MEMORANDUM

TO: Los Alamos Work Group
FROM: SC&A, Inc.
DATE: July 27, 2017
SUBJECT: Review of SEC Petition Evaluation Report Addendum (SEC-00109) for Los Alamos National Laboratory

SC&A was tasked on May 4, 2017, to review *Addendum to Los Alamos National Laboratory (SEC-00109) Special Exposure Cohort Evaluation Report*, issued April 24, 2017 (NIOSH 2017; hereafter referred to as the Evaluation Report [ER] Addendum), for Los Alamos National Laboratory (LANL) for the post-1995 period. This ER Addendum addresses "*post-1995 unmonitored intakes of the radionuclides for which dose reconstruction limitations were identified in Rev. 1 of the SEC-00109 ER,*" with the evaluated class remaining the same as in Revision 1 to the ER (NIOSH 2012) with the exception of the start year being changed from 1976 to 1996 (NIOSH 2017). The evaluated class, as provided in the Addendum, is defined as:

> *Service Support Workers (which includes, but is not limited to, security guards, firefighters, laborers, custodians, carpenters, plumbers, electricians, pipefitters, sheet metal workers, ironworkers, welders, maintenance workers, truck drivers, delivery persons, rad technicians, and area work coordinators) who worked in any operational Technical Areas with a history of radioactive material use at the Los Alamos National Laboratory from January 1, 1996 through December 31, 2005.* [NIOSH 2017, page 4]

The National Institute for Occupational Safety and Health (NIOSH) selected the class end date of December 31, 1995, based on a presumption of full compliance with the U.S. Department of Energy's (DOE's) newly promulgated 10 CFR Part 835, "Occupational Radiation Protection," which took effect on January 1, 1996. With full compliance, NIOSH assumes that all DOE work sites, including LANL, would have satisfied the monitoring requirements contained in the rule[1] thereby resolving any limitations that make dose reconstruction infeasible prior to that date. For LANL, these limitations included the "*inability to bound unmonitored intakes of exotic alpha-emitters, fission products, and activation products*" (NIOSH 2017, page 3).

[1]Specifically, 10 CFR 835.402, "Individual Monitoring," states: *(c) For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) shall be conducted for: (1) Radiological workers who, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year*" (10 CFR 835.402).

SC&A views the application of this presumptive criterion, for LANL and for other DOE sites, from two vantage points. First, is the use of 10 CFR Part 835 promulgation a valid basis for presumptive relief from the dose reconstruction limitations defined in preceding Special Exposure Cohort (SEC) classes for a site such as LANL? Section 1.0 below addresses this question in the context of DOE radiation protection policy and program history.[2] Second, assuming January 1, 1996, as a reasonable milestone for internal dosimetry program progress, what metrics can be applied to confirm or validate that substantive implementation of 10 CFR Part 835 was achieved? Substantive, in this context, means those parts of the rule that bear most directly on individual monitoring and recordkeeping. Section 2.0 below addresses this question.

1.0 Use of 10 CFR 835 Presumptive Criterion

As noted in the ER Addendum, prior to January 1, 1996, an SEC class was defined[3] for 1976–1995, given dose reconstruction limitations for "*exotic alpha-emitters, fission products, and activation products*" (NIOSH 2017). These limitations included inadequate monitoring records, process descriptions, and source-term data to complete internal dose reconstructions with sufficient accuracy (ABRWH 2012a). Based on a presumption of compliance with DOE's then newly promulgated occupational radiation safety rule, 10 CFR Part 835, NIOSH finds that dose reconstruction becomes feasible by the effective date of that rule, January 1, 1996. This presumption is based on the rule's provision that internal dosimetry programs shall be conducted "*for radiological workers who, under typical conditions, are likely to receive a committed effective dose equivalent of* [100 mrem] *or more from all occupational intakes in a year*" (10 CFR 835.402), as well as other advancements made, including LANL's response to the 1990 Tiger Team findings and the development of a Technical Basis Standard for Internal Dosimetry in 1992.[4] Coupled with that requirement under 10 CFR 835.402 was one under 10 CFR 835.702, which required that "*records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to §835.402 and doses received during planned special exposures, accidents, and emergency conditions*" (10 CFR 835.402). In effect, the presumption derives from an enforcement milestone beginning in 1996 which would hold LANL accountable for monitoring all workers with a likelihood of receiving 100 millirem (mrem) of internal exposure in a year and maintaining corresponding records, thereby encompassing those potentially exposed to exotics, mixed activation products (MAPs), and mixed fission products (MFPs). This is, in turn, the basis for NIOSH's conclusion that "*given the presumption of compliance, the absence of internal dosimetry records indicates that unmonitored workers were deemed unlikely to have received intakes resulting in a CEDE 0.1 rem or more from all occupational radionuclide intakes in a year*" (NIOSH 2017).

