NIOSH Response to “SC&A Review [April 2023] of NIOSH Response [January 2023] to SC&A’s Supplemental Review of M&C Work Group Issues [August 2022]”

Response Paper

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Pat McCloskey, CHP, CIH
Mutty Sharfi, CHP, CIH
Nick Bailey
Oak Ridge Associated Universities Team

Reviewed by
Brant Ulsh, Ph.D., CHP
LaVon Rutherford, CHP
Timothy Taulbee, Ph.D., CHP
Division of Compensation Analysis and Support

INTRODUCTION

Since NIOSH completed the Special Exposure Cohort (SEC)-00236 Evaluation Report in 2017 [NIOSH 2017], NIOSH, SC&A, and the Advisory Board on Radiation and Worker Health, including members of the Metals and Control (M&C) Work Group, have conducted numerous follow-on discussions, meetings, and technical assessments regarding topics of interest identified by SC&A and Advisory Board members. This response paper addresses the most recent SC&A review in a series of response papers between SC&A and NIOSH, starting with SC&A's *Supplemental Review of M&C Work Group Issues* [SC&A 2022].

- On August 22, 2022, NIOSH received SC&A's *Supplemental Review of M&C Work Group Issues* [SC&A 2022].
- On January 13, 2023, NIOSH issued its response, *NIOSH Response to SC&A's Supplemental Review of M&C Work Group Issues* [NIOSH 2023], to SC&A's August 2022 supplemental review.
- On April 25, 2023, NIOSH received SC&A's response, *SC&A Review of NIOSH Response to SC&A's Supplemental Review of M&C Work Group Issues* [SC&A 2023], to NIOSH's January 2023 review.

This NIOSH response paper addresses M&C Work Group concerns about NIOSH's ability to bound doses associated with (1) the effects of a coagulant on the source term, (2) the aerosolization of drain line contamination, and (3) work in confined spaces. Below, NIOSH presents the concerns that SC&A identified in their latest response, *SC&A Review of NIOSH Response to SC&A's Supplemental Review of M&C Work Group Issues* [SC&A 2023] as new or not addressed and follows each with a response. Beyond responding to SC&A's latest review, as agreed during the May 12, 2023, M&C Work Group meeting, NIOSH has provided additional information concerning intrusive activities and dose potential that can be used to augment Table 1 in SC&A's *Supplemental Review of M&C Work Group Issues* [SC&A 2022, PDF p. 16]. Additionally, NIOSH has responded to M&C Work Group concerns raised during recent meetings, including concerns identified in the M&C Work Group presentation at the August 16, 2023 Advisory Board on Radiation and Worker Health meeting.

Note: NIOSH has added bold text throughout this document to show emphasis.

EFFECTS OF COAGULANT ON SOURCE TERM

SC&A Comment – Atomic Weapons Employer (AWE)-Related Coagulants in Drain Lines

> *The release of nonradioactive coagulant oil to drain lines was done separately from any HFIR operational radioactive releases and may have had a collateral influence on how AWE-related uranium and thorium contamination already in the piping would have concentrated over the years following those original discharges. In fact, in its response, NIOSH supports this interpretation by making the case that "wire operations during the*

> *residual period did not process radioactive materials; therefore, most material rinsed into the drains was non-radioactive except for residual contamination that remained in cracks and crevices" (NIOSH 2023, p. 12). SC&A agrees with NIOSH that the wiring operations did not contribute radioactive materials to the drain lines. It was the coagulant oil itself that may have consolidated the uranium and thorium already entrained in the pipes ("cracks and crevices") that would have impacted the covered AWE material from prior years (the resulting sediment would not have been distinguishable between AWE and HFIR residual contamination).* [SC&A 2023, PDF pp. 7–8]

NIOSH Response – AWE-Related Coagulants in Drain Lines

There appears to be a misinterpretation of the following NIOSH statement:

> *More specifically, wire operations during the residual period did not process radioactive materials; therefore, most material rinsed into the drains was non-radioactive except for residual contamination that remained in cracks and crevices, **as shown in the following figures**.* [NIOSH 2023, PDF p. 17]

Although it is still possible that there were cracks and crevices within the drain lines as SC&A describes, NIOSH refers to the low-level contamination that remained in the cracks and crevices *under the wire machines*, as shown on the subsequent pages in Figures 1 and 2 of NIOSH [2023, PDF pp. 18–19].

SC&A Comment – Coagulant Concentrations and Maintenance Workers

> *The AWE sediment was clearly present within the system following the cessation of AWE operations; any later introduction of oil-based coagulant solutions within that system may have collected and concentrated the uranium and thorium already present in that system and led to higher sedimentation to which M&C maintenance workers would have been exposed. This concern represents a new issue that has not been addressed.* [SC&A 2023, PDF p. 8]

NIOSH Response – Coagulant Concentrations and Maintenance Workers

The following excerpts from an interview with a [redacted] that worked from [redacted] provide some insight into M&C's issues with coagulant:

> *Mr. McCloskey: Let's go back to those roof drains. We understand that those drains that came down from roof were, for the most part, cast iron.*
>
> *Worker #7: Yes, for the most part they were cast. They went out to Building 11. They were routed out there. There was a pond out there. Do you know how I know that? The*

Wiredrawing line with the wire mill had that green lube in it. The motors were in a pit in the floor. They asked, "What are we going to do about the rainwater? Well, when we have a flood, we'll just pump it into roof drain and let it go out with the clean water." They had a malfunction in the wiredrawing machine, and it filled that up with green lube. I came in one morning and the pond was green. The fountain was green. [Redacted] was the VP at the time, so I had to go tell him that the pond was green. [ORAUT 2017, PDF pp. 12–13]

Mr. McCloskey: This photo shows where they took out the concrete floor in Building 10. This might have more meaning for you. This photo is of the Priority One Drains that were underneath the ground right in this area.

Worker #7: This is where the M125 was. There was a big tank in the ground here.

Mr. McCloskey: How deep was it into the ground? Was that the 6-foot by 6-foot tank?

Worker #7: No, that was a big tank. They used that for the Wire Drawing. This tank was already here for the M125. What happened was, instead of putting another tank in that had the capacity for both machines, we dug a trench through here, and behind Building 10 to pipe this all the way over to the Beckett Line. That's where they mixed the green goop. [ORAUT 2017, PDF p. 17–18]

Although these excerpts do not directly address SC&A's concern, they do reveal that this maintenance supervisor may know additional details worth pursuing. In addition, this worker also indicated the Beckett (aka Beckhart) line was installed in 1983–84, which is after all radioactive work ceased. This machine was a major source of coagulants to Area 9 drain lines in Building 10; therefore, NIOSH may ask this worker follow-up questions to ensure appropriate details are incorporated into the M&C Technical Basis Document (TBD).

As part of incorporating concerns related to the presence of coagulants in drain lines into the TBD, NIOSH will:

- Identify the locations of wire machines in Building 10 and overlay their locations above the drain lines to indicate their distance from Priority 1 drain lines.
- Mark-up the drain lines with flow paths to determine which lines were downstream of the coagulant sources (*i.e.,* wire machines).

The drainage system consisted of 4-inch floor drains and feeder lines at various locations above the subsurface drainage system. They flowed to 4-inch vitreous clay (VC) and 4-, 5-, and 6-inch cast iron (CI) lines (referred to as arterial lines) located 2 to 3 feet below facility grade. These arterial lines typically ran from north to south or south to north, and usually flowed into east-west lines of 6 to 12 inches in diameter (referred to as main lines). Main lines were routed to a lift station, followed by discharge into a stream channel running from the facility [Weston 1996a, PDF p. 168].

NIOSH will also consider the following:

- Weston could have noted and collected coagulant when they characterized the drain lines, as described in the following. "After pipes were opened, a sample of the sediment **or other residue** in the pipe was collected and submitted for isotopic and/or total uranium analyses" [Weston 1996b, PDF p. 11]. For example, the clay pipe with the highest interior surface contamination (1,000,000 disintegrations per minute [dpm]/100 cm^2) "did not contain a visible accumulation of residue" [Weston 1996b, PDF p. 11].

- The airborne hazard associated with cleaning clogged pipes was minimal because the material was wet, and the presence of coagulants functioned as glue, effectively locking/fixing contamination in place along the pipe's interior surfaces. These conditions significantly reduced the resuspension and respirability of the source term, eliminating the coagulant concern from consideration as a bounding internal dose scenario for NIOSH to incorporate. The fixed contamination could be an external contributor that NIOSH's external dose model will address. NIOSH requests SC&A to supply a technical justification showing that a coagulant can function as both a substance that is sticky enough to clog drains **and** allow resuspension of respirable particles.

- NIOSH's experience with surface contamination indicates it would either travel through and exit the system or become fixed such that an aggressive decontamination technique would be required to move it through the system. NIOSH performed a literature search to confirm SC&A's assertion and studied vegetable/mineral oils to determine their physical properties (e.g., pH) to see if they possessed solvent properties sufficient to mobilize a fixed contaminant and accumulate it downstream. NIOSH did not find any supporting information in the technical literature. If SC&A is aware of such information, NIOSH will consider it.

Using the best science available to generate its models, NIOSH has determined that it can describe plausibly, and bound exposures associated with unclogging pipes while accounting for the effects of introducing a nonradioactive coagulant to the drain line source term.

AEROSOLIZATION OF DRAIN LINE CONTAMINATION (1,000,000 dpm/100 cm^2)

SC&A Comment – Cleaning/Cutting Drain Lines

> *Another historical aspect of M&C drain lines is the accumulation of contaminant scale that has plated out inside the piping. This scaling was found in at least one instance at M&C to exceed 1,000,000 dpm/100 cm^2 in a 4-inch mainline drain that was being cut and removed (NIOSH, 2021a, p. 7). While such pipe scale has been identified at other AWE sites, M&C maintenance workers frequently cut, repaired, replaced, and cleaned out such piping during the residual years using power tools such as saws, drills, grinders, and powered snakes, as well as cutting torches.* [SC&A 2022, PDF p. 22]

NIOSH Response – Cleaning/Cutting Drain Lines

SC&A begins the paragraph above discussing drain lines, which NIOSH and SC&A agree represent the most significant source term.

