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Advisory Board on Radiation and Worker Health
National Institute for Occupational Safety and Health

Review of NIOSH "Response to SC&A-TR-2017-007, Draft Review of NIOSH's Evaluation Report for Petition SEC-00219, Idaho National Laboratory: Burial Ground, 1952-1970"

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SC&A, Inc. Technical Support for the Advisory Board on Radiation and Worker Health's Review of NIOSH Dose Reconstruction Program

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Abbreviations and Acronyms

ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
Am	americium
ANC	Aerojet Nuclear Company
ANL-W	Argonne National Laboratory – West
CAM	continuous air monitor
CFA	Central Facilities Area
CPP	Chemical Processing Plant
DOE	U.S. Department of Energy
dpm/cm^2	disintegrations per minute per square centimeter
ER	evaluation report
EWR	Early Waste Retrieval
HASL	Health & Safety Laboratory
HP	health physics
I	iodine
ICC	Interstate Commerce Commission
ID	Idaho Operations Office
IDR	Initial Drum Retrieval
INL	Idaho National Laboratory
MFP	mixed fission product
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
NRTS	National Reactor Testing Station
OAC	Operating Area Confinement
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
OTIB	ORAUT technical information bulletin
Phillips	Phillips Petroleum Company
Pu	plutonium
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex

SAM-II	Stabilized Assay Meter
SEC	Special Exposure Cohort
SRDB	Site Research Database
SWP	safe work permit
TRU	transuranic

1 Introduction and Background

The National Institute for Occupational Safety and Health (NIOSH) issued a white paper, "Response to SCA-TR-2017-007, *Draft Review of NIOSH's Evaluation Report for Petition SEC-00219, Idaho National Laboratory: Burial Ground, 1952–1970*" (NIOSH, 2020), on January 13, 2020, and forwarded it to the Idaho National Laboratory (INL)/Argonne National Laboratory – West (ANL-W) Work Group and SC&A on February 18, 2020. It responds to SC&A's preliminary review of NIOSH's Special Exposure Cohort (SEC) Petition SEC-00219 evaluation report (ER) for the INL Burial Ground, 1952–1970, issued on May 1, 2017 (SC&A, 2017).

As noted in SC&A's 2017 review, NIOSH's ER basis for deeming dose reconstruction feasible for Burial Ground workers in 1952–1970 is:

> the availability of "procedural information" and the "data on-hand," from which NIOSH finds that it has "adequate monitoring data" to estimate dose, with sufficient accuracy, from exposure to both internal fission product and "other radionuclides" (most notably, plutonium). In conjunction with these findings, the ER emphasizes the programmatic strength of the prevailing radiological control program at the Burial Ground in 1952–1970 (NIOSH 2017[a]).

Given these stipulations, SC&A's focus has been directed at (1) ascertaining the adequacy and completeness of the "data on-hand," including bioassay data and its availability for workers exposed at the Burial Ground, as well as supporting source-term, contamination survey, and air sampling data, and (2) reviewing whether the ER's programmatic description of radiological controls is accurate, complete, and representative based on records and former worker accounts of that time period.

The following is a brief summary of SC&A's original preliminary findings on positions that NIOSH had taken in its ER, SC&A's summary of NIOSH's response from NIOSH (2020), and SC&A's assessment of that response.

2 Position 1(a) – Contamination Control Program

2.1 Summary of NIOSH response

In its response, NIOSH (2020) disputes SC&A's preliminary finding that it is questionable whether a "strict" contamination control program existed at the Burial Ground in 1952–1970. NIOSH (2020, p. 5) notes that a "relatively mature HP program" was put in place at the Burial Ground from the onset, with an emphasis on the use of safe work permits (SWPs) and established procedures to provide the framework for controlling radiological work. As NIOSH noted, the "AEC health physicist in the CFA was responsible for [both] the operation of and radiological control at the Burial Ground" (NIOSH, 2020, p. 5).

To exemplify the radiological control framework in place, NIOSH cites a 1955 procedure for routine waste management that includes radiological control protective actions and health physics (HP) surveillance (Piccot, 1956). Another procedure, for 1962, addressed the conduct of operations at the Burial Ground, including radiation limits for waste acceptance, vehicle

surveillance, and contamination control. (Phillips, 1962). Finally, NIOSH provides five sample forms used in Burial Ground operations to record and authorize receipt of radioactive waste.

NIOSH concludes that "there is little evidence to support the assertion that INL management considered the Burial Ground as 'low priority,' as suggested in SCA-TR-2017-SEC007." NIOSH provides in figure 1 a copy of a 1961 memorandum from the operating contractor that states that "no distinction is made between our responsibility for this facility and others which we have operated for some time" (INL, 1960–1961, PDF p. 103).

In terms of radiological monitoring, NIOSH found that "monitoring practices at other INL facilities and an evaluation of the Burial Ground in the 1970s demonstrates that radiological monitoring was based on the exposure potential of workers" (NIOSH, 2020, p. 11). To support this finding, NIOSH conducted a review of available Central Facilities Area (CFA) monthly HP reports, CFA HP logbooks, and CFA HP log sheets, as well as SWPs, contamination smear records, and air sampling documentation. Interviews that had been conducted in the past were reviewed, as well. NIOSH provides examples of each of these documents, as an indication of radiological control and HP presence at the Burial Ground during the 1952–1970 period.

NIOSH concludes that there is "ample evidence to support the conclusion [Position 1(a)] that the Burial Ground was a well-managed facility and 'the Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring' (NIOSH 2020, p. 28).

2.2 SC&A Response

SC&A offers the following responses to the two NIOSH conclusions discussed in the previous section.

2.2.1 Burial Ground's low priority

NIOSH concludes that "there is little evidence to support the assertion that INL management considered the Burial Ground as 'low priority,' as suggested in SCA-TR-2017-SEC007" (NIOSH, 2020, p. 9), and that "the [SC&A] conclusion that the Burial Ground was 'considered a low priority by INL management' is simply not substantiated for the 1952–1970 period" (NIOSH, 2020, p. 55).

This was not SC&A's assertion. As noted in our May 2017 report, it was a finding by the Atomic Energy Commission (AEC) Idaho Field Office in February 1970 about the then-National Reactor Testing Station (NRTS) solid waste disposal burial ground. The AEC found that "until approximately six months ago, the operation of the burial ground was not considered by INC [Idaho Nuclear Corporation, the operating contractor]to be a priority function" (AEC/ID, 1970, p. 2). The basis of this finding was that routine inspections of the Burial Ground "performed by HASL [INL's Health and Safety Laboratory] have disclosed that the above criteria have not always been adhered to" and that the Burial Ground "did not receive the attention and support from INC management" (AEC/ID, 1970, p. 2). The "above criteria" cited by the AEC include the need for "specifying the quantity of radioactive material which may be buried" and documenting "restrictions concerning the disposal of liquids" (AEC/ID, 1970, p. 2). These criteria also

included the need to address the deterioration of buried drums from Rocky Flats Plant (RFP) and to provide for proper and complete fill coverage for trenches, pits, or sections of either.

