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REVIEW OF INTERNAL EXPOSURES TO URANIUM AT THE KANSAS CITY PLANT USING TBD-6000 AND ORAUT-OTIB-0070 AS SURROGATE DATA

Contract No. 211-2014-58081

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July 2014

S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No.: Internal Exposures to Uranium at KCP
	Effective Date: Draft – July 24, 2014
	Revision No.: 0 (Draft)
REVIEW OF INTERNAL EXPOSURES TO URANIUM AT THE KANSAS CITY PLANT USING TBD-6000 AND ORAUT-OTIB-0070 AS SURROGATE DATA	Page 2 of 17
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Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	07/24/2014	Initial issue

TABLE OF CONTENTS

LIST OF EXHIBITS

INTRODUCTION

The Special Exposure Cohort (SEC) Petition Evaluation Report (PER), SEC-00210, for the Kansas City Plant (KCP) (January 7, 2014) presents a detailed description of the uranium operations that took place at the KCP and the methods that NIOSH plans to use to reconstruct the internal exposure to workers due to these operations. This white paper presents a review of the information provided in the SEC PER and the supporting site profile (ORAUT 2006) and SC&A's position regarding the degree to which internal doses to workers at the KCP from uranium can be reconstructed in a scientifically sound and claimant-favorable manner using TBD-6000 (Battelle 2011) and ORAUT-OTIB-0070 (ORAUT 2012) protocols as a surrogate for time periods with limited air sampling data and workers with limited bioassay data. This report specifically addresses uranium machining operations that took place from 1950 to 1955 and the associated residual period from March 1, 1955, to 1958; in 1958, other uranium operations and substantial air sampling and bioassay data became available.

Detailed descriptions of the uranium handling operations that took place at the KCP are described in several sections of the SEC PER. Section 5.1.2 states the following:

> *NIOSH has information that KCP workers inspected and assembled uranium components, machined uranium slugs, and handled uranium billets and ingots at KCP in the early 1950s. Starting in May 1950 and continuing to February 1955, uranium components were inspected and assembled in Department 3A (KCP, 1950–1963). In February 1951, KCP set up a machine shop to produce 1,000 slugs per day to fuel AEC production reactors at the Savannah River Site in South Carolina, and Argonne National Laboratory near Chicago, Illinois. KCP received some of the 10-foot long uranium rod stock for this work from the Lackawanna Test Site in New York. Forty-five thousand (45,000) slugs were produced for the initial order. Ongoing work to produce 5-tons per month was also scheduled. The work was performed in the Main Manufacturing Building in Department 49X, also known as Area X. This area was specifically prepared for this work: a smooth finished concrete floor was laid and painted, steel panel walls were erected, an adjacent storeroom was prepared, and the entire area was cleaned and painted. The equipment used to make slugs in this area included: an 8'' Springfield bench lathe; a Fay Automatic lathe; a Schauer air collet machine; a power cut-off saw; and four Gisholt turret lathes (see Figure 5-3). Work was performed during two shifts utilizing machine operators (14), inspectors (3), an accountability officer, and a packaging man (Mahaffey, 1952; Paine, 1951).*

Additional description of the uranium machining operations, including the machining of billets and ingots, is provided in Section 5.2.1. As will be discussed later in this report, these types of uranium machining operations were common and extensively studied by the Health and Safety Laboratory (HASL) at about the same time these operations were taking place at the KCP. It is these investigations that helped establish the technical underpinnings of TBD-6000, which, as will be discussed later, is used as a surrogate for reconstructing exposures to uranium to KCP workers during this time period. It is noteworthy that the uranium machining operations appear to be limited to lathe operations and power saw cutting of natural uranium metal slugs.

Section 5.2.1.1 provides additional information on the types of exposures the uranium machining operators experienced, emphasizing that the uranium was natural uranium. However, Section 5.2.1.2 explains that substantial quantities of depleted uranium (DU) were machined from April 1958 to 1971. Also, uranium oxide powder with an AMAD (activity median aerodynamic diameter) of 1.175 was handled at the facility in the 1960s, but it is not apparent exactly what was done with the powder.

