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National Institute for Occupational Safety and Health

Reply to NIOSH's Response to SC&A's Review of the Sandia National Laboratories – Albuquerque SEC-00188 Addendum 2 Evaluation Report

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Abbreviations and Acronyms

ABRWH	Advisory Board on Radiation and Worker Health
BZ	breathing zone
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
DAC	derived air concentration
DAC-hr	derived air concentration-hour
ER	evaluation report
H-3	tritium
HCF	Hot Cell Facility
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
Pu	plutonium
SEC	Special Exposure Cohort
SNL-A	Sandia National Laboratories – Albuquerque
SRDB	Site Research Database
SPR	Sandia Pulse Reactor

1 Executive Summary

SC&A reviewed the National Institute for Occupational Safety and Health (NIOSH) Special Exposure Cohort (SEC) petition evaluation report (ER) for Petition SEC-00188, Addendum 2 (1977–2011), for Sandia National Laboratories – Albuquerque (SNL-A) (NIOSH, 2019; hereafter "Addendum 2 ER"), and issued its assessment on December 4, 2020 (SC&A, 2020). SC&A agrees with the conclusion of the Addendum 2 ER regarding the feasibility of dose reconstruction for SNL-A during 1997–2011 based on the weight of available evidence. However, SC&A's review made one finding and seven observations about clarifying questions surrounding data completeness, use of breathing zone sampling analyses, and a specific concern over interpretation of exposure data from the Sandia Pulse Reactor (SPR) where a radiation dose gradient was identified. NIOSH provided a response to each of these issues on May 3, 2021 (NIOSH, 2021).

SC&A reviewed NIOSH's response. Section 3 of this report provides an iterative discussion of the one finding and seven observations, NIOSH's response, and SC&A's recommended work group disposition for each. Those recommendations are as follows.

Finding 1: Direct evaluation of record completeness is not possible

SC&A noted that without information about the number of breathing zone (BZ) samples issued and analyzed during the period of interest, it is not possible to definitively quantify the completeness of the BZ data available to NIOSH for evaluation. NIOSH provided supplementary analysis indicating the available data is likely biased high. SC&A agrees this supplementary analysis is beneficial, but the issue of completeness should be discussed with the Sandia Work Group. SC&A recommends the finding remain in progress pending work group discussion.

Observation 1: Duplicate samples and total breathing zone samples

SC&A identified duplicate samples in the NIOSH analysis for 2002 and also observed inconsistent reporting of total BZ results in one of the NIOSH (2019) Addendum 2 ER tables (table 6-1e). NIOSH acknowledges the existence of the duplicate samples; however, followup analysis indicates that exclusion of the duplicate samples showed negligible differences in the results. NIOSH and SC&A appear to disagree on the inconsistent reporting of BZ samples in table 6-1e that warrants work group discussion. Therefore, SC&A recommends observation 1 remain open pending work group discussion. However, SC&A notes that observation 1 would not materially affect the feasibility conclusion.

Observation 2: Temporal variation indicates incomplete dataset

This observation is a corollary to finding 1 regarding completeness. NIOSH and SC&A agree that the available BZ dataset is incomplete. SC&A recommends observation 2 be subsumed under finding 1.

Observation 3: Use of WebDose to establish completeness and bounding dose estimate

This observation is a corollary to finding 1 regarding completeness. NIOSH and SC&A agree that the available BZ dataset is incomplete. NIOSH indicates the purpose of WebDose was as one piece of evidence to support a bounding dose reconstruction approach. SC&A recommends observation 3 be subsumed under finding 1.

Observation 4: Distribution of breathing zone samples among individual workers

This observation analyzed the available data to determine the number of times an individual worker would have been monitored via BZ to characterize the number of exposure events[1] per year that might have been experienced. SC&A determined it is unlikely that a worker exceeded 200 BZ events without also participating in the internal bioassay program. NIOSH concurs with this observation and affirms that it does not adversely affect the conclusion of a feasible bounding internal dose estimate. SC&A recommends the work group close observation 4.

Observation 5: Workers frequently monitored by breathing zone also participated in bioassay program

This observation noted that the workers most frequently monitored via BZ also submitted non-tritium bioassay samples. NIOSH concurs with SC&A's observation 5 and affirms that it does not adversely affect the conclusion of a feasible bounding internal dose estimate. SC&A recommends the work group close observation 5.

Observation 6: Fluctuations in exposure potential by year and work area

SC&A analyzed the BZ data by year and work area to compare against the NIOSH-derived value of just less than 0.5 millirem (mrem) per event for all years and work locations. While SC&A found that the exposure potential could vary above and below the NIOSH estimate depending on the year and work location, SC&A identified several key mitigating factors that support the use of 100 mrem per year, including: (1) general selection of the highest derived air concentration (DAC) value for evaluation plutonium (Pu)-239 when information indicated a lesser contaminant (e.g. depleted uranium), (2) no consideration for respiratory protection, and (3) the likely number of exposure events per year per worker. SC&A recommends the work group close observation 6.

Observation 7: Sandia Pulse Reactor radiation gradient dose

SC&A reviewed and concurs with NIOSH's plans to address SPR radiation doses and revise the SNL-A site profile. SC&A recommends that this observation remain open until SC&A has determined that the SNL-A site profile has been adequately revised to address this observation.

[1] "Events," as defined by SC&A for this analysis, indicates a single task or job that was monitored and evaluated as a single BZ result. Singular events may include several consecutive reentries into radiological areas during the course of a workday; however, only a single BZ device was used to quantify the exposure environment for that day's work. SC&A did not find evidence of a single BZ device used over multiple days. However, in rare cases, two BZ devices may have been used by an individual during the course of a single day (for example, if the worker changed areas and task assignment during the day). In these rare cases, each separate BZ device is considered a separate event.

