Metals and Controls Corp. Subsurface Exposure Model

White Paper

National Institute for Occupational Safety and Health

April 23, 2018

Pat McCloskey
Mutty Sharfi
Oak Ridge Associated Universities Team

Reviewed By:
Peter A. Darnell, CHP, RRPT
Dr. James W. Neton, Ph.D. CHP
Division of Compensation Analysis and Support

INTRODUCTION

NIOSH presented the Evaluation Report (ER) for SEC-00236, Metals and Controls Corp. (M&C) to the Advisory Board on Radiation and Worker Health (Board) on August 24, 2017. At the conclusion of that presentation, a petitioner raised a concern about the adequacy of the ER in addressing subsurface work.

On September 5, 2017, in response to this concern, NIOSH initiated plans to continue research and further develop SEC-00236, including a review of monitoring records in the Site Research Database (SRDB) and a search for former workers to interview.

From October 24 through October 26, 2017, the National Institute for Occupational Safety and Health (NIOSH), Oak Ridge Associated Universities (ORAU), and Sanford Cohen & Associates (SC&A) personnel interviewed 12 former M&C workers and individuals knowledgeable of subsurface work. By March 13, 2018, information obtained from the interviews was upload into the SRDB (ORAUT, 2017-a,-b, -c, -d, -e, -f, -g, -h, -i, -j, -k, -l). Interviewers asked questions regarding the frequency and duration of subsurface work, including utility and drain line maintenance, and new equipment installations. During the interviews it became apparent that Building 10 experienced recurring issues with water drainage (ORAUT, 2017-b, PDF p. 6; 2017-e, PDF p. 5; 2017-g, PDF p. 8; 2017-i, PDF p.7; 2017-j, PDF, p. 5), and underwent multiple equipment change-outs that necessitated subsurface work. Although this work was sporadic and sometimes emergent in nature, it exposed workers in a manner that did not agree with the method described in the ER (surface contamination resuspension). Interview responses also showed that covered workers performed significant subsurface work in areas outside of Building 10 (ORAUT, 2017-h, p. 11; 2017-j, PDF pp. 4, 9), and because the site was non-union, the work could be assigned to several different groups (ORAUT, 2017-b, PDF p. 6; 2017-c, PDF p. 12; 2017-g, PDF pp. 4, 8, 11), which is also corroborated by Nuclear Regulatory Commission (NRC) inspections (NRC, 1981-1982, PDF p. 13).

On November 8, 2017, the Board, SC&A, DCAS, and ORAU team members held a teleconference to discuss technical issues associated with developing exposure models regarding subsurface and other work. On February 6, 2018, NIOSH obtained additional monitoring data regarding remediation work performed by Creative Pollutions Solutions in 1992 and 1994 (CPS, 1992-b; CPS, 1994), and on February 13, 2018, NIOSH received SC&A's report titled, *Review of SEC Petition ER SEC-00236*.

This White Paper provides a revised exposure assessment model based on data obtained since the SEC-00236 ER was written.

INSIDE BUILDING 10

The subsurface environment inside the walls of Building 10 that workers were exposed to is well characterized. The residues inside the worst case (i.e., Priority-1) drain lines are characterized in Exhibit 1 (Weston, 1996-a) provided by the petitioner. The [Name Redacted], who started working in the Environmental Safety and Health department in 1983 and was the [Job Title

Redacted], stated that Exhibit 1 represents conditions prior to Decontamination and Decommissioning (D&D) activities; therefore, it offers "good insight into conditions to which employees were exposed" (Affidavit, 2016, PDF, p. 4). In Exhibit 1, characterization methods are described, and sample locations and analytical results are provided (in pCi/g) for pipe residues. Radiation surveys were also performed with Nal(Tl) gamma scintillation detectors (Weston, 1996-a, PDF p. 14). The locations selected for sampling were based upon:

- Review of "as-built" diagrams;
- Historical information and/or suspected transfer of contaminated material in drain lines; and
- Radiological survey data from previous investigations and removal actions (p. 7).