Regarding the following SC&A excerpt from above:

> *M&C maintenance workers frequently cut, repaired, replaced, and cleaned out such piping during the residual years using power tools such as saws, drills, grinders, and powered snakes, as well as* ***cutting torches****.*

The drain lines of concern were either cast iron or clay and would have been cut with a snap-cutter or saw and not routinely cut with torches. There *were* other services that traversed the subsurface (e.g., airlines, recirculation piping); however, NIOSH does not consider work performed in the subsurface at a distance (>5 ft) from the drain lines to represent the bounding scenario. This is discussed below under the "NIOSH Response – Confined Spaces and Work Not Associated with Drain Line Cleaning" heading.

SC&A Comment – Bridgeport Brass Hazard Assessment (Torch Cutting)

> *…As noted by DOE in its hazard assessment of the Bridgeport Brass AWE, "the residual uranium could eventually be released . . . through intrusive work activities such as pipe cutting and removal" (DOE, 1996, PDF p. 11), and that "it is possible that under certain conditions (such as cutting through a* ***steel*** *pipe with a cutting torch) surface activity attached to the* ***steel*** *could be released with the* ***steel*** *particles" (DOE, 1996, PDF p. 48).* [SC&A 2022, PDF p. 22]

NIOSH Response – Bridgeport Brass Hazard Assessment (Torch Cutting)

The excerpt above shows why the reference provided by SC&A is concerned with the torch cutting of drain lines, and since M&C's drain lines were not steel, NIOSH did not select torch cutting of drain lines as a bounding scenario.

NIOSH reviewed the U.S. Department of Energy (DOE) Bridgeport Brass AWE Hazard Assessment [DOE 1996] referenced by SC&A to determine the types of pipes that were cut with torches and found the following:

> *Many of the drain lines at the GM site are constructed of **carbon steel**. It is unlikely that contamination could penetrate uniformly as deep as 1 cm into **carbon steel** (or even clay tile pipes).* [DOE 1996, PDF p. 47]

SC&A Comment – Bridgeport Brass Hazard Assessment (Pipe Cutting)

> *NIOSH fails to address the source of this concern: the U.S. Department of Energy's (DOE's) Bridgeport Brass AWE hazard assessment, where it was warned that pipe cutting involving internal radioactive contamination could lead to airborne releases that may involve worker exposure (DOE, 1996, PDF p. 48).* [SC&A 2023, PDF p. 8]

NIOSH Response – Bridgeport Brass Hazard Assessment (Pipe Cutting)

NIOSH reviewed the complete Bridgeport Brass Hazard Assessment [DOE 1996] referenced by SC&A and found the following:

- DOE assessed the potential exposure to residual uranium located in the extrusion press pits, the oil collection system (including manholes, sumps, and drain lines), and the former floor drains [PDF p. 32].
- The maximum U-238 concentration was reported as 21,000 pCi/g (Manhole 2) [PDF p. 29] and a maximum surface contamination level of 1.3 million dpm/100cm^2 (Drain Line C) [PDF p. 26].
- Routes of exposure for a maintenance worker included direct exposure to external gamma radiation, inhalation of contaminated dust, and ingesting contaminated material during intrusive work activities below the building floor [PDF p. 33].
- It was assumed that workers could be exposed through participation in large-scale renovation operations at the facility, including partial demolition of the building, removal of part of the floor, or removal of selected portions of the old underground drain system [PDF p. 33].
- Two job categories: non-routine maintenance worker and future renovation worker. The non-routine maintenance worker category assumes 23 working days per year and the renovation worker category assumes 71 [PDF p. 36].
- Mass loading was assumed to be 1E-4 g/m^3 (100 µg/m^3). The respirable fraction was assumed to be 30% [PDF p. 36].
- The estimated worst-case exposure calculated for maintenance workers was 30 mrem/year. For renovation workers the dose estimate was 43 mrem/year [PDF p. 44].

- Respiratory protection was not considered in the dose estimates [PDF p. 49].

As shown in Table 1 below, the ratio of assigned dose to source term level using the Bridgeport Brass reference SC&A recommended compares favorably to that proposed for M&C.

Table 1: Max Source Term and Annual Total Effective Dose for Bridgeport Brass and M&C

Site	Max Source Term (pCi/g)	Annual Total Effective Dose (mrem)
Bridgeport Brass	21,000	43
Metals and Controls	53,224	120

SC&A Comment – Systemic or Isolated Drain Line/Pipe Scale (1,000,000 dpm/100 cm^2)

> *NIOSH contends that cutting of drain lines with contaminated **scale** exceeding 1,000,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) would constitute "isolated hot spots," not a systemic condition, and that in any case, it does not believe there is any evidence that even higher activity levels might have existed.* [SC&A 2023, PDF p. 8]

NIOSH Response – Systemic or Isolated Drain Line/Pipe Scale (1,000,000 dpm/100 cm^2)

SC&A's line of inquiry about pipe scale stems from a misinterpretation of one survey indicating a contamination level of 1,000,000 dpm/100 cm^2 found in the Screen Print Room (Area 7). The following is from SC&A's *Supplemental Review of M&C Work Group Issues*:

> *Another historical aspect of M&C drain lines is the accumulation of contaminant **scale** that has plated out inside the piping. This **scaling** was found in at least one instance at M&C **to exceed** 1,000,000 dpm/100 cm^2 in a 4-inch mainline drain that was being cut and removed (NIOSH, 2021a, p. 7).* [SC&A 2022, PDF p. 22]

The Weston [1996b] drainage system characterization does not identify any scale found at the location SC&A references [PDF pp. 10–11]. As NIOSH previously noted, this drain line was clay; scale/rust is associated with cast iron drain lines. To further clarify, this pipe had contamination levels **as high as** 1,000,000 dpm/100 cm^2 and was cut and removed by Weston decontamination and decommissioning (D&D) workers, not as part of M&C maintenance work.

SC&A Comment – Systemic or Isolated Drain Line/Pipe Scale (Additional Survey Evidence)

> *NIOSH presents no evidence that this contaminated scale would not have been present elsewhere in the piping system, could have involved both metal and clay pipes, or that*

> *even higher activity levels may have been present elsewhere in the pipe network.* [SC&A 2023, PDF p. 8]

NIOSH Response – Systemic or Isolated Drain Line/Pipe Scale (Additional Survey Evidence)

NIOSH relies on the available source-term survey data because of the comprehensiveness exercised by Weston and Texas Instruments as indicated in the following December 1994 statement:

> *The Tl Environmental Department, its consultants, and retained counsel performed a review of historical documents including reports, drawings, maps and photographs, previous radiological surveys, and interviewed selected employees who had knowledge of past nuclear operations in order to identify any open land areas and building interiors that had the potential for residual contamination. Details of this review are contained in TI files. The results of this review are reflected in the supplemental survey design, Sections 3.0 to 7.0, as it influenced the selection of areas and methods for further study.* [Texas Instruments 1994, PDF p. 29]

Regarding existing scale data, Weston executed intrusive drain line sampling according to their Sampling and Analysis Plan (SAP) submitted to the Nuclear Regulatory Commission (NRC) in July 1995. The SAP provided a method to identify contamination on the concrete floor and underlying soils within the 8000 ft^2 Building 10. In addition to the systematic sampling prescribed by NUREG/CR-5849, Weston collected **biased** samples at "cracks or other locations across the grid exhibiting elevated surface activity measurements" [Weston 1995, PDF p. 6].

Weston reported collecting scale samples at locations 2, 3, 4, and 5 [Weston 1996b, PDF pp. 15, 17] that provide contamination data as high as 507.7 pCi/g [Weston 1996b, PDF p. 18]. In addition, NIOSH has the following information:

- In the Caged Area (Areas 1 and 4 where the fuel rod was found), radiological surveys of this piping typically showed marginal surface contamination on the interiors of the pipes, typically ranging from less than 3000 dpm/100 cm^2 [Weston 1996b, PDF p. 10].
- Locations 4 and 5 accessed lines that had previously supported assay laboratories associated with nuclear material manufacturing activities. Sampling and visual observation confirmed that these lines had little to no residue accumulation. Analytical data for both CI lines showed a total uranium concentration of approximately 500 pCi/g in the thin layer of scale [Weston 1996b, PDF p. 17].
- Areas 3 and 4 were identified as having scale and rust with a total uranium concentration of 1,864 pCi/g [Weston 1996a, PDF p. 174].

In addition, NIOSH can use Weston [1996b] Table 3, Building 10 Feed Drain Surveys [PDF p. 21], particularly the beta scintillator data as scale activity measurements, because Weston [1996b] states:

> *Prior to use of the 1-inch by 1-inch sodium iodide system, a Ludlum Model 44-1 beta scintillator/Model 2221 scaler/ratemeter was used in 8 to 10 feed lines. Although the geometry of this system is not optimal for detecting large accumulations in or around pipes, it is adequate for identifying contaminated scale within the line.* [Weston 1996b, PDF p. 12]

M&C also developed a method to calculate surface contamination levels on pipe interiors using the thickness of residue lining the pipes and the total uranium concentration in the residue. Both parameters were determined using samples for representative sections of the drain lines. Sampling methodologies, frequencies, and locations are discussed in the 1997 Texas Instrument drainage supplemental analysis report (Appendix 1) [Weston 1997a, PDF p. 11]. Using the method described in Weston [1997a], additional data are available to NIOSH, including drain calculations with conversions to surface activity where total surface contamination levels prior to decontamination ranged from 53,000 to 95,000 dpm/100 cm^2 [Weston 1997a, PDF pp. 13, 15].

In summary, neither SC&A nor the M&C Work Group has provided any evidence explaining why these surveys are not a suitable basis for NIOSH's bounding source term. This issue boils down to a demand that NIOSH prove a negative (*i.e.*, prove something did not exist). NIOSH has cited credible evidence to support its calculations. Assertions that there could have been other higher contamination levels—with no supporting evidence—rely on speculation. NIOSH's model using the pre-D&D survey that included a fuel pin in the pipe is the highest plausible bounding scenario. NIOSH has not received any technical evidence contradicting the use of this survey in a bounding model.

