Memorandum

To: Hanford Work Group
From: SC&A, Inc.
Date: June 24, 2020
Subject: Review of NIOSH White Paper: "Assessment of Certain Special Exposure Cohort-Related Issues for the Hanford Site"

This memorandum responds to a white paper issued by the National Institute for Occupational Safety and Health (NIOSH) on January 7, 2020, regarding its "Assessment of Certain Special Exposure Cohort-Related Issues for the Hanford Site" (NIOSH, 2020a). That paper "presents the status of the assessment of dose reconstruction feasibility for several Special Exposure Cohort (SEC)-related issues for the Hanford site. It reflects the current state of knowledge based on extensive site research actions accomplished since the approval of SEC petition SEC-00201 in 2012" (NIOSH, 2020a, p. 2). NIOSH clarifies that it "addresses only SEC issues and only those that are not dependent on the implementation of the revised guidance for co-worker methods" and only addresses employees of certain named prime contractors during the period January 1, 1984, through December 31, 1990 (p. 2).

The white paper outlines the history of SEC petition reviews for Hanford to date. As noted by NIOSH, that paper addresses those SEC-related issues that remain for the Petition SEC-00201 period, 1984–1990. SC&A's review focuses on these SEC-related issues, as they were identified through consensus recommendations of NIOSH and SC&A to the Hanford Work Group and reflected in the Board Review System (BRS) in November 2018.

SC&A's preliminary findings from its ongoing assessment were presented and discussed in a Hanford Work Group teleconference meeting on April 14, 2020. At that meeting, based on SC&A's agreement with a number of NIOSH's conclusions for SEC exposure issues for Hanford SEC-00201, the work group proceeded to close those issues.

The following assessment and status summary tracks the SEC issues in question and notes their status as of the April 14, 2020, Hanford Work Group teleconference meeting,[1] including those that were closed by the work group.

[1] Issue 7 is the exception: Since the Work Group meeting and at its request, NIOSH has provided further clarification regarding uranium-233 use at Hanford for 1984–1990. That clarification is reflected in this memorandum report.

Key Radionuclides of Concern

As summarized in the background section of the white paper,

> The basis for the class established by SEC-00201 [all Hanford employees, 1972–1983] was that NIOSH lacked sufficient information, including biological monitoring data, sufficient air monitoring information, or sufficient process and radiological source information, to allow it to estimate with sufficient accuracy the potential internal exposures to purified highly-enriched uranium, U-233, neptunium, or thorium to which the proposed class may have been subjected. (NIOSH, 2020a, p. 2)

Excluding named contractors and subcontractors for which an SEC class was defined for 1984–1990 under SEC-00226,[2] NIOSH addressed remaining "radionuclides of concern" (ROCs) for this period, as well as a number of additional exposure sources and programmatic issues.

Thorium-232

As outlined in NIOSH's white paper and the BRS,

> This SEC issue relates to: (1) potential thorium exposures during remediation of certain areas; (2) the potential use of thorium in nuclear fuel fabrication and related operations within the 300 Area during 1984 through 1990; and (3) possible thorium use in other areas at Hanford during that time. (NIOSH, 2020a, p. 5)

In terms of dose reconstruction feasibility, NIOSH reviewed thorium-232 (Th-232) sources and inventories for 1984 through 1990 and documented specific details of inventory on hand and transactions involving thorium at Hanford for this time period. One radiological occurrence of note was thorium contamination found in the 3720 Building following a "'rigorous' radiation survey of several rooms." This contamination was found "within the radiation area and in locations not routinely accessed by personnel," and "presented no safety, health, or environmental concerns" (NIOSH, 2020a, p. 21).

Based on its extended site research, NIOSH had "not identified any processes or operations involving Th-232 at Hanford from 1984 through 1990" (NIOSH, 2020a, p. 21). In its earlier evaluation report for SEC-00201, NIOSH had indicated that it "believes that maturation of Hanford work practices and programs as well as the nature of work performed after 1983 were such that dose from potential intakes of thorium or neptunium can be bounded with sufficient accuracy" (NIOSH, 2012, p. 25).

[2] Based on a recognition that "'construction trades workers' fundamental type of work, as well as radiological monitoring practices, were substantively different from other Hanford operational workers,' and that NIOSH lacked 'sufficient radiobioassay monitoring data for construction trades workers, and sufficient workplace monitoring and source term data, that would allow it to estimate with sufficient accuracy the potential internal doses from radionuclides associated with fuel handling, reactor operations, fuel reprocessing, or research activities to which the proposed class may have been exposed during the period from January 1, 1984 through December 31, 1990'" (NIOSH, 2020, p. 3, quoting NIOSH, 2015a).