[2] In other words, SC&A is not addressing this as a policy question, which is reserved for NIOSH and Advisory Board deliberations.
[3] For "*all employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Los Alamos National Laboratory in Los Alamos, New Mexico from January 1, 1976 through December 31, 1995*" (NIOSH 2012).
[4] These additional considerations were outlined by James Neton, NIOSH, during the last LANL Work Group meeting on September 11, 2012 (ABRWH 2012b).

First, the use of a presumption of compliance can be taken to infer that regulatory compliance equates to program implementation. Program compliance with 10 CFR Part 835, while necessary under DOE's Price-Anderson regulatory framework, is not sufficient for demonstrating that actual radiation program practice is adequate. For compliance purposes, Part 835 required an approved radiation protection program (RPP) that addressed the 10 prescribed occupational RPP elements, as well as a compliance plan encompassing all sections of the rule, with any foreseen exceptions requiring an exemption. However, actual implementation of an adequate RPP entails that radiological hazards be adequately defined (with corresponding standards and procedures), communicated (with appropriate expertise and training), controlled, and self-assessed, keeping pace with standards, as well as operational and technological developments.[5] While the DOE rule or its antecedent, DOE Order 5480.11, *Radiation Protection for Occupational Workers* (DOE 1988), had requirements that were to be translated into contractor procedures, in the end, the real question is whether those procedures appropriately interpreted the requirements and were carried out by all concerned. External regulatory oversight is typically a blunt instrument for identifying what are often imbedded culture-based workplace safety program gaps and deficiencies. This was the primary reason DOE's Office of Enforcement relied on field guidance, self-assessments, and self-reporting, with prompt corrective actions if any noncompliances were found (GAO 1999). Reliance on oversight findings based on noncompliances or incidents is likewise necessary, but not sufficient, for validating that LANL or any DOE contractor had implemented 10 CFR Part 835 in a complete and substantive manner.

Second, while the Price Anderson program for 10 CFR Part 835 entailed a clearly defined review and approval process and enactment date, the actual upgrades to DOE's site-specific radiological control programs were more evolutionary in nature and paced successive Departmental policy developments. As noted in the ER Addendum, the 100 mrem committed effective dose equivalent (CEDE) criterion for individual monitoring was first defined for DOE-wide application by DOE Order 5480.11 in 1989. These provisions were, in turn, referenced by the Tiger Team compliance assessments in 1989–1990. They were adapted in guidelines applied across the Department through the Radiological Control Manual beginning in 1992. External and internal dosimetry programs had to meet the dosimetry technical standards of 10 CFR Part 835, which became an explicit requirement for actual Department of Energy Laboratory Accreditation Program (DOELAP) accreditation in the amendments to 10 CFR Part 835 in 1998, which, in turn, required accreditation to be accomplished by January 1, 2002. As experience under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) has shown, it was often that last milestone—DOELAP accreditation—that compelled remaining upgrades important to internal dosimetry (and dose reconstruction) at a number of DOE sites.

As pointed out recently by the DOE headquarters lead manager on 10 CFR Part 835 implementation in the 1990s:

> *Overall it seems as though the basic elements of [the] current dosimetry system have been [in] place since 1989. Accordingly, 1/1/1996 may not be such an*

[5] This is consistent with the elements of "integrated safety management," which became an operating philosophy of all DOE sites beginning in the mid-1990s (DOE 2017).

important date with regard to the completeness of dose records for DOE workers. [Rabovsky 2017]

The more important question is the extent to which implementation of onsite programs was upgraded to conform to these new requirements and program expectations. If LANL or other site radiological programs did not adhere to DOE Order 5480.11 (as they were obliged by administratively enforceable contract[6]) in terms of individual radiological monitoring at 100 mrem potential in 1 year (and for other required programs, e.g., radiation work permits (RWPs) and bioassays), would they have done so later under 10 CFR Part 835? As noted later in this memorandum, while a formal RPP review and approval process was conducted by DOE, implementation guidance for that process was not available at the time, and wide latitude was given to the contractor's interpretation of whether and how their actual radiation protection procedures and practices satisfied 10 CFR Part 835 compliance. While 10 CFR Part 835 included an internal dosimetry technical standard, an actual requirement for accreditation of internal dosimetry programs was not included until the 10 CFR Part 835 amendments of 1998.