SC&A Comment – Bounding Exposure Pathway

> *NIOSH's reliance on "mass-based sample data" and "soil-sampling plans" does not address the simple question raised: Given that an AWE hazard assessment raised this general worker exposure concern, can this* [1,000,000 dpm/100 cm^2] *potential exposure pathway at M&C be characterized and bounded? This concern represents a new issue that has not been addressed.* [SC&A 2023, PDF p. 8]

NIOSH Response – Bounding Exposure Pathway

NIOSH used the source term concentration calculation from the Bridgeport Brass AWE Hazard Assessment [DOE 1996], recommended by SC&A, to calculate an inside subsurface dose that incorporates the million dpm survey value that can be used to model cutting through a contaminated pipe.

DOE [1996, PDF p. 47] shows:

$$pCi/g = (SC \times CF)/(T \times \rho)$$

where

SC = source concentration in dpm/cm^2

CF = conversion factor of 0.45 pCi/dpm

T = thickness of surface activity (cm)

ρ = density of contamination

using

1,000,000	dpm/100 cm^2
10,000	dpm/cm^2
0.45	pCi/dpm
0.1	cm
1.5	g/cm^3 (density)

$$pCi/g = (10{,}000 \times 0.45)/(0.1 \times 1.5)$$

This calculation shows that adding this one survey result to NIOSH's other subsurface data will increase maintenance worker dose from 71 to 96 mrem committed effective dose (CED).

This adjustment is based on only adding the single value (1,000,000 dpm/100 cm^2) to NIOSH's dataset. According to Weston [1996b], this was the highest surface contamination value, and as shown above, additional data are available. Therefore, adding this single value biases the dataset in a very claimant-favorable way (*i.e.*, it increased the 95th percentile by almost a factor of 2). NIOSH has determined that it has methods for incorporating surface contamination data into a bounding method, eliminating the aerosolization of drain line contamination as an SEC issue.

WORK IN CONFINED SPACES

SC&A Comment – Routine Drain Line Repair in Pits or Trenches (Six Month Occupancy)

> *As emphasized in former worker interviews, it was not uncommon to be working in a trench doing routine utility repairs or pipe cleanouts for days and up to a week (NIOSH, 2017c, pp. 1–2). One installation project in Building 10 involved the cutting out of an existing drain line and installation of new equipment, piping, and large tanks, necessitating a trench 100 feet long, with a depth of 8–10 feet in places, that was worked in for 6 months in 1983–1984 (NIOSH, 2017d, p. 11).* [SC&A 2023, PDF p. 9]

NIOSH Response – Routine Drain Line Repair in Pits or Trenches (Six Month Occupancy)

There appears to be some misinterpretation in SC&A's description of work performed in confined spaces that requires clarification. SC&A stated that M&C workers were performing confined space work for six months, presumably to install the Beckett line mentioned in the following interview excerpts from a [redacted] who worked from [redacted]:

> *Mr. McCloskey: If someone needed to cut into the floor, was there attention given to it by Health and Safety people who would evaluate the work that you were going to do—to say we need to think about the dust you're going to create when you cut the concrete?*
>
> *Worker #7: No. The only time we used to call Health and Safety was for confined space entries. They would have to do air sampling because we had a lot of trichloroethylene in the early days, and that's heavier than air. So, if there was a pit—some of the slitting equipment had pits. Some of them were 18- to 20-feet deep—cement pits with lights in them, and the control loops on slitters. If we had to go down there and change the lights, we had to get Safety to come over and do air sampling for chemicals or whatever. Then you would have to wear a harness…*
>
> *Mr. McCloskey: So, the only reason to call Safety would be if you were going down into a deep pit. But if you were going to be cutting concrete to access some soil, you were not going to call Safety unless you were going to go down into a deep pit where you had to do air monitoring?* [ORAUT 2017, PDF pp. 7–8]

The exchange above implies M&C would impose confined space controls at times, but did not consider concrete penetrations and subsurface work to be a confined space entry.

> *Worker #7:* ***We would have somebody come in*** *and cut two lines in the floor, and then would jackhammer it out, dig a trench, lay some pipes, cover them over, put sand in and compact it, and then re-cement it.* [ORAUT 2017, PDF p. 8]
>
> *Mr. Darnell: So, the process was that you would go and get the snake first…*
>
> *Worker #7: Yes.*
>
> *Mr. Darnell: … and then the power snake.*
>
> *Worker #7: Yes.*
>
> *Mr. Darnell: Would the next step be to cut the cement, and going in with the power snake?*
>
> *Worker #7: Well, after Facilities and R&M, it would be Facilities going in and doing whatever they had to do to fix it.*

Mr. Darnell: How often would you get to that third stage? Did the first two stages took care of it 50% of the time, or ***60%*** *of the time, or…?*

Worker #7: ***Probably more than that****, but there were times when they had to get the floor up and replace pipes.* [ORAUT 2017, PDF p. 9]

Mr. McCloskey: So, the lines coming down from the roof are mostly 4-inch cast iron. We have heard that the lines underneath the floor servicing the floor drains are vitreous clay.

Worker #7: I'm not sure what they are under there, because I've never dug them up. I have never cut them out. That was somebody else's problem.

Dr. Mauro: When that happened, was that a relatively rare occasion, maybe ***once a year*** *when someone had to go down and do that special job?*

Worker #7: ***Probably****.*

Mr. McCloskey: If we looked at the floor of Building 10 in 1990, how many sections of floor would we see that were cut out?

Worker #7: The whole Beckett Line was cut out. That's right here.

Mr. McCloskey: It was cut out so you could install new equipment, not so you could clear out drains. So, you cut out the concrete. What do you do after you cut out the concrete?

Worker #7: You dig down to whatever level you needed because that was all trenches installed behind the Beckett. All of the piping was put in the floor. Then there were a couple of tanks put in for the annealing solution that pumped in the solution.

Mr. McCloskey: How big were the tanks?

Worker #7: I would say they were 6 feet by 6 feet by 6 or 8 feet deep. [ORAUT 2017, PDF p. 13]

Worker #7: When the Beckett was installed, the ground was probably open for six months. I was [redacted], so I'm going to say that was around 1983 or 1984.

Mr. McCloskey: Would that have been six months active work with people in the hole? Would you be waiting for equipment to arrive?

Worker #7: From the time you cut out the concrete, dig out the trenches, form everything up, and relocate whatever pipes you hit—and you hit stuff because the trench ran the whole length of the machine…

Dr. Mauro: How big was that?

Worker #7: From the spooler back, it was five bays. I'll say 100 feet. [ORAUT 2017, PDF p. 13]

This appears to be where SC&A stopped and took their information; however, reading further, the transcript includes the following excerpts:

Dr. Mauro: So, you're opening up a place in the floor that's 100 feet wide. How wide?

Worker #7: It varied. They only cut 6 feet wide where the tank was, and then there's probably a 4-foot wide trench there. So, to form it they probably had to go out 12 feet to form it.

Dr. Mauro: And how deep?

Worker # 7: Well, they probably went down 10 feet for the tank. Then they had to ***put in clean soil*** *and compact it, and build it up from there.*

Dr. Mauro: Would they have done that with a shovel?

Worker #7: No, with a backhoe.

Dr. Mauro: So, you had a backhoe that would reach down into the dirt. What did they do with the old dirt?

Worker #7: They took it away.

Dr. Mauro: Was there a place where they dumped it?

Worker #12: I have no idea. They had a contractor come in. I think that it was Swanson Construction, because [redacted] worked for them.

Mr. McCloskey: Did they bust concrete too, and then excavate?

Worker #7: That went out for bids. ***Swanson Construction cut the concrete and dug that up****.*

Mr. Darnell: Did you ever hear of a company called Cut-Rite?

Worker #7: ***They used to come in all of the time to cut the floors****. Swanson could have Cut-Rite come in and cut the floors. Cut-Rite was onsite all the time for us.*

Mr. McCloskey: We have heard that the water table was pretty high around there. The hole for the Beckett installation was pretty deep. Did they encounter water during that dig?

Worker #7: Sometimes, ***they put pumps in to keep the water down while they were working****.*

Dr. Mauro: This information about digging is important to us. I'm a radiation guy. I can visualize that there's a guy going down there to do what he has to do; and sometimes, they kick up dust. If it's wet, there's not going to be too much dust coming up. But, if it's dry, then the guy can inhale it. Do you remember, or can you visualize these guys wearing dust masks or deliberately wetting down the soil to keep the dust down? When the backhoe brought it up, was it dusty or was it so wet that there wasn't a problem?

Mr. McCloskey: Did they have to relocate people from that area?

Worker #7: When they saw-cut, that's a wet process any way. So it's wet, but you end up with that powdery residue when it dries.

Ms. Gogliotti: You talked about jackhammering too. Didn't you?

Worker #7: That was for small trenches, but when they take out big sections of floor square, they square it. They cut all four sides, and then heavy equipment lifts it and carts it off. [ORAUT 2017, PDF p. 14]

Note: Maintenance workers only jackhammered for small jobs.

Dr. Mauro: This question is about the excavation, and about all of the people who worked for M&C and Texas Instruments who were reporting to you. Did a lot of them spend a lot of time in the hole—in the ground?

Worker #7: It depends. We did our own electrical work. ***We contracted the digging. They went in and did the digging, and then we did the electrical****. If it was a union job, then we couldn't go in the hole.*

*Dr. Mauro****: In any given year, did you have any guys who spent 3, 4, or 5 months in a hole?***

Worker #7: ***No, maybe a week. Out of the year, you dig up this and*** that. *Most of the time, we were putting the pipes in, throwing sand over them, and secure them. Then the contractor would come back, fill it in or compact it, and build it up from there.*

Worker #7: If we couldn't get it out with a snake, it would wait until the next day and Facilities would do it. Once I was in [redacted], if it was during the day, by then there *was an R&M and Facilities, so if it was a floor drain problem, they would automatically call Facilities.* [ORAUT 2017, PDF p. 18]

Dr. Mauro: ***Were there people who worked there that spent more than one week per year in a hole?***

Worker #7: ***Probably, especially in facilities****.*

Dr. Mauro: Do you have a feel for how long?