2 Background

SC&A reviewed the NIOSH ER for Petition SEC-00188, Addendum 2 (1977–2011), for SNL-A (NIOSH, 2019) and issued its assessment in December 4, 2020 (SC&A, 2020). That review was the first opportunity for SC&A to assess SEC-related issues for this site, given that prior NIOSH evaluations led to three successive SEC classes being defined under Title 42 of the Code of Federal Regulations (42 CFR) 83.14 for all employees for 1949 through 1996.

To support its assessment, SC&A reviewed relevant program documentation, monitoring records, and operational information, including incident and compliance tracking reports. SC&A also conducted an interview on January 15, 2020, with Sandia [redacted] whose tenure included the SEC time period in question and participated in an onsite tour of [redacted]. Overall, SC&A agrees with the conclusion of the Addendum 2 ER regarding the feasibility of dose reconstruction for SNL-A during 1997–2011 based on the weight of available evidence.

For external radiation doses, SC&A found "no evident issues that would preclude dose reconstruction with sufficient accuracy, although there still remain questions about how exposures by personnel to severe radiation gradients at the SPR were handled by [SNL-A], and how NIOSH will apply the available dosimetry data for such exposures to dose reconstruction" (SC&A, 2020, p. 47). These issues are addressed in this report and are the subject of observation 7.

For internal radiation doses, SC&A found that the weight of evidence supports dose reconstruction with sufficient accuracy for the time period in question. SC&A found that NIOSH's approach to apply a 100 millirem (mrem) committed effective dose equivalent (CEDE) per year as a maximum bounding estimate to be reasonable based on a review of Sandia's programmatic implementation of 10 CFR 835 regulatory requirements for internal dose monitoring in 1995–1996. Likewise, SC&A agrees with NIOSH's reliance on personnel air sampling results to justify the annual assignment of 100 mrem (CEDE) internal dose for workers who were not monitored, partially monitored, or solely monitored via BZ results. However, SC&A was unable to validate fully this conclusion due to lack of certain records pertaining to total number of workers monitored and BZ samples issued and processed (subject of finding 1). Additionally, SC&A's (2020) review noted several observations pertaining to the BZ data and its use in assigning unmonitored or partially monitored internal dose (observations 1–6). NIOSH's responses to these observations are addressed in this current review.

Finally, SC&A concurred with the conclusion of the Addendum 2 ER that it is unlikely that [redacted] personnel would have received an intake for which a 100 mrem annual dose (CEDE) would have been exceeded. This conclusion was based on interviews with [redacted], onsite tours, and review of relevant records pertaining to radiological incidents and internal intakes of bioassayed personnel at SNL-A facilities.

3 SC&A's Review of the SEC Petition Evaluation Report, NIOSH's Response, and SC&A's Reply

The following subsections summarize SC&A's (2020) one finding and seven observations from its review of the NIOSH evaluation report for SEC-00188 Addendum 2, NIOSH's response (NIOSH, 2021) to SC&A's review, and SC&A's reply and suggested status of the finding or observation based on NIOSH's response.

3.1 SC&A finding 1: Direct evaluation of record completeness is not possible

> SC&A was unable to locate references, such as periodic health physics reports, that tabulate the total number of workers monitored via breathing zone nor the total number of breathing zone samples issued and processed. Thus, a direct evaluation of the completeness of captured breathing zone results is not currently feasible. [SC&A, 2020, p. 17]

3.1.1 SC&A summary of NIOSH response

NIOSH (2021) agrees that the dataset of raw field-monitoring data sheets is incomplete. This fact is acknowledged in the Addendum 2 ER, section 7.1.1.6 (NIOSH, 2019). However, NIOSH notes that an evaluation of captured monthly derived air concentration-hour (DAC-hr) tracking logbooks for the years 1997–2002 can provide some evidence about the completeness of the BZ samples that exceed a predetermined exposure threshold because they were being tracked for internal dose purposes. NIOSH notes that during the period that can currently be evaluated (1997–2002), there were 965 sample entries in the DAC-hr tracking logs and a dataset of 3,741 raw breathing zone samples available to NIOSH to evaluate for the same period. NIOSH's comparison of these two data sources indicates that 952 (or 98.7 percent) of the samples found in the DAC-hr logbooks were also located in NIOSH's available dataset for evaluation. NIOSH concludes that this indicates that nearly all (i.e., 98.7 percent) of the dosimetrically significant breathing zone samples were included in the dataset available for evaluation.

3.1.2 SC&A reply and recommended status

SC&A finds that NIOSH concurs with SC&A's finding 1 that the available BZ data are incomplete. While not stated in the NIOSH response, SC&A assumes that NIOSH also concedes that the level of incompleteness is not known (i.e., we do not know how much missing data there is). For perspective, NIOSH's (2012) original SEC-00188 ER stated that the site reached its maximum population in 1992 at approximately 10,080 workers and still had 4,189 workers in 2010. An analysis of the claimant population in NIOSH (2019) indicates that 4 percent of the population were monitored internally (though SC&A assumes this does not include BZ results) and 44 percent were monitored externally during the period under evaluation (1997–2011). Table 2 of SC&A (2020) indicates that the number of unique individuals in the raw BZ data ranged from a low of [redacted] workers in 2006 and 2009 to a high of 109 workers in 2002.

