White Paper

NIOSH Evaluation of the Internal and External Monitoring Programs at the Lawrence Berkeley National Laboratory

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Summary:

As a result of the Lawrence Berkeley National Laboratory (LBNL) Work Group's (LBNLWG) Meeting on February 3, 2012, NIOSH was tasked with evaluating the adequacy of the LBNL internal and external monitoring programs. This white paper arose out of an SC&A review of the NIOSH Site Profile for the Lawrence Berkeley National Laboratory (SCA-TR-SP2010-0002, dated January 22, 2010). The reader is referred to SC&A's original report for their full text.

This white paper responds to LBNLWG matrix issues Numbers 2, 4, 11, and 12. It should be noted that issues 2, 4, and 11 overlap with regards to minimum detectable activitiy (MDA) information. With regards to the Matrix Issues listed above, the LBNLWG's focus is summarized by the following items:

1. Completeness of the bioassay monitoring MDA information.
2. Completeness of the internal and external dosimetry records.
3. Adequacy of the monitoring that was done for those exposure pathways.

Based on the review described in the Discussion section of this white paper concerning the noted matrix issues and the LBNLWG primary focus items, NIOSH has determined that:

1. After review of the additional data capture information, NIOSH has determined that LBNL's bioassay monitoring MDA information is adequate for the determination of internal dose. Additional LBNL site data captures took place during 2012 and various bioassay laboratory procedures were collected that provide sample analysis methods and their associated MDAs, as discussed in the Issue 2 response below. These bioassay laboratory procedures had not been collected in previous site data capture efforts. These recently captured LBNL bioassay laboratory procedures provide a fairly extensive description of the bioassay programs capabilities. Additional information collected will be added to the Site Profile during the next revision.
2. NIOSH uses internal and external dosimetry records directly provided by LBNL for each individual claimant and does not use a data base to reconstruct doses for claimants. This is discussed in the Issue 4 response below.
3. LBNL's internal and external monitoring program, discussed in the Issue 12 response below, was such that workers with internal and external exposure potential were adequately monitored. As a result, internal and external dose coworker studies are not warranted at this time.

Discussion:

Issue 2: Insufficient information for internal dose reconstruction, especially during the early years

This matrix issue has several sub-issues that are all related to the adequacy of the internal monitoring program. This section specifically discusses information regarding the completeness and availability of the bioassay monitoring MDA information. Other sub-issues raised by SC&A in the October 2012 white paper on issue 2 are addressed in a separate white paper titled "NIOSH Response to SC&A Comments Concerning Part of Issue 2 Regarding the Internal Monitoring Program at the Lawrence Berkeley National Laboratory".

NIOSH Response:

Since the discussion of the initial issues during the February 2012 Work Group meeting, additional site related data have been collected and reviewed. The most recent site data capture effort during 2012 has provided additional documentation regarding the LBNL bioassay monitoring program, bioassay procedures, and MDA information.

Prior to 1959, Lawrence Berkeley National Laboratory (LBNL) bioassay samples were assessed offsite at Los Alamos National Laboratory up through 1956, and the Lawrence Livermore National Laboratory after that time (ORAUT-TKBS-0049). In 1959, LBNL discontinued sending all bioassay samples to Lawrence Livermore National Laboratory, and began a small routine bioassay sampling program in 1960. From that time, the LBNL bioassay program increased to where it was fully operational by 1962. The pre-1962 era is covered by an SEC class for LBNL.

The reader is referred to (Unknown 1962, Low-Beer 1964, Buckley 1969, LBNL 1985, LBL 1989, and Unknown 1993) for additional information, including MDAs, concerning the in-vitro bioassay methods discussed below. The additional bioassay MDA and analytical methods information from the most recent site data capture, cited above, will be added to the next revision of the LBNL Site Profile.

LBNL's internal bioassay program, which was fully operational by 1962, was capable of determining specific alpha, beta, and gamma emitting radionuclides. Urinalysis and fecal sampling were performed, as well as whole body counting.