Based on a 1970 review of circumstances surrounding leaking drums received at the Burial Ground from RFP, the AEC requested that those operations be suspended pending an independent internal review of HP procedures. That review (AEC/ID, 1971) found that because HP personnel were assigned a dual operational role to manage waste management and provide radiological control surveillance, an organizational conflict of interest was partly to blame for these problems. Following this review, the conflict was resolved by assigning line management responsibility for the Burial Ground to the INL Waste Management Division and making HP oversight an independent function.

A later (1973)[1] radiological exposure incident investigation by the AEC found that a "near-miss" raised "basic questions as to the adequacy of Burial Ground supervision, health physics coverage, documentation, and employee training" and "demonstrates the need for more stringent radiological safety measures in the operation of the Burial Ground" (AEC/ID, 1973, p. 1).

2.2.1.1 SC&A updated conclusion

SC&A supports the AEC's contemporary finding that operation of the Burial Ground was not considered to be a priority function of the INL contractor until late 1969. We believe the AEC and its HASL program, based at the INL site since the inception of the Burial Ground and conducting regular inspections there during that time (1954–1970), including the specific findings cited in their 1971 audit, possessed sufficient knowledge and evidence to support their conclusion.

2.2.2 Burial Ground management and internal dose monitoring program

NIOSH concludes that there is "ample evidence to support the conclusion [Position 1(a)] that the Burial Ground was a well-managed facility and '*the Burial Ground's internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring*'" (NIOSH, 2020, p. 28).

As noted by NIOSH in its response:

> Additional information on the Burial Ground was captured while performing a subsequent evaluation of the RWMC, which was designated in the 1970s and included the Burial Ground. This information was not available either to NIOSH during the SEC-00219 petition evaluation or to SC&A during the generation of their draft review. (NIOSH, 2020, p. 4)

SC&A focused on this additional new information in terms of how it augments and expands the basis for NIOSH's conclusion that the "internal dose monitoring program was based on a strict contamination control program with entry and exit monitoring." SC&A also strove to reconcile

[1] While this report falls outside of the Petition-00219 qualification time period, SC&A considers it relevant to the question of the adequacy of the Burial Ground radiological control program prior to 1971 because program deficiencies that persisted into the early 1970s, with the greater attention afforded the exhumation program, likely existed in that earlier timeframe, as well.

the program documentation and forms provided by NIOSH with the sometimes-conflicting interview accounts of Burial Ground workers during the 1952–1970 timeframe.

2.2.2.1 Safe work permits

NIOSH notes that "despite waste burial being a radiological low-level risk activity, the use of SWPs and survey of equipment/personnel were indicative of a structured monitoring program" (NIOSH, 2020, p. 5). However, their use at the Burial Ground was qualified in SC&A's 2017 report, as follows.

> SWPs were prepared for certain dumping operations, but a cursory review of those for RFP waste disposal from the 1960s shows a wide range of work controls prescribed, from no controls or precautions identified (except for steel toe guards), to a wide range of provisions calling for tool checks, hand and foot counting, intermittent surveying, and final monitoring with an alpha survey meter (Phillips 1965, Phillips 1964). Generally, the SWPs for RFP waste dumping required a hard hat, coveralls ("no street clothes"), gloves and shoe covers, with none found, in the sample years 1961 and 1966 requiring special dosimetry ("metering") or bioassay (Phillips 1965, Phillips 1960). In fact, the SWP form had no checkoff box for a followup bioassay requirement. (SC&A, 2017, p. 25)

As also noted, no Burial Ground SWPs were found for 1964, although RFP waste was being routinely received that year (Phillips, 1964). One former worker interviewee recalled that SWPs were reserved for "unusual" Burial Ground jobs but does not recall them being used in the earlier, AEC days ([redacted], 2016). From this sampling, it can be concluded that SWPs were used at the Burial Ground, at least in the mid to late 1960s, but were not applied consistently and were not uniformly employed to ensure that adequate radiological controls were implemented.

2.2.2.2 Smear counting program

NIOSH acknowledges SC&A's finding that while "CFA monthly HP reports routinely list hundreds of 'smears collected and counted' in the early and mid-1960s," there is "no way to ascertain how many of those were taken at the Burial Ground" (NIOSH, 2020, p. 11). However, NIOSH stresses that "contamination smears were indeed performed at the Burial Ground" (p. 11) and are cited in CFA reports. NIOSH's table 1 records which years CFA monthly HP reports are available and is supported by examples of report entries that mention contamination smears. SC&A is not disputing that smears were done for Burial Ground workers, transport vehicles, and radioactive shipments, just that it is not clear from records and interviews how complete that program was and whether it was even implemented adequately in the late 1960s into the early 1970s due to instrumentation problems.

NIOSH even acknowledges this uncertainty in several places in its response:

> A review of interview summaries for former workers who worked at the Burial Ground between 1952 and 1970 revealed some inconsistencies in the recollections regarding if and when contamination smears were taken. (NIOSH, 2020, p. 14).

> Smear-counting equipment does not appear to have been available at the Burial Ground. (NIOSH, 2020, p. 15).

In response to an SC&A line of inquiry regarding outdated and inadequate smear counting equipment at the Burial Ground as cited in a 1972 INL assessment, NIOSH responded that the 1972 report "covers a time period outside the 1952–1970 period for SEC-00219" (NIOSH, 2020, p. 29). SC&A disagrees, noting that the April 1972 assessment by the operating contractor emphasizes the "long-standing" nature of the problem and the fact that "our [the Burial Ground contractor's] contamination control is compromised by the old, outdated equipment that now must be used" (ANC, 1972, PDF pp. 2, 3). As made clear in this internal assessment, this problem stemmed from continued reliance on 1950s-era smear counting equipment that was outdated and no longer reliable and functioning adequately.

As noted by the Burial Ground contractor:

> So far, all that has been said concerns the Central Facilities Area and nothing has been said about the Burial Ground operation. Prior to February 1972, there was absolutely no smear counting equipment at the Burial Grounds. This is a completely intolerable situation which must be corrected as soon as possible if we are to avoid a serious contamination incident. (ANC 1972, PDF p. 5)

Contrary to NIOSH's comment regarding timeframe, this clearly implicates the 1960s at the Burial Ground. Regardless of what motivated the contractor to conduct the assessment, it revealed a fundamental gap in contamination control. Without smear counting capability at the Burial Ground, it would not be practical and timely to check on potential surface contamination on waste containers and drums while being handled by workers. Smears being mentioned in CFA documentation and in worker interviews do not alone substantiate the adequacy and completeness of that component of the contamination control program.