Nonetheless, SC&A finds that NIOSH's comparison to the DAC-hr tracking logbooks for a portion of the evaluated period (1997–2002) does provide valuable information to indicate what those missing BZ data might represent in relation to exposure potential. Specifically, if the samples in the DAC-hr logbooks are also included in the raw BZ data available to NIOSH, this would indicate that the evaluated BZ data would be biased high (i.e., claimant favorable) because

the missing data did not meet the threshold for inclusion in the DAC-hr tracking system. SC&A notes that this determination is predicated on the assumption that the radiological monitoring program was fully implemented and functioning appropriately. The implementation of the internal dose monitoring program is discussed in section 3 of SC&A's (2020) review of the Addendum 2 ER. In that review, SC&A concluded:

> SC&A concludes that based on documented program implementation experience and oversight results before and after the end of 1996, the 10 CFR Part 835 provisions for radiation exposure monitoring and recordkeeping were adequately implemented to support the application of a 100 mrem (CEDE) maximum dose as a means to bound internal dose in NIOSH's co-exposure model for [SNL-A]. [SC&A, 2020, p. 47]

SC&A reviewed the DAC-hr logbooks in relation to the raw BZ data and concurs with NIOSH's determination that nearly all of the dosimetrically significant BZ results were included in the data available for 1997–2002. The NIOSH (2021) comparison indicates that only 13 of the 965 DAC-hr entries available for comparison were missing from the raw BZ data available to NIOSH for evaluation. All 13 missing entries were from the same month (February 1998), which reported a total of 163 DAC-hr entries during that period (i.e., for February 1998, 150 out of 163, or 92 percent, of the DAC-hr entries were in the NIOSH dataset).

Per NIOSH (2019), the main facilities in operation during this period were the Radiological and Mixed Waste Management Facility, Annular Core Research Reactor, SPR, and the Hot Cell Facility (HCF). Except for 14 BZ monitoring results related to soil piles in the radioactive waste landfill, all available raw BZ results are related to Building 6580/HCF, though the work description was not specifically defined on the radiological survey form for the job. (These forms generally contain the date, time, area, respiratory requirements, contaminants of interest, and BZ results.) All the available BZ results from HCF located in the basement of Building 6580 required either an air purifying respirator with a protection factor ranging from 50 to 100 or a full-face respirator.[2] Per the SNL-A technical basis document (NIOSH, 2013), the HCF was established in 1996 to examine radioactive materials produced in the SNL-A reactors and other experiments. Although NIOSH (2013) indicates that the HCF primarily handled fission products, the available BZ records also specified Pu-239 as a contaminant of concern for February 1998.

SC&A also notes that the comparisons between DAC-hr tracking logbooks and the raw BZ data available to NIOSH could not be made for the following months:

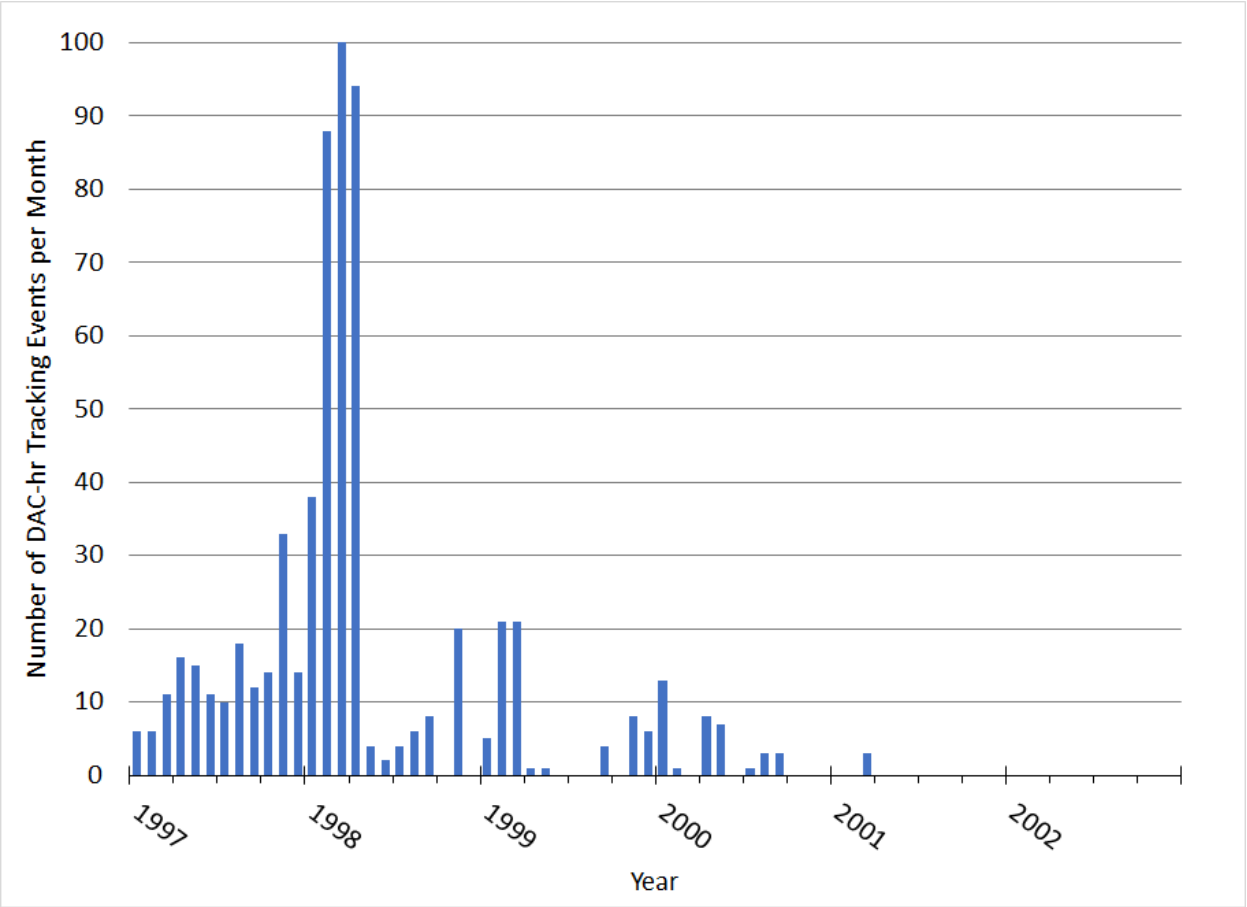
- March and June 2000
- April and July–October 2001
- February and December 2002
- January 2003–May 2011

[2] Although SC&A was unable to locate a specific protection factor for the full-face respirator in SNL-A documentation, it is assumed to equal or exceed that of the air purifying respirator.