Worker #7: When we installed equipment, a lot of the services had to be in the floor because of the overhead cranes. Most of the time when we were in a hole in dirt, it was because we were installing something.

Dr. Mauro: ***Could some people have been down in there for a month, or maybe two months per year?***

Worker #7: ***I would think that a month to repair a floor drain would be unacceptable****.*

Dr. Mauro: The reason that we ask these things is that these were people who would have had more potential for radiological exposure. The more time that someone spends down in a hole kicking up dirt working in that situation, the more inhalation there will be. ***The take away that I am getting is that there probably people who spent a lot of time working down in the dirt, but it probably wasn't more than two months. There may have been 200 or 300 hours when he may have been working inside a hole, but probably wasn't the rest of the time****.* [ORAUT 2017, PDF pp. 18–19]

Worker #7: As far as the soils, most of our involvement was when we were installing equipment. We would dig the foundations. When we did PT4, we started that up in 1978 between Buildings 10 and 4. That was an addition. I was running [redacted] then. We worked out there for a year, but it was ***mostly on concrete****. (Sounds like) West Bar Construction did the building. We did the foundation.*

Mr. McCloskey: So, the dig lasted a long time, but that was done by contractors. By the time you did your install, you were on concrete.

Worker #7: Yes. They had to put the foundation in for the building. They had to do the foundations for the equipment, and then they had to bring the equipment in to install it before they built the building around it because it was too big to fit through a door. That's the way that it was done.

Mr. McCloskey: So, that was a long, drawn out process. Do you remember any issues with it?

> *Worker #7: No. That was all typical stuff for us. Dig a big hole, put in the floor drains, pour the concrete, everything.* [ORAUT 2017, PDF p. 20]

The main points from the worker interview include the following:

- Maintenance workers using a snake while standing on the undisturbed concrete floor, addressed probably more than 60% of clogged drains (*i.e.*, primary source term).
- "Stage 3" excavations, (*i.e.,* when the snake did not work), happened approximately once a year.
- Contractors, not maintenance personnel, cut the concrete using a wet process and excavated the hole for the Beckett Wire machine with a backhoe.
- A pump was needed to remove the water from the wet subsurface environment.
- Once excavated, the contractors lined the hole with clean dirt, and M&C workers installed the equipment on top of the clean fill.
- Of the various M&C groups, Facilities personnel spent the most time performing subsurface work, which amounted to less than two months per year.

SC&A Comment – Confined Spaces Standard

SC&A previously supplied a confined space definition:

> *OSHA defines confined spaces and cites examples including pits, tanks, silos, maintenance holes, sewers, enclosed drains, and manholes (NIOSH, 2022b). OSHA notes that pits, although typically open on top, can be completely underground or below grade and can still be a confined space (OSHA, 2015). Supporting industry literature following promulgation of the Subpart AA standard noted that confined spaces "include tight work areas with reduced air flow" where work such as "welding, cutting, grinding, sanding or any high-energy activity can create . . . respirable particles and/or toxic aerosols (Chase, 2019)."* [SC&A 2022, PDF p. 33]

NIOSH Response – Confined Spaces Standard

Although there were confined spaces at M&C, the concern within the EEOICPA program is only for those with a radiological hazard. The source term of primary concern at M&C was the drain lines in the subsurface of Building 10. The Weston [1996b] drainage system characterization describes that system as follows:

> *Buildings 4 and 10 drainage systems consist of 4-inch vitreous clay (VC) and 4, 5, and 6-inch cast-iron (CI) lines (referred to as "arterial lines")* ***located 2 to 3 feet below facility Grade****.* [PDF p. 7]

Considering the Weston [1996b] statement above, NIOSH does not consider a Facilities worker spending two months during a particular year working on a drain line in such a shallow hole to have performed that work in a confined space.

For the remaining 40% of the time when the snake would not work, workers had to dig ~3 feet to access the clogged pipe. A safety professional would not control this work as a confined space entry, especially in an industrial facility with active ventilation. The hole is too shallow to "include tight work areas with reduced air flow" as the reference SC&A provided above states. Furthermore, as pointed out in the *SNM License Termination Radiological Dose Assessment*, "Scenario assumptions for ventilation and work times understate the true dilution effects of ventilation" [Weston 1997b, PDF p. 14]. M&C had two exhaust fans that ventilated and removed air from Building 10. One ventilation stack equipped with a high-efficiency filter exhausted air from the press room at a rate of 616 ft^3 per minute (cfm), and another stack exhausted air from the furnace area at a rate of 500 cfm [Texas Instruments 1979, PDF p. 20].

Within the OSHA confined space standard, there are no strict definitions as to the exact depth required to designate, which allows room for professional judgment. However, standard practice indicates that safety professionals would not control a 3.5-foot-deep trench dug to service a drain line as a confined space. In general, work on the drainage system, identified as the worst-case exposure scenario for maintenance workers, would not have been performed within a confined space work environment.

SC&A Comment – Confined Spaces and Work Not Associated with Drain Line Cleaning

> *While the 1995 drain line sediment reading is a high concentration level, can it be applied as a bounding exposure for* ***unrelated*** *inside subsurface work (i.e., non-drain line cleaning) for which little, if any, information is available and for which confined space atmospheres were involved?* [SC&A 2022, PDF p. 22]

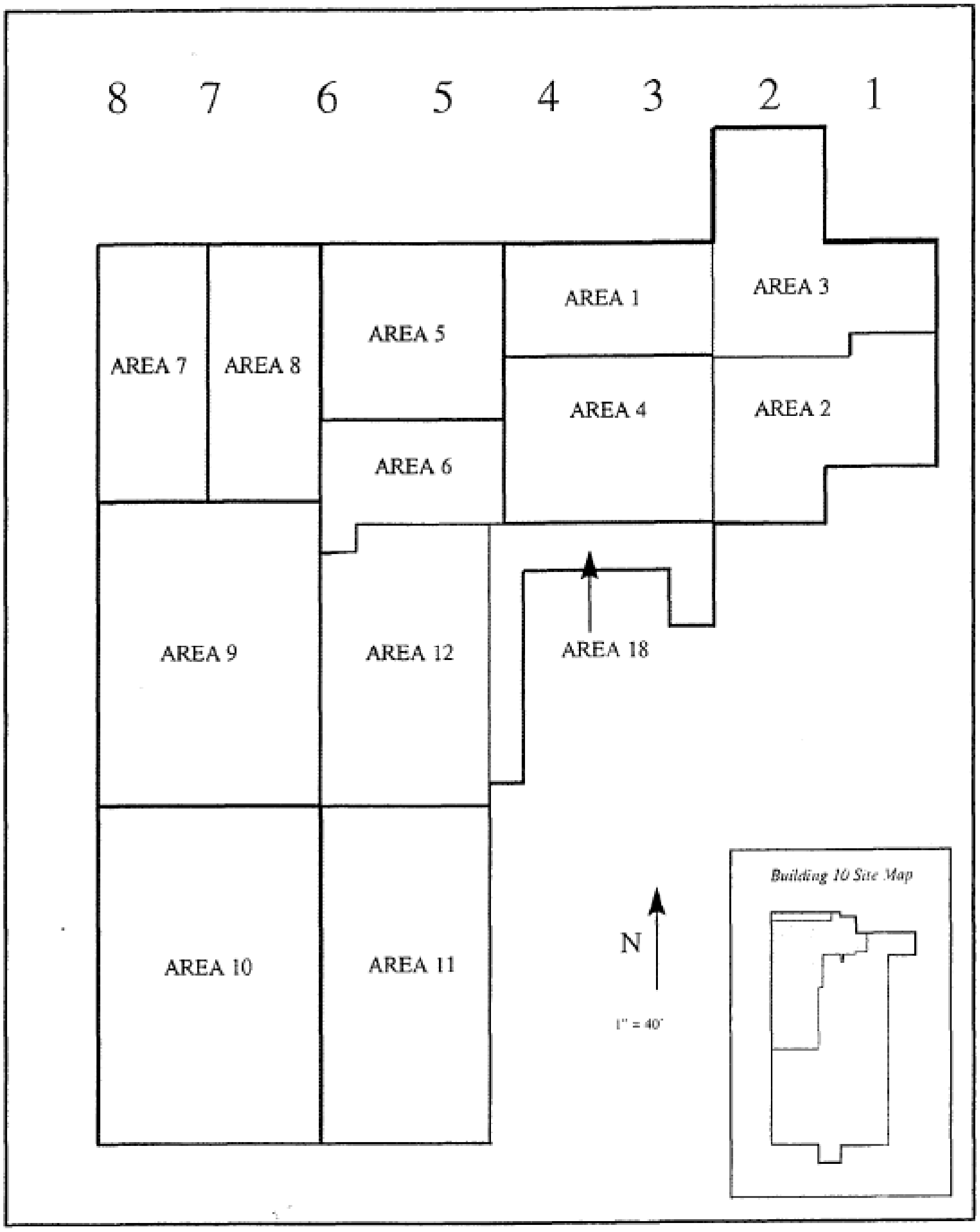
NIOSH Response – Confined Spaces and Work Not Associated with Drain Line Cleaning

NIOSH acknowledges there were confined spaces at M&C. However, the key consideration is whether there were **contaminated** confined spaces associated with the Building 10 subsurface where M&C workers incurred exposures that represent a plausible scenario for which NIOSH cannot bound doses. NIOSH finds:

- The pathway for contaminants to get to the subsurface was through the floor drains, and to a lesser extent, through cracks in the concrete when the floor flooded, and contaminants got washed into the subsurface.
- The subsurface is well described and shows that after contaminants flowed to the subsurface, they generally stayed within 5 feet of the drainage system network of pipes, which were approximately 3-feet deep.

Interviewees described subsurface work that included some confined space work; however, their recollections included work in other buildings and areas not associated with the source term. When workers **did** describe work in Building 10, they referred to the entire building and did not differentiate whether their work was in the part of the building that contained the source term of primary concern: Priority 1 drain lines. This is an important distinction because nuclear manufacturing operations were primarily performed in the northern third of Building 10, and support activities, including transportation and storage, were performed in the balance [Weston 1996a, PDF p. 10].