When asked about smear counting, one of the Burial Ground health physicists for the 1960s commented:

> [redacted] ([redacted], 2016, p. 5)

In terms of the "consequences" of an inadequate smear counting program, the operating contractor was explicit:

> The Burial Ground has been **operating for years** without any smear counting equipment and has avoided serious contamination incidents by luck and/or by the experience of well-trained health physicists. The Burial Ground operation cannot comply with present radioactive on-site shipping regulations because of a lack of proper detection equipment . . . .
>
> Without smear counting equipment, or [with] outdated and inadequate smear counting equipment, there is, at best, only a **token effort of contamination control**. [Emphases added.] (ANC 1972, PDF p. 6)

From all accounts, there appears to be inconsistencies in NIOSH's accounting of the smear counting program at CFA and the Burial Ground. While NIOSH indicates that Burial Ground smears were counted at the CFA, the operating contractor's assessment at the time indicates that smears were to be taken and counted at both locations, and that the lack of smear counting at the Burial Ground, itself, was "intolerable" from the standpoint of contamination control. SC&A finds that the contractor's own admissions about the inadequacy of the smear counting program brings into serious question the completeness of this critical component of the Burial Ground radiological control program in the 1960s.

Even with state-of-the-art equipment and stringent monitoring procedures, the implementation of a thorough contamination control program using smears was challenging, as indicated by a health physicist involved with the Radioactive Waste Management Complex (RWMC) radioactive waste retrieval program in the 1970s:

> [redacted] a lot of confidence in the air sampling program but was less confident in contamination smears "[redacted]." [redacted] concerned about low-level transuranic activity [redacted] in the Health Physics trailer using large area wipes. It was concerning because they were very careful with the use of personal protective equipment. Pu-238, Pu-239, and Pu-240 were detected on wipes and smears at the CPP analyses lab. Although the smears were less than 20 dpm/cm^2 alpha (upper limit), analytical results of large area wipes indicated the presence of Pu-239, Pu-240 in the HP trailer (clean area). ([redacted], 2018, p. 4)

Coupled with inadequate smear counting equipment and alpha monitoring instruments at CFA and the Burial Ground, the ability of smearing to adequately control for actinide contamination from RFP drum spills is questionable.

2.2.2.3 Air sampling program

In its response, NIOSH provides "multiple examples" of air sampling at the Burial Ground based on a survey it conducted and issued in July 2017 (NIOSH, 2017b), following the release of SC&A's original report. In SC&A's earlier May 2017 report, our position is summarized, as follows.

> This [concern about potential intakes due to resuspended airborne contamination] seems to be borne out by the relative lack of sampling results for the Burial Ground. A review of available air monitoring reporting confirmed onsite and offsite environmental monitoring of airborne gross alpha, gross beta, and iodine-131 (I-131) in the 1960s, but only a few records were located in the Site Research Database (SRDB) of hi-vol and low-vol air sampling results for airborne occupational exposure at the Burial Ground, with most results for CPP, test reactors, and research reactors . . . . These latter results were found to be positive for alpha, beta, and MFPs (using an I-131 marker), but typically only in fractions of the unrestricted Radiation Concentration Guide values. Given that entries in Central Facilities Area (CFA) logbooks and monthly health physics reports indicate that air sampling was being performed at the Burial Ground, records may exist but have not been identified to date. (SC&A, 2017, pp. 9–10)

NIOSH's examples of available Burial Ground air sampling results were drawn from HP log sheets, and included two examples of lapel air sampling in 1965–1966, continuous air samples taken at six separate times in 1962–1966, three event-driven sets of air samples taken during two fires in 1966 and a waste barrel fire in 1970, and an event-driven high-volume sampling conducted after the "Chinook" flooding in 1962. NIOSH observes that while a routine air sampling program was not implemented at the Burial Ground until the mid-1970s, there is evidence that high-volume air samplers were available for use as early as 1963. Finally, NIOSH notes that "there are likely further records of air sampling at the Burial Ground that have not been identified to date" (NIOSH, 2020, p. 23).

As noted in its 2017 report, SC&A acknowledges that there is evidence that both low- and high-volume air sampling was conducted at the Burial Ground, on occasion, during the period in question. However, as NIOSH notes, this use was not routine and there is no evidence of a procedural protocol that required it. Worker interviews (SC&A, 2017) seem to confirm this sporadic or occasional use, with accounts of no or very limited air sampling, or intermittent sampling only tied to RFP dumping operations (a practice confirmed by the highlighted photographs of RFP drum unloading included in the NIOSH response).[2] However, as noted in our 2017 report, SC&A found that this air sampling would not have been representative of resuspended airborne contamination levels other than at the immediate perimeter of the waste pit or trench:

> Given the location of these samplers, they (and other perimeter samplers) would not have sampled the immediate working area of the workers working inside or in close proximity to the pits or trenches when positioning drums or cleaning up spills. Also, the constant crushing of waste containers by heavy tractors and the pushing of contaminated soils over them by bulldozers would have led to frequent resuspension of airborne contaminants . . . . (SC&A, 2017, p. 8)

Lack of routine and representative air sampling, and selective use based on HP judgment (e.g., in response to certain events or special operations), would not constitute an adequate or complete air sampling monitoring database for 1952–1970, nor one that would adequately inform a "stringent contamination control" program.

2.2.2.4 Contamination control at the Burial Ground

In its response, NIOSH cites "ample evidence" to support its claim that a "strict contamination control program" was in place at the Burial Ground from 1952 to 1970. This body of evidence includes waste management procedures, monitoring practices at other INL facilities, an evaluation of the Burial Ground in the 1970s, examples of contamination smears and air sampling conducted, SWPs issued, and selected worker interviews. Finally, in its conclusion,

[2] However, the location of the air samplers visible in the photographs raises concern. While the positioning of the samplers shown may have been adequate for monitoring resuspension of radioactive particulates at the crest of the pit near the truck, it would not have been adequately monitoring airborne levels in the vicinity of the unloaded drums inside the pit or even downwind from the waste dumping operation. Other photographs clearly show workers working with and positioning drums, and interviews and SWPs indicate that workers routinely cleaned up after spills.

NIOSH notes that, given the HP organization was actually in charge of the operation, it would only be logical that strict contamination control would be made a priority (NIOSH, 2020, p. 28).

The preceding discussion has already responded to NIOSH's conclusions regarding the smear counting, air sampling program, and SWPs. SC&A considers monitoring practices at other INL facilities, such as the test and research reactors, and the Chemical Processing Plant (CPP), not to be relevant, particularly for internal dose monitoring, to what for many years in the 1950s and 1960s was essentially a landfill operation. Likewise, the relevancy of post-1970 HP practices is questionable given the programmatic upgrades to what became the RWMC, with increasingly more stringent HP procedures and practices that accompanied a major program to exhume and provide aboveground storage of buried drums. In terms of worker interviews regarding the state of contamination control at the Burial Ground, NIOSH acknowledges "inconsistencies in the recollections regarding if and when contamination smears were taken. However, the interviews are fairly clear on the issue of the CFA HP being present and in charge of waste-disposal activities" (NIOSH, 2020, p. 14).