The raw BZ data for these months cannot be compared to the tracking reports because the DAC-hr tracking logbooks have not been located and captured for these periods. Therefore, for the full SEC-00188 Addendum 2 evaluated period (January 1997–May 2011), comparisons were available for just 63 of 173 applicable months, or approximately 36.4 percent. SC&A is unaware whether DAC-hr tracking reports are potentially available for comparison of the remaining months via any future data capture efforts. Capture of the additional DAC-hr reports would, at a minimum, indicate the number of workers being tracked per month for DAC-hr exposures.

An important facet would be to characterize the radiological operations and relative exposure potential for the missing months, in particular after 2002 when the largest gap is observed. One potentially informative metric would be to characterize the trend in the number of trackable DAC-hr events per month over time. Figure 1 displays the number of DAC-hr events per month from available reports for the period 1997–2002. SC&A defines a DAC-hr event as an exposure period for which a single BZ device was used to characterize the exposure. A single DAC-hr evaluation can span multiple entries into radiological areas; however, in some rare cases, multiple entries into a radiological area on a given day were treated with separate BZ devices (these were considered separate DAC-hr events in figure 1). SC&A compiled this figure in an attempt to determine if there is an associated trend in exposure potential over time based solely on the number of workers exposed above a certain threshold. While such trend analysis has clear limitations, it appears that the number of workers tracked in the DAC-hr reports generally decreased over time. After 1998, trackable DAC-hr events were less frequent and were generally less than 20 events per month.

Figure 1. Number of samples reported in DAC-hr tracking reports by month (1997–2002)



Note: While this figure does reflect months with zero reported entries for DAC-hr tracking, the following months do not represent zeros but rather unavailable DAC-hr tracking logbooks: March and June 2000, April 2001, July–October 2001, and February and December 2002.

While comparison of the missing DAC-hr reports to the available raw BZ data would certainly be useful in buttressing the conclusion that the BZ dataset available to NIOSH is biased high, SC&A finds that the limited comparison of DAC-hr reports to the available BZ data is another useful piece of evidence that a bounding dose reconstruction approach is likely feasible using available data. SC&A reiterates that the conclusion reached in its Addendum 2 ER review was that a bounding dose reconstruction approach for unmonitored workers or partially monitored workers is likely feasible based on the weight of available evidence (SC&A, 2020, p. 7). Nonetheless, the determination of acceptable levels of incompleteness in a feasibility context is ultimately a subjective judgment that should be discussed by the work group. Therefore, SC&A recommends this finding remain in progress pending work group discussion.

3.2 SC&A observation 1: Duplicate samples and total breathing zone samples

SC&A identified 151 duplicate samples in the 2002 report and analyzed in NIOSH (2019). These samples should not be included in reported BZ totals and should be removed from any exposure estimates. Furthermore, when reporting the total number of BZ samples, the distinct measurements (gross alpha, gross beta, low energy beta, and tritium) should not be counted as separate and distinct BZ

> samplers. These totals should be corrected in any subsequent revisions to the evaluation report to accurately reflect the number of individual workers/events who were monitored via BZ samplers. [SC&A, 2020, p. 20]

3.2.1 SC&A summary of NIOSH response

For ease of discussion, SC&A is separating observation 1 into two parts:

1. duplicate entries identified for 2002
2. discrepancies in the number of BZ results reported in NIOSH (2019) table 6-1e and SC&A's tabulation of available BZ results

The following subsections summarize NIOSH's response to each part of the observation, followed immediately by SC&A's response for that part of the observation. Sections 3.2.1.1 and 3.2.1.2 address duplicate entries identified for 2002, and sections 3.2.1.3 and 3.2.1.4 address discrepancies in the number of BZ results reported.

3.2.1.1 SC&A summary of NIOSH reply on duplicate entries identified for 2002

NIOSH (2021) notes that they have confirmed the presence of 148 usable samples[3] that were indeed duplicates. The cause of this duplication was overlap in the sampled datasets and inconsistencies in how the location code from different files had been coded. In response to this, NIOSH removed the duplicate entries, repeated the original analysis, and was able to confirm that the duplicate samples did not ultimately impact the results of the analysis. NIOSH notes that no impact was to be expected due to the large number of zero or negative results that had to undergo multiple imputation prior to analysis.

The results of this reanalysis are presented in table 3 of NIOSH (2021), which is reproduced as table 1 in this document for ease of reference. As seen in table 1, for the internal dosimetric quantity of interest for SNL-A (alpha), the removal of duplicate samples had little to no effect on the results. NIOSH also states that they were not able to verify the presence of duplicate samples in other years identified in table 1 of SC&A's (2020) review.

[3] NIOSH (2021) actually indicates there were 150 duplicate samples, but two measurements were not usable because of a lack of air flowrate to convert the numerical results into a dose quantity.

Table 1. Evaluation of BZ dataset with and without duplicate values by event and by date

Case	Original dataset with duplicates: mean person dose by event in mrem (GSD)	Revised dataset without duplicates: mean person dose by event in mrem (GSD)	Original dataset with duplicates: mean person dose by date in mrem (GSD)	Revised dataset without duplicates: mean person dose by date in mrem (GSD)
Alpha	0.48 (5.73)	0.48 (5.8)	0.52 (5.2)	0.51 (5.3)
Beta	0.00054 (8.0)	0.00058 (7.6)	0.00066 (7.0)	0.00066 (6.9)
Tritium	0.0065 (4.4)	0.0065 (4.4)	0.0070 (4.3)	0.0070 (4.3)

Note: An event is defined two ways: a radiological work task at a given location on a given day, and all radiological work on a given day (NIOSH, 2019, PDF p. 25).

Source: Reproduced from table 3 of NIOSH (2021), page 9.