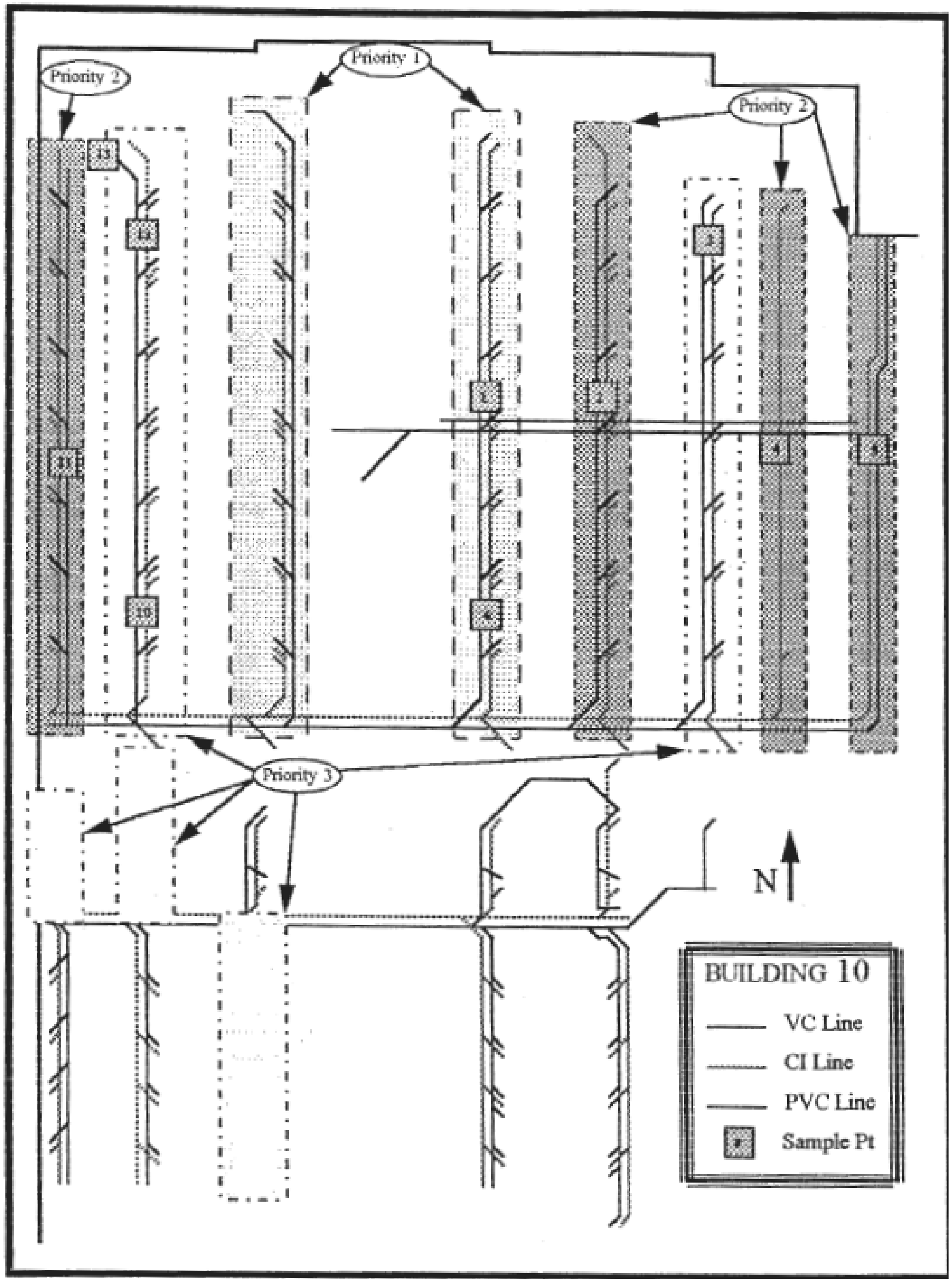
To elaborate, the area of Building 10 with the Priority 1 drain lines is small compared to the rest of the building. Although all of Building 10 was resurveyed in 1995, Figure 1 shows the portion that M&C determined would require further remediation.



Note: The scale indicates 1 inch = 40 feet in the original Weston [1996a] document.

Figure 1: Building 10 – Affected Areas [Weston 1996a, PDF p. 15].

This, 1/3 northwest portion of Building 10, is enlarged to show the location of the source term, Areas 1–12 and 18.



Note: ~1/8 inch represents 5 feet in the original Weston [1996b] document and is the extent of contamination migration from any drain line.

Figure 2: Building 10 Pipe Grouping for Uranium-235 Inventory Development [Weston 1996b, PDF p. 27].

When M&C did work in the northwest third of Building 10, considering that Priority 1 data dominate NIOSH's bounding model and that contamination did not migrate far into the subsurface environment, it should be noted that not all Building 10 work was associated with the higher contamination levels NIOSH uses to calculate a bounding model. The following excerpt describes contamination migration:

> *Based on observations during the 1996 remediation project, some wash water went into the Building I0 floor drains. Some portion of the water that entered the drains apparently leaked from the pipes depositing uranium in the surrounding soils. However, the uranium did not get into the ground water. Its travel in the ground had extended only about 5 feet from the pipes through the soil when it was excavated during site remediation. Tl measured this in 1996. This observation is explained by the geochemistry of uranium (see below). Tl excavated the uranium contaminated soil in 1996. Where acid is known to have been used to decontaminate non-nuclear materials (e.g., west side of Building 5), excavation also found that the uranium had traveled only a limited distance in the soil.* [Elliott 1997, PDF p. 40–41]

Whenever M&C workers accessed areas beyond 5 feet of the source term used in NIOSH's bounding model, they would have incurred exposures described in the following excerpts from *SNM License Termination Hypothetical Radiological Dose and Exposure Rate Assessment Priority 2 Drain Lines* [Weston 1997a] and *SNM License Termination Radiological Dose Assessment* [Weston 1997b].

> *The purpose of this dose and exposure rate assessment is to consider the potential radiological dose and gamma exposure to a hypothetical receptor as a result of exhuming Priority 2 drain lines at the Texas Instruments Incorporated (TI), Attleboro Facility.* [Weston 1997a, PDF p. 4]
>
> *The source term for this report is defined as the total inventory of radioactive material contained within the area occupied by exhumed Priority 2 drain lines. The source term was calculated based on radionuclide concentrations of residuals within the volume of the drain lines in place before hydrolasing decontamination (used for the pre-decontamination scenario)…*[Weston 1997a, PDF p. 4]
>
> *All possible environmental transport pathways for this dose assessment were used to perform the Priority 2 drain lines pre- and post-decontamination dose assessments. Pre-decontamination concentrations of residual total uranium in the drain lines were used to provide an upper bound for the exercise. Use of the concept of "bounding scenarios" provided streamlined final output dose assessment data and conclusions that can be used to support decision-making. When evaluating potential scenarios, it became evident that postulated doses from the Priority 2 pipes would be significantly higher than the Priority 3 drain lines. Analysis of potential doses from Priority 3 drain lines would result in significantly lower doses and is therefore unnecessary because the pre-decontamination scenario for Priority 2 drain would result in significantly higher doses.*

> *In developing the methodology for this hypothetical dose assessment, both current- and future-use exposure scenarios were evaluated. The current-use and future-use scenario analyses accounted for all potential uses for the hypothetical drain line source area, given that there was absolutely no corporate control of the TI site. The analysis identifies the activity with the highest dose potential as exhuming the entire lot of Priority 2 drain lines during a one-time maintenance activity.* [Weston 1997a, PDF p. 5]

> *The TEDE resulting from the proposed hypothetical scenario prior to decontamination of drain lines which represents the upper bound case is estimated to be 0.71 mrem in the first year after exposure. The inhalation pathway contributed 0.41 mrem, approximately 57% of the TEDE. Ingestion and direct gamma doses contributed 41%, combined.* [Weston 1997a, PDF p. 7]

> *During typical drain line maintenance in unaffected areas of the facility, workers are not significantly exposed to pipe interiors. Common handling involved removal and disposal of complete sections, or breakage to reduce volume.* [Weston 1997a, PDF p. 11]

> *Maintenance worker intrusion into any of the five source areas was selected as the bounding scenario for dose assessment. Further, the Building 4, 5, and 10 residual areas were selected as having the highest localized uranium concentrations and highest likelihood of worker intrusion resulting from building maintenance operations This scenario location was selected because intrusion would allow multiple exposure pathways including direct exposure to gamma radiation, inhalation of resuspended dust, and ingestion of contaminated soils…Under the current exposure scenario, Tl maintenance workers are assumed to excavate into contaminated areas within the Buildings 4, 5 and 10 interiors, which contain the highest concentrations of residual radioactive materials. Therefore, dose assessment using application of conditions associated with the building interiors is assumed to bound potential doses resulting from similar activities in any of the other four source areas outside the buildings. In the current exposure scenario, maintenance workers excavate a trench 10 m long, 3 m wide, and 1.5 m deep. Postulated environmental transport pathways associated with this scenario are described in Table 3. This maintenance is assumed to be performed twice per year.* [Table 3 omitted] *Postulated future uses of the site included continued performance of manufacturing operations in an industrial setting…*[Weston 1997b, PDF pp. 13–14]

To summarize, M&C evaluated exposures to maintenance workers using pre-D&D survey data, developed a bounding scenario for all work activities except those associated with Priority 1 drain lines, and calculated a dose of <1 mrem. Conservatively, NIOSH applies **its** model to **all** subsurface work at M&C, including work in most of Building 10 that was not associated with the Priority 1 drains.

Regarding SC&A's concern about other types of work, when M&C did perform other work, such as replacing large pieces of machinery, they (or contractors) dug deeper holes. There is some potential that contaminants migrated into some of those soils, especially if they were close to a drain line. However, NIOSH does not consider that work extensive enough to be selected as the plausible bounding scenario.