LBNL bioassay sampling methods consisted of, though not exclusively; gross alpha, specific actinide determinations, uranium, radium, gross beta, strontium, gamma emitters, carbon-14, tritium, specific rare earths (lanthanides) determinations, polonium, phosphorus, sulfur, and protactinium. Additional bioassay procedures were adopted over time.

The LBNL gross alpha analysis method, which used lanthanum fluoride co-precipitation, was a screening assay used to indicate the presence of any actinide, actinium through einsteinium. Specific actinide determinations on positive gross alpha results for thorium, neptunium, plutonium, americium, curium, californium, and einsteinium were made through additional processing of the gross alpha preparation by means of column chromatography, electrodeposition, and pulse height analysis. Gross alpha analysis was performed from the beginning of the bioassay program through 1994, when it was replaced by alpha spectroscopy. Polonium, radium and uranium were determined by separate bioassay methods (Low-Beer 1964). These methods were performed from the beginning of the bioassay program.
The gross beta analysis was used primarily for screening purposes. This method was also performed from the beginning of the bioassay program. The gross beta procedure was done after gamma counting the unprocessed sample. For gross beta analysis, a volume of the sample is deposited on an aluminum planchette and counted in a proportional gas flow counter (PGFC) for beta activity. This would not identify the specific radionuclide. Positive gross beta results were followed by specific procedures to identify the particular radionuclides. Special procedures were used to identify radioactive strontium, phosphorus, and the rare earth (lanthanide) elements. The lanthanide series consists of; scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.

Low energy beta emitters were analyzed via the separate method of liquid scintillation counting for tritium (H-3), carbon-14 and sulfur-35. These methods were performed from the beginning of the bioassay program.

Gamma emitters were analyzed via gamma spectroscopy on an unprocessed sample. Gamma emitters were also analyzed via gamma spectroscopy with monovalent ions, such as potassium-40 and cesium-137, removed from the sample. These methods were performed as early as 1965.

Monovalent x-ray emitters were determined in the raw urine sample. The principle radionuclide of interest in this assay is I-125. X-ray emitter methods were performed as early as 1968.

Whole body counting was performed on a routine and special basis starting in 1962. In 1964 whole body counting was carried out on special or emergency requests (Various 1961-1964). Whole body counting was primarily used to identify specific gamma emitting radionuclides. After 1996, LBNL no longer performed WBCs but rather relied on Lawrence Livermore National Laboratory (LLNL) for occasional monitoring (ORAUT-TKBS-0049).

Based on a review of the LBNL bioassay and MDA information from the most recent site data capture, NIOSH has determined that LBNL had an adequate bioassay monitoring program to detect workplace radionuclides. The additional bioassay MDA and analytical methods

information from the most recent site data capture will be added to the next revision of the LBNL Site Profile.

Issue 4: Internal and external data legacy, completeness, and accuracy not addressed

This issue regarded completeness of the internal and external data records, specifically the adequacy of the bioassay database and the bioassay program for short-lived radionuclides and concerns related to monitoring practices that varied by building.

NIOSH Response:

NIOSH does have a spreadsheet of bioassay data that was provided to NIOSH by LBNL. However, this spreadsheet is not used to reconstruct doses for LBNL claims. LBNL routinely provides NIOSH the medical files that contain the original individual records. In addition, NIOSH has captured bioassay logbooks (e.g. Unknown 1991), Bioassay Cards (e.g. LBL 1983), and EH&S Bioassay Lists (e.g. EH&S 1981). The information from these logbooks is associated to the Energy Employee's claim. This ensures that all bioassay associated with an Energy Employee is available for the Dose Reconstructor to assess the claim accurately. NIOSH has not attempted to validate the adequacy of the bioassay database, nor does it believe it is necessary, since NIOSH does not rely on the database to assess claims.