3.2.1.2 SC&A reply on duplicate entries for 2002

SC&A and NIOSH agree that there were duplicate BZ results inadvertently entered and analyzed for 2002. NIOSH has appropriately reanalyzed the data and it had little to no effect on the calculated results. Furthermore, NIOSH indicated that it could not find duplicate entries for other years identified in table 1 of SC&A (2020). The other duplicate entries identified in table 1 of SC&A 2020 are as follows: one duplicate sample each in 2004 and 2005, nine BZ samples that were recounts in 2008, and three repeat counts of the sample in 2010. SC&A notes that these minor notations of potential duplicates were to rectify the NIOSH (2021), table 6-1e, total BZs to SC&A's tabulation of BZs and were not specifically included in observation 1. Resolving these few discrepancies observed by SC&A would have no effect on the resulting analysis and proposed methods for dose reconstruction. Therefore, SC&A recommends the part of observation 1 concerning duplicate samples be closed. However, the next two sections further discuss other discrepancies observed by SC&A in NIOSH (2021), table 6-1e.

3.2.1.3 SC&A summary of NIOSH's reply on apparent discrepancies in BZ totals

In addition to the duplicate entries identified in the first part of observation 1 for 2002, NIOSH (2021) discusses the second part of observation 1 concerning how BZ samples were tabulated in table 6-1e of NIOSH (2019) and the discrepancies identified by SC&A. Specifically, NIOSH states the following concerning the tabulation in table 6-1e:

> This tabulation lists the number of measurements available for each year and is not necessarily the same as either the number of individual analytical results (for a particular measurement type) or the number of samples collected from individuals. This is because gross alpha, beta/gamma, low-energy beta, and tritium results were sometimes recorded on separate data sheets. The presence of sample recounts also complicated the ability to consistently tally the number of samples available each year. For these reasons, the tabulation for Section 6 (i.e., Table 6-1e) is related to the number of line items of data available to NIOSH – with each line item potentially containing more than one result type. [NIOSH, 2021, p. 7]

NIOSH states that the more appropriate comparison would be to the actual number of BZ measurements used in the separate exposure analyses for each relevant dosimetric component:

alpha, beta/gamma, and tritium (in NIOSH (2019) tables 7-1b, 7-1c, and 7-1d, respectively). NIOSH (2021), table 2, compares tables 6-1e, 7-1b, 7-1c, and 7-1d with table 1 of SC&A (2020); this table is reproduced as table 2 in this report for ease of reference.

Table 2. Comparison of NIOSH and SC&A datasets

Year	NIOSH dataset (available BZ results) table 6-1e	NIOSH dataset (no. of alpha measurements) table 7-1b	NIOSH dataset (no. of beta measurements) table 7-1c	NIOSH dataset (no. of H-3 measurements) table 7-1d	SC&A dataset (no. of samples)
1997	357	357	357	0	367
1998	1583	1581	1583	0	1568
1999	708	708	708	0	687
2000	336	334	336	0	336
2001	172	172	172	0	164
2002	585	405[a]	405[a]	0	436
2003	0	0	0	0	0
2004	274	131	137	119	128
2005	388	177	177	165	176
2006	208	75	72	88	108
2007	231	111	170	52	111
2008	445	189	358	8	174
2009	76	38	74	0	38
2010	26	23	26	0	20
2011	0	0	0	0	0

[a] Measurement count adjusted to remove duplicate measurements identified in SC&A's analysis

Source: Reproduced from table 2 of NIOSH (2021); original sources: NIOSH (2019); SC&A (2020).

Finally, NIOSH states that analyzing the BZ data by alpha, beta, and tritium samples separately is appropriate and claimant favorable because the analysis is based on the dosimetric value of interest and the associated DAC values. In this case, the dose from alpha was orders of magnitude larger than the other components (beta/gamma, low-energy beta, and tritium).

3.2.1.4 SC&A reply on discrepancies in BZ totals

NIOSH is correct that the comparisons in SC&A (2020), table 1, were to the Addendum 2 ER, table 6-1e, "Available Breathing Zone Air Monitoring Results: 1997–2011." This table is found in section 6 of the Addendum 2 ER, "Summary of Available Monitoring Data for the Class Evaluated by NIOSH." Both table 6-1e (showing the available BZ air monitoring results) and tables 7-1b, 7-1c, and 7-1d (showing the number of data points in each radiation category) were presented to the Advisory Board on Radiation and Worker Health (ABRWH) at its April 2019 meeting (ABRWH, 2019).

Therefore, SC&A believes that the information presented in all four tables should be clear and consistent, as it is a demonstration of the amount of data NIOSH has to evaluate potential exposures for workers at SNL-A during the SEC-00188 evaluation. It is SC&A's opinion that the

data in table 6-1e should represent an individual BZ sampler evaluated for an individual exposure period.

It is not clear to SC&A what NIOSH's (2021) response to the observation is meant to convey when it states that the tabulation in table 6-1e is "not necessarily the same as either the number of individual analytical results (for a particular measurement type) or the number of samples collected from individuals" (NIOSH, 2021, p. 7).

One potential interpretation of this sentence is that table 6-1e of NIOSH (2019) is a mixed bag of the following:

- in some cases, individual BZ samplers worn
- in other cases, the results of a single BZ sampler split by data sheet (this would result in a single BZ result being input as a separate line item by radiation type in NIOSH's compiled database)

SC&A believes such a tabulation is inconsistent and therefore loses important meaning in assessing the amount of data available.

For example, in SC&A's (2020) review of table 6-1e, SC&A was able to exactly match the total number of BZ samplers for 1997 and 2000 when no splitting of the BZ into separate line items based on radiation type was observed by SC&A in the compiled database. Conversely, for 2004 and other years (as noted in SC&A (2020), table 1), SC&A identified examples where a single BZ result was split into three separate line items based on radiation type (alpha, beta, and tritium) and was counted as three results in table 6-1e.