SC&A/Work Group Comment – Applying Mound Surrogate Data to Dust Loading Factor

> *NIOSH does not respond to the central question posed: In applying the Mound surrogate data to derive a dust loading factor, did they address confined space considerations? From a larger perspective, did they consider the impact of confined spaces on their modeled airborne resuspension of uranium and thorium? The answer appears to be "no" in both cases. Confined spaces represent a new issue that has not been addressed.* [SC&A 2023, PDF pp. 9–10]
>
> *…M&C maintenance workers doing subsurface work routinely had to snake out and repair (cut, saw, grind, weld) underground pipes. These routine components of M&C operations also created additional sources of radioactive dusts and particulates, beyond those from the (Mound-based) dust-loading. The current NIOSH bounding model does not appear to account for these and should.* [ABRWH 2023a, PDF p. 20]

NIOSH Response – Applying Mound Surrogate Data to Dust Loading Factor

The hazards associated with working in confined spaces are not new to the field of industrial hygiene and were also recognized by M&C personnel. NIOSH is committed to reviewing recent suggestions to upgrade its dust loading models, including enhancement factors and confined spaces, and will consider incorporating methods suggested by SC&A in their supplemental review. In addition, as discussed by SC&A in *SC&A Commentary on NIOSH's Approach to Quantifying Outdoor and Indoor Airborne Dust Loadings*, airborne contamination levels can be modeled (*i.e.,* bounded) up to a choking level [SC&A 2021, PDF p. 22], making the confined space effect on dust loading factors a TBD issue and not an SEC issue. This addresses SC&A's remaining issue with applying the Mound surrogate data to derive a dust loading factor.

ADDITIONAL INTRUSIVE ACTIVITY INFORMATION FOR TABLE 1, COMPARISON OF AWE SITES

In the *Supplemental Review of M&C Work Group Issues* [SC&A 2022], SC&A provided a table with the following five column headings: (1) AWE site, (2) source of exposure potential, (3) intrusive work activity (covered), (4) SEC class designated, (5) and reference. During the May 12, 2023, M&C Work Group meeting, NIOSH indicated it would provide information that could serve to update Table 1 with additional detail concerning intrusive activities and dose potential. The following table completes that action.

Table 2: Additional Information to Augment SC&A's *Comparison of AWE Sites* Table 1

AWE Site	Available Data for Residual Period	Intrusive Work Activities in the Residual Period	First Year Residual Period – Radionuclide(s) of Concern	First Year Residual Period – Internal Dose (mrem CED)
Carborundum (Residual period **NOT** added to the SEC)	Battelle-TBD-6000 default values and air data from the preceding operational periods	Lathe and diamond wheel grinding plant: "Very dusty and dirty environment. You always had to wash your face and hands at the end of the day. People wore dust masks and maintenance people wore blue uniforms" [ORAUT 2015, PDF pp. 4–5].	Uranium	3483
Baker Brothers (Residual period **NOT** added to the SEC)	First residual period: Battelle-TBD-6000 default values at the start and air data near the end of the period Second residual period: air data during the preceding remediation period	General machine shop maintenance [NIOSH 2012]	Uranium	229
Hooker Electrochemical (Residual period **NOT** added to the SEC)	Air data during the preceding operational period and surrogate air data	Construction and maintenance of 10" water line, 42" river water line, and outfall sewer line - portions both on and off AEC Property. Maintenance of the contractor's plant, CC2 laboratory, BNP plant, storage area, combined shops, locomotive shed, garage, men's change house, office building, general storehouse, material shed, and parking garage. Position descriptions for the contract include operation department superintendents who would oversee the maintenance of the chemical plant [AEC 1953; Hooker 1953, PDF pp. 2–3; Fry 1953; Hooker 1957; AEC 1958]	Uranium	13

AWE Site	Available Data for Residual Period	Intrusive Work Activities in the Residual Period	First Year Residual Period – Radionuclide(s) of Concern	First Year Residual Period – Internal Dose (mrem CED)
Chapman Valve (Residual period **NOT** added to the SEC)	Contamination and soil data toward the end of the residual period and back projected	Worker types included: mechanics, heat treaters, steamfitters, machine repairers, steam fitters, plumbing and general maintenance, electricians, milling machine operators, centerless grinder operators, portable grinder machinists, chipper machinists, assemblers, tool crib machinists, turret lathe operators, janitors, decontamination workers, firefighters, and general foremen [NIOSH 2006]	Uranium	8
Bliss & Laughlin (Residual period **NOT** added to the SEC)	Air data from the preceding operational period	The trench was cleaned, scabbled, jack-hammered, and sand-blasted. Ceiling trusses and perpendicular members were decontaminated. The concrete pad over trenches and pits was removed and the trench was remediated (max 1420 pCi/g) [USACE [1999, PDF pp. 9–14]	Uranium	24
Simonds Saw (Residual period **NOT** added to the SEC)	Air data from the preceding operational period and the residual period	Steel-mill maintenance activities [NIOSH 2010a]	Uranium, Thorium	4518+ 1.09 WLM (Radon)
Blockson (Residual period **NOT** added to the SEC)	Bioassay from the preceding operational period; radiation and air data from the residual period	Maintenance work on the filtration and duct system [NRC 1984, PDF p.12]	Uranium, Thorium	778+[a] 0.1 WLM (Radon)

AWE Site	Available Data for Residual Period	Intrusive Work Activities in the Residual Period	First Year Residual Period – Radionuclide(s) of Concern	First Year Residual Period – Internal Dose (mrem CED)
Dow Chemical (Madison) (Residual period **NOT** added to the SEC)	Air data from the preceding operational period and the residual period	Metal sanded in the rolling mill, billets scalped, and scrap handling [Simmons Cooper 2007, PDF p. 7]	Uranium, Thorium	8204+ 0.39 WLM (Radon)
General Steel (Residual period **NOT** added to the SEC)	Surrogate air data	Activities listed include the following: pipefitter, electrician, laborer, pattern shop sweeper, utility man, tunnel laborer, carpenter, iron worker, roofer, concrete finisher, janitor, gardener, and Production & Maintenance Department-clerks [GSI 1967, PDF pp. 3-165]	Uranium	60[a]
Wah Chang (Residual period **NOT** added to the SEC)	Air data from the preceding operational period	Excavation and removal of 100,000 yd^3 contaminated surface and subsurface sediments exceeding the gamma radiation action level [Gaines 1997, PDF p.13]	Uranium	0.04
United Nuclear (Residual period **NOT** added to the SEC)	Air data from the preceding operational period and the residual period	General nuclear production facility maintenance [NIOSH 2010b]	Uranium	103
Norton (Residual period **NOT** added to the SEC)	Air data from the operational (pre-1958) and residual (1963–2009) periods	1963–2009: General nuclear production facility maintenance [NIOSH 2011a,b]	Uranium, Thorium	342+ 0.10 WLM (Radon)

AWE Site	Available Data for Residual Period	Intrusive Work Activities in the Residual Period	First Year Residual Period – Radionuclide(s) of Concern	First Year Residual Period – Internal Dose (mrem CED)
Norton (Residual period added to the SEC)	Bioassay and air data for the periods before and after the 1958–1962 part of the residual period that is insufficient to bound potential internal exposures during these operations	1958–1962: Refractory kilns and furnaces dismantled brick-by-brick and transferred to barrels. Equipment and materials solvent-washed, dried with paper towels, dismantled, and transferred to barrels. Surface areas of the building were cleaned and residue was placed in barrels. Materials removed included: bricks, batts, dust-collecting ventilation ducts, and pipes. There were 287 barrels (~19 tons) of waste, including 15 pounds of thorium and 25 pounds of uranium [NIOSH 2011a,b].	N/A	N/A
Linde (Residual period **NOT** added to the SEC)	Contamination data from 2001	1970–2006: Subsurface utility tunnel maintenance activities [NIOSH 2011c]	Radium, Thorium, Uranium	35256+ 3.94 WLM (Radon)
Linde (Residual period added to the SEC)	Air data from one building in 1969	1954–1969. Renovations, including jack-hammering the primary process building. NIOSH also proposed to use the same data to bound all exposures in the other five buildings and outside areas [NIOSH 2011c].	Radium, Thorium, Uranium	5479
Vitro (Residual period **NOT** added to the SEC)	Air data from 1977	October 1, 1965–1985: Manufacturing plant facility maintenance [NIOSH 2011d; NIOSH 2015]	Lead, Uranium	88[a] 9.16 WLM (Radon)

AWE Site	Available Data for Residual Period	Intrusive Work Activities in the Residual Period	First Year Residual Period – Radionuclide(s) of Concern	First Year Residual Period – Internal Dose (mrem CED)
Vitro (Residual period added to the SEC)	None	1960–October 1, 1965: D&D of the Process building. Movement and burial with bulldozers of two residue stockpiles (leftover from uranium ore processing). One pile was 4,268 dry tons and the second was 85 tons. NIOSH did not find a description of shutdown or D&D activities, nor were interviewees able to provide any detailed information [NIOSH 2011d; NIOSH 2015]	N/A	N/A
M&C	Contamination data from the preceding operational period and pre-D&D characterization soil and contamination data	General nuclear production facility maintenance: Subsurface work: 17% occupancy, with a 2x TIB 70 resuspension factor applied. Roof and ceiling work: 8% occupancy, with a vigorous work resuspension factor applied. Welding work: 2% occupancy, with a 10x vigorous work resuspension factor applied. HVAC work: <<1% occupancy, with a barely tolerable resuspension factor applied. Remaining work: 73% occupancy, with a 10x TIB 70 resuspension factor applied.	Uranium, Thorium	71

[a] Dose prorated to reflect the full year.

NIOSH has included information in Table 2 that provides context regarding the intrusive types of work performed at the other AWE sites where the Advisory Board agreed with NIOSH's ability to bound exposures during residual period work. The precedents set by the Advisory Board in their SEC deliberations are essential because they provide consistency and fairness in implementing the EEOICPA Program.