NIOSH has addressed the issue of short lived mixed activation products and an analysis of the need for bioassay monitoring in a separate white paper ("NIOSH Response to SC&A Comments Concerning Part of Issue 2 Regarding the Internal Monitoring Program at the Lawrence Berkeley National Laboratory"). Additional bioassay MDA and analytical methods information from the most recent site data capture will be added to the next revision of the LBNL Site Profile.

NIOSH has found no indication that different monitoring standards were in place for different buildings at LBNL. NIOSH requests any interview transcripts or detailed notes that could help elaborate on any assertions that different monitoring standards were in place for different buildings at LBNL. Information beyond what is already available regarding work conducted at the Donner Laboratory and other laboratories at the University of California campus which would qualify under the EEOICPA would require additional site data captures.

Issue 11: Inadequacy of bioassay analyses presentation

This issue regarded completeness of the bioassay monitoring MDA information.

NIOSH Response:

As indicated in the NIOSH Response to Issue 2, recently captured LBNL bioassay laboratory procedures provide a fairly extensive description of the bioassay programs capabilities. This additional bioassay MDA and analytical methods information from the most recent site data capture will be added to the revision of the LBNL Site Profile.

Issue 12: Failure to provide sufficient guidance for unmonitored workers

This issue regarded whether there was sufficient information in the Site Profile to adequately assess internal dose for all workers and how doses to unmonitored workers are to be assigned.

NIOSH Response:

NIOSH maintains that based on additional research of LBNL procedures and policies on the selection of workers for external and internal monitoring, there are no indications that there were unmonitored workers who worked in radiation areas or worked with uncontained radioactive material (i.e. should have been monitored). Details of the monitoring program are discussed below. Issue 12 concerned the internal monitoring program at LBNL. However, external monitoring program information is provided here as well. Based on this information, it is not necessary at this time to develop internal and external coworker models for the LBNL site. Unmonitored workers should be assigned ambient exposures as outlined in the site profile.

Internal Radiation Monitoring Program:

In 1961, LBNL established a routine internal monitoring program of sampling all employees working in radiation areas after being hired. The frequency of sampling was quarterly for employees working closely with significant quantities of those isotopes of long effective half-life (Sr-90, radium, transuranics), annually for employees working with activity, but not described under quarterly (e.g., researchers working in Bldg. 70, but not with transuranics; building trades personnel frequently working in 70 or 71), every five years for employees of even less potential exposure, and upon termination for employees potentially exposed since their last routine sample. Non-routine bioassays would be promptly made in all cases where other evidence (survey results, air samples, wound from contaminated object) indicated a significant possibility of an intake (Howe 1961).

In 1962, the bioassay monitoring program, which at that time was fully operational, scheduling was revised to annual sampling for radiochemists and Health Chemistry personnel, semi-annual for radiochemists and Health Chemistry personnel more highly exposed to alpha emitters, annual sampling of selected members of the building trades frequently assigned maintenance work in active areas, and selected administrative personnel whose exposure was essentially zero and could be considered control samples (Soule 1962).

LBNL maintained bioassay lists from the start of the bioassay program to 1996 when the bioassay program changed such that personnel were selected for operational bioassay based on the radionuclide authorization program and reviews of work performed. Bioassay lists of names of individuals were supplied by the Health Chemistry Department to the Bioassay Laboratory (Various 1961-1964). The Health Chemistry Department maintained personnel in key experimental facilities. These Health Chemistry operations personnel provided coordination for both engineering needs and monitoring needs. The normally staffed locations were Buildings 1, 3, 19, 8, 70, 70A, 71, 74, and 88 (UCRL 1964). The Health Chemistry Department later became part of the Environmental Health and Safety Department (EH&S). The EH&S department also maintained personnel in key experimental facilities. The normally staffed locations were Buildings 1, 3, 51, 70, 70A, 71, 74, and 88 (EH&S 1981). The EH&S department continued the practice of providing names of individuals who were to be monitored for intakes at LBNL (Haley 1979). The bioassay lists included the worker, their location, and specific radionuclide samples to be taken. These lists were updated periodically based on individuals being added and deleted from the list.