SC&A believes whether the raw source data was split by datasheet or included as a separate line item is not relevant when the intent should be to tabulate the number of distinct BZ samplers worn by workers (or, more specifically, represent the number of distinct monitored exposure events regardless of radiation type). SC&A clearly states this in observation 1:

> Furthermore, when reporting the total number of BZ samples, the distinct measurements (gross alpha, gross beta, low energy beta, and tritium) **should not be counted as separate and distinct BZ samplers**. [SC&A, 2020, p. 20; emphasis added]

SC&A requests further clarification and discussion with NIOSH and the work group to understand exactly what is being tabulated in table 6-1e and, therefore, recommends the second part of observation 1 remain in progress for discussion. However, SC&A would stress that such tabulations do not impact the overall conclusions of SC&A's (2020) review that the data are sufficient to establish a bounding internal dose approach for unmonitored or partially monitored workers.

SC&A agrees with the final aspect of the NIOSH (2021) response, which defends separating BZ results by radiation type for the purpose of evaluating the magnitude of exposures. However, SC&A never questioned separating out radiation type (as was done in tables 7-1b, 7-1c, and 7-1d) to evaluate exposure potential in its review of the Addendum 2 ER (SC&A, 2020).

SC&A's intent with observation 1 was to assure that table 6-1e, which reports "Available Breathing Zone Air Monitoring Results: 1997–2011," was clear and consistent in its reported totals.

3.3 SC&A observation 2: Temporal variation indicates incomplete dataset

> It is SC&A's opinion that the observed temporal variation in the number of captured BZ samples suggests that the available dataset does not represent a complete set of monitoring records for the affected worker population. Therefore, any conclusions regarding the exposure potential reflected in captured BZ samples are likely based on incomplete data. However, as stated previously, the level of incompleteness is not known at this time. [SC&A, 2020, p. 22]

3.3.1 SC&A summary of NIOSH response

Similar to NIOSH's response to finding 1 discussed in section 3.1.1, NIOSH agrees that the BZ dataset is not complete. However, NIOSH believes the dataset is likely biased high by the fact that all of the data transmitted to the internal dosimetry group for DAC-hr tracking purposes is included.

3.3.2 SC&A reply and recommended status

SC&A and NIOSH are in agreement. For a discussion of the DAC-hr reports and their implications for data completeness, please refer to section 3.1.2 of this report and pages 4–6 of NIOSH (2021). SC&A recommends that observation 2 be subsumed under the finding 1 discussions.

3.4 SC&A observation 3: Use of WebDose to establish completeness and bounding dose estimate

> Comparison of BZ entries contained in WebDose to captured hardcopy records demonstrates that WebDose does not represent a complete data source reflecting who was monitored via BZ at [SNL-A]. Therefore, the use of WebDose to support the 100 mrem dose threshold may not be appropriate. [SC&A, 2020, p. 22]

3.4.1 SC&A summary of NIOSH response

NIOSH concurs with the SC&A observation that the WebDose dataset does not contain entries for every BZ sample collected. However, similar to the NIOSH response to finding 1 and observation 2, NIOSH notes that the WebDose entries represent a complete assessment of the most highly exposed worker population and, therefore, are another piece of evidence to support the conclusion that a bounding dose reconstruction methodology is feasible. NIOSH notes that the WebDose database contains 100 percent of the entries in the available DAC-hr tracking logbooks, which represent those BZ results that exceeded an established threshold (i.e., 10 percent of a DAC-hr) and were forwarded to the Internal Dosimetry department for tracking.

3.4.2 SC&A reply and recommended status

SC&A reviewed the WebDose database against the available DAC-hr logbooks and agrees with NIOSH's conclusion that 100 percent of those logbook entries are contained in WebDose. For a discussion of the DAC-hr reports and their implications for data completeness, please refer to section 3.1.2 of this report and pages 4–6 of NIOSH (2021). SC&A recommends that observation 3 be subsumed under the finding 1 discussions.

3.5 SC&A observation 4: Distribution of breathing zone samples among individual workers

> A substantial portion of the available BZ samples per year are often assigned to just a few individuals. Approximately 8 percent of the total BZ samples were associated with just a single individual, though over 195 monitored individuals were identified. Nearly 80 percent of the identified individual workers in a given year had 20 BZ samples or less. [SC&A, 2020, p. 23]

3.5.1 SC&A summary of NIOSH response

NIOSH concurs with this observation and believes that it does not affect the conclusion that a bounding dose reconstruction methodology is feasible. This methodology using 100 mrem per year of internal dose for unmonitored or partially monitored workers is claimant favorable and appropriate.

3.5.2 SC&A reply and recommended status

SC&A and NIOSH are in agreement. For perspective, the purpose of observation 4 was to analyze the available raw data to determine how many individual exposure events requiring BZ monitoring might occur during a given year. This information, coupled with reasonably conservative estimates of the amount of internal dose incurred during an event, would provide the work group with a reasonable estimate of the amount of annual dose that could have been potentially accrued by an unmonitored or partially monitored worker. This can then be compared to the median dose of approximately 0.5 mrem or less per event (i.e., 200 events per year to reach 100 mrem) calculated by both NIOSH (2019, pp. 30–31) and SC&A (SC&A, 2020, p. 30). In the text preceding observation 4, SC&A notes that the largest number of observed events per year for any individual in the available data was 109 in 2002. Also, as noted in appendix B to SC&A (2020, p. 61):

> Interestingly, aside from 1997 and 1998, nearly all the captured BZ samples were taken on Monday through Thursday.

This is important when considering a work year of 50 weeks per year (i.e., 50 weeks per year, 4 days per week, is exactly 200 events if the worker was in a BZ environment every day). Therefore, SC&A believes the likelihood of exceeding 200 BZ monitoring events without being included in the bioassay monitoring program (refer to observation 5) is remote. SC&A recommends that observation 4 be closed by the work group.