In summary, while 10 CFR Part 835 provides a clear regulatory milestone with the Department's first enforcement mechanism, it was one of several policy milestones for DOE's occupational RPP, with the basic provisions being first defined in DOE's 1989 Order 5480.11. By itself, this regulatory milestone does not necessarily guarantee conformance with program requirements and expectations for individual monitoring, no more than did Order 5480.11 and the Radiological Control Manual before it. If anything, core requirements for and change to how DOE internal dosimetry programs were implemented did not come until the internal dosimetry technical standard of 10 CFR Part 835 was coupled with an accreditation requirement (for overall dosimetry program functionality) under DOELAP in the 1998 amendments to the rule, which required all sites to achieve accreditation by January 1, 2002.

2.0 SC&A Review of 10 CFR Part 835 and Internal Dosimetry Program Implementation

The second part of SC&A's review is to validate NIOSH's presumption that full compliance with 10 CFR Part 835 equates to an occupational radiation program implemented at LANL whose internal dosimetry policies and practices in 1996–2005 demonstrably resolve the limitations identified previously for which dose reconstruction was deemed infeasible. To accomplish this goal, SC&A pursued the following objectives (in terms of lines of inquiry):

1) **Was the occupational radiation program for LANL that was deemed compliant with 10 CFR Part 835 fully defined, evaluated, and independently reviewed and certified prior to January 1, 1996?**

   SC&A's evaluation focused on the RPP review process followed by DOE and LANL in 1994–1995 to verify that compliance with 10 CFR Part 835 was being achieved. Was that

[6] DOE was on the record emphasizing that contract provisions are a better mechanism than civil penalties (under Price-Anderson) for holding nonprofit contractors (such as LANL) accountable for safe nuclear practices. (GAO 1999).

process comprehensive for LANL and was there validation that LANL achieved program compliance?

2) **Is there any evidence of site-specific or general nonconformances with 10 CFR Part 835 that would have substantive implications for dose reconstruction within the LANL occupational RPP following the effective implementation of the rule on January 1, 1996?**

   SC&A's review includes records related to assessments conducted by the contractor, DOE field, and headquarters program offices, as well as external entities such as the Defense Nuclear Facilities Safety Board (DNFSB). It includes any DOE enforcement activities and actions, as well as unusual-occurrence reporting. Beyond site-specific findings, SC&A's review scope includes more general 10 CFR Part 835 nonconformance issues stemming from experiences at other DOE sites that may have implications for program implementation at LANL. SC&A strove not to duplicate the broad review conducted by NIOSH of a number of these references, as summarized in the ER Addendum, but instead, focused on information sources that would both augment and validate what has already been reviewed.

3) **Are there any LANL occupational protection program or internal dosimetry program implementation issues identified after January 1, 1996, that may hamper or preclude dose reconstruction? These would include concerns identified in the ER, including neptunium and special tritium compounds (addressed separately).**

   Beyond instances of regulatory nonconformance with 10 CFR Part 835, SC&A looked for any evidence that there were persistent gaps, deficiencies, or program issues with the internal dosimetry program at LANL that would have implications for dose reconstruction, particularly in the context of the limitations identified previously. This is particularly relevant for LANL, given that program accreditation (e.g., under DOELAP) is defined in 10 CFR Part 835 (1998 amendments) as the "*means to demonstrate*" compliance with Section 835.402 for internal dosimetry. LANL did not achieve DOELAP accreditation for its internal dosimetry program until January 1, 2002.

SC&A pursued the above lines of inquiry through Site Research Database (SRDB) document review, online databases (i.e., DOE's Noncompliance Tracking System [NTS], Occurrence Reporting and Processing System [ORPS], and the Nuclear Materials & Safeguards System [NMMSS]), and a data capture at DOE headquarters, Office of Worker Safety and Health Policy, for review of archived 10 CFR Part 835 files. This organization is the successor to the Office of Worker Protection Policy and Programs, the headquarters program under the then-Assistant Secretary for Environment, Safety and Health that was responsible for development and promulgation of 10 CFR Part 835 in the 1990s. An inquiry was also made of the DOE and National Nuclear Security Administration (NNSA) field organizations in Albuquerque, New Mexico, but no records related to past implementation of 10 CFR Part 835 at LANL were located.

SC&A addressed each of the above objectives, as follows.

Was the occupational radiation program for LANL that was deemed compliant with 10 CFR Part 835 fully defined, evaluated, and independently reviewed and approved prior to January 1, 1996?