A report of the bioassay laboratory for 1972/1973 indicated that employees in the bioassay program were requested to supply 24-hour urine samples for bioassay. Requests were generally made either once or twice per year for each employee in the bioassay program. These persons worked with, or in areas containing, unsealed radioactive materials (Various 1973).

A 1983 internal audit of the bioassay lists indicated that anyone working with radioisotopes (exclusive of sealed sources) was automatically placed on the list, and that routine bioassay samples were submitted on an annual basis. Additional samples were submitted by the following; large quantity radioisotope users, Decon and Waste Disposal Group of EH&S, Tritium facility personnel, and any person involved in a suspected spill. Also, newly listed people were normally sampled within the first two months (Young 1983).

Bioassay program and whole body count procedures in 1986 indicated that all persons at LBNL working with radioactive materials, exclusive of sealed sources, were requested to be in the bioassay program. The program, which also included periodic whole body counts, was administered by the Medical Services Department. Termination bioassay was requested of all employees working with radioactive material upon their termination of the radioactive work at LBNL. For the Tritium Room facility, urine samples were submitted on a weekly basis, visitors included. Also, any employee suspected of an exposure from some type of incident involving radioactive material was to immediately submit a bioassay sample in the Medical Department. The EH&S Operations group assisted in the implementation of this program. EH&S submitted names of personnel to be added to or deleted from the bioassay list (Unknown 1986).

Beginning in 1996, the bioassay program changed such that personnel were selected for operational bioassay based on the radionuclide authorization program and reviews of work performed (ORAUT-TKBS-0049).

A review of present LBNL claim in early 2013, indicates that internal monitoring is available for various job titles listed in Table 1, and supports the conclusion that LBNL monitored workers for intakes of radioactive material across varied job disciplines based on exposure potential and their bioassay program selection process as discussed above.

Table 1. Job titles of internally monitored workers based on the NIOSH claimant population (as of February 2013, each row represents one or more individuals with given job title.

Job Title
Administrative Assistant
Accelerator Technician
Accelerator Operator
Animal Technician
Cyclotron Operator
Director of Materials Research Division
Electrician
Engineer/Lab Tech/Mechanical Eng.
Instrument Maintenance, Health Chemist
Lab Assistant, Chemist
Mechanical Engineer, Laboratory Technician
Machinist
Mechanical Engineering Technician, Assembly Machinist
Mechanical Technologist
Medical Technologist
Nuclear Chemist
Painter
Physicist
Physicist, Health and Safety Department
Principal Research Technician
Radiation Safety Supervisor
Research Specialist
Research Specialist/Journeyman Machinist
Research Technician
Research, in Charge of Cancer Department
Scientist

Senior Technical Associate
Staff Scientist-Chemist
Supervisor of Outpatient Clinic
Technician
Technologist, Research Associate
Thin Film Coating

Based on a review of the LBNL's bioassay program information and worker bioassay program selection process, NIOSH maintains that LBNL had an operational bioassay monitoring program since 1962 and individuals who worked with uncontained radioactive materials were monitored for intakes, and their individual bioassay results can be used to assess their internal dose. The pre-1962 era was recommended as an SEC based on the absence of an internal dosimetry program and available records.

The LBNL Site Profile will be updated with any pertinent information that was collected since the last revision of the Site Profile.