3.6 SC&A observation 5: Workers frequently monitored by breathing zone also participated in bioassay program

> Seventy-nine of the 194 identified individuals in the captured BZ records also participated in the non-tritium bioassay program during the evaluated SEC period. This includes the identified workers with the highest number of BZ results per year as well as the 11 workers with the highest number of BZ results over the entire period. Therefore, evidence suggests that workers who were most often monitored via BZ were also often monitored via non-tritium bioassay. [SC&A, 2020, p. 25]

3.6.1 SC&A summary of NIOSH response

NIOSH concurs with SC&A's observation and reaffirms its conclusion that the captured set of raw BZ monitoring records were among those with the highest potential for internal exposure. This conclusion is supported by their preferential inclusion in the internal monitoring bioassay program as well as their inclusion in the DAC-hr tracking reports designed to report exposures above an established threshold (i.e., 10 percent of the DAC-hr).

3.6.2 SC&A reply and recommended status

SC&A and NIOSH are in agreement. For a discussion of the DAC-hr reports and their implications for data completeness, please refer to section 3.1.2 of this report and pages 4–6 of NIOSH (2021). SC&A notes that the purpose of this observation was to determine the overlap between the workers consistently in radiological areas requiring BZ monitoring and workers who participated in the biological sampling program. SC&A found that, in general, the workers who entered BZ areas with the highest frequency on an annual basis also submitted bioassay. If the opposite had been true, this may have called into question the representativeness of the BZ data for unmonitored or partially monitored workers. SC&A recommends that observation 5 be closed by the work group.

3.7 SC&A observation 6: Fluctuations in exposure potential by year and work area

> SC&A's analysis of relative exposure potential demonstrates that noteworthy fluctuations in exposure potential can exist by year and by work area. Specifically, work in the general area designated by SC&A as "TA-V/6580" during the years 1997 and 1998 showed significantly elevated exposure potential when compared to all years and areas. However, SC&A does not believe these fluctuations necessarily obviate the use of 100 mrem as a maximizing dose assignment to unmonitored workers, as several significantly conservative assumptions were included in the dose estimates. [SC&A, 2020, pp. 35–36]

3.7.1 SC&A summary of NIOSH response

NIOSH concurs with the observation and does not believe these fluctuations obviate the use of 100 mrem as a maximizing dose assignment to unmonitored workers.

3.7.2 SC&A reply and recommended status

SC&A and NIOSH are in agreement. As SC&A's (2020) analysis shows, there are indeed circumstances where elevated exposure potential existed (both temporally and area specific) that, if encountered repeatedly, may call into question the use of 100 mrem as a bounding exposure scenario for unmonitored or partially monitored workers. However, as noted in SC&A (2020), there are three mitigating factors used in the NIOSH exposure analysis that led SC&A to the conclusion that 100 mrem is likely bounding for the time period in question:

1. Pu-239 was assumed for nearly all (i.e., greater than 99 percent) dose calculations, though lower DAC value radionuclides were applicable in several specific scenarios (e.g., depleted uranium or mixed fission products were specifically identified as the contaminant of concern) (SC&A, 2020, pp. 34–35).

2. Respiratory protection was never considered in any of the dose estimates based on BZ data even though consideration of such protection factors would lower the dose anywhere from a factor of 40 (standard air purifying respirator) to 10,000 (supplied-air bubble suit). Respiratory protection was used in over two-thirds of the available BZ events when transuranic material was identified as the contaminant of interest (SC&A, 2020, p. 26).

3. The number of probable exposure events per year was likely much less than 200 (SC&A, 2020, p. 23), which was calculated by NIOSH to result in 100 mrem at approximately 0.5 mrem per event (NIOSH, 2019, p. 30). Additionally, observed individuals with the most frequent number of BZ events were also included in the non-tritium bioassay program (SC&A, 2020, p. 25).

Therefore, SC&A believes the dose assessment using incomplete BZ data is sufficiently conservative to allow the conclusion that a bounding internal dose estimate of 100 mrem on an annual basis is appropriate for unmonitored or partially monitored workers. SC&A recommends that observation 6 be closed by the work group.

3.8 SC&A observation 7: Sandia Pulse Reactor radiation gradient dose

> SPR radiation gradient dose issue. The issue of exposure to severe radiation gradients would not be applicable to personnel working outside the immediate area of the bottom of the reactor vessel. However, the potential exposures to maintenance and operating personnel while performing close-up work on the SPR has not been sufficiently addressed and resolved. [SC&A, 2020, p. 41]

3.8.1 SC&A summary of NIOSH response

SC&A has summarized NIOSH's (2021) response (pp. 12–14) as follows.

1982 – The issue of elevated exposure to SPR workers was identified during the early 1980s. As a result of the elevated exposures, the following measures were put into place:

1. Dosimetry would be supplied to measure the head doses of personnel performing SPR-III maintenance.

2. Body dose information would be accepted for head measurements for the period it was not available since calculational efforts were not supportable.

3. Both head and whole-body doses would be reported in SNL-A dosimetry records.

4. An attempt would be made to get more uniformity in the location of dosimetry units worn by SNL-A personnel.

1984 – Further dose-reduction efforts were implemented:

1. modifications to the KIVA facility
2. modifications to the SPR-III reactor stand
3. procurement of a remotely controlled forklift
4. design, fabrication, and use of a personnel maintenance shield
5. administrative changes

Pre-1997 dose reconstruction – NIOSH finds that further research is needed for dose assignments for SPR workers. NIOSH intends to conduct additional review and research to determine the need for adjustment to recorded dosimetry doses. NIOSH will revise the external dose section of the SNL-A site profile to reflect any necessary changes to external dose assignment to SPR workers when using recorded dosimetry results.

1997–2011 – The following events are relevant to the evaluated SEC class period (1997–2011):

- The SPR-III operated between 1997 and 2000, and again during January through September 2006.

- In 1998, a weakness was identified in the placement of the real-time electronic dosimeters (placed on the chest instead of the head). There is some indication that there was no significant difference in head and chest dose. Corrective action was initiated to better define exposure potential as a function of location near the SPR.

- In 2000, a review of the radiation work permits indicated that multi-badging was required for work around the SPR.