SC&A reviewed Section 7.2.1 of the ER Addendum, "Evaluation of Bounding Process-Related Internal Doses," and found it a complete summary of the compliance implementation review process for LANL. For LANL, as well as for other DOE sites, a formal process was followed through which an RPP established the program functions and procedures by which a site would comply with 10 CFR Part 835. The RPP would be reviewed by the DOE field and headquarters program offices and formally approved prior to the January 1, 1996, deadline.

In terms of LANL, DOE's Albuquerque Operations Office made the formal recommendation to the DOE headquarters cognizant program offices[7] for approval of LANL's 10 CFR Part 835 RPP on May 24, 1995, and it was subsequently approved (DOE/AL 1995). That recommendation was based on a "DOE Review Team" assessment, composed of DOE program representatives with radiological protection expertise, who assessed the compliance status of LANL for RPP implementation through review of supporting documentation for all ten 10 CFR Part 835 sections and onsite validation of actual implementation. This validation consisted of a "*systematic process of field verification, in which each applicable 835 article was assigned lines of inquiry, to be used by LANL RP* [radiation protection] *points of contact for each major LANL facility*" (LANL 2014). The Review Team noted that all of its technical comments were successfully resolved with LANL, and it supported LANL's proposed exemption request for radon monitoring.

Despite the formal reviews and approvals involved, reliance should not necessarily be placed on the RPP review process as ensuring the full implementation of 10 CFR Part 835 program requirements. There were apparent concerns expressed by DOE headquarters and field organizations about the efficacy of the RPP process as it was being implemented across all DOE sites. Concerns were expressed during the July 27–28, 1995, meeting of DOE's Radiological Control Coordinating Committee (RCCC) that the "*criteria for review of the RPP development were followed by very few people*" and that the "*big issue with the RPP was that the contractors were afraid of committing to anything…they wanted to minimize compliance as much as possible*" (RCCC 1995). Implementation guides had been developed to aid the field organizations with how radiological programs should satisfy 10 CFR Part 835 requirements, but these came out too late and had "*little impact with the final* [RPP] *product*" (RCCC 1995). From these and other internal DOE discussions about 10 CFR Part 835 implementation, it is clear that LANL and other contractors were afforded wide latitude in how 10 CFR Part 835 implementation was interpreted for their respective sites and what changes, if any, were necessary. As one field office representative observed, "*he's* [the operating contractor] *got no guidance, but a lot of latitude to define what is an acceptable program*" (RCCC 1995). This is not to say that good faith was not exercised by all parties, but to point out that clear and uniform

[7] These were the Offices of Defense Programs, Environmental Management, Energy Research, and Nuclear Safety, respectively.

acceptance criteria were lacking, and that what particular RPP commitments were made were done so with the understanding that they would carry the weight of regulatory enforcement.

SC&A concludes that both LANL and DOE followed a deliberate review and verification process for validating compliance with 10 CFR Part 835 prior to final enactment on January 1, 1996. However, it is apparent that uniform acceptance criteria (i.e., implementation guidance) were not available in time for use in the field and that wide latitude was apparently given to LANL and other DOE sites to interpret how 10 CFR Part 835 was to be applied to occupational RPPs. Therefore, that compliance review, at the time, may not have been adequate to validate the conformity of existing LANL dosimetry programs to corresponding dosimetry requirements in the rule.

Is there any evidence of site-specific or general nonconformances with 10 CFR Part 835 that would have substantive implications for dose reconstruction within the LANL occupational RPP following the effective implementation of the rule on January 1, 1996?

In terms of implementation of LANL requirements and procedures for occupational radiation protection under 10 CFR Part 835, the available record of program conformance can be found in LANL self-assessments, DOE oversight reviews (as well as those of the independent DNFSB), and reports of violations and other regulatory nonconformances from the DOE Office of Enforcement. Radiological incidents, program deficiencies, and overexposures that may point to nonconformances with 10 CFR 835 can be found in the contractor and DOE occurrence and incident reporting systems, such as the DOE ORPS. Violations, site responses, and corrective actions are available in the DOE NTS.

As noted in the ER Addendum in Section 4.0 and discussed in Section 7.2.1, NIOSH has reviewed these information sources and found no findings that were relevant to the substantive implementation of 10 CFR Part 835 as it pertains to dose reconstruction under EEOICPA. However, in SC&A's review of the NTS, one noncompliance report was identified, but not highlighted in the ER Addendum, that has substantive implications for dose reconstruction. Noncompliance report NC ID 484 was identified in NIOSH's list of NTS items reviewed (NIOSH 2016) but was not discussed in the ER Addendum as being significant (the two noncompliances that were highlighted were deemed as not involving 835.402(c)(1) and not relevant to dose reconstruction with sufficient accuracy).