However, the interviews cited by SC&A in its 2017 report paint a much different picture (these are quoted in more detail in that report, with the following being excerpts). As emphasized by one HP technician, "[redacted]," with "[redacted]" ([redacted], 2016, p. 3). One Burial Ground worker from 1967 recalls intentionally unloading drums in a rough manner to batter them and breach them ("[redacted]"), without any protective equipment or clothing, and obviously without any HP supervision ([redacted], 1990, p. 8). A Burial Ground HP technician "[redacted]" ([redacted], 2016, p. 3). Another worker recalled having to unload drums of mixed radioactive waste originating from offsite colleges, hospitals, research laboratories, etc., and roll them into Pit 9, where sometimes the barrels would crack open and spill their contents, which would then need to be handled and cleaned up (SC&A, 2017, p. 14). Various former workers noted that "[redacted]" ([redacted], 2016, p. 2), that alpha monitoring was sporadic and not reliable, and that HP technicians were not always present for dumping operations, particularly in the early days. Former workers also attested to inconsistency in required protective clothing, with some workers wearing anti-contamination clothing (e.g., bulldozer operators), while others worked in work clothes (e.g., coveralls). Workers recalled becoming contaminated, although the significance and frequency seemed to vary in those accounts depending on the particular worker (SC&A, 2017, pp. 14–15).

As noted by an HP technician, [redacted] ([redacted], 2016, p. 5). This [redacted] got contaminated on several occasions from contaminated personnel coming into the Health Physics office (p. 5).

Regarding the NIOSH conclusion that because Health Physics was in charge of the Burial Ground, it follows that the contamination control program must have been stringent, the record shows that the AEC disagreed with this line of thinking. As noted previously in SC&A's 2017 report (and in section 2.2.1 of this report), an audit conducted by the AEC in 1971 concluded that

this dual responsibility of Health Physics to both manage waste management operations and also conduct HP oversight and surveillance was seen as an organizational conflict of interest that had led to the diminishment of the HP function.[3] An interview conducted with a former HP technician is instructive in this regard:

> To distinguish TRU from naturally occurring radiation in the field, HP Techs would have to wait a few hours and recount the smear or soil sample (allowing for decay of short-lived radon, thorium, and uranium daughters). An HP could get into conflicts if he held up work to verify the source of positive readings. ([redacted], 2016, p. 4)

The AEC subsequently directed the operating contractor to assign line management responsibility for waste management to the Waste Management Division and to restore HP oversight as an independent function for the Burial Ground. SC&A finds that the AEC recognized that this dual organizational responsibility was detrimental to a strong and independent HP function and may have contributed to a compromised contamination control program (e.g., with leaking RFP drums) when waste management priorities conflicted with those of contamination control.

2.2.2.5 Alpha monitoring

This section responds to NIOSH's response to a suggested line of inquiry posed in SC&A's 2017 report.

NIOSH (2020, p. 29) stated that "NIOSH has not found inadequacies in alpha monitoring at the Burial Ground." NIOSH notes that the HP group knew alpha emitters were part of the buried source term and that alpha monitoring was performed for shipments.

As noted in its 2017 report, SC&A disagrees with NIOSH's finding about the state of alpha monitoring at the Burial Ground in the 1960s. As noted by a Burial Ground HP technician:

> After the waste burial was complete, the HP techs surveyed the workers and the vehicles. They tried to check for beta/gamma and alpha, but alpha instruments for use in the field weren't very good in those days. They relied upon smear analysis and whatever was on the filters or air samples. ([redacted], 2016, p. 2)

An AEC health physicist with responsibilities for the Burial Ground substantiates this same finding:

> At that time, the alpha portable monitors were hard to come by and were not really reliable. There was probably a lot more beta-gamma monitoring done than alpha. The portable detectors were available and were sometimes used; they were just not well developed. ([redacted], 2016, p. 4)

[3] Due to leaking barrels received at the Burial Ground from RFP in 1970, the AEC request that operations be suspended pending an independent internal review of HP procedures, which found this organizational conflict to be a contributing problem (AEC/ID, 1971).

As late as 1988, from the "breached box" contamination incident investigation at the RWMC, it was found that "personnel survey procedures did not exist for alpha monitoring as required," "portal monitors were inadequate for the detection of alpha contamination," and "practical knowledge of alpha contamination was not adequate," and that these and other radiological control deficiencies were the "result of practices over the past years" (DOE/ID, 1988, pp. 78, 79, 2).

2.2.2.6 SC&A updated conclusion

While there is documentation of radiological controls being proceduralized and implemented at the Burial Ground in 1952–1970, there are contradictory accounts in AEC and contractor reviews, and in interviews with former Burial Ground workers. SC&A views the Burial Ground as having a contamination control program commensurate with a radioactive waste landfill of its era—the 1950s and 1960s—when less management priority was assigned to such operations, and sporadic low-level contamination from unloading and dumping drums and containers was a regular part of work that did not warrant a special response from the radiological control program. While NIOSH portrays the burial of RFP waste as an orderly approach, with prescheduled emplacements and prompt burying of drums (NIOSH, 2020, p. 3), it is clear from photographs and worker accounts that RFP drums were literally "dumped" into pits and trenches, and then compacted by bulldozers to save space – all the time causing potential airborne contamination to which workers would have been potentially exposed. SC&A concludes that NIOSH's examples of procedures and monitoring, alone, do not necessarily demonstrate the stringency of the Burial Ground contamination control program or support the ethos of "defense-in-depth" that it ascribes to its radiological control program, particularly in the face of contradictory and contemporary AEC, contractor, and worker accounts and reviews.

3 Position 1(b) – Radioactive Waste Source Terms

3.1 Summary of NIOSH response

In response to SC&A's concern over not knowing the specific radionuclide content of both onsite and offsite solid waste shipments, NIOSH notes that while it is true "that the exact isotopic mix (as applicable) and activity content were unknown for many shipments," this information is "not needed to perform proper radiological monitoring" (NIOSH, 2020, p. 31). Regarding the inclusion of unknown types and quantities of commercial and military radioactive waste, NIOSH indicates that despite isotopic data and quantities not being available for many shipments, "radiation and contamination surveys were performed by the site of origin and then again by INL when received" (NIOSH, 2020, p. 31). NIOSH further noted that INL routine radiological monitoring programs were, and still are, based on dosimetrically "limiting" radionuclides. Example radioactive material shipment records are provided, as well as an account of how special radiological monitoring was employed to ascertain isotopic content of contaminants in the flooding that took place at the Burial Ground in 1962. NIOSH concludes by reaffirming its original conclusion that, based on the weight of evidence, "*with the exception of Rocky Flats waste, mixed fission products were considered the controlling radionuclides*."

3.2 SC&A response

SC&A accepts NIOSH's explanation regarding an assumption that mixed fission products (MFPs) were limiting for onsite INL waste but continues to find a problem with ascribing an

assumed source term for radiological monitoring and dose reconstruction purposes for offsite waste, such as that from RFP, the military, or commercial sources. As noted in SC&A's 2017 report, the "RFP waste was dominated by plutonium, but also contained a spectrum of radionuclides, including americium, thorium, and uranium, that would have been difficult to monitor given that lack of monitoring and bioassay [for actinides], and the prevalence of specific radionuclides would have differed by shipment" (SC&A, 2017, p. 20).

