; Lawrence Radiation Laboratory (LRL); January 1964 through October 1964; SRDB Ref ID: 36071

LRL, August 1964-December 1964, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); August 1964 through December 1964; SRDB Ref ID: 35156

LRL, 1965, *Hazards Control Radioactivity Sampling Records*, Building 400; Lawrence Radiation Laboratory (LRL); May 1965 through November 1965; SRDB Ref ID: 35127

LRL, January 1965-December 1965, *Hazards Control Radioactivity Sampling Records*, Building 125; Lawrence Radiation Laboratory (LRL); January 1965 through December 1965; SRDB Ref ID: 36227

LRL, January 7, 1965- April 12, 1965, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); January 7, 1965 through April 12, 1965; SRDB Ref ID: 35152

LRL, April 2, 1965-January 3, 1966, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); April 2, 1965 through January 3, 1966; SRDB Ref ID: 35125

LRL, April 7, 1965-March 9, 1966, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); April 7, 1965 through March 9, 1966; SRDB Ref ID: 35149

LRL, August 30, 1965-November 29, 1965, *Hazards Control Radioactivity Sampling Records*, Building 900; Lawrence Radiation Laboratory (LRL); August 30, 1965 through November 29, 1965; SRDB Ref ID: 35126

LRL, 1966, *Hazards Control Radioactivity Sampling Records*, Building 193; Lawrence Radiation Laboratory (LRL); March 1966 through November 1966; SRDB Ref ID: 35140

LRL, 1967, *Hazards Control Radioactivity Sampling Records*, Building 171; Lawrence Radiation Laboratory (LRL); January 1967 through February 1967; SRDB Ref ID: 35123

LRL, January 2, 1968-January 3, 1969, *Hazards Control Radioactivity Sampling Records*, Building 281; Lawrence Radiation Laboratory (LRL); January 2, 1968 through January 3, 1969; SRDB Ref ID: 36240

LRL, January 3, 1969-December 31, 1969, *Hazards Control Radioactivity Sampling Records*, Air monitoring for Site 300; Lawrence Radiation Laboratory (LRL); January 3, 1969 through December 31, 1969; SRDB Ref ID: 35037

Mansfield, May 2006, *Correspondence Regarding Copy of LLNL MAPPER Bioassay Results Database*, letter from W. Gary Mansfield, LLNL, to Jennifer L. Hoff; W. Gary Mansfield; May 17, 2006; SRDB Ref ID: 28120

Mansfield, September 2006, *Email regarding Questions for Gary Mansfield*, electronic mail message from W. Gary Mansfield, LLNL, to Don E. Bihl, PNNL; Gary Mansfield; September 28, 2006; SRDB Ref ID: 26886

Miller, 1979, *Radiochemical Procedures for Bioassay*; Holly H. Miller; May 1, 1979; SRDB Ref ID: 13880

Myers, 1974, *Recommended Radiation Protection Guidelines for Proposed Site 300 Experiments*, correspondence from D. S. Myers/T. A. Gibson to J. L. Olsen; D. S. Myers and T. A. Gibson; May 2, 1974; SRDB Ref ID: 35056

Myers, 1988, *Activated Air from the Airline Experiment at Site 300*, correspondence to Dave Brekkle; Dave Myers and Mike Trent; March 15, 1988; SRDB Ref ID: 16157

ORAUT, 2007a, *Bioassay Data from MAPPER*, 34,904 records in Microsoft Excel format; Oak Ridge Associated Universities; last accessed August 2007; SRDB Ref ID: not currently in the SRDB—located on the O Drive in the Coworker Data folder

ORAUT, 2007b, *Tritium Bioassay Data*, 47,473 records in Microsoft Excel format; Oak Ridge Associated Universities; last accessed August 2007; SRDB Ref ID: not currently in the SRDB—located on the O Drive in the Coworker Data folder

Soule, 1962, *Revision to Bioassay Schedule*, memo to Howard G. Parker; Harvey F. Soule; March 22, 1962; SRDB Ref ID: 20908

Unknown author, 1961, *Internal Ionizing Radiation Exposure Standards, Procedure 202*; author not identified; September 1, 1961; SRDB Ref ID: 15686

Williams, 1975-1977, *Urinalysis Results*; Gordon Williams; January 23, 1975 through March 30, 1977; SRDB Ref ID: 15483

Williams, 1977, *Air Samples Inside Building 850 and 851*, correspondence to W. E. Keheley that includes measurements; G. E. Williams; November 15, 1977; SRDB Ref ID: 16192