The facility map depicts the relative locations of the drain lines (Weston, 1996-c, PDF pp. 172, 173) and classified according to their sediment content and total uranium concentrations in pCi/g as follows:

- Priority-1 1,000 to 53,000 (max);
- Priority-2 500 to 1,000; and
- Priority-3 Less than 500.

An October 1996 report from remediation contractor Weston describes the work controls and exposures associated with the removal of the worst-case drain lines. The report includes volumetric (pCi/g) soil-sample data, breathing-zone air-monitoring data (Highest monthly average reported as <2.4E-12µCi/ml), and assigned doses for the work (20 mrem/quarter CEDE) (Weston, 1996-c, PDF p. 22).

The Priority-1 drain lines, worked on by M&C employees and removed by Weston, contained the highest subsurface radioactive material concentrations to which workers were exposed. According to the D&D project manager, "…in the exterior soils, [contamination] was not insignificant. Although, I will tell you that clearly the "mother lode," to use a colloquial term, was in drains in Building 10" (ORAUT, 2017-c, PDF p. 10).

AREAS OUTSIDE OF BUILDING 10

Some workers performed maintenance and new installations that required them to dig in soils in outside areas contaminated with radioactive material from Atomic Weapons Employer (AWE) operations (ORAUT, 2017-j, PDF pp. 4, 9; ORAUT, 2017-h, PDF p. 11). These subsurface areas are well characterized.

At the request of the NRC, ORAU conducted a radiological survey of the waste burial site located to the southwest of Building 12, and the outdoor area surrounding Building 10 during April and May of 1984 (Sowell, 1985, PDF p. 9).The survey included a ground-penetrating radar survey to locate buried materials. Areas were gridded and surveyed with Nal (Tl) gamma scintillation detectors to identify locations for volumetric sampling (Sowell, 1985, PDF p. 10). Surface samples were collected and boreholes were drilled 2 to 3.5 meters deep to collect additional samples (Sowell, 1985 PDF pp. 11, 13). Soil samples analyzed by gamma spectrometry included radionuclides of U-238, U-235, Th-232, and Ra-226 (Sowell, 1985, PDF p. 13). Analytical results are found in Tables 4 and 5 of the survey (Sowell, 1985, PDF pp. 62−76) for surface samples from the Burial Area, and in Table 6 (Sowell, 1985, PDF pp. 77−82) for the borehole samples. Table 11 contains the analytical results for the surface samples taken of the outdoor area surrounding Building 10 (Sowell, 1985, PDF pp. 92−95). In their summary, ORAU concluded that the results indicated the presence of isolated areas of surface and subsurface contamination that were located mainly within the boundaries of the suspected burial site; however, there were small areas of surface contamination outside the burial site and in a few locations around Building 10 (Sowell, 1985, PDF p. 23).

Creative Pollutions Solutions (CPS) summarized the results from the 1984 ORAU subsurface characterization of the Burial Area in a 1992 report which included updated sampling and analysis that supported the 1984 ORAU results and conclusions (CPS, 1992-a, PDF p. 5). The 1992 CPS report also documents a pilot study where CPS excavated contaminated portions of the Burial Area while performing air monitoring. Four out of five breathing zone results were less than Minimum Detectable Activity (MDA), and the fifth resulted in 4.1E-2 MPC-h (CPS, 1992-a, PDF p. 25).

The **Metals Recovery Area** near Building 5 was the location where some open burning occurred during AWE operations. Subsurface volumetric soil sample data are available (CPS, undated, PDF pp. 7−20; Texas Instruments, 1994, PDF p. 9).

The soils in the **Stockade Area**, located between Buildings 10 and 11, were contaminated because of staging wastewater and pickling acid solutions in drums on the ground within an area enclosed with a stockade fence (Weston, 1996-b, PDF p. 110; Texas Instruments, 1994, PDF p. 33).