- Individual dosimeter results from multi-badging, and weighted averages, are recorded in claimant records provided for dose reconstruction.

NIOSH plans to document these practices in an update of the external dose section of the SNL-A site profile.

3.8.2 SC&A reply and recommended status

SC&A reviewed NIOSH's response and agrees as follows.

Pre-1997 dose reconstruction – SC&A concurs with NIOSH's plan to conduct additional review and research to determine the need for adjustment to recorded dosimetry doses and to

revise the external dose section of the SNL-A site profile to reflect any necessary changes to external dose assignment to SPR workers when using recorded dosimetry results. SC&A recommends that SC&A review the revised SNL-A site profile when it becomes available.

1997–2011 – SC&A concurs with NIOSH's plan to document dosimetry practices in an update of the external dose section of the SNL-A site profile. SC&A recommends that SC&A review the revised SNL-A site profile when it becomes available.

SC&A recommends that this observation remain in progress until SC&A has determined that the SNL-A site profile has been adequately revised to address this observation.

4 Summary and Conclusions

SC&A reviewed NIOSH's response (NIOSH, 2021) to SC&A's finding and observations (SC&A, 2020) for SEC ER Petition SEC-00180, Addendum 2 (1997–2011) (NIOSH, 2019).

4.1 Summary

The following summarizes SC&A's evaluation of NIOSH's response.

Finding 1: Direct evaluation of record completeness is not possible

SC&A finds that based on NIOSH's response, there is agreement that the available BZ data are incomplete and that, accordingly, the actual level of data completeness cannot be definitively established. However, as NIOSH points out, there is supplementary information that indicates data completeness, including NIOSH's comparison to the DAC-hr tracking logbooks for a portion of the evaluated period (1997–2002). However, the raw BZ results for specific months during the relevant SEC period in question cannot be compared to the tracking reports because the DAC-hr tracking logbooks have not been located and captured for these periods. Therefore, for the full SEC-00188 Addendum 2 evaluated period (January 1997–May 2011), comparisons were available for just 63 of 173 applicable months, or approximately 36.4 percent. Given that the determination of acceptable levels of incompleteness in a dose reconstruction feasibility context is ultimately a subjective judgment, SC&A recommends that this finding remain in progress pending further work group discussion about the weight of evidence presented for this issue.

Observation 1: Duplicate samples and total breathing zone samples

SC&A and NIOSH agree that there were duplicate BZ results inadvertently entered and analyzed for 2002. NIOSH has appropriately reanalyzed the data and found the duplication had little to no effect on the calculated results. For those other discrepancies observed by SC&A for which agreement could not be reached, there would be no effect on the resulting analysis and proposed methods for dose reconstruction. Therefore, SC&A recommends the part of observation 1 concerning duplicate samples be closed.

For the second part of observation 1, SC&A requests further clarification and discussion with NIOSH and the work group to understand exactly what is being tabulated in table 6-1e. Again, SC&A understands that such tabulations do not impact the overall conclusions of SC&A's review, that the data are sufficient to establish a bounding internal dose approach for unmonitored or partially monitored workers.

Observation 2: Temporal variation indicates incomplete dataset

SC&A and NIOSH are in agreement. SC&A recommends that this observation be subsumed under the finding 1 discussions.

Observation 3: Use of WebDose to establish completeness and bounding dose estimate

SC&A reviewed the WebDose database against the available DAC-hr logbooks and agrees with NIOSH's conclusion that 100 percent of those logbook entries are contained in WebDose. SC&A recommends that this observation be subsumed under the finding 1 discussions.

Observation 4: Distribution of breathing zone samples among individual workers

SC&A and NIOSH are in agreement. For perspective, the purpose of observation 4 was to analyze the available raw data to determine how many individual exposure events requiring BZ monitoring might occur during a given year. This information, coupled with reasonably conservative estimates of the amount of internal dose incurred during an event, would provide the work group with a reasonable estimate of the amount of annual dose that could have been potentially accrued by an unmonitored or partially monitored worker. SC&A recommends that the work group close observation 4.

Observation 5: Workers frequently monitored by breathing zone also participated in bioassay program

SC&A and NIOSH are in agreement. SC&A notes that the purpose of this observation was to determine the overlap between the workers consistently in radiological areas requiring BZ monitoring and workers who participated in the biological sampling program. SC&A found that, in general, the workers who entered BZ areas with the highest frequency on an annual basis also submitted bioassay. SC&A recommends that the work group close this observation.

Observation 6: Fluctuations in exposure potential by year and work area

SC&A and NIOSH are in agreement. While there are circumstances where elevated exposure potential existed that, if encountered repeatedly, may call into question the use of 100 mrem as a bounding exposure scenario, there are mitigating factors in the exposure analysis (e.g., conservatively assuming Pu-239 as the source term, not taking credit for respiratory protection) that would offset this possibility. Therefore, SC&A believes the dose assessment using incomplete BZ data is sufficiently conservative to allow the conclusion that a bounding internal dose estimate of 100 mrem on an annual basis is appropriate for unmonitored or partially monitored workers. SC&A recommends that the work group close this observation.

Observation 7: Sandia Pulse Reactor radiation gradient dose

SC&A reviewed and concurs with NIOSH's plans to address SPR radiation doses and revise the SNL-A site profile. SC&A recommends that this observation remain in progress until SC&A has determined that the SNL-A site profile has been adequately revised to address this observation.

4.2 Overall conclusion

SC&A recommends the following:

- some additional work group discussion to clarify issues remaining for finding 1 about data completeness
- clarification of the contents of table 6-1e in the second part of observation 1
- addressing the SPR radiation gradient dose in the next revision of the SNL-A site profile for observation 7

Assuming these followup activities, SC&A does not have any remaining concerns about the Addendum 2 ER and its conclusion that a bounding dose reconstruction method is feasible,

sufficiently accurate, and claimant favorable for SNL-A during the evaluated period (January 1, 1997–May 21, 2011).

5 References

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