In response to SC&A's suggested lines of inquiry, NIOSH indicates that for these offsite waste sources, it assumes that INL would have performed "special monitoring to determine the radionuclides involved and would request special bioassay, if deemed necessary." (NIOSH, 2020, p. 36). NIOSH would then use these bioassay results to assign internal dose. Of course, as SC&A noted in its response (section 4 below) to Position 1(c), this assumes that a special bioassay program was implemented for Burial Ground workers and bioassay requests can be linked to potential intakes or contamination events, for which SC&A finds little evidence.

Regarding the lack of actinide internal monitoring data for RFP and other offsite shipments, NIOSH proposes to apply, for all Burial Ground workers in 1952–1990, the bioassay data from the late 1970s for the 18 workers who participated in the exhumation work for buried RFP drums. SC&A addresses the lack of actinide monitoring data and NIOSH's proposed dose reconstruction alternative approach in our response to Position 2 (section 5).

3.2.1 SC&A updated conclusion

SC&A agrees that MFPs would be dominant radionuclides for onsite waste but finds that the source term for offsite waste, including that from Rocky Flats, would be more uncertain and would include actinides for which bioassay monitoring was lacking.

4 Position 1 (c) – Special Bioassay Program Implementation

4.1 Summary of NIOSH response

In its ER, NIOSH has already confirmed that "special bioassay also exists, but the results could not be directly related to a contamination event at the Burial Ground" (NIOSH, 2017a, p. 233). Likewise, NIOSH notes, in its response, that "the ability to definitively tie a special bioassay with the Burial Ground is difficult at best" (NIOSH, 2020, p. 37). NIOSH also agrees that the "responsibility for operations by CFA-based personnel included not only CFA and the Burial Ground, but also other areas" (pp. 37–38). NIOSH further indicates (p. 38) that "1963 Standard Practice on whole-body counting" (McCaslin, 1963) defines requirements for workers at INL facilities that would have applied to CFA (and "by default" the Burial Ground), and would have led to a request for a special whole body count when requested by Health Physics. However, in the end, NIOSH was unable to "find evidence of a worker between 1952–1970 being placed on special bioassay as a result of a specific contamination event at the Burial Ground," attributing that result to the "little evidence" of actual contamination events at the Burial Ground (by virtue of available HP monthly reports, HP logbooks, and HP log sheets). NIOSH cited several interviews in which former workers did not recollect an incident or event for which a special bioassay would have been requested (NIOSH, 2020, p. 38).

Finally, NIOSH noted, in response to SC&A's concern regarding the unlikelihood that RFP drum contamination events would have been detected, reported, and be the basis for special bioassays, that "if contamination events had been commonplace due to mass dumping [of RFP drums], it is highly unlikely that the practice would have persisted over an almost 7-year period and special bioassay would have been commonplace" (NIOSH, 2020, p. 39).

Drawing from its July 2017 review of additional Burial Ground and RWMC records (issued after SC&A's 2017 report), NIOSH (2017b) provided a number of examples of special bioassays for CFA workers whose work duties likely included the Burial Ground.

4.2 SC&A response

SC&A stands by its original conclusion that "while special or event-driven bioassays may have been the practice at INL at the time, there is no evidence (i.e., actual results traceable to exposure at the Burial Ground) that this practice was implemented at the Burial Ground, despite repeated instances where potential contamination was released during dumping operations" (SC&A, 2017, p 21). None of the additional information provided by NIOSH in its 2020 response changes that conclusion or its basis, and most of NIOSH's supporting findings (above) are consistent with those of SC&A, other than those discussed further below.

SC&A does not accept (1) that INL sitewide procedures for special bioassay program implementation would have necessarily been applied to the Burial Ground, where incidental low-level contamination from drum and container unloading would have been a common experience, or (2) that there were no special bioassay requests because there was no evident contamination at the Burial Ground over the many years of its operation. As a Burial Ground health physicist noted:

> The saddest thing is that the insight for internal dosimetry was not well developed at the early period of time; there were not a lot of biological samples taken in the early days at the burial ground. **Sampling was primarily event-driven, and they didn't really have events that would be considered accidents** with the solid waste disposal during the early years. (Emphasis added.) ([redacted], 2016, p. 3)

As SC&A explained in its 2017 report:

> This observation is telling in that actual radiological "accidents" or "events" would not have been recognized or defined, as such, in a waste dumping operation where contamination may have been released in the pits and trenches but would not necessarily have been considered of concern to the workers involved, including heavy equipment operators, who would have handled the waste or buried it. In this context, even the spilling of the contaminated contents of RFP drums during dumping would not have been considered a contamination "event" triggering a special bioassay, but rather an expected experience of routine dumping operations. (SC&A, 2017, p. 21)

There is considerable evidence of contamination from Burial Ground operations during the period 1952–1990, including the many surveillance reports and in interviews cited by both NIOSH and SC&A that refute the premise NIOSH is advancing for the lack of special bioassay

requests. SC&A agrees that a few interviewees did not recollect contamination events during their work at the Burial Ground (as cited in our 2017 report), but it is also clear that a number of other interviewees did, in fact, recall specific instances of such events.

The rationale offered by NIOSH that breaching of RFP drums may not have led to any contamination due to the use of inner polyethylene liners is dubious from a number of vantage points. First, accounts of Burial Ground workers involved with unloading of these drums noted that when lids would pop off, the contents would be scattered in the pit (i.e., if a liner were present, it was apparently torn in the process of unloading or dumping). Second, there is evidence that one recurring problem was the leakage of radioactive liquids from the drums, meaning that if there were a liner involved, it too was breached. Third, there is no way to confirm if such a liner was used and in place for all drums received at the Burial Ground (drums were not opened for inspection). Finally, the actions of unloading, dropping, and bulldozing dirt over the drums may have torn any liner present. This is borne out by a confirmatory survey conducted during the initial radioactive waste retrieval program in 1972, when it was determined that out of 16 retrieved drums inspected, "three barrels had no liner, five liners were folded over and not taped shut, three were taped shut but were punctured or rotted, and five were taped shut and intact"; i.e., 11 of 16, or 68 percent, of the liners lacked integrity (Allied Chemical, 1972, p. 46).

4.2.1 Updated SC&A conclusion

SC&A reaffirms its original conclusion that there is no evidence that the sitewide INL procedure to request a special bioassay when workplace indicators indicate an intake may have occurred was, in fact, actually implemented at the Burial Ground. This is because no records exist to tie specific workers to a request for such bioassays related to a contamination event at the Burial Ground. The CFA HP records cited by NIOSH only provide examples of special bioassays performed on workers whose work history happened to include the Burial Ground, but whose potential intakes could have occurred elsewhere.

5 Position 2 – Dose Reconstruction Approach with Actinides in Mixed Waste

5.1 Summary of NIOSH response

NIOSH acknowledges that information about RFP wastes being shipped to INL was not available before 1964, but that radioactive waste inventories at the Burial Ground were estimated in terms of the volume and prevalence of key radionuclide source terms, with actinides such as plutonium and americium being the largest components by percentage. Dose contributions from MFPs would be estimated using "applicable coworker models being developed for INL workers and ORAUT-OTIB-0054 to determine isotopic contributions." (NIOSH 2020, p. 53). The actinide internal dose contribution due primarily to offsite burials (e.g., RFP) cannot be accounted for by the approach for MFPs, and NIOSH proposes to "use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s to provide a bounding estimate for internal actinide doses to identified Burial Ground workers during the burial period (1952–1970)" (NIOSH, 2020, p. 54).