The **Railroad Spur Area** is located between the Metals Recovery and Stockade areas. M&C did not handle radioactive material in this area; however, it is believed that soils became contaminated due to transference from the two neighboring areas (Weston, 1996-b, PDF p. 110−113; Texas Instruments, 1994, PDF p. 33).

The **Building 12 West and South Lawn Areas** were contaminated during the 1968 Building 12 construction project when contaminated soils from the Burial Area were transferred during final grading (Weston, 1996-b, PDF pp. 108−110; Texas Instruments, 1994, PDF p. 35).

BOUNDING EXPOSURE MODEL

ORAUT-OTIB-0070 (2012) provides guidance on mass-based assignments used here to calculate air concentrations, given volumetric sample data and appropriate dust loading factors. In addition, former workers provided information regarding frequency, duration, and safety controls associated with the subsurface work that allows NIOSH to determine occupancy rates. Based on information gained from interviews, workers could have had as much as 1 month per year exposure to subsurface work (ORAUT, 2017-i, PDF p.7; ORAUT, 2017-j, PDF p. 5;

ORAUT, 2017-e, PDF p. 5; ORAUT, 2017-b, PDF p. 6; ORAUT, 2017-g, PDF p. 8). M&C workers in the Facilities Construction and Maintenance Services Organization (Facilities) or Production Machine Operators/Helpers and Production Repair & Maintenance (R&M) organizations having access to, and worked within production areas had the potential for subsurface exposure (ORAUT, 2017-c, PDF p. 11).

Inside Building 10 Volumetric Sample Data

The subsurface work environment inside Building 10 was characterized with 44 soil samples collected prior to remediation of the Building 10 drainage system. Those 44 samples were analyzed for uranium with isotopic identification and were compiled in a spreadsheet where the geometric mean (147.12 pCi/g) and geometric standard deviation (7.68) were calculated.

Outside Areas Volumetric Sample Data

The following outside areas including the area surrounding Building 10, in the former Burial Area, the Metals Recovery Area, the Building 11 Stockade Area, the Building 11 Railroad Spur Area, and in the Building 12 West and South Lawn Areas were characterized with 292 soil samples collected prior to remediation. Two hundred twenty-nine (229) of these samples were analyzed for gross alpha, and the remaining 63 were analyzed for uranium and thorium using isotopic identification.

The gross alpha and uranium samples were compiled in a spreadsheet where the geometric mean (53.52 pCi/g) and geometric standard deviation (4.54) were calculated. Since the calculated geometric standard deviation is less than the default value listed in Battelle-TBD-6000, Section 5.2.1, the default value of 5 will be used.

The gross alpha and thorium samples were compiled in a spreadsheet where the geometric mean (25.94 pCi/g) and geometric standard deviation (5.36) were calculated.

Dust Loading

Worker affidavits and interviews described the subsurface work as very intrusive and included accessing contaminated materials that had accumulated for decades without work controls to mitigate the hazard. The default dust-loading value of 100 $\mu g/m^3$ value suggested in ORAUT-OTIB-0070 (2012) and NUREG/CR-5512 (1992), meant for use in screening analysis as a long-term average, is not appropriate for M&C subsurface work where workers actively disturbed the contaminated material during episodic responses throughout a given year. ORAUT-OTIB-0070 (2012) provides justification for increasing resuspension factors, as operations become more vigorous (PDF p. 8).

In addition, this justification is corroborated by research performed to determine dust-loading factors during contaminated-soil excavation activities for the Mound Plant Canal Clean-up Project (Taulbee, 2018). During the Mound Project, air-sample collection media were weighed before and after taking each sample to determine their dust loading in grams. The volume flow rate was recorded before and after taking each sample, then the average flow rate was determined and multiplied with the sampling duration to determine the total volume of air in cubic meters.

In total, data from 294 hi-volume air samples were recorded to get a distribution of the dust-loading factor (Figure 1). From the Figure 1 plot, the geometric mean is identified as 7.18×10^{-5} g/m^3 and the 95th percentile as 2.2×10^{-4} g/m^3.