SC&A had noted in our January 2019 update summary (SC&A, 2019) to the Hanford Work Group that:

> SC&A views this combined question of whether thorium exposure potential can be demonstrated after 1983 and whether internal dosimetry advanced to a stage where results could be applied to bound such exposures, as the focus of remaining onsite records reviews. If no exposure potential can be found, the second issue of whether a bounding dose can be derived is rendered moot. (SC&A, 2019, p. 5)

NIOSH's site research actions in support of its conclusion that there were no "processes or operations involving Th-232 at Hanford from 1984 through 1990" (NIOSH, 2020a, p. 21) included a review of material control and accountability (MC&A) data, interviews with cognizant personnel, and incident reports of radiological occurrences involving thorium. The MC&A inventory review showed only "occasional work involving small amounts of thorium" having taken place at Pacific Northwest Laboratory (PNL) facilities in the 300 Area, with no evidence of large-scale operations for which a potential for chronic intakes may have existed. (NIOSH, 2020a, p. 21). An interview with the internal dosimetry program (IDP) manager at the time found that he "did not recall any incidents or exposure concerns involving thorium" (NIOSH, 2020a, p. 22). The only reported positive Th-232 intakes found on the Hanford Radiation Exposure (REX) database involved a whole-body count for a worker, which was followed up with additional confirmatory counts for this and a coworker from the same work location.

Regarding "legacy" thorium contamination, a radiological occurrence was documented for 3720 Building, where a contamination survey of several rooms identified residual thorium contamination "outside of normal containment" in two of them. It was subsequently determined that the contamination was "either fixed, inaccessible to normal operations, or of reasonably low levels and presented no safety, health, or environmental concerns" (NIOSH, 2020a, p. 21).

NIOSH response to key SC&A lines of inquiry (from SC&A (2019) and BRS)

- Remediation of certain Hanford areas (e.g., 200 and 300 areas):

  NIOSH notes that "significant clean-up work did not begin at Hanford until after 1990 and was performed by prime contractors other than those considered within this document. Any thorium present in the soil or residual matter would likely have been commingled with other radioactive materials, notably uranium." NIOSH concludes that "if any such work was performed during 1984-1990 it would have been limited in scope and likely would have been performed by individuals already covered by the 83.14 class created by SEC-00226" (NIOSH, 2020a, p. 21).

  Although not definitive in terms of confirmatory records, SC&A agrees that potential exposure to legacy Th-232 contamination would have been unlikely and, in any case, would have been likely detected and reported as a radiological occurrence during this particular timeframe. As construction trade workers were largely encompassed by the cited SEC-00226 class, these likely decontamination and decommissioning workers would have been already covered by an SEC, in any case.

- Potential use of thorium in nuclear fuel fabrication and related operations in 300 Area:

  NIOSH notes that "a review of large volumes of MC&A data provided indications that occasional work involving small amounts of thorium may have taken place within PNL facilities in the 300 Area during 1984 through 1990." NIOSH concluded that "however, any such work would have involved small amounts of thorium where the potential for intake, if any, would be associated with radiological incidents." NIOSH determined that there is no evidence that such intakes or investigations of such intakes involving thorium had taken place during the time period in question (NIOSH, 2020a, p. 21).

  SC&A had established the presence of residual thorium contamination in process drains, piping, and sewers in the 300 Area, which was corroborated by a former worker interview and by the Hanford Solid Waste Information and Tracking System (SWITS) database (SC&A, 2019). Buildings implicated are 340, 325, and 308 Buildings. However, SC&A also noted that the thorium exposure potential from such contamination was unclear. Based on NIOSH's review of MC&A inventory data and its review of incident reporting, SC&A agrees that the exposure potential would have been small, and that any incidental intakes would have been likely detected.

- Operational sources of Th-232:

  NIOSH's review of PNL operational thorium inventories for 1984–1990 and facility transfers and other transactions involving thorium for the same timeframe indicates a wide spectrum of applications, but no indications of likely exposure potential (most stocks were in storage, with the remainder in secure forms or being handled in gloveboxes). No uncontained thorium sources were identified.

SC&A agrees that this overall review resolves its original question about whether any operational sources of Th-232 had an exposure potential. Based on discussions at the April 14, 2020, Hanford Work Group teleconference meeting, the work group agreed to close this issue (BRS Issue 3).

Highly enriched uranium (HEU)

As outlined in NIOSH's white paper and the BRS,

> This SEC issue pertains to whether workers who potentially received intakes of HEU during the post-1983 period were monitored by alpha spectrometry (for urinalysis) or by other appropriate means. This issue is contingent upon the identification of a potential source of HEU intakes by Hanford workers from 1984 through 1990. (NIOSH, 2020a, p. 5)

NIOSH further observed that based on MC&A records, there "appeared to be potential sources of HEU within 200 Area and the Plutonium Finishing Plant (PFP)" and in the 300 Area, particularly the 308 Building. For the 308 Building, late-1980s operations included fabricating nuclear fuel fins from fuel pellets and, possibly, pressing of powders into fuel pellets (NIOSH, 2020a, p. 22). Other operations took place in the 308 Building, such as mixed oxide fuel

fabrication, but these would have also contained plutonium that would entail routine chest counts.