5.2 SC&A response

SC&A agrees that MFPs are the dominant source term for estimating internal dose contribution for onsite waste but disagrees that Burial Ground workers were necessarily "exposed to similar levels of MFPs as other unmonitored INL workers," as concluded by NIOSH (2020, p. 62). That conclusion is premised on an overall conclusion that "(1) the Burial Ground was not operated differently than other facilities at INL . . . and (2) the available monitoring data does not demonstrate uncontrolled source terms" (NIOSH, 2020, p. 53). As noted earlier in this review and in its 2017 report, SC&A continues to find that management and radiological controls at the Burial Ground differ from those at CPP, the test and research reactors, and other INL facilities in the 1952–1970 timeframe. SC&A also finds with regard to the reported release of contents from RFP drums, which would have constituted an uncontrolled radiological source, and that there is no evidence of related monitoring data, including special bioassays, that would characterize the exposure involved.

With regard to the proposed NIOSH approach for estimating the actinide internal dose contribution for the RFP (and other offsite) waste, SC&A's assessment is as follows.

5.2.1 Proposed NIOSH bounding internal dose estimate for actinides

As presented in NIOSH 2020, page 62, the proposed method for reconstructing internal exposures to actinide material (primarily RFP plutonium) during the 1954[4]–1970 period uses available plutonium/americium monitoring data obtained in the late 1970s. These monitoring data are associated with workers directly involved in either the Initial Drum Retrieval (IDR), Early Waste Retrieval (EWR), or "general" operations at the RWMC. Specifically, 18 individual workers were originally targeted for a first round of transuranic internal monitoring and were sampled (often multiple times) between June 1977 and May 1978 ([redacted], 1977, PDF pp. 12–15; [redacted], 1977a, PDF pp. 8–11; [redacted], 1977b, PDF pp. 6–7; [redacted], 1977c, PDF pp. 4–5; [redacted], 1978, PDF pp. 2–3; –; INL, 1978, PDF p. 2).

Table 1 provides the breakdown of the 18 workers by operation and job designation. As shown, the 18 monitored workers were equally split between the IDR, EWR, and general RWMC operations. The majority of monitored workers in this group were equipment operators, although initial calculations performed by NIOSH indicate that health physics may have had the greater exposure potential among the group (see below). SC&A also notes that an additional five workers[5] were monitored for transuranic material in 1977 and 1978 as part of the transuranic exposure potential characterization effort. However, information is not currently available to determine their specific job titles, operations, or responsibilities at the RWMC. One of the additional five workers had a positive fecal result for americium-241 (Am-241), and another had a positive fecal result for plutonium-239/240 (Pu-239/Pu-240).

[4] Although the evaluated period is 1952–1970, RFP waste material was not received at the Burial Ground until April 1954 (NIOSH, 2020).

[5] The five additional workers are [redacted].

Table 1. Overview of 18 monitored workers proposed for use in transuranic dose reconstruction during the 1954–1970 time period

Job title	Initial Drum Recovery	Early Waste Retrieval	General operations	Total
Health Physics	1	2	1	4
Equipment Operator	4	3	3	10
Laborer	0	0	1	1
Supervisor	1	1	1	3
Total	6	6	6	18

Source: [redacted] (1977), PDF p. 15.

SC&A's immediate concern with this proposed method is the relatability of operations such as the IDR and EWR during the mid to late 1970s to the radiological conditions present during the 1950s and 1960s. NIOSH (2020) pointed out that the waste retrieval operations would represent a greater exposure potential than what would have been experienced by Burial Ground workers in the 1952–1970 period who were performing general waste barrel transfers from the trucks into pits. Specific to exposure potential and dose reconstruction, NIOSH (2020) states:

> For actinide dose reconstruction, NIOSH proposes to use the bioassay data from the 18 workers that participated in the exhumation work in the 1970s to provide a bounding estimate for internal actinide doses to identified Burial Ground workers during the burial period (1952–1970). This would be considered bounding because the burial activities had a much lower potential for contamination and therefore a lower potential for internal exposure than the unearthing activities that took place. (NIOSH, 2020, p. 62)

While SC&A agrees that the exhumation activities likely represent a greater potential for airborne contamination, the assertion that exposure potential was also greater is not as clear. For example, the EWR operation often involved highly deteriorated drums and exposed contaminated material (including transuranics) for potential resuspension. However, workers involved in this project wore full air-supplied suits and worked inside a moveable containment building known as the Operating Area Confinement (OAC) (see figure 1). Workers would enter and exit the OAC through a three-part changing station to further assure that contamination was not spread to other areas in which the stringent protective equipment was not required. Such containment structures, contamination control, and personal protective equipment would significantly limit the availability of resuspended material for actual inhalation and uptake by the workers.

Contamination control, protective equipment, and HP oversight may not have been quite as stringent for the IDR operation as it was for the EWR operation. However, IDR workers still wore full anti-contamination suits with respirators worn around the neck in case a breached drum was encountered or other field indicators detected airborne contamination. Such field indicators included dedicated air monitoring stations that were strategically placed and present throughout the IDR operation. Examples of the HP controls for the IDR are shown in figure 2. The upper half of the figure shows an HP technician monitoring the dose rate on the outside of a drum that appears relatively intact. The worker is in full anti-contamination clothing and is wearing a half mask respirator around the neck. The lower half of the figure shows another HP technician

working on a continuous air monitor (CAM) that was placed next to a trench in which barrels of radioactive waste were being exhumed.

Figure 1. 1977 photograph of the inside of the Operating Area Confinement building during the Early Waste Retrieval operation

Source: NIOSH (2019).

Figure 2. Two photographs from 1977 during the Initial Drum Retrieval

Source: NIOSH (2019).

As NIOSH (2020) noted, the Burial Ground underwent significant changes during the last 2 years of the period under evaluation. Specifically:

> It was not until the 1969–1970 period that significant changes in facility work scope, federal regulations, and increased shipments for burial created a need for change in the operation of the Burial Ground. . . .
>
> In 1969–1970, the Burial Ground had (in a very short period) gone from a simple single objective (buried waste disposal) low-risk operation to a much more complex operation that was reflected in the change in organization. (NIOSH, 2020, pp. 11, 56)

SC&A agrees that the exhumation operations occurring at the RWMC during the 1970s likely represented a greater source of general contamination; however, SC&A also believes that protective equipment, policies, and procedures that would limit the actual potential for uptake were also significantly increased during these activities.[6] Therefore, SC&A does not believe it has been sufficiently established that exhumation activities in the 1970s are an appropriate representative exposure scenario for earlier Burial Ground activities, nor that such exhumation activities are necessarily bounding from the standpoint of the potential for uptake by the affected workers. The appropriateness of applying transuranic monitoring data taken in 1977 and 1978 from exhumation activities to earlier dumping operations involving RFP waste in the 1950s and 1960s warrants careful consideration by the INL/ANL-W work group.

