

# Lawrence Livermore National Laboratory Special Exposure Cohort Evaluation Report

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Advisory Board on Radiation and Worker Health

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Division of Compensation Analysis and Support

# ORAU Evaluation Team

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# Petition Overview

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- Special Exposure Cohort (SEC) petition received October 7, 2015
- Petitioner-requested class definition:

*All DOE or DOE contractor employees who worked in any area at the Lawrence Livermore National Laboratory [LLNL] within the 7000 East Avenue location in Livermore, California, or within the Site 300 location in Tracy, California from January 1, 1975 through October 28, 2014*



# Petition Overview

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- Qualified for evaluation on January 6, 2015
- Basis for qualification:

Information available to NIOSH did not provide evidence that the gross alpha *in vitro* bioassay measurements, upon which some coworker analyses are based, were capable of detecting all potential exposure scenarios of concern



# Petition Overview

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- Previous SEC classes:
  - SEC-00092: Class added for January 1, 1950 through December 31, 1973, for employees who were monitored for radiation exposure
  - SEC-00163: Class expanded to include “all employees” for January 1, 1950 through December 31, 1973, eliminating the “who were monitored” distinction
  - Limited *in vitro* and *in vivo* pre-1974 bioassay data are insufficient to support sufficiently accurate coworker fission product intake models



# Proposed Class

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All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at the Lawrence Livermore National Laboratory in Livermore, California, during the period from January 1, 1974 through December 31, 1989, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees in the SEC.



# Background

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- Covered facility from 1950-present
- Original mission was thermonuclear weapons development and diverse scientific and engineering research activities
- Current mission is scientific, technical, and engineering capability with a special focus on national security
- *Past research activities:* testing of nuclear weapons lifecycle, strategic defense research, arms control and treaty verification technology, fusion research, atomic vapor laser isotope separation (AVLIS), magnetic fusion, atmospheric sciences, and commercial nuclear waste



# Background

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- LLNL is comprised of two sites:
  - 1.5-square-mile Main Laboratory Site located at 7000 East Avenue in Livermore, CA; and
  - 11-square-mile Explosive Test Site, also known as Site 300, located 15 miles southeast of Livermore, near Tracy, CA
- The Main Laboratory consists of approx. 500 buildings and structures
  - Approx. 50 of the operational buildings contained radiological materials areas



# Data Capture Efforts

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- On-site personnel interviews were conducted during January, February, April, and September 2015
  - 14 crafts and trades workers (electricians, H&S techs, machinists, maintenance, sheet metal workers, waste management techs, and welders)
  - LLNL program staff (Engineering, Global Security, Haz Waste, Laser Programs, Nuclear Chemistry, Rad Protection, and Weapons Control and Integration)



# Data Capture Efforts

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- A total of ten week-long site visits were made between January and December of 2015
  - Document review and selection
  - Review of Material Accountability and Control records
- LLNL released 1,400 documents on October 1, 2015
  - Documents reviewed by NIOSH through mid-December 2015



# Previous Dose Reconstructions

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Total number of claims submitted for dose reconstruction	1047
Total number of claims submitted for energy employees who worked during the period under evaluation (January 1, 1974 through December 31, 1989)	942
Number of dose reconstructions completed for energy employees who worked during the period under evaluation (i.e., the number of such claims completed by NIOSH and submitted to the Department of Labor for final approval)	628
Number of claims for which internal dosimetry records were obtained for the period under evaluation (January 1, 1974 through December 31, 1989)	387
Number of claims for which external dosimetry records were obtained for the period under evaluation (January 1, 1974 through December 31, 1989)	757



# Radiological Buildings for SEC-00221

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- For purposes of timeliness, NIOSH has narrowed the scope of the current evaluation, focusing on available data sufficiency and feasibility conclusions as related to Building 251 for the period from January 1, 1974 through December 31, 1989
- NIOSH will continue to review and evaluate the entire LLNL site for the period from January 1, 1974 through December 31, 1995, and will proceed with issuing another evaluation report



# Radiological Buildings for SEC-00221

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- Building 251, the Heavy Element Facility, was a major facility for supporting the U.S. nuclear testing program and for basic research.
- Building 251 had three main tasks under the nuclear testing program: (1) nuclear tracer fabrication, (2) radiochemical analysis of bomb debris, and (3) chemical research into transuranic radionuclides.



# Building 251 Operations

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- Specialized equipment for manufacturing tracer sets. Most of the tracer sets used in the U.S. nuclear testing program were manufactured in Building 251
- Separations on post-shot samples performed in Building 251, after initial sample processing at Building 151
- Room 1235 contained the uranium tracer line, used to fabricate tracer sets containing U-233 and U-235. Process included pressing oxide powders into pellets and soldering into brass containers



# Building 251 Uranium Operations

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- LLNL U-233 operations occurred almost exclusively in Bldg 251
- LLNL received U-233 metal and oxide from Rocky Flats Plant for use in tracer applications.
- Inventory documents imply U-233 was also received from Oak Ridge National Laboratory.