In its January 2019 update, SC&A noted that

> it is clear that HEU inventory continued to exist at Hanford in the SEC time period of interest (1984-1990), and that some exposure potential may have existed in the handling or packaging of scrap or other material for shipping or storage. However, as noted by SC&A, it was likely confined to HEDL [Hanford Engineering Development Laboratory], to PFP (scrap inventory), and to a much smaller extent, in some other facilities, such as the 222-S laboratory. (SC&A, 2019, p. 6)

As also indicated in SC&A's summary, "while the presence of HEU in inventory for 1984-1990 was established, the exposure potential to workers handling the material involved was not." (SC&A, 2019, p. 7). From interviews conducted with former workers at the 308 Building, operations were conducted in gloveboxes, workers received routine whole-body and chest counts, in vitro bioassay, and nasal smears when needed, and routine contamination surveys and air sampling was performed daily (NIOSH, 2020a, pp. 23–24). From interviews with a former process engineer at PFP, there was no routine processing or handling of HEU at that facility. While there were quantities of HEU stored in Hanford vaults (e.g., PFP) in 1984–1990, there was no handling other than inventory confirmation or verification (SC&A, 2019).

NIOSH concludes that while "it is unknown how frequently operations involving enriched uranium took place in 308 Building . . . it appears that the only internal exposure potential from HEU would have been associated with radiological incidents" (NIOSH, 2020a, p. 24). NIOSH also points out that "workers in the 308 Building received routine bioassays including whole-body and chest counting," with uranium-235 (U-235) being one of the radionuclides routinely reported.

SC&A agrees with NIOSH's conclusion regarding the lack of an exposure potential and the likelihood that any incident involving HEU contamination would have been detected and monitored by the existing radiological control and surveillance program. Based on discussions at the April 14, 2020, Hanford Work Group teleconference meeting, the work group agreed to close this issue (BRS Issue 4).

Uranium-233 intakes

As outlined in NIOSH's white paper and the BRS:

> This SEC issue pertains to potential sources of U-233 intakes during 1984 through 1990, and the adequacy of Hanford's internal monitoring practices for U-233 in the event such sources existed. This issue is contingent upon the identification of a potential source of U-233 intakes by Hanford workers from 1984 through 1990. (NIOSH, 2020a, p. 5)

SC&A's review confirmed an inventory of U-233 being held in four organizations at Hanford in fiscal year 1974, with its presence in "scrap solutions in PFP and possible continuing

experimental work with it in the 300 Area" posing a question of potential exposure (SC&A, 2019, p. 10). However, SC&A agreed with NIOSH's conclusion "that a source term for potential intakes of U-233 by Hanford workers has not been [to date] identified for the period 1984 through 1990" (SC&A, 2019, p. 10).

SC&A continues to agree with NIOSH's conclusion but sought clarification on any confirmatory reviews conducted by NIOSH since 2017 regarding SC&A's line of inquiry about U-233 in scrap solutions and in possible experimental work in the 300 Area. In response to an inquiry on this question, NIOSH clarified:

> The comprehensive site research activities accomplished by NIOSH in support of the Hanford SEC issue evaluations are discussed in Attachment A. These activities considered all current SEC issues, including searches and reviews for information indicating operations involving uranium-233. Broad reviews of site contractor and operating area-specific records were performed, as were detailed reviews of material control and accountability records. NIOSH also conducted numerous interviews with individuals that worked at Hanford during the evaluation period. None of these site research activities identified any operations involving U-233 at Hanford during the 1984 through 1990. (Nelson, Charles; Personal Communication, February 6, 2020)

At the Hanford Work Group's request, NIOSH expanded this initial clarification in a memorandum on May 21, 2020 (NIOSH, 2020b), which provided more specific details of their corroboratory review of these two issues. For scrap solutions, NIOSH referenced its supporting interviews and records indicating no routine operations involving U-233 in scrap solutions at Hanford. Uranium-233 in solution and oxide form were held in materials inventory, with the vault at PFP being identified as one such location. In terms of the 1982 reference cited by SC&A indicating past experimental use of U-233, NIOSH notes that the radiation effects research involved was apparently performed using sealed sources in bench-scale studies and, therefore, would not have posed a routine exposure potential. Finally, NIOSH reiterated that materials accountability records at Hanford for 1984–1990 show no routine use of U-233 at the site.

SC&A agrees with NIOSH's corroboratory assessment and recommends closure of this issue by the work group.

Neptunium-237 intakes

As noted in SC&A's 2019 update summary, "NIOSH and SC&A agree that there is a need to complete the confirmation process, notably for PUREX, to establish whether any potential for Np-237 exposures existed in the 1984-1990 timeframe" (SC&A, 2019, p. 13).