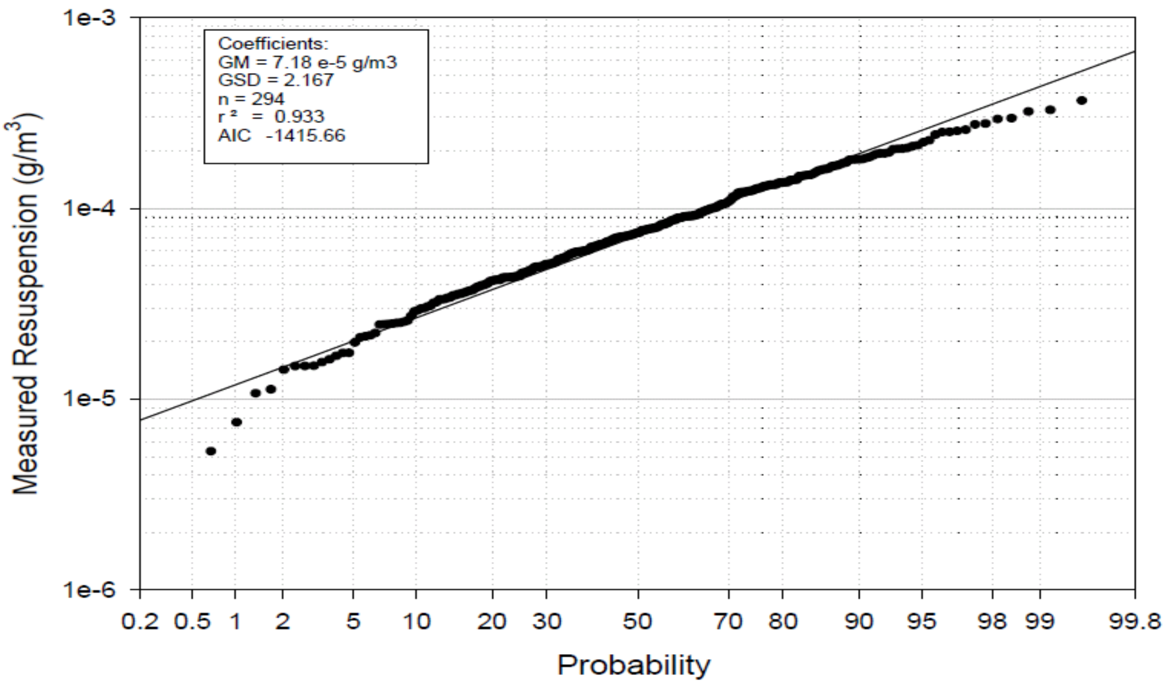

Figure 1. Measured Dust-loading Factor from High Volume Air Sample Data taken spring 1997 during Mound Canal Project.

NIOSH analyzed operations at Mound and M&C to determine if the Mound dust-loading data could be used as a surrogate for dust loading at M&C in accordance with OCAS-IG-004. The following underlined headings show the criteria listed in Section 3 of OCAS-IG-004 and describes how the criteria are applicable to dust loading at M&C.

Source Term: NIOSH has knowledge of the types and general quantities of material processed at M&C. NIOSH has access to extensive sample data and process information of uranium and thorium-generating activities at M&C as referenced above.

Facility and Process Similarities: Excavation activities for the Mound Plant Canal Clean-up Project occurred over several months during the spring of 1997. The Mount Plant is located near Miamisburg in western Ohio. Excavation activities at Mound involved using a backhoe to remove soils. Using water as a dust suppressant was sporadic and not consistently applied. In addition, windbreaks, tents, or ventilation were not used.

Both outside and inside subsurface work at M&C occurred from 1968 through 1996. As with Mound's excavation activities, outside subsurface work involved using a backhoe to remove soils. Inside subsurface work at M&C involved shoveling and snaking soils and drain residues. Also like Mound, there was sporadic and inconsistent application of water used as a dust suppressant during outside and inside subsurface work. Windbreaks, tents, or ventilation were also not used.