Noncompliance report NC ID 484 was based on an assessment of the LANL internal dose evaluation program conducted by representatives from Savannah River Site (SRS), MJW Corporation, LANL's Radiation Protection Services Group (ESH-12), and Quality Assurance Group (ESH-14) on March 22–25, 1999. The assessment had 10 noncompliance findings, summarized as follows (DOE/NTS 2017), the first three of which impaired LANL's ability to

monitor individuals "*likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year*" (10 CFR 835.402(c)(1)).[8]

> *1. Some workers and their supervisors are not accurately completing the "health physics checklist" (utilized for enrolling workers into dosimetry programs) to the extent that these checklists may not identify those radionuclides actually handled by the worker. Thus, some workers are not being assigned to the appropriate routine bioassay program in accordance with site requirements. [835.402(c)(1)]*
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> *2. Some radiological workers are not complying with specific RWPs that require them to participate in a bioassay program. As an example, [redacted] out of [redacted] workers who performed work under a specific RWP did not participate in the bioassay program in accordance with requirements of the RWP. [835.402(c)(1)]*
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> *3. Johnson Controls of Northern New Mexico (JCNNM), the principle* [sic] *subcontractor to Los Alamos National Laboratory, may not be enrolling all workers who are potentially exposed to radionuclides into the appropriate bioassay program in accordance with site requirements. [835.402(c)(1)]*
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> *4. There are no provisions within existing documents to address whether visitors (members of the public) should be assigned to bioassay programs. Because visitor monitoring is required at half the level of worker monitoring, separate guidelines are necessary for reviewing the potential for intake. [835.402(c)(3), 835.402(d)]*
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> *5. The annual report to individuals did not include a field for reporting the dose equivalent to the embryo/fetus of declared pregnant workers for calendar years 1996, 1997, and 1998. [835.801(a)]*
>
> *6. In a few cases (< 1%), the dose of record has not been finalized because of the difficulty in obtaining the necessary historical information related to the time of intake. These doses have been identified through the routine bioassay program and the interviews required for gathering this information have not been completed yet. This lag in assigning the dose of record could potentially result in not controlling doses to applicable regulatory limits and ALARA requirements. [835.101(c), 835.202(a)(1), 835.202(a)(2), 835.402(d)]*
>
> *7. Termination bioassay samples are not being collected in all cases. [835.202(b), 835.402(d)]*

[8] These findings are characteristically measured and understated, with terms used such as "some workers" and "may not be enrolling all workers," which is necessary in a regulatory enforcement context if a definitive and comprehensive survey of the full scope of noncompliance was not conducted. Under the circumstances, the actual scope of noncompliance is likely broader.

8. Routine and special in vitro bioassay samples are not being submitted as required by a small percentage of bioassay program participants (< 2%). [835.101(c), 835.202(b), 835.402(d)]

9. During 1998, in vivo measurements were not obtained for some workers on the required frequency. [835.101(c), 835.202(b), 835.402(d)]

10. ESH-12 does not have applicable procedures formalized to administer the IDEP.

Corrective actions undertaken and closed by 2000 included the following:

- Establishment of a Web-based Dosimetry Participation Verification Program to ensure better management of worker bioassay participation
- Development of LANL-wide dosimetry enrollment criteria, facility-specific dosimetry matrices, and implementation of a new dosimetry enrollment process
- New or revised procedures for the following:
  - Health physics checklist procedure
  - Bioassay enrollment procedure
  - Bioassay kit circuit procedure
  - Radiological dose assessment process and examples
  - Special internal dosimetry and bioassay process
  - Terminations
  - Annual report card to workers
  - Radiation Exposure Information and Reporting System

In SC&A's view, the above noncompliances and corrective actions are important to the LANL bioassay program, quite apart from 10 CFR Part 835 compliance, and evince likely longstanding implementation issues with that program. They are similar to, but not as apparently extensive as, violations found at two other DOE sites (Mound and SRS) in the late 1990s.[9]

The other two sites had followed an RPP development, review, and approval process similar to that described for LANL. For all three sites, certification of 10 CFR Part 835 compliance via full implementation of their respective RPPs on January 1, 1996, confirmed that the basic tenets and