Investigations into possible sources of neptunium-237 (Np-237) intakes for 1984–1990 focused on three operational activities at Hanford (NIOSH, 2020a, p. 24):

- Potential exposures associated with the Multi-Isotope Production (MIP) Test performed in the FFTF.
- Potential exposures associated with nuclear waste characterization research.

- Potential exposures at the PUREX plant associated with the side-pocketing of impure neptunium solutions, and from legacy materials in Q Cell.

NIOSH (2020a) indicates that a "short-duration test irradiation known at the MIP test" was performed at FFTF" (p. 25). Neptunium oxide pins were fabricated in 308 Building, irradiated in the Fast Flux Test Facility (FFTF), processed in 324 and 325 Buildings, and transferred to PFP for disposition during the 1989–1990 timeframe. As NIOSH notes, an incident involving Np-237 intakes for two workers in July 1989, which was confirmed by in vitro bioassay, is likely associated with these MIP activities (an incident report was not located).

For nuclear waste characterization purposes, PNL apparently used gram quantities of Np-237 for fabrication of glass-encased forms to be used for research throughout the U.S. Department of Energy (DOE) complex. As NIOSH notes, the Np-237 was apparently located in 325 Building, but it remains unclear how long PNL provided such forms. These was no apparent exposure potential involved with this fabrication.

The Np-237 was purified at PUREX in the 1960s to 1970s and was held in unpurified form for future processing at PUREX until the early 1990s (although PUREX restarted in 1983, the Np-237 recovery process was not reactivated), at which point it was disposed as waste in the Hanford high-level waste tanks. As noted by NIOSH, "the SRDB [Site Research Database] includes records showing entries being made into Q Cell in March 1981 to perform activities such as glovebox work and leak repairs [PNL 1981]. It is reasonable to assume such activities may also have taken place during the period 1984-1990, but it seems unlikely such activities would have resulted in unknown intakes of purified Np-237 even if such sources existed" (NIOSH, 2020a, p. 26).

SC&A (2019) summarized its review and conclusions as follows:

> There remains a question of potential intakes of Np-237, and the adequacy of Hanford's internal monitoring practices for Np-237 in the event such sources existed. Unpurified Np-237 could have been encountered during glovebox entries or cleanup activities within Q Cell during restart and maintenance activities at the Purex plant during the 1980s. NIOSH and SC&A agree that there is a need to complete the confirmation process, notably for PUREX, to establish whether any potential for Np-237 exposures existed in the 1984-1990 timeframe. (SC&A, 2019, p. 13)

In response, NIOSH (2020a) cites interviews conducted with several former workers at Hanford. In particular, three interviews are cited, one with the staff member responsible for reactivation of the Np-237 process at PUREX, one was the dosimetry lead for Rockwell Hanford during 1984 through 1987, and the third was with a former radiation control supervisor from PUREX.

The first interviewee confirmed that the impure Np-237 solution in J Cell contained plutonium and other impurities. Respirators were used in Q Cell when "bagging equipment in or out of a hood, or during activities with a potential for airborne contamination, and swipe samples were used to determine if respiratory protection was needed" (NIOSH, 2020a, pp. 26–27). This

individual stated there were "no positive [bioassay] results from 1984 onwards" and did not recall any incidents or problems (ORAUT, 2013, p. 4).

The dosimetry lead confirmed that "supplied air respiratory protection [was] used in Q cell" (ORAUT, 2014, p. 4), and the PUREX supervisor stated that "internal monitoring at Purex was primarily urinalysis and chest counts" (ORAUT, 2017, p. 2). NIOSH (2020a) also summarized this interview as stating that "there was never a need to monitor workers for Np-237 during the time he worked at PUREX, and that PUREX workers were essentially monitored internally by default" (NIOSH, 2020a, p. 27).

NIOSH provided additional discussion that responds to SC&A's concerns about SWITS database reports of Np-237 in waste streams of several Hanford facilities (e.g., PFP, 324 Building, other 300 Area facilities). NIOSH observes that "Np-237 appears to have been associated with liquid wastes or other similar materials present in the 325 Building in support of its various radiochemical research missions" (NIOSH, 2020a, p. 27). NIOSH further notes that "MC&A data show only accountable materials, not fission products or other radioactive materials, in general, that might also be present" (p. 27). At the April 14, 2020, Hanford Work Group teleconference meeting, SC&A responded that its information source is the SWITS waste management database, not a nuclear material accountability database, so it was not clear that NIOSH's explanations would necessarily hold. NIOSH responded that it had considered broader operational considerations wherein comingled waste streams (Np-237 combined with other radionuclides, e.g., mixed fission products, plutonium, and americium) would have been generated given the radiological source terms being handled and would have been monitored accordingly. SC&A considered this an acceptable response given that MC&A data alone were not being relied upon.