M&C WORK GROUP CONCERNS

Work Group Concern – Data Applicability

The following excerpts show data applicability concerns that have been presented at an Advisory Board meeting and M&C Work Group meeting:

> *NIOSH applies 1995 D&D survey data as basis for an upper bound for residual period exposure. For radiological data from one time period to be considered informative about exposures during another time period, there should be sufficient similarity of conditions and processes between the two periods.* [ABRWH 2023b, PDF p. 20]
>
> *M&C maintenance workers were given no radiological health and safety (H&S) information or training during the residual period, and only occasionally received personal protective equipment (PPE). Also, after 1983, following the NRC's removal of radiation work restrictions for Building10, they believed they were not working under hazardous radiological conditions.*
>
> *Thus, certainly after 1983, M&C maintenance workers could not be expected to have followed the ordinary, common-sense precautions that any intelligent person would follow when working on and near the piping in a potentially hazardous radiation environment.*
>
> *The Result: The M&C maintenance workers would be expected to experience greater doses of radiation than assessed in the NIOSH bounding model.* [ABRWH 2023a, PDF p. 11]

NIOSH Response – Data Applicability

If NIOSH identified **air** monitoring during an operation (e.g., grinding) in one time period and tried to apply that data to a different time period and operation (e.g., welding), then the Work Group's concern could be valid. Similarly, if NIOSH used Priority 3 drain line data to bound exposures during work with the Priority 1 **source term**, then again, the Work Group would have a valid data applicability argument. On the contrary, NIOSH validated a bounding source term (pre-D&D to the extent a fuel pin was still present) and applied appropriate resuspension/dust loads for the various operations described by interviewees.

Furthermore, one of the primary reasons the Weston [1996b] drainage system characterization (the report where NIOSH obtained the subsurface data) was performed before D&D in 1995, was to quantify the risk to ongoing drain line maintenance workers as documented in the following excerpt:

> *The drainage system investigation was performed immediately after the Pilot-Scale Interiors Remediation Project and prior to the Full-Scale Interiors Remediation Project. An aggressive investigation schedule was implemented in support of Nuclear Regulatory*

> *Commission (NRC) license termination and* ***to assess the potential for inadvertent exposures to non-radiological workers performing routine· drainage system maintenance****.* [Weston 1996b, PDF p. 7]

The excerpt above confirms that drain line maintenance was still being performed at the time of the 1995 survey. In fact, after these data were obtained, and because of the results, M&C implemented controls on future drain line maintenance using three levels of priority designation [Weston 1996b, PDF p. 29].

Although the frequency of clogged drains may have increased over time as the building aged, the techniques employed to unclog drains did not change throughout the residual period (*i.e.*, snake technology did not change significantly from 1968 to 1995).

Work Group Concern – Worker Protection

An August 16, 2023 M&C Work Group presentation stated that "maintenance workers were unaware of radioactive contamination and operated without radiological controls and health physics oversight" [ABRWH 2023b, PDF p. 8].

NIOSH Response – Worker Protection

Work practices such as those specified in the Work Group's concern do not affect the source term or **any** of the "three legs of the stool" that form NIOSH's bounding method because the M&C model does not assume any worker training or the use of engineering and administrative controls.

Work Group Concern – Claimant Favorable Assumptions

An August 16, 2023, presentation states [ABRWH 2023b]:

> *How does M&C compare with other AWEs?*
>
> - *SC&A finds M&C to be comparable to facilities with more intrusive activities, e.g., those related to renovation as defined by NRC and found at Linde Ceramics (SEC class designee).*
> - *Why is this important?*
>   - *Standard models from OTIB-0070 and TBD-6000 assume more passive worker activities related to occupancy, like other non-SEC AWEs.* [PDF p. 10]
>
> *NIOSH use of "extreme conservatism" to account for M&C's "intrusive activities, high exposure conditions, uncertain facility activities, or unknown contamination sources" (NIOSH, 2023a) results in a high bounding value –but is it plausible?* [PDF p. 13]

NIOSH Response – Claimant Favorable Assumptions

The information presented at the August 16, 2023, Advisory Board meeting is inaccurate, especially regarding OTIB-0070. It could be argued that TBD-6000 allows default assumptions which may be considered more passive, but OTIB-0070 makes no such assumptions and requires the user to make a thoughtful selection. It is a document that provides options to select models that are as aggressive or passive as appropriate.

SC&A and the Work Group are misinterpreting NIOSH's use of the phrase "extreme conservatism" to mean implausibly high. NIOSH is using conservative assumptions that are appropriate for a bounding scenario. The maximum predicted committed effective dose equivalent is still only 71 mrem which is not implausibly high and is on par with normal background radiation levels every American experiences.

Work Group Concern – AWE Equipment

An August 16, 2023, presentation states [ABRWH 2023b]:

> *What were typical intrusive activities and exposure pathways during M&C residual period?*
>
> - *Maintenance, movement, and replacement of repurposed AWE equipment* [PDF p. 11]

NIOSH Response – AWE Equipment

NIOSH has previously responded to this concern. Texas Instruments reported to the NRC that the AWE operations (Buildings 3, 4, and 10) were decontaminated and decommissioned and that all radioactive materials were removed during the period from 1955 to 1968; the largest Building 10 cleanup effort occurred at the end of 1958. "…contaminated noncombustible scrap material and machinery were collected in 55-gallon steel drums and disposed of through authorized agencies or buried on-site in compliance with 10CFR20.304" [Sowell 1985, PDF p. 12].

Work Group Concern – Burial Area

An August 16, 2023, presentation states [ABRWH 2023b]:

> *What were typical intrusive activities and exposure pathways during M&C residual period?*
>
> - *Excavating contaminated soils, including those near or within radioactive waste burial sites* [PDF p. 11]

NIOSH Response – Burial Area

NIOSH developed a model to bound exposure during subsurface work in areas outside of Building 10 including the burial ground. However, during Work Group discussions NIOSH agreed to assign doses from the Building 10 subsurface model to all workers since workers constantly moved about the site and because those doses were more claimant favorable. In addition, at the July 13, 2023, M&C Work Group meeting, the Work Group conceded other exposures including those from the burial ground with the following statement:

> *Attention to subsurface exposures in Building 10. NOTE: The Work Group (WG) and staff generally agreed that the greatest exposures to the M&C maintenance workers came from the subsurface work in Building 10. Since the NIOSH bounding model is applied to all claimants, further discussion during this presentation focuses solely on such subsurface work and whether or not it is bounded.* [ABRWH 2023a, PDF p. 8]

If the Work Group is aware of new technical information related to the burial ground, NIOSH requests a copy so we may consider it.

Work Group Concern – Confined Spaces and Applying Mound Surrogate Data

A July 13, 2023, presentation states [ABRWH 2023a]:

> *The Mound database: Collected under different conditions than the M&C subsurface trenching.*
>
> - *The Mound project trenching data were collected outdoors on a country lane, whereas the M&C maintenance subsurface exposures, of course, took place indoors in Building 10.*
> - *As such, using the Mound data as surrogates for M&C violates one of the Criteria for the Use of Surrogate Data, adopted by the Board in 2014.* [PDF p. 17]
>
> *The Mound database seems a poor fit for M&C*
>
> *Because of the major differences in work environments between Mound and M&C – an outdoor, relatively placid country lane vs. an indoor, dirty, often muddy industrial worksite, respectively – this WG member believes the Mound database is a poor fit for M&C surrogacy.* [PDF p. 18]

NIOSH Response – Confined Spaces and Applying Mound Surrogate Data

The Mound surrogate issue was considered in *SC&A Commentary on NIOSH's Approach to Quantifying Outdoor and Indoor Airborne Dust Loadings*. For that work, SC&A enlisted the services of Lynn R. Anspaugh, Ph.D., Fellow of the University of California, National Science Foundation Biophysics and University of California, U.S. Atomic Energy Commission (AEC) Radiological Physics. He is Research Professor of Radiobiology Emeritus, University of Utah. Dr. Anspaugh is an expert on radiation dosimetry and radiation dose reconstruction. He worked 33 years at Lawrence Livermore National Laboratory in a number of positions, including 10 years as Leader of the Environmental Sciences Division. Dr. Anspaugh has been involved in dose-reconstruction studies for people exposed to fallout from nuclear weapons tests, the

Chernobyl accident, releases from the Mayak Production Association in Russia, and the Fukushima accident. Dr. Anspaugh is the author or co-author of 350 papers and reports, most of which are related to radiation-dose-reconstruction activities. Dr. Anspaugh has been a consultant to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Atomic Energy Agency, and the World Health Organization. He has been a member of the U.S. delegation to UNSCEAR since 1987 [NCRP, no date].

The following excerpts show what SC&A, with Dr. Anspaugh as a co-author, stated in *SC&A Commentary on NIOSH's Approach to Quantifying Outdoor and Indoor Airborne Dust Loadings* [SC&A 2021] about the use of the Mound surrogate data at M&C:

> In SC&A [2021, Section 5.2], SC&A considered the use of Mound outdoor dust loading values to M&C indoor environments. SC&A cites NUREG/CR-5512, Volume 1 (p. 6.11), *For this analysis,* ***the radioactive concentrations in indoor air for the building renovation*** *and residential* ***scenarios have been assumed to be*** $\mathbf{10^{-4}}$ *and* 5×10^{-5} ***g/m***^{3}*, respectively. This range is a fraction of the maximum total dust limits, representing longer-term average concentrations and accounting for airborne dust from nonradioactive sources.* ***This range provides a prudently conservative estimate of actual radioactive dust-loadings in the workplace*** *or household****, and serves as an adequate basis for the first-level generic screening analysis.*** [PDF pp. 18–19]
>
> SC&A further concludes, *The renovation indoor dust loading of* 10^{-4} g/m^3 *(100 ug/m*^{3}*) might include excavation and would seem to independently support NIOSH's use of 212 ug/m*^{3} *as a reasonable estimate when applied to the M&C subsurface indoor excavation scenario and also to indoor excavation dust loading in general. Since this is an indoor dust loading value, SC&A suggests that NIOSH also refer to NUREG/CR-5512 (in addition to the Mound outdoor data) as a basis for the selected dust loading for both M&C and for use in OTIB-0070.* [SC&A 2021, PDF p. 19]

NIOSH concurs with SC&A's recommendation. The favorable comparison with the indoor renovation dust loading value recommended in NUREG/CR-5512 provides confidence in NIOSH's 212 ug/m^3 dust loading value for M&C, in spite of the differences between the Mound and M&C physical environments.