Therefore, the Mound excavation activities and the outside subsurface work at M&C are substantially similar. There could be differences that make the Mound excavation activities more likely to generate airborne dust than the *inside* subsurface work at M&C; however, the Mound data provide a plausible upper bound for M&C dust loading.

Temporal Considerations: The era of excavations at Mound (1996) and at M&C (1968−1996) are similar enough when considering the equipment, methods, and work performed at both sites. For example, the hi-volume air samplers used for the Mound study are still an appropriate method for quantifying dust loading to this day. Furthermore, the passage of time has not significantly altered backhoe operations, or their ability to generate airborne dust.

Data Evaluation: The quality of the mound surrogate data, depicted in Figure 1 above, can be described as having a high degree of precision and consistency throughout the 294 samples, with a geometric standard deviation of 2.167.

Review of Bounding Exposure Models: The geometric mean (7.18×10^{-5} g/m^3) and 95th percentile dust-loading factor (2.2×10^{-4} g/m^3) calculated from the Mound study are realistic to use for M&C subsurface exposure modeling. The dust-loading factor is more than double the ORAUT-OTIB-0070 (2012) default value (described above to be unrealistically low for modeling M&C operations).

In addition to the OCAS-IG-004 criteria, another method to assess if the 95th percentile dust-loading factor is appropriate for modeling M&C subsurface work is to compare the urinalysis results for remediation workers to the postulated model. CPS conducted remediation of the Burial Area in 1993 (CPS, 1993), which involved the use of a backhoe, hand shoveling, and screen separation of soils. CPS's use of water as a dust suppressant was sporadic and not consistently applied largely because the water table was encountered at a depth of approximately 6 feet. In addition, CPS did not use windbreaks, tents, or ventilation. During this work, *in vitro* bioassay was performed for all site personnel requiring access to the Burial Area Exclusion Zone during excavation. The bioassay process involved fluorometric analysis of uranium within urine. At no time did the bioassay results exceed action levels (45 pCi/L) specified within the Health and Safety Plan (CPS, 1992-b, PDF p. 30), and all reported values were less than 4 μg/L total uranium (CPS, 1992-b, PDF p. 49).

In 1994, CPS conducted remediation of the Metals Recovery Area using the same methods as before; however, they performed bioassay for only the primary excavation personnel. The scope of uranalysis was limited this time based on air sampling results. The bioassay process again involved fluorometric analysis of uranium within urine, and all reported bioassay results were less than 1 μg/L total uranium (CPS, 1994, PDF p. 31).

NIOSH projected the amount of uranium that could be collected from a reference man breathing air at a concentration of the proposed 95th percentile dust-loading factor (2.2×10^{-4} g/m^3) for 30 days. The calculation determined that M&C subsurface workers, for the three uranium solubility classes, should have an expected excretion rate of Type F 268 μg/L, Type M 40 μg/L, and Type S 1.2 μg/L at the end of a 30 day exposure. Comparing these calculated results with the measured results for the CPS workers demonstrates that the selected dust-loading factor is bounding and claimant favorable.

For comparison and perspective, it may be useful to consider the full-scale remediation of M&C's worst-case subsurface contamination. A report from remediation contractor Weston, from July 1995 through September 1996, describes the work controls and exposures associated with extensive remediation of the Building 10 subsurface. During this work, Weston removed and disposed of all the Priority-1 drain lines and surrounding soils, including 520 linear feet (lf) of 4-inch vitreous clay drainpipe, 400 lf of 4-inch cast iron drainpipe, and 360 lf of 4-inch polyvinyl chloride drainpipe. An additional 620 lf of Priority 2 drainpipes were decontaminated in place during this work. Standard removal techniques included the application of concrete saws, breakers, and heavy equipment such as Bobcats and backhoes. No respiratory protection was required, and safety measures such as dust suppressants, containment tents, or ventilation were used sparingly. Comprehensive personal monitoring was performed, and all Weston workers performing this remediation of the "motherlode of M&C contamination" were assigned doses of 20 mrem/quarter TEDE (Weston, 1996-c, PDF p. 21).