NIOSH concludes that "with respect to chronic intake potential, there were no significant sources of purified Np-237 at Hanford from 1984 through 1990. Any intakes, therefore, would have been the result of radiological incidents" (NIOSH, 2020a, p. 28). Only one incident involving Np-237 was identified, confirmed by internal monitoring, and its timing suggests it was associated with the MIP test.

SC&A agrees that sufficient confirmation has been accomplished, particularly for potential exposure potential at PUREX, to conclude that no sources of potential Np-237 exposure existed at Hanford for 1984–1990. Based on discussions at the April 14, 2020, Hanford Work Group teleconference meeting, the work group agreed to close this issue (BRS Issue 9).

Programmatic Issues

Special tritium compounds

As noted in NIOSH's white paper, this issue was prompted by a statement in the Hanford site profile that "metal tritides were potentially present as part of the Tritium Target Program that began in 1988" (NIOSH, 2020a, p. 28; NIOSH, 2015b, p. 37). However, NIOSH "has not identified any references indicating that dissolving or other post-irradiation examinations of irradiated tritium target rods took place at Hanford during 1984 through 1990. PNL did begin testing of light water reactor-type tritium target rods in 1989, but the initial test irradiation was not completed until December 1990" (NIOSH, 2020a, pp. 28–29). NIOSH further concludes that

no sources of metal tritide exposure were identified for 1984 through 1990, and if any were to be identified, NIOSH has developed methods for assigning dose from intakes of such compounds.

SC&A agrees with this confirmatory review. Based on discussions at the April 14, 2020, Hanford Work Group teleconference meeting, the work group agreed to close this issue (BRS Issue 10).

Skin contamination at N Reactor

This issue pertains to the "adequacy of monitoring data for skin contamination resulting from radiological incidents involving primary cooling water at the Hanford N Reactor" (NIOSH, 2020a, p. 5). NIOSH confirms that "site data indicate considerable potential for skin contamination during such activities" and that "this contamination potential was not limited to just maintenance workers (i.e., it also existed for operations personnel and other employees)" (NIOSH, 2020a, p. 5). The issue is confirmation of such potential exposures and whether adequate radiation monitoring information existed from which skin dose could be estimated.

NIOSH's review found that "a formal, mandatory process for documenting skin contamination events at N Reactor was in place long before 1984" (NIOSH, 2020a, p. 29). Skin-contamination survey forms were required to be filled out, and these were reviewed by NIOSH for 1984 and 1985 (N Reactor was shut down in 1987). All the forms reviewed included "maximum contamination levels, the instrument used (e.g., 'GM'), and an indication (checkbox) if the individual was sent for whole-body counting" (NIOSH, 2020a, p. 29). This review of contamination surveys was augmented by NIOSH with a review of Hanford claim cases for 1984 through 1990 in terms of reported skin contaminations. Based on that review, NIOSH found that such cases were infrequent, but when they occurred, the workers involved were sent for whole-body counting or bioassay sampling.

SC&A agrees with NIOSH's conclusion that "typical skin contamination events do not result in significant dose rates to the skin. However, the information on the individual skin contamination survey forms could be used to estimate a skin dose if desired" (NIOSH, 2020a, p. 30). Based on discussions at the April 14, 2020, Hanford Work Group teleconference, the work group agreed to close this issue (BRS Issue 20).

Internal monitoring associated with minor radiological incidents

As currently described in the BRS, this issue is one of "whether sufficient bioassays were taken to account for potential worker internal exposures from minor radiological incidents during 1984-1990. (NIOSH, 2020a, p. 30). This issue originated in SC&A's conclusion that employees involved in serious incidents were monitored, but "it may be worthwhile to review less significant incidents (not rising to the level of formal investigation at B and C) for further insights regarding incidental exposures that may have taken place" (SC&A, 2013, p. 8).

NIOSH's site research followup activities included a review of Hanford's guidance to site contractors regarding incidents [which was "to refer employees for internal dosimetry evaluation any time there was an incident or workplace indication that suggested a potential for a radiological intake" (NIOSH, 2020a, p. 31)], as well as a review of available Hanford site radiological incidents files for 1984-1990. These files included a PNL incident file that covered

the period from 1983 through 1991, and a United Nuclear incident file that covered incidents (usually skin contaminations) at N Reactor. An interview with a former radiological control technician from PUREX plant is also referenced in terms of their recording of nasal contamination incidents in radiation monitoring logs. Another interview with workers from 308 Building included statements that the occurrence reporting process was "very formalized" in the 1980s and that "formal incident reporting had been implemented in the 1970s." (NIOSH, 2020a, p. 33; ORAUT, 2013).