> *Considering the totality of information compiled in this report, SC&A believes that the use of a dust loading of 212 µg/m3 for subsurface work both indoors and outdoors at M&C is reasonably compatible with data and information summarized in this report, including the data reported from Mound by the interviewed SME.* [PDF p. 21]
>
> *While SC&A's survey and interpretation of the data indicate that the suggested value of 212 µg/m*^{3} *may not necessarily be sufficiently conservative for many excavation scenarios, a number of mitigating factors are also present at M&C that should be*

> *considered. First, the soil at M&C was likely moist. Second, the dust loading used for dose reconstruction at M&C covered the entire assumed time period of 2 months; i.e., the suggested exposure models are not trying to reconstruct short-term exposures, where dust loading might peak during active and aggressive excavation, but are making use of the dust loading for deriving inhalation exposures over a more protracted period of time.* [PDF p. 22]

If the Work Group considered the mitigating factors present at M&C referenced above and disagrees, NIOSH requests any technical supporting information so we may augment our model.

CONCLUSION

The Work Group's concerns [ABRWH 2023b, PDF p. 20] with the back application of the 1995 drainage system characterization data were a result of Building 10 subsurface work associated with the effects of coagulants, the aerosolization of drain line contamination, and work in confined spaces. This paper has demonstrated how NIOSH can address each of those concerns and that the concerns have no effect on the bounding source term identified by NIOSH and previously agreed upon by SC&A.

REFERENCES

ABRWH [2023a]. Statement by David Kotelchuck, Work Group Metals & Controls. Presentation. In: Advisory Board's Work Group Meeting on Metals and Controls, virtual meeting, July 13, 2023. [SRDB Ref ID: 197979]

ABRWH [2023b]. Update: M&C work group review of SEC-related issues. Presentation. In: Meeting of the Advisory Board on Radiation and Worker Health meeting held in Augusta, GA, August 16, 2023. [SRDB Ref ID:197978]

AEC [1953]. Contract for Hooker electrochemical to operate at LOOW site. Washington DC: U.S. Atomic Energy Commission. Contract No. AT(30-1)-1524, July 01. [SRDB Ref ID: 61274]

AEC [1958]. Appendix A to contract AT-(30-1)-1524. Lake Ontario Ordnance Works, Washington DC: Atomic Energy Commission. Contract No. AT(30-1)-1524. [SRDB Ref ID: 64773]

DOE [1996]. Hazard assessment for the General Motors site. Final. Washington, DC: U.S. Department of Energy, Oak Ridge Operations Office. DOE/OR/21950-1017, June. [SRDB Ref ID: 14422]

Elliott MJ [1997]. Groundwater radiological monitoring report 1995. Correspondence to M. Roberts (with attachment). Attleboro, MA: Texas Instruments Incorporated. February 24. [SRDB Ref ID: 197837]

Fry HB [1953]. BMP project, Hooker Electrochemical undertake maintenance and operations. Correspondence to A Wilcox II. Lake Ontario Ordnance Works, Niagara Falls, NY. July 7. [SRDB Ref ID: 63956]

Gaines BA [1997]. Five year review for Teledyne Wah Chang. Seattle, WA: U.S. Environmental Protection Agency Region 10. December 29. [SRDB Ref ID: 42743]

GSI [1967]. Job descriptions for GSI occupations. GSI Castings Division. September. [SRDB Ref ID: 36098]

Hooker [1953]. BMP project with Hooker Electrochemical Company. Lake Ontario Ordnance Works, Niagara Falls, NY: Hooker Electrochemical. [SRDB Ref ID: 63777]

Hooker [1957]. Surveys of water lines and contamination. Lake Ontario Ordnance Works, Niagara Falls, NY: Hooker Electrochemical. [SRDB Ref ID: 61585]

NCRP [no date]. National Council on Radiation Protection and Measurements (NCRP) profile of Lynn R. Anspaugh. Web Page. Bethesda, MD: National Council on Radiation Protection and Measurements. Date accessed: August 13, 2023. [SRDB Ref ID: 197980]

NIOSH [2006]. Special exposure cohort petition evaluation report petition SEC-00043 rev. 0 Chapman Valve Manufacturing Co. qualified November 9, 2005. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. August 8. [SRDB Ref ID: 32744]

NIOSH [2010a]. Special exposure cohort petition evaluation report petition SEC-00157 rev. 0 Simonds Saw and Steel Co. qualified March 8, 2010. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. October 29. [SRDB Ref ID: 135195]

NIOSH [2010b]. Special exposure cohort petition evaluation report petition SEC-00116 Rev. 1 United Nuclear Corp. qualified November 4, 2008. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. January 28. [SRDB Ref ID: 101606]

NIOSH [2011a]. Special exposure cohort petition evaluation report petition SEC-00173 Rev. 0 Norton Co. qualified July 22, 2010. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. January 24. [SRDB Ref ID: 94436]

NIOSH [2011b]. Special exposure cohort petition evaluation report petition SEC-00173 addendum 1 Norton Co. qualified July 22, 2010. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. August 4. [SRDB Ref ID: 133455]

NIOSH [2011c]. Special exposure cohort petition evaluation report petition SEC-00107 rev. 1 Linde Ceramics Plant qualified July 2, 2008. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. January 28. [SRDB Ref ID: 120949]

NIOSH [2011d]. Special exposure cohort petition evaluation report petition SEC-00177 rev. 0 Vitro Manufacturing (Canonsburg) qualified September 9, 2010. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. February 4. [SRDB Ref ID: 94854]

NIOSH [2012]. Special exposure cohort petition evaluation report petition SEC-00204 Baker Brothers qualified July 24, 2012. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. November 13. [SRDB Ref ID: 180810]

NIOSH [2015]. Special exposure cohort petition evaluation report petition SEC-00177 addendum 1 Vitro Manufacturing (Canonsburg) qualified October 21, 2011. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. September 28. [SRDB Ref ID: 180814]

NIOSH [2017]. Special exposure cohort petition evaluation report petition SEC-00236 rev. 0 Metals and Controls Corp. qualified November 14, 2016. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Petition SEC-00236 Rev. 0, April 5. [SRDB Ref ID: 176720]

NIOSH [2023]. NIOSH/ORAU: NIOSH response to SC&A's supplemental review of M&C work group issues. Response paper. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. January 13. [SRDB Ref ID: 195738]

NRC [1984]. Materials license SUB-1138 amendment 11. Glen Ellen, IL: Nuclear Regulatory Commission. August 28. [SRDB Ref ID: 101595]

ORAUT [2015]. Documented communication SEC-00223 with [redacted] on Carborundum February 17, 2015. Oak Ridge, TN: Oak Ridge Associated Universities Team. February 17. [SRDB Ref ID: 142174]

ORAUT [2017]. Documented communication SEC-00236 with [redacted] on Metals and Controls Corporation October 25, 2017. Oak Ridge, TN: Oak Ridge Associated Universities Team. October 25. [SRDB Ref ID: 169938]

SC&A [2021]. SC&A commentary on NIOSH's approach to quantifying outdoor and indoor airborne dust loadings. Arlington, VA: SC&A. SCA-TR-2021-SEC005 Rev. 0 (draft), October 25. [SRDB Ref ID: 190929]

SC&A [2022]. Supplemental review of M&C work group issues – draft 2022. Arlington, VA: SC&A. SCA-TR-2022-SEC002 Rev. 0 (draft), August 22. [SRDB Ref ID: 193691]

SC&A [2023]. SC&A review of NIOSH response to SC&A's supplemental review of M&C work group issues – draft. Arlington, VA: SC&A. April 25. [SRDB Ref ID: 198227]

Simmons Cooper [2007]. Affidavits of former DOW Madison employees regarding thorium. East Alton, IL: Simmons Cooper Attorneys at Law. April 16. [SRDB Ref ID: 54160]

Sowell LL [1985]. Radiological survey of the Texas Instruments site Attleboro, Massachusetts. Final Report. Oak Ridge, TN: Oak Ridge Associated Universities. January. [SRDB Ref ID: 94371]

Texas Instruments [1979]. Environmental information report for 1979 HFIR facility license renewal by NRC. Metals and Controls, Inc., Attleboro, MA: Texas Instruments Incorporated. February 15. [SRDB Ref ID: 13633]

Texas Instruments [1994]. Supplement to the 1992 remediation plan Metals and Controls. Metals and Controls, Inc., Attleboro, MA: Texas Instruments Incorporated. Special Nuclear Material License No. 23 Rev. 0.0. December. [SRDB Ref ID: 197834]

USACE [1999]. Closure report decontamination of the former Bliss & Laughlin facility, Buffalo, New York. Washington, DC: U.S. Army Corps of Engineers Buffalo District. September 30. [SRDB Ref ID: 59199]

Weston [1995]. Sampling and analysis plan for the development of decontamination profiles – interior building areas, Texas Instruments Attleboro facility 1995. West Chester, PA: Roy F. Weston, Inc. July. [SRDB Ref ID: 197836]

Weston [1996a]. Remediation of building interiors buildings 4, 5, and 10. Version 1.0. Metals and Controls Corp., West Chester, PA: Roy F. Weston, Inc. October. [SRDB Ref ID: 114246]

Weston [1996b]. Texas Instruments Incorporated Attleboro facility building interiors remediation drainage system characterization. West Chester, PA: Roy F. Weston, Inc. January 10. [SRDB Ref ID: 165965]

Weston [1997a]. SNM license termination hypothetical radiological dose and exposure rate assessment priority 2 drain lines 1997. West Chester, PA: Roy F. Weston, Inc. NRC License/Docket No: SNM-23/70-33. March 10. [SRDB Ref ID: 197835]

Weston [1997b]. SNM license termination radiological dose assessment 1997. West Chester, PA: Roy F. Weston, Inc. NRC License/Docket No: SNM-23/70-33. February 20. [SRDB Ref ID: 197838]