In addition to the question of whether it is appropriate to use 1977-1978 transuranic monitoring data as the basis for a co-exposure model, SC&A believes the current dose estimates derived by NIOSH based on this data warrant further discussion. NIOSH's dose estimates were first presented to the INL/ANL-W work group via a teleconference meeting on March 25, 2019 (NIOSH, 2019). The highest calculated doses were assigned to two HP workers with total effective doses ranging from 163 to 303 millirem (mrem) (limiting organ-specific equivalent doses ranged from 963 mrem to ~1.7 rem to the lung and 1.8 to 3.4 rem to the bone surface). These doses were, in part, based on the assumption of a chronic intake period ranging from January 1, 1971, to December 31, 1980.

The ending date of the assumed chronic intake period is inappropriate because available references indicate the samples were taken (at the latest) in May 1978, and the highest observed Am-241 result was taken on August 27, 1977 (INL, 1978). Furthermore, the assumed start date of the intake period (January 1, 1971) is likely inappropriate because the IDR and EWR started in 1974 and 1976, respectively. Waste retrieval operations predating the IDR and EWR were known to occur, such as the Solid Waste Retrieval Test in 1971 and another retrieval operation in November 1969, which might warrant the earlier start date for the intake evaluation. However, no evidence has been offered to tie any of the 18 workers to the 1971 operation. Regarding the November 1969 operation, NIOSH has identified six workers who were known to have been directly involved (NIOSH, 2020, appendix A). However, only one of these workers is included in the group of 18 workers proposed for use in co-exposure modeling.

The effect of assuming longer chronic exposure periods is a decrease in the calculated daily intake rate associated with the exhumation activities. If the intent is to quantify the intake potential from these exhumation activities, then the start date of the actual activity would represent the appropriate time period to start the evaluation, and the date of the observed bioassay sample would be the appropriate end date of the assumed chronic intake. Therefore, if the transuranic monitoring associated with exhumation operations in the latter 1970s is deemed acceptable for the basis of a co-exposure model, the calculated intakes should be revisited to more accurately reflect the actual operational dates as well as the observed transuranic monitoring results.

[6] A thorough discussion of available evidence characterizing the contamination control and monitoring practices of the Burial Ground during the evaluated period (1952–1970) is found in SC&A (2017), NIOSH (2020), and elsewhere in this report. Therefore, it is not discussed further in this section.

5.2.2 SC&A updated conclusion

SC&A agrees that MFPs are the dominant source term for estimating internal dose contribution for onsite waste but disagrees that Burial Ground workers were necessarily "exposed to similar levels of MFPs as other unmonitored INL workers," as concluded by NIOSH. Regarding NIOSH's proposed approach for bounding internal dose to actinides, SC&A does not believe it has been sufficiently established that exhumation activities in the 1970s are appropriately representative of earlier Burial Ground activities, nor that such exhumation activities are necessarily bounding from the standpoint of the potential for uptake by the affected workers. The appropriateness of applying transuranic monitoring data taken in 1977 and 1978 from exhumation activities to earlier dumping operations involving RFP waste in the 1950s and 1960s warrants careful consideration by the INL/ANL-W work group. A secondary concern relates to the assumed start and end dates for the assumed chronic intake period for exhumation activities for the 18 workers involved in NIOSH's proposed bounding dose assessment, which may not be sufficiently representative of actual operations.

6 Position 3 – Radiological Monitoring Program: Rigor and Defense in Depth

6.1 Summary of NIOSH response

NIOSH disputed SC&A's questioning of the "rigor and effectiveness of the radiological monitoring program at the Burial Ground" and the suggestion "that the dual operational and radiological oversight roles of the CFA HP group might have represented an organizational conflict of interest. Further, NIOSH claimed that SC&A's conclusion that the Burial Ground was "considered a low priority by INL management" is "simply not substantiated for the 1952–1970 time period" (NIOSH, 2020, p. 55). To substantiate its response, NIOSH cites a 1961 internal memorandum on management expectations for the Burial Ground (INL, 1960–1961), and programs such as SWPs, as being indicative of the rigor being applied.

In terms of the low-risk nature of Burial Ground operations, NIOSH makes special mention of the fact that routine respiratory protection was not required in the later exhumation of buried drums in the 1970s (although respirators were handy if a breached drum were encountered). NIOSH also mentions the drum retrieval project in the 1970s as indicative of INL proportionately increasing the rigor of internal dose protection measures given the radiological hazards involved and the possibility of breached drums (up to requiring full plastic suits and a moveable containment hut) (NIOSH, 2020, p. 57).

6.2 SC&A response

Most of SC&A's response is already addressed in section 2.2.1. This includes the question of the rigor of the radiological control program (including contamination control), the issue of an organization conflict of interest for the CFA HP organization, and whether management afforded the Burial Ground a "low priority." However, this section clarifies SC&A's response in the context of specific comments made by NIOSH about Position 3.

NIOSH statement:

> In 1969–1970, the Burial Ground had (in a very short period) gone from a simple single objective (buried waste disposal) low-risk operation to a much more complex operation that was reflected in the change in organization. . . .
>
> The radiological monitoring at the Burial Ground was considered proportional to the radiological risk per the work reviews conducted by health physicists. (NIOSH, 2020, pp. 56–57)

SC&A response: Yes, but as made clear in NIOSH's response, the new organization for what was now the RWMC recognized the potential radiological hazards of breached RFP drums containing actinides, such as plutonium and americium, and backed its workers with considerable, state-of-the-art instrumentation (alpha and beta/gamma portable survey instruments, a portable gas-proportional counter, Stabilized Assay Meter (SAM-II), CAMs, and area radiation monitors), and personal protective equipment (anti-contamination clothing, gloves, booties, and half-mask respirators) to minimize the potential for intakes during exhumation operations (NIOSH, 2019). It is clear that this level of hazard recognition and protection was not available to Burial Ground workers who may have been exposed to breached drums during unloading and dumping operations in the 1960s.

NIOSH statement:

> The Standard Practice procedure for the Burial Ground required compliance with the radiation and contamination limits promulgated by the Interstate Commerce Commission (ICC), which was responsible for the standards for transportation of radioactive material at the time [[Phillips, 1962]]. (NIOSH, 2020, p. 56)

NIOSH then provides the regulated contamination limits and corresponding maximum committed effective doses from inhalation and ingestion (NIOSH, 2020, p. 56.

SC&A response: While the ICC standards would have applied for interstate transportation of radioactive waste containers and their surface contamination, it would not have applied to contamination that occurred in the unloading and burial of the offsite wastes (e.g., RFP drums) at the Burial Ground. It is for that contamination that SC&A is raising questions about adequate contamination control, worker monitoring, and dose reconstruction feasibility.

NIOSH statement: "There is no evidence to support the notion that the Burial Ground was reorganized due to poor radiological controls" (NIOSH, 2020, p. 57).