SC&A agrees with NIOSH's conclusion:

> Reviews of the numerous examples of contractor radiological incident reports available in the SRDB show that the prime contractors had systems in place for: (1) recognizing and documenting radiological incidents in the field; (2) following through to further investigate exposures; and (3) revising protocols to prevent reoccurrence when warranted. The documentation included indications (e.g., distribution lists, form instructions, bioassay requests, and procedural guidance) of having been distributed across organizations. Hence, no dose reconstruction infeasibility associated with insufficient attention to internal dose from workplace radiological incidents was identified. (NIOSH, 2020a, p. 33)

At its April 14, 2020, Hanford Work Group teleconference meeting, the work group concurred with SC&A's conclusion and closed this SEC issue (BRS issue 22).

Building 324 leaks

As described by the NIOSH white paper, "this is a due diligence item regarding the adequacy and completeness of internal monitoring data for workers who may have been affected by radiochemical-cell leakage incidents that occurred within the 324 Building" (NIOSH, 2020a, p. 33). As noted by NIOSH, SC&A "had conducted interviews" and noted that the health physics coverage at 324 Building was reportedly good," but recommended that NIOSH verify that sufficient monitoring data existed for workers at 324 Building affected by radiological incidents (NIOSH, 2020a, pp. 33-34; SC&A, 2011, p. 9).

To that end, NIOSH reviewed radiological incidents at 324 Building that occurred in 1984–1990. Three incidents were identified: (1) a March 1986 contamination from a B-Cell HEPA filter change-out incident (Gray, 1986), (2) a July 1989 contaminated water leak from B-Cell (Jarrett, 1990), and (3) an October 1990 cesium-137 (Cs-137) contamination incident at the Shielded Materials Facility (Hikido 1991). However, only the first two incidents were considered directly relevant to the 324 Building radiochemistry cells (NIOSH, 2020a, p. 34). Incident reports for the two B-Cell incidents indicate that workplace monitoring was in place, there were no intakes reported, and no special bioassays were deemed necessary.

From the standpoint of data adequacy and completeness, SC&A finds that, given there were no bioassay data taken for the two B-Cell incidents because no intake potential was identified by the health physics staff, there are no bioassay data to evaluate.

For the third incident at the Shielded Materials Facility, workplace monitoring had indicated the need for special bioassays. For that incident, SC&A verified these bioassays by correlating the

information in the "REXADM_INV_ISO_RESULT" and "REXADM_INV_RESULT" files. The whole-body counts (WBCs) were performed on October 23, 1990, with positive results above the minimum detectable activity for some workers for Cs-137, antimony-125, and zirconium-95, with less than minimum detectable activity for all cobalt-60 results. SC&A found the bioassay adequate and complete for this incident.

SC&A's review of the three incident reports cited supports NIOSH's finding that "evaluation of pertinent radiological incidents that occurred within the 324 Building did not identify any personnel monitoring deficiencies or indications of unmonitored internal dose" (NIOSH, 2020a, p. 35). Therefore, SC&A agrees with NIOSH's conclusion that "no dose reconstruction infeasibility associated with cell leakage events at 324 Building has been identified for Hanford prime contractor employees from 1984 through 1990" (NIOSH, 2020a, p. 35).

Data adequacy and completeness

Internal dosimetry program practices, 1984–1990

SC&A agrees with NIOSH's summary of IDP practices and concurs that the Hanford program administered and operated by PNL was well defined and documented. As noted by NIOSH, "a key philosophy of the Hanford IDP was that workplace monitoring, including air sampling and contamination surveys of personnel and work areas, was the primary means for identifying internal exposures," with routine bioassay being secondary (NIOSH, 2020a, p. 8). While PNL provided this guidance to the Hanford contractors, these operating contractors were responsible for implementation, making their own decisions regarding which workers were monitored and in what fashion. This became clear during a review of subcontractor bioassays for this time period, where it became apparent that line management decisions were made not to monitor certain construction trade workers (leading to an SEC class being defined under SEC-00226). However, as NIOSH pointed out, "a Hanford dosimetry advisory committee evaluated whether contractors were following PNL's guidance," and interviews with key dosimetry managers indicated that "contractors would have to provide an explanation to DOE if they did not follow PNL's guidance" (NIOSH, 2020a, p. 8). SC&A agrees that such programmatic oversight mechanisms were in place but, given the experience with subcontractor monitoring and the resulting SEC class definition, concurs with NIOSH's approach to validate routine and incident-based bioassay monitoring by operating contractors.

Internal monitoring data, 1984–1990

The white paper provides a breakdown of the in vivo bioassay data available for Hanford prime contract workers for the period 1984–1990 in tables 1–14 (pages 12–15). The tables are organized by contracting company and by bioassay method (WBC and chest count). The data in the tables are further broken down into the reason for the bioassay (e.g., routine, special, termination, etc.).

In addition to the general bioassay data, the white paper provides details of specific bioassays for ROCs to determine if there is any evidence of large-scale use of such radionuclides (pages 16–18).

SC&A evaluated the prime contractor bioassay data by using the Hanford Radiation Exposure (REX) database[3] provided to SC&A by NIOSH.