Therefore, the default ORAUT-OTIB-0070 (2012) dust-loading value will be increased to the 95th percentile value of 2.2×10^{-4} g/m^3 (220 μg/m^3) from the Mound Project study, and when multiplied with the geometric mean of the applicable volumetric sample data, results in air concentrations of:

- Inside uranium 3.24 E-14 μCi/ml;
- Outside uranium 1.18 E-14 μCi/ml; and
- Outside thorium 5.71 E-15 μCi/ml.

Based on affidavits and interview responses, NIOSH will assume an occupancy rate of 1 month per year (i.e., 173 hours or 22 workdays). If the subsurface work area (e.g. inside or outside) cannot be determined, the most claimant favorable work location will be assigned. Subsurface workers will also receive assigned residual exposures for the remaining 11 months of each year at the same rate as the other workers that did not perform subsurface work.

Ingestion Rates

Ingestion rates were determined using NUREG/CR-5512 (1992) Volume 1, Section 6.3.2 methods (50 mg/workday).

External Exposures

Film badges at the end of AWE operations (i.e., 1967) were processed quarterly by Landauer. NIOSH will use all of the 1967 results and determine the quarterly, geometric mean dose, and the geometric standard deviation. Since the subsurface work lasted no more than one month per year, external exposures will be assigned at the rate of one third the quarterly dose rate determined for the beginning of the residual period using the quarterly geometric mean dose and geometric standard deviation. No source-term depletion will be applied because of the potential for the subsurface environment (e.g., inside clogged drains) to be less impacted by environmental reduction factors.

CONCLUSION

NIOSH has considered all of the information presented in this paper and has used it to develop a subsurface exposure model for Metals and Controls Corp. that accounts for the descriptions of work by former employees, pre-remediation sample data, and a realistic dust-loading model. NIOSH believes that this model adequately bounds subsurface exposures experienced by M&C workers during the residual radiation period.

REFERENCES

Affidavit, 2016, *Affidavit in Support of SEC-00236 Petition Basis*; Name Redacted; August 13, 2016; SRDB Ref ID: 170329

CPS, undated, *Appendix D, Radiological Survey Results, Appendices 1-4*; assuming author is Creative Pollution Solutions, Inc. (CPS) based on prior work and reports; undated; SRDB Ref ID: 165968

CPS, 1992-a, *Radiological Characterization of Texas Instruments, Incorporated-Attleboro Industrial Facility*; Creative Pollution Solutions, Inc. (CPS); 1992; SRDB Ref ID: 164755

CPS, 1992-b, *Radiological Health and Safety Plan—Appendix A, Health and Safety Activities During Remediation of the Texas Instruments Incorporated Attleboro Site*; Creative Pollution Solutions, Inc. (CPS); modified September 1, 1992; SRDB Ref ID: 169474

CPS, 1993*, Remediation of the Former Radioactive Waste Burial Site (NRC License SNM-23)*; Creative Pollution Solutions, Inc. (CPS); September 1993; SRDB Ref ID: 24626

CPS, 1994, *Radiological Health and Safety Plan—Appendix A, Health and Safety Activities During Remediation of the Texas Instruments Incorporated Attleboro Site*; Creative Pollution Solutions, Inc. (CPS); April 24, 1994; SRDB Ref ID: 169475

NRC, 1981-1982, *NRC Inspection Reports*; U.S. Nuclear Regulatory Commission (NRC); various dates from 1981-1982; SRDB Ref ID: 161187

NUREG/CR-5512, 1992, *Residual Radioactive Contamination From Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent,* Final Report, Volume 1; NUREG/CR-5512, PNL-7994; U.S. Nuclear Regulatory Commission; October 1992; SRDB Ref ID: 23558

OCAS-IG-004, *The Use of Data from Other Facilities in the Completion of Dose Reconstructions Under the Energy Employees Occupational Illness Compensation Program Act*, Rev. 0; Office of Compensation Analysis and Support (OCAS); effective August 21, 2008; SRDB Ref ID: 49029