External Radiation Monitoring Program:

A document entitled "The History of Accelerator Radiological Protection, Personal and Professional Memoirs," (Patterson 1994) describes in Chapter 2 "Early Years at the Rad lab," radiation protection challenges and practices from the earliest days at LBNL. The beginning of the Radiation Laboratory personnel film dosimetry program is described along with routine practices to assign, exchange, and process dosimeters. There are recorded dose histories for individual Berkeley Radiation Laboratory workers beginning in the latter 1930s (UCRL 1937). Several examples of a career radiation dose report prepared from 1948 to 1972 are available (LBNL 1948). There are individual film dosimeter results for nearly every exchange period during the period from 1948 until 1972. The series of routine reports entitled "*Medical and Health Physics Quarterly Report,"* such as the one for October, November, and December of 1950, provides summary statistics of the routine dosimetry program (UCRL 1950). A 1950 document describes elements of the LBNL radiation safety program (Garden 1950). It is stated that all personnel on the project were issued and required to wear film badges. These were exchanged and read weekly. Badges which showed greater than 0.3 roentgens were given special investigation.

As stated previously, the Health Chemistry and EH&S Departments maintained personnel in key experimental facilities. They required each employee or visitor working with or near radioactive materials to have in their possession, and use according to instructions, a current Laboratory film badge, plus any other dosimeter specified for the work to be done. Health Chemistry and EH&S,

also, routinely reviewed the exposure records of all employees working with radioactive materials for compliance with radiation control limits.

A 1968 document stated that a film badge shall be worn by everyone entering either a "High Radiation Area" or a "Radiation Area". A film badge shall be worn by all employees and permanent visitors or guests within controlled and restricted areas. If working conditions make a short-time indication of exposure desirable, the wearing of a pocket ionization chamber may be required by the supervisor or the Health Physics Department. All film badges shall contain a beta-gamma monitoring film, and in addition any person may request that a neutron-monitoring film be issued to him, or his supervisor or the Health Physics Department may require it (LBL1968).

A 1980 letter in a review of the personnel dosimetry program indicated that inspection of personal dosimetry records of several years past showed that whole body beta-gamma and neutron exposures did not approach that level for which personal dosimetry is mandated (Young 1980a). The letter stated that area monitoring would be expanded to ensure that significant exposure in the case of the unbadged individual who, for instance, inappropriately enters an accelerator area can be evaluated.

The criteria for issuance of personnel dosimeters was changed in a 1980 memorandum to where gamma film dosimeters would be issued to employees who work directly with the following radiation producing items; particle accelerators, x-ray generators, irradiators, and radioisotopes. Firemen, certain Protective Services personnel, and other selected individuals would also be issued personal gamma dosimeters (Young 1980b).

The 1980 memorandum also stated that neutron dosimeters would be issued to a limited number of personnel who work full time at accelerator sites that fall in the following categories; operations and onsite maintenance personnel, users (experimenters, radiation therapy personnel), and special cases as determined by Environmental Health and Safety (EH&S) on an individual basis.

LBNL Radiation Safety requirements dated 1990 (LBL 1990), indicated that gamma dosimeters were issued quarterly to anyone who worked directly with the following radiation producing items; particle accelerators (10 hours or more per month), X-ray generators, irradiators, and radioisotopes (does not apply to exclusive users of low-energy beta emitters, such as ^{3}H, ^{14}C, and ^{35}S). In addition, anyone having the potential for occupational exposure (such as experimenters, radiation therapy personnel, LBL firefighters, certain Protective Services personnel, etc.), would also receive a gamma dosimeter quarterly.

Neutron dosimeters were also issued quarterly to personnel in the following categories who work at accelerator sites; operations and maintenance personnel who work 35 hours or more per month, users (experimenters, radiation-therapy personnel), and special cases as determined by EH&S on an individual basis.

Employees whose work only occasionally falls into one of the above categories would be issued dosimeters only as required.

Based on a review of the above external monitoring program information, LBNL issued external dosimetry to laboratory personnel that had the potential of external exposure. For those workers who were not monitored, on-site ambient external dose would be appropriate.

In addition, based on the above information, NIOSH has determined that an external coworker study is not warranted.

The LBNL Site Profile will be updated with this additional information.

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