[9] For Mound, on October 21, 1997, DOE issued its first Severity Level 1 Notice of Violation, with civil penalty, against EG&G, the operating contractor for Mound Laboratory, for "*failure to adequately assure that the Mound Plant's Bioassay Program for workers was implemented in accordance with the contractor's own established procedures*" (DOE 1998a, page 10). For SRS, on September 21, 1998, DOE issued a Notice of Violation, with civil penalty, against Westinghouse Savannah River Company, the operating contractor for SRS, indicating that "*workers and their management routinely failed, over a period of approximately two years, to ensure that job-specific bioassay samples were submitted for analysis as required by WSRC internal procedures*" (DOE 1998b, page 1).

requirements of 10 CFR Part 835 were in place and that management was accountable for their implementation. However, long-held site safety practices did not necessarily change in keeping with the introduction of a regulatory enforcement program. While the then-existing site procedures may have been in keeping with the letter of the rule,[10] the actual implementation of those procedures clearly required greater management accountability, worker training, self-assessment, and changes in the workplace safety culture itself than had occurred in 1996. At all three sites, the bioassay program deficiencies only came to light as a result of self-assessments conducted by the operating contractors (self-reporting was incumbent on the contractors under the Price-Anderson Amendments Act enforcement program), when it became known that serious inadequacies existed.

SC&A also reviewed reports, correspondence, and findings of the DNFSB as they pertain to occupational radiation protection at LANL in the 1995–2005 period. In particular, SC&A reviewed Recommendation 91-6, "Radiation Protection for Workers and the General Public at DOE Defense Nuclear Facilities," in terms of Departmental response and implementation concerns that would be relevant to LANL during the active disposition of that recommendation (1991–1996) (DNFSB 2017). SC&A evaluated other LANL reviews by the DNFSB addressing radiation protection, including staff issue reports and resident inspector weekly reports. While there were some program deficiencies cited, none were found to have substantive implications for dose reconstruction under EEOICPA.

SC&A reviewed the ORPS incident database at DOE for purposes of ascertaining any reported occurrences that may have had implications for substantive compliance with 10 CFR Part 835. This was accomplished by running a sort of the database using "occupational radiation protection" as the search term. This elicited a total of 523 relevant reports for 1995–2005. A review of these reports determined that the vast majority involved radiological contaminations, leaks, unexpected or elevated exposures, or airborne releases. None were determined to involve a substantive nonconformance with 10 CFR Part 835 that would have implications for dose reconstruction with sufficient accuracy.

SC&A concludes that the 1999 LANL noncompliance notwithstanding (which derived from an independent review with outside reviewers), solely relying on the lack of Notices of Violation (NOVs) and other recorded nonconformances as a benchmark of effective RPP implementation is questionable. Key provisions of 10 CFR Part 835, e.g., application of the 100 mrem criterion under 835.402(c)(1), do not lend themselves easily to assessment and verification by external compliance reviews, incident occurrences, or procedure reviews. Traditional validation and verification sampling for adequacy and completeness, and interviews with workers and radiation protection personnel, have proven effective in the past to establish the status of program implementation.

[10] But not the intent or appropriate interpretation of the rule, as in all three cases, corrective actions included a complete rewrite of affected procedures.

Are there any LANL occupational protection program or internal dosimetry program implementation issues identified after January 1, 1996, that may hamper or preclude dose reconstruction?

SC&A originally raised concerns about exotic alpha-emitters, fission products, and activation products in its 2010 focused review of the LANL evaluation report (SC&A 2010). That review noted that as far back as in its 2006 site profile review, SC&A had found that "*inadequate consideration was given to potential exposure and missed dose from radionuclides other than the 'well documented' ones cited in the TBD (e.g., plutonium, polonium, tritium, etc.)*" (SC&A 2010, page 8). This was borne out in terms of LANL practice from interviews with LANL staff and other experts; a summary of findings from those interviews is provided below (SC&A 2010):

- *It is fairly well recognized that most DOE facilities, such as LANL, Rocky Flats Plant (RFP), etc., had the capability to detect, identify, and quantify MFP/MAP in workers beginning in the early 1970s. However, it is not as certain (or as well documented) that it was standard practice to actually analyze and record the activity from these radionuclides in the worker's file.*

- *MFP/MAP activities appear to have been investigated in certain situations, but it has not been documented that it was performed on a routine basis at LANL.*