# Building 251 Uranium Operations

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- Tracer sets were fabricated for all nuclear tests overseen by LLNL, and for select sets of nuclear tests conducted and overseen by LANL.
- Bomb fraction tracer sets were used to help determine fission and fusion yields in the post-shot analysis of bomb debris.
  - Capsules filled with a radioactive isotope that was not produced by the explosion. LLNL fabricated these tracer sets in Building 251.
  - Tracer U-233 exposure entails alpha emissions as internal dose concern, and gamma radiation associated with the decay product impurities.



# Building 251 Uranium Bioassay (In Vitro)

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- Site-wide routine *in vitro* monitoring was accomplished through a combination of four procedures:
  - Gross alpha urinalysis (primary for Bldg 251);
  - Gross beta urinalysis (also called mixed fission product, MFP) (added for Bldg 251 in 1984);
  - Plutonium urinalysis (secondary for Bldg 251); and
  - Uranium urinalysis (uncommon for Bldg 251).



# Building 251 Uranium Bioassay (In Vitro)

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- Though MAPPER database is no longer used by LLNL, *in vitro* data contained within MAPPER span the 1974 - 1989 period of concern.
  - MAPPER database contains monitoring data from the early 1960s through ca. 1995 and is believed to be complete from approx. the mid-1970s forward
  - A “fully identified” version of the database was received by NIOSH in 2015.
  - MAPPER contains over 35,000 records; approximately 16,100 records are from within the 1974–1989 evaluation period.
  - Results are predominantly for urinalysis (354 fecal samples)



# Building 251 Uranium Bioassay (In Vitro)

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## *In Vitro* Results for Building 251, 1974-1989

Analyte	Number of Urinalysis Results	Number of Fecal Results
MFP	9	0
U-238	5	0
Alpha	135	6
Am-241	12	7
Beta	79	0
Cm-242	5	0
Cm-244	7	0
Pu-239	134	6
Sm-145	1	0



# Building 251 Uranium Bioassay (In Vitro)

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- Available *in vitro* results do not indicate evidence of routine *in vitro* monitoring for uranium associated with Building 251
- MAPPER database reveals only five urinalysis results for uranium associated with Building 251 from 1979–1989 (no area field pre-1979)
  - All five results are from 1980
  - LLNL used either fluorometric or phosphorescence measurements in its uranium urinalysis program. The sample results are therefore expressed in terms of total uranium by mass



# Building 251 Uranium Bioassay (In Vitro)

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- Routine *in vitro* monitoring for workers in Building 251 during 1974–1989 focused on transuranic materials via gross alpha and plutonium urinalyses
- Gross alpha procedure was essentially identical to the LANL americium urinalysis procedure
  - In addition to Am and Pu, the procedure states it also carried actinium, curium, neptunium, and thorium and there is no mention of uranium
- LLNL gross alpha procedure was a bismuth phosphate extraction with addition of sulfate to the solution prior to the bismuth phosphate extraction
  - Sulfates kept the uranium in solution while allowing the plutonium to form an insoluble precipitate



# Building 251 Uranium Bioassay (In Vitro)

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- NIOSH cannot assume Th decay products from U-233 (or the U-232 impurity) would have been sufficiently present in the gross alpha *in vitro* analysis given the fact it could have been removed during production
- Gross beta *in vitro* analysis, if performed, is deemed insufficient for U-233 given the lack of countable electron emission from U-233 + U-232 and the fact the beta-emitting decay products cannot be assumed to have been present
- The plutonium urinalysis procedure was specific for plutonium



# Building 251 Uranium Bioassay (In Vivo)

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- *In vivo* monitoring at LLNL was accomplished via whole-body scanning and/or organ counting
- LLNL has no electronic repository for *in vivo* monitoring data
- LLNL “official” *in vivo* records are in the form of hard copies stored in personnel files



# Building 251 Uranium Bioassay (In Vivo)

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- For Building 251 workers, chest/lung counting method is likely, given the wide variety of transuranic materials handled in Building 251
- Using LLNL's *in vivo* data to assign potential doses from intakes of U-233 + U-232 would be highly uncertain given that gamma-emitting decay products cannot be assumed to have been present



# Building 251 Uranium Bioassay (In Vivo)

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- *In vivo* monitoring results for seven LLNL employees associated with Building 251 from 1974–1995
  - Though some whole-body counts, most of the monitoring was for lung scans as would be expected for a transuranic facility
- NOCTS *in vivo* monitoring found for only two workers associated with Building 251 from 1974–1989
  - Seven lung counts
  - Fourteen whole-body counts
  - One liver count