Whole-body counts

The bioassay data for Hanford prime contractor employees from 1984 through 1990 are contained in the REX database. SC&A evaluated the WBC data in this database to (1) verify the information in the white paper and (2) obtain an indication of the adequacy and completeness of the available WBC data for dose reconstruction feasibility. The WBC data are presented in tables 1–7 of the white paper for 1984–1990 by contracting company, as follows:

- Table 1: Rockwell Hanford
- Table 2: Boeing Computer Services
- Table 3: DOE
- Table 4: United Nuclear Industries
- Table 5: PNL
- Table 6: Westinghouse Hanford (1984–1987)
- Table 7: Westinghouse Hanford (1987–1990)

SC&A verified the data in these tables using the information in the data file "REXADM_INV_RESULT" ("INV" stands for "in vivo" in the REX files), sorted for WBCs and then by contracting company. SC&A did not identify any notable discrepancies in the data in the tables compared to the REX database information.

Chest counts

SC&A evaluated the chest count data in the REX database to (1) verify the information in the white paper and (2) obtain an indication of the adequacy and completeness of the available chest count data for dose reconstruction feasibility. The chest count data are presented in tables 8–14 of the white paper for 1984–1990 by contracting company, as follows:

- Table 8: Rockwell Hanford
- Table 9: Boeing Computer Services
- Table 10: DOE
- Table 11: United Nuclear Industries
- Table 12: PNL
- Table 13: Westinghouse Hanford (1984–1987)
- Table 14: Westinghouse Hanford (1987–1990)

SC&A verified the data in these tables using the information in the data file "REXADM_INV_RESULT," sorted for chest counts and then by contracting company. SC&A

[3] The external and internal exposure data for Hanford contractors and employees from 1984 through 1990 are contained within the REX database. The database was provided to the Oak Ridge Associated Universities Team (ORAUT) in 2014. NIOSH provided SC&A with access to the REX database for evaluation of the Hanford exposure data in 2020. SC&A used various extensions of the REXADM files in the REX database in the following analyses.

did not identify any notable discrepancies in the data in the tables compared to the REX database information.

SC&A's evaluation

SC&A did not identify any notable discrepancies in the data in the tables compared to the REX database information. While a comparison of each individual prime contract worker at Hanford during the period 1984–1990 and the information in the REX database was not performed, the in vivo data available in the REX database is indicative of a structured and consistent bioassay program with appropriate recordkeeping for the stated time periods covering the prime contractors addressed in the white paper. This indicates that there exist sufficiently adequate and complete data for dose reconstruction purposes. This is in contrast to the class of contractors and subcontractors defined by SEC-00226 and NIOSH's evaluation report, table 7-1 (NIOSH, 2015a). The SEC-00226 class resulted because there was a lack of consistent monitoring programs and available records, which does not appear to be the case for the prime contractors and periods analyzed in the white paper and reviewed by SC&A.

Radionuclides of concern

SC&A evaluated the ROCs addressed on pages 16–18 of the white paper to determine (1) if there were indications that these radionuclides were used infrequently and, therefore, presented little potential for internal exposure, or (2) if there were frequent bioassays, which could indicate routine use and chronic exposure potential. Infrequent bioassays for a specific radionuclide (especially if they were incident driven) would indicate infrequent use. The ROCs addressed in the white paper were:

- Th-232 by in vivo bioassays, page 16
- U-235 by in vivo bioassays, page 17
- U-235 and U-233 by in vitro bioassays, page 17
- Np-237 by in vitro bioassays, pages 17 and 18

For the Th-232 and U-235 in vivo evaluation, SC&A used the information from the data files "REXADM_INV_RESULT" coupled with "REXADM_INV_ISO_RESULT" ("ISO" stands for "radioisotope" in the REX files). For the U-235, U-233, and Np-237 in vitro evaluation, SC&A used the information in the data files "REXADM_EXC_RESULT" ("EXC" stands for "in vitro" in the REX files). The following outlines SC&A's analysis and conclusion for each of the ROCs:

- Th-232 (in vivo): SC&A used the "REXADM_INV_RESULT" file coupled with the "REXADM_INV_ISO_RESULT" file to verify the 16 in vivo bioassays, and their quantitative results, as presented on page 16 of the white paper. SC&A found the Th-232 bioassays and results to be correctly stated. The results indicate infrequent use of Th-232.

- U-235 (in vivo): SC&A used the "REXADM_INV_RESULT" file coupled with the "REXADM_INV_ISO_RESULT" file to verify the in vivo U-235 bioassays, as presented on page 17 of the white paper. SC&A found the U-235 bioassay information to be correctly stated. The results show that U-235 was routinely reported from chest counts, not because of positive results, but because it was reported along with other radionuclides. U-235 was very infrequently analyzed when WBCs were performed: 4 out

of over 12,000 WBCs for prime contractor workers during 1984–1990 included U-235, and the results were less than the minimum detectable activity. This would indicate infrequent use of U-235.