- *Prior to 1998, LANL primarily relied upon the Phoswich detectors for in-vivo (whole-body or lung counting) measurements. An in-vivo count spectrum was typically not analyzed for fission or activation product radionuclides, unless a peak associated with a certain nuclide was visible in the spectrum, or LANL knew or suspected that an exposure had occurred. When that peak was identified, the nuclide was added to the radionuclide library, and the spectrum was converted to activity and reported in the record. Identification of a peak could be subjective at times and not directly correlated to MDA* [minimum detectable activity] *or critical levels, especially with the broad peaks that appeared in the photon spectra, because of the low resolution of these scintillation-type detectors.*

- *Phoswich detectors were unable to resolve peaks for exotic and MFP or MAP radionuclides, particularly those that emitted low-energy photons.*

- *To overcome the detector's inability to resolve peaks, LANL set up regions of interest for the photon spectra, and used control groups of non-nuclear workers to estimate body and room background contributions, and to statistically determine net counts above background and identify peaks of interest.*

- *After germanium detectors became available, if a known or suspected exposure had occurred, then measurements were repeated with high-*

resolution germanium detectors to verify and identify the presence of a radionuclide if the peak was determined not to be one of the primary radionuclides. If detected, the radionuclide was added to the analysis library and confirmed as a positive identification that needed a dose assessment. In most of the cases, in-vitro bioassay samples were also collected.

- *There is a higher likelihood that peaks could have been missed when the germanium detectors were not in operation or had not yet been installed (i.e., before 1998)….*

- *A programmatic assessment of the internal dosimetry program by DOE in 2001 found that thorium-232 and the short-lived MAP radionuclides generated at LANSCE, while required for routine internal dosimetry evaluation, were not included in the in-vivo program library. The absence of this routine monitoring capability as late as 2001 brings into question the ability of the LANL program to detect these and other exotics on a routine basis as a matter of practice (vs. technical capability). As DOE noted in its finding, "Without this information, the in-vivo laboratory cannot identify monitoring strategies or ensure adequate energy calibrations;" and that "interviews with the in-vivo staff indicated that they were not aware of the need for this capability."*

These and related concerns likely contributed to the lack of monitoring records for MFPs and MAPs, which was a basis for NIOSH's recommendation to the Advisory Board in 2012 to define the SEC class extending to end of 1995 corresponding to the promulgation of 10 CFR Part 835. In its March 19, 2013, *Response to NIOSH Questions for LANL Staff Regarding 10CFR 835 Implementation and Unresolved Issues*, LANL noted that its internal dosimetry monitoring programs are established on an as-needed basis and that monitoring is only required for radiological workers likely to receive 100 mrem annually from internal exposure (LANL 2013). LANL further notes:

> *LANL has an in vivo monitoring program established for fission products and activation products, and has historically used in vivo monitoring for these radionuclides. A spectral analysis of each count was performed by the in vivo staff. During this review, all peaks were identified and quantified.* [LANL 2013, page 3]

It is not clear for what time period LANL is making the above claim, given the DOE oversight finding cited previously in 2001 that thorium-232 and MAPs generated at the Los Alamos Neutron Science Center (LANSCE), while required for routine internal dosimetry evaluation, were not included in the in-vivo program library. Without this information and capability (of which LANL internal dosimetry staff was found to be unaware), LANL's in-vivo laboratory would not have been able to "*identify monitoring strategies or ensure adequate energy calibrations*," as concluded by DOE (DOE 2001). This may not have been of great consequence after the introduction of more sensitive germanium detectors in 1998, but it clearly may have

hampered in-vivo monitoring for these radionuclides before that time when Phoswich detectors were being relied upon.[11]

These and other programmatic and dosimetry issues were discussed at length during the LANL Work Group review of the ER during 2010–2013. They contributed to the basis for NIOSH's conclusion that its proposed approach applying substitute radionuclides for exposure bounding purposes fell short, and that given the sparse monitoring data available, it could not reconstruct these doses with sufficient accuracy. However, for at least MAPs and MFPs, it is not clear that this circumstance changed with the advent of 10 CFR Part 835. Notwithstanding the RPP being approved in 1995 based on LANL's compliance with the 10 major program elements of 10 CFR Part 835, could LANL have fully assessed the potential dose contribution due to LANSCE without having thorium-232 and MAPs in its in-vivo program library? While it is likely that radiological air emissions from LANSCE in the 1990s were a smaller percentage of what they were in the 1980s due to stack holdup of short-lived MAPs, what LANL assessments exist to estimate even that lower dose contribution for the post-1995 period? If, as stated for the NIOSH recommendation for the SEC class for 1972–1995, that inadequate air sampling data existed for exotics, MAPs, and MFPs to support dose reconstruction, how is that different after 1995?