SC&A response: This statement has no basis in either SC&A's report or in what we believe is the 1971 AEC assessment to which NIOSH may be referring. That assessment rated the Burial Ground segment of the program as only "fair" because of "the dual responsibilities that the Health and Safety Branch has for operations concurrent with health physics coverage" and "recommended that the INC [the operating contractor] initiate steps to eliminate this conflict of interest" (AEC, 1971, pp. 1, 3). Nowhere in that report does the AEC find "poor radiological controls" existed at the Burial Ground and on that basis, recommend a reorganization. However, as SC&A has emphasized, the AEC did initiate an independent assessment "as a direct

consequence of leaking barrels arriving from Rocky Flats," with the review performed by another INL organization "on the basis that the Health and Safety Branch personnel were too closely involved with the operational aspects of the problem ["leaking barrels"] to conduct such a review," and subsequently concluded that "the dual responsibility of the Health and Safety Branch for operations and health and safety at the burial ground is not consistent with good health and safety practices" (AEC, 1971, p. 3). There is no mention of waste management program transitioning or increased operations in AEC's explanation for its finding, conclusion, or requested action.

NIOSH statement: "Review of all the available CFA monthly reports . . . , available CFA HP logbooks, and available CFA HP log sheets does not show contamination events to be common" (NIOSH, 2020, p. 62).

SC&A response: From interviews with Burial Ground health physicists and workers, SC&A has demonstrated, from first person accounts, that contamination was a common aspect of work at the Burial Ground, although actual reporting of it may not have occurred given the perceived insignificance of such events. With respect to the dumping of RFP drums, a May 1972 review of the initial Solid Radioactive Waste Retrieval Test noted that "it was apparent that damage to the barrels during the original dumping operations was extensive and resulted in many open barrels" (Allied Chemical, 1972, p. iii). The extent of scattering of contaminated contents of drums in the pits was made clear in this same report:

> Many seriously damaged barrels were found, some of which were open with the inner liner ruptured. Loose material--such as protective mask canisters, tags, plastic material, and barrel lids--were found. The main cause of the loose material and damaged barrels appears to have been the practice of dumping barrels. (Allied Chemical, 1972, P. 29)

The polyethylene liners that NIOSH claims were a mitigating factor in contaminated waste scattering upon drum ruptures were not necessarily effective at preventing release of drum contents, as noted in section 4.1 of this report.

With Burial Ground workers involved in unloading and cleaning up after drum spills, and equipment operators crushing drums and moving overburden cover, the potential exposure of these workers to a relatively "common" source of waste contamination remains a concern. This concern was shared at the time by Burial Ground health physicists:

[redacted] ([redacted], 2016, p. 5)

Finally, a comment in 1972 by the Director of the AEC's Operational Safety and Technical Support Division at INL is instructive about the "strictness" of the Burial Ground radiological monitoring program and its "defense-in-depth" ethos (he was conducting an onsite surveillance of the Burial Ground on July 16, 1971):

> During my checkout for contamination on leaving the burial ground, I noted that the Eberline air proportional counter was light sensitive. The HP technician

> indicated that there were other problems with the scintillation detector. Perhaps we should check out the instrumentation used at Rocky Flats. With their vast experience in handling plutonium contamination, they may have instrumentation which would be more appropriate for field activities at the NRTS. (Horan, 1971, p. 1)

With the noted inadequacies of this and other existing detectors being used at the Burial Ground (e.g., the 1950s-era beta-gamma detectors still in use in the 1970s (ANC, 1972), and the Eberline PAC-1S detector found to be inadequate for field use (NIOSH, 2019)), it is questionable whether adequate HP surveillance would have been feasible even if such surveillance would have been routinely performed.

6.2.1 SC&A updated conclusion

While there are examples of HP monitoring and surveillance having taken place at the Burial Ground, there are contradictory accounts and information that indicate that this radiological monitoring lacked the rigor and comprehensiveness to be considered "defense in depth" and, for the dumping of RFP drums in particular, would have likely missed internal intakes due to contamination from breached drums.

7 Conclusions

There is no evidence of an internal dose assessment program at the INL Burial Ground during the 1952–1970 time period. As the AEC health physicist responsible for the Burial Ground during this period pointed out, "[redacted]" ([redacted], 2016, p. 6). Workers in 1952–1970 were not routinely bioassayed, and there is no evidence that the sitewide INL procedure to request a special bioassay when an intake may have occurred was, in fact, actually implemented at the Burial Ground.

The NIOSH conclusion that the Burial Ground was a well-managed facility is contradicted by AEC audits that respectively found that its operation was not considered a "priority" of its operating contractor and rated it as only "fair" based on an organizational conflict of interest involving its Health Physics program. NIOSH's conclusion that there existed a "strict contamination control program" is undercut by the AEC's finding of a longstanding inadequacy in the smear counting program, and accounts by former Burial Ground health physicists, HP technicians, and workers of inadequate contamination control practices and prevalent contamination.

SC&A agrees that MFPs are the dominant source term for estimating internal dose contribution for onsite waste but disagrees that Burial Ground workers were necessarily "exposed to similar levels of MFPs as other unmonitored INL workers," as concluded by NIOSH. That overall conclusion is premised on "(1) the Burial Ground was not operated differently than other facilities at INL . . . and (2) the available monitoring data does not demonstrate uncontrolled source terms" (NIOSH, 2020, p. 53). As noted earlier in this review and in its 2017 report, SC&A continues to find that management and radiological controls at the Burial Ground were of lesser or indeterminate rigor when compared with those at CPP, the test and research reactors, and other INL facilities in the 1952–1970 timeframe. SC&A also finds with regard to the

reported release of plutonium, americium, and other actinides from RFP drums, which would have constituted an uncontrolled radiological source, that there are no related monitoring data, including special bioassays, upon which dose assessment would be based.

Regarding NIOSH's proposed alternate approach for bounding internal dose to actinides from RFP (and other offsite) waste using bioassay data from 18 workers from the 1970s waste retrieval program, SC&A does not believe it has been sufficiently established that exhumation activities in the 1970s are appropriately representative of earlier Burial Ground activities of the 1950s and 1960s, nor that such exhumation activities are necessarily bounding from the standpoint of the potential for uptake by the affected workers.

SC&A views the Burial Ground as having a contamination control program commensurate with a radioactive waste landfill of its era—the 1950s and 1960s—when less management priority was assigned to such operations, and sporadic low-level contamination from unloading and dumping drums and containers was a common part of work that did not warrant a special response from the radiological control program. SC&A concludes that the examples and samples of past procedures and various monitoring activities cited by NIOSH do not necessarily demonstrate the stringency of the Burial Ground contamination control program, particularly in the face of contradictory and contemporary AEC, contractor, and worker accounts and reviews. Workers at the Burial Ground in 1952–1970 were potentially exposed to radioactive waste contamination for which there is no bioassay data, inadequate air sampling and contamination smear data, and insufficient radionuclide source term characterization of what leaks and spills of RFP drums may have been involved.

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