- U-235 (in vitro): SC&A used the "REXADM_EXC_RESULT" file to verify the 111 in vitro bioassays and their results, as presented on page 17 of the white paper. SC&A found the U-235 bioassays and results to be correctly stated. None were routine bioassays.

- U-233 (in vitro): SC&A used the "REXADM_EXC_RESULT" file to verify the 32 in vitro bioassays and their results, as presented on page 17 of the white paper. SC&A found the U-233 bioassays and results to be correctly stated.

- Np-237 (in vitro): SC&A used the "REXADM_EXC_RESULT" file to verify the 12 in vitro bioassays in 1989 and their quantitative results, as presented on pages 17 and 18 of the white paper. SC&A found the Np-237 bioassays and results to be correctly stated. The codes for the reason for the bioassays were all listed as "SP" for "special" in the REX database, indicating a potential incident as opposed to frequent use and chronic potential exposures.

Conclusion: Internal monitoring data 1984–1990

SC&A's analysis of the bioassay data in the REX database indicates infrequent bioassays for the ROCs and that, in general, bioassays for the ROCs were event driven. This would indicate that there was no large-scale usage of the ROCs; therefore, there was low potential for chronic exposures from the ROCs.

Overall Conclusions

SC&A concurs with NIOSH's overall conclusion that nothing has been found "contrary to the determination made in the SEC-00201 [evaluation report] that dose reconstruction was feasible from 1984 onward for employees of the prime contractor organizations, as defined in the SEC-00226 class definition" (NIOSH, 2020a, p. 6).

References

Gray, D. (1986). Event fact sheet contaminated filter tipped over resulting in spread of contamination in surrounding and adjacent work spaces. Retrieved from SRDB Ref ID 106089

Hikido, T. (1991). Occurrence report for contamination spread in SMF gallery [Pacific Northwest Laboratory RL-PNL-324-1990-0034]. Retrieved from SRDB Ref. ID 106091

Jarrett. J. H. (1990). Final unusual occurrence report [Pacific Northwest Laboratory PNL-89-07]. Retrieved from SRDB Ref. ID 106090

National Institute for Occupational Safety and Health (NIOSH). (2012). *SEC petition evaluation report Petition SEC-00201: Hanford Engineer Works* (rev. 0). Retrieved from https://www.cdc.gov/niosh/ocas/pdfs/sec/hanford/hanford201er.pdf

National Institute for Occupational Safety and Health (NIOSH). (2015a). *SEC petition evaluation report Petition SEC-00226: Hanford*. Retrieved from https://www.cdc.gov/niosh/ocas/pdfs/sec/hanford/hnfrder-226-r0.pdf

National Institute for Occupational Safety and Health (NIOSH). (2015b). *Hanford Site – Occupational internal dose* (ORAUT-TKBS-0006-5, rev. 06). Retrieved from SRDB Ref. ID 148938

National Institute for Occupational Safety and Health (NIOSH). (2020a). *Assessment of certain Special Exposure Cohort-related issues for the Hanford Site* [White paper]. Retrieved from https://ftp.cdc.gov/pub/FOIAREQ/179051_red-508.pdf

National Institute for Occupational Safety and Health (NIOSH). (2020b, May 21). *Information requested during the April 2020 working group meeting* [Memorandum from Charles Nelson, DCAS Health Physicist, to Bradley Clawson, Hanford Special Exposure Cohort (SEC) Working Group Chair]. Retrieved from SRDB Ref. ID 181257

Oak Ridge Associated Universities Team (ORAUT). (2013). Documented communication with former employees on Neptunium at PUREX in the 1980s, July 30, 2013. Retrieved from SRDB Ref. ID 132191

Oak Ridge Associated Universities Team (ORAUT). (2014). Documented communication SEC-00057 with William Decker about his employment with Hanford November 4, 2014. Retrieved from SRDB Ref. ID 141150

Oak Ridge Associated Universities Team (ORAUT). (2017). Documented communication SEC-00057 with Ed Adams on Hanford Team, June 28, 2017. Retrieved from SRDB Ref. ID 168562

Pacific Northwest Laboratory (PNL). (1981). Radiation surveys at PUREX facility. Retrieved from SRDB Ref. ID 109604

SC&A, Inc. (2011, August 19). *Remaining Hanford SEC issues for SEC Petition SEC-00057-2 and SEC-00152*. Retrieved from SRDB Ref. ID 178509

SC&A, Inc. (2013, April 24). *Update on review of SEC issues relating to Hanford SEC Petition SEC-00057-2 for the period January 1, 1984, to December 31, 1990* [Memorandum from Arjun Makhijani and Joe Fitzgerald to Hanford Work Group]. Retrieved from SRDB Ref. ID 178508

SC&A, Inc. (2019, Jan. 31). *Update summary of Hanford SEC issues: Th-232, HEU, U-233, Np-237* [Draft memorandum]. SRDB Ref. ID 180372