ORAUT (Oak Ridge Associated Universities Team), 2017-a, *Interview Worker #1*; documented communication with former Metals and Controls Corporation worker; October 24, 2017; SRDB Ref ID: 169918

ORAUT (Oak Ridge Associated Universities Team), 2017-b, *Interview Worker #2;* documented communication with former Metals and Controls Corporation worker; October 24, 2017; SRDB Ref ID: 170018

ORAUT (Oak Ridge Associated Universities Team), 2017-c, *Interview Worker #3*; documented communication with former Metals and Controls Corporation worker; October 24, 2017; SRDB Ref ID: 169920

ORAUT (Oak Ridge Associated Universities Team), 2017-d, *Interview Workers #3 and #4*; documented communication with former Metals and Controls Corporation worker; October 24, 2017; SRDB Ref ID: 169925

ORAUT (Oak Ridge Associated Universities Team), 2017-e, *Interview Worker #5*; documented communication with former Metals and Controls Corporation worker; October 24, 2017; SRDB Ref ID: 169916

ORAUT (Oak Ridge Associated Universities Team), 2017-f, *Interview Worker #6*; documented communication with former Metals and Controls Corporation worker; October 25, 2017; SRDB Ref ID: 169921

ORAUT (Oak Ridge Associated Universities Team), 2017-g, *Interview Worker #7*; documented communication with former Metals and Controls Corporation worker; October 25, 2017; SRDB Ref ID: 169938

ORAUT (Oak Ridge Associated Universities Team), 2017-h, *Interview Worker #8*; documented communication with former Metals and Controls Corporation worker; October 25, 2017; SRDB Ref ID: 169923

ORAUT (Oak Ridge Associated Universities Team), 2017-i, *Interview Worker #9*; documented communication with former Metals and Controls Corporation worker; October 25, 2017; SRDB Ref ID: 169924

ORAUT (Oak Ridge Associated Universities Team), 2017-j, *Interview Worker #10*; documented communication with former Metals and Controls Corporation worker; October 26, 2017; SRDB Ref ID: 169919

ORAUT (Oak Ridge Associated Universities Team), 2017-k, *Interview Worker #11*; documented communication with former Metals and Controls Corporation worker; October 26, 2017; SRDB Ref ID: 169922

ORAUT (Oak Ridge Associated Universities Team), 2017-l, *Interview Worker #12*; documented communication with former Metals and Controls Corporation worker; October 26, 2017; SRDB Ref ID: 169917

ORAUT-OTIB-0070, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*; ORAU Team Dose Reconstruction Project for NIOSH; effective March 5, 2012; SRDB Ref ID: 108851

Sowell, 1985, *Radiological Survey of the Texas Instruments Site Attleboro, Massachusetts*, Final Report; L. L. Sowell, Oak Ridge Associated Universities (ORAU); January 1985; SRDB Ref ID: 94371

Taulbee, 2018, *Resuspension Factors During Excavation Activities*, E-mail correspondence regarding Mound, with attachment; Timothy Taulbee; January 16, 2018; SRDB Ref ID: 170425

Texas Instruments, 1994, *Supplement to the 1992 Remediation Plan*, Rev. 0.0; Texas Instruments Incorporated; December 1994; SRDB Ref ID: 114177

Weston, 1996-a, *Texas Instruments Incorporated Attleboro Facility Building Interiors Remediation Drainage System Characterization*; prepared by Roy F. Weston, Inc.; January 1996; SRDB Ref ID: 165965

Weston, 1996-b, *Texas Instruments Incorporated, Remediation of Exterior Areas Adjacent to Buildings 11 and 12*, Final Report; prepared by Weston, Inc.; May 1996; SRDB Ref ID: 24625

Weston, 1996-c, *Texas Instruments Incorporated Remediation of Building Interiors—Buildings 4, 5, and 10*, Report Version 1.0; prepared by Weston, Inc.; October 1996; SRDB Ref ID: 114246