# Building 251 Air Monitoring

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- NIOSH has no evidence of a comprehensive LLNL repository for air monitoring data. NIOSH has very few results from within the 1974–1989 evaluation time and/or from Building 251.
- *A 1980 DOE review of Building 251 operations:*
  - *Noted “excessive” failure rate for the CAMs used in the various laboratories in Building 251, and recommended that LLNL “vigorously pursue” improving the air monitoring in the building*
- *1990 DOE Tiger Team assessment:*
  - *Noted air monitors and air samplers did not appear to be strategically placed with respect to capturing representative samples*
  - *Further noted that BZ monitors were not used at LLNL and CAM placement appeared to emphasize general room air monitoring rather than representative workplace monitoring*



# Building 251 Access Control Information

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- Building 251 was surrounded by security fencing with access controlled by a Controlled Access by Individual Number (CAIN) booth. NIOSH's first reference of CAIN booths is March 1980.
  - 1980 logbooks indicate construction workers, electricians, and site visitors were routinely present in the building during that time
- Machinist interviews indicate:
  - Access controls were less stringent during the 1970s
  - More common for them to work in different facilities across the site
  - Researchers and support staff routinely went back and forth between Building 151 and Building 251



# Building 251 Access Control Information

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- 1980 logbook entries for Building 251 indicate:
  - The north door of Building 251 was wedged open while construction was going on in the building
  - Visitors to Building 151 were going over to Building 251 without wearing dosimeters
- NIOSH data capture and interview efforts have been unable to locate historical access control records for the site, or for Building 251.



# Building 251 Access Control Information

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- Information currently available to NIOSH contains insufficient access control information or records for Building 251, and insufficient general site worker movement data, to accurately assess whether an energy employee, or class of employees, did or did not potentially enter Building 251 during the period 1974 through 1989



# Feasibility of Dose Reconstruction

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- NIOSH has determined that it has insufficient information to verify that the routine *in vitro* bioassay program for Building 251 workers (combinations of analyses for gross alpha in urine, gross beta in urine, and plutonium in urine) was adequately sensitive for detection of U-233 intakes during the period 1974-1989
- Similarly, NIOSH has determined that photon-emitting decay products and contaminants cannot be assumed to have been sufficiently present in the U-233 source term to verify that the routine *in vivo* bioassay program for Building 251 workers was capable of detecting U-233 intakes during the period 1974-1989



# Feasibility of Dose Reconstruction

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- Information available to NIOSH from multiple site inspections performed from 1980 to 1991 indicate deficiencies in LLNL's implementation of the air monitoring program in Building 251
- NIOSH has determined the available air monitoring data from Building 251 may not be adequately representative of the worker breathing zones, and are consequently not considered sufficient for Building 251 dose reconstruction during the period 1974-1989



# Feasibility of Dose Reconstruction

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- It is not feasible to estimate with sufficient accuracy the U-233 internal doses for LLNL workers in Building 251 during the period from January 1, 1974 through December 31, 1989
- Information currently available to NIOSH contains insufficient access control records for Building 251, and insufficient general site worker movement data, to allow NIOSH to accurately assess whether a class of employees did or did not potentially enter Building 251 during the period under evaluation
- NIOSH therefore recommends the extension of the recommended class to include all LLNL workers during the period from January 1, 1974 through December 31, 1989



# Feasibility of Dose Reconstruction

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- NIOSH finds that it is feasible to reconstruct occupational medical dose for LLNL workers with sufficient accuracy during the period from January 1, 1974 through December 31, 1989
- Consistent with the findings of NIOSH's 2010 evaluation of the LLNL SEC-00163, NIOSH finds that external dose for photon, beta, and neutron exposures can likely be reconstructed for all members of the evaluated class for the period from January 1, 1974 through December 31, 1989. NIOSH will continue to perform a full evaluation of external exposures during the period from 1974–1995



# Feasibility of Dose Reconstruction

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- For the purposes of timeliness, NIOSH is issuing this report covering available data sufficiency and feasibility conclusions to-date, but will continue to review and evaluate internal and external exposures other than U-233 during the period from 1974–1989, and all internal and external exposures during the period from 1990–1995



# Health Endangerment

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- The evidence reviewed in this evaluation indicates that some workers in the class have accumulated chronic radiation exposures through intakes of radionuclides and direct exposure to radioactive materials, without exposure during a discrete incident likely to have involved levels of exposure similarly high to those occurring during nuclear criticality incidents
- 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



# Proposed Class

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*All employees of the Department of Energy, its predecessor agencies, and its contractors and subcontractors who worked in any area at the Lawrence Livermore National Laboratory in Livermore, California, during the period from January 1, 1974 through December 31, 1989, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees in the SEC*