SC&A concludes that there is no evidence that the internal dosimetry and monitoring shortfalls cited in deliberations that led to the recommendation by the Advisory Board to define an SEC class for 1976–1995 (ABRWH 2012c) have been resolved for the time period after 1995.

Special Tritium Compounds and Neptunium

For special tritium compounds (STCs), SC&A agrees with NIOSH's assessment that LANL was aware of their presence in the late 1990s and took measures to communicate appropriate dose assessment considerations within the LANL health physics program and to DOE. The potential for significant exposure was deemed small and handled on a case-by-case basis. The capability for NIOSH to bound intakes of STCs exists if found necessary, and methods are available (e.g., ORAUT-OTIB-0066) by which dose reconstruction can be performed.

For neptunium, SC&A agrees that "100-gram quantities" were involved in the operations discussed in the 2005 inspection report and related NOV and, the question of a threshold for routine bioassay notwithstanding, there does not appear to be any evidence of a breech in containment during those operations. However, for reasons touched on earlier in this memorandum, SC&A does not necessarily agree with NIOSH's conclusion that the RPP inadequacies found by the DOE Office of Independent Oversight "*do not indicate that unmonitored intakes occurred*" (NIOSH 2017). These findings are similar to those highlighted for LANL in 1998, Mound for 1997, and SRS for 1998, all of which led to apparent unmonitored intakes.

[11] DOE's oversight finding did not address how long this deficiency may have existed at LANL; given that "*interviews with the in-vivo staff indicated that they were unaware of the need for this capability*," this suggests that it may not have been in place for an extended period (DOE 2001).

SC&A is also concerned about the NIOSH conclusion that "*unmonitored workers involved **with these operations** were unlikely to have received intakes that would have resulted in 100 mrem CEDE*" (emphasis added; NIOSH 2017). Without NIOSH having consulting the NMMSS database[12] and matching that data with corresponding LANL operations over time, it is not clear that such a conclusion can be made solely based on the specific operations being addressed in the 2005 inspection report. For confirmatory purposes, SC&A did review the NMMSS for LANL for 1995–2005 and finds some doubt on this question.

3.0 Conclusion

SC&A concludes that the use of a presumption of compliance with a regulatory requirement (in this case, 10 CFR Part 835 for occupational radiation protection), in place of a deliberate assessment of dose reconstruction feasibility with sufficient accuracy, deserves particular consideration by the Work Group given the precedent it establishes for all DOE sites under EEOICPA. For LANL, NIOSH has previously found that the lack of internal dosimetry monitoring data and records for the radionuclides in question made it infeasible to bound unmonitored intakes, leading to a defined SEC class until the end of 1995. SC&A finds that NIOSH has not demonstrated that this particular condition had changed by 1996.

While SC&A agrees with previous NIOSH statements that this time period (early to mid-1990s) was a time of significant policy and program enhancements to DOE-wide RPPs (ABRWH 2012a), the enactment of 10 CFR Part 835, by itself, did not guarantee effective implementation of its requirements, including those pertinent to dose reconstruction under EEOICPA. In fact, most of those program requirements, including the 100 mrem criterion for individual monitoring, were in place as early as 1989, with no discernable change in LANL monitoring practices (at least for the radionuclides in question) at that time.

A broad finding of noncompliance of the LANL bioassay program in 1999 (NC ID 484), including 10 CFR 835.402(c)(1) for bioassay programs, underscores that enactment of 10 CFR Part 835 alone did not serve to resolve program implementation deficiencies that would impact dose reconstruction with sufficient accuracy after December 31, 1995. Likewise, the two major NOVs at Mound and SRS in 1997–1998 serve to illustrate the deficiencies in dosimetry program implementation that obviously existed at DOE sites despite the onus of Price-Anderson enforcement.

Regarding specific questions related to special tritium compounds, SC&A agrees with NIOSH's position that methods exist by which exposure to these compounds can be bounded. On the question of LANL neptunium monitoring, however, SC&A finds premature any conclusion regarding potential exposure from and monitoring for neptunium founded on findings from one facility and a particular oversight investigation, without ascertaining sitewide inventories and the full scope of operations that may have handled neptunium.

[12] The ER Addendum noted that "*this database* [NMMSS] *turned out to be not directly searchable; therefore, no 'exotics' information was found*" (NIOSH 2017). While NMMSS is not searchable in a conventional sense, it can be queried for information relevant to this subject.

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