On page 26, this section concludes with a description of another uranium process performed in 1997, where a new program was initiated:

> *DU metal was reduced in size and shape by an electrochemical process that involves the placement of DU metal in an acid bath. The parts are rinsed with water and dried before handling. Because the uranium does not become volatile during the electrochemical process, remaining in the acid solution, there is minimal personnel internal dose hazard with this process. There is also no removable contamination with this process (ORAUT-TKBS-0031).*

Given this as background information on the different types of uranium operations that took place at the facility, Section 6.1 of the SEC PER provides a description of the data that are available for reconstructing internal exposures to uranium. On page 31, the section quotes an AEC survey in 1952 (Safety Survey 1952) that states:

> *Atmospheric dust analysis and general observation within the Machining of Uranium Metal Area indicated that personnel are being properly safeguarded. The dust count in the lathe area during cutting operations was well below any limit wherein the toxicity might be considered. Some smoke and oxides were noticed, but the hood ventilation appeared to be adequate. Assembly Area dust samples were negative and the neatness of the area was impressive.*

The section also states that the routine air sampling monitoring was performed from 1958 to 1971. The following table extracted from page 32 of the SEC PER presents a summary of the data. Note that these data are part of the ongoing review of the KCP site profile and SEC PER.

Exhibit A. Reproduction of Table 6-2 from NIOSH's KCP SEC PER

Table 6-2: Statistical Parameters of Measured DU in KCP Workplace Air [(a),(b)] for 1958–1970

KCP Measured Results [(a)]				Lognormal Fit		
				Air Concentration		
Year	No. of Measurements	Mean (μCi/cm^3)	Maximum (μCi/cm^3)	Median (μCi/cm^3)	95% (μCi/cm^3)	GSD
1958	22	7.18E-12	4.90E-11	4.01E-13	1.74E-10	4.02E+01
1959	27	8.82E-13	1.22E-11	2.89E-13	2.53E-12	3.74E+00
1960	33	1.32E-12	1.50E-11	3.41E-13	3.94E-12	4.43E+00
1961	31	1.00E-12	2.04E-11	1.97E-13	1.52E-12	3.46E+00
1962	31	7.73E-13	1.13E-11	2.50E-13	2.03E-12	3.58E+00
1963	31	1.25E-12	1.63E-11	2.47E-13	1.90E-12	3.46E+00
1964	31	2.21E-12	3.90E-11	3.91E-13	2.98E-12	3.44E+00
1965	31	1.99E-13	8.70E-13	1.05E-13	8.02E-13	3.45E+00
1966	23	7.01E-13	6.24E-12	2.00E-13	2.00E-12	4.06E+00

Exhibit A. Reproduction of Table 6-2 from NIOSH's KCP SEC PER

Table 6-2: Statistical Parameters of Measured DU in KCP Workplace Air [(a),(b)] for 1958–1970						
KCP Measured Results [(a)]				Lognormal Fit		
				Air Concentration		
Year	No. of Measurements	Mean (µCi/cm^3)	Maximum (µCi/cm^3)	Median (µCi/cm^3)	95% (µCi/cm^3)	GSD
1967	22	1.40E-12	1.30E-11	5.70E-13	3.12E-12	2.81E+00
1968	19	1.21E-12	9.88E-12	2.31E-13	3.47E-12	5.19E+00
1969	19	1.88E-11	8.55E-11	3.88E-12	1.42E-10	8.92E+00
1970	19	7.32E-14	5.91E-13	4.02E-14	1.98E-13	2.64E+00
Average	**1958-1970**	**2.85E-12**	**2.15E-11**	**5.49E-13**	**2.62E-11**	

Source: This table is a slightly modified version of Table 11 from ORAUT-TKBS-0031.
(a) All departments.
(b) Based on maximum measured KCP workplace airborne uranium concentrations at several monitoring locations.

The section also describes the urine bioassay program and minimum detectable levels (MDLs) performed at the time that DU powder was handled and refers the reader to each worker's bioassay records. The following table, extracted directly from page 34 of the SEC PER, provides a summary of the bioassay results (these data are also part of the KCP site profile and SEC PER review):

Exhibit B. Reproduction of Table 6-3 from NIOSH's KCP SEC PER

Table 6-3: Statistical Parameters of Recorded DU in Urine for 1959–1971[(a)]								
Year	Recorded Annual Urine Concentration[(b)]			Lognormal Fit		Chronic intakes (pCi/d)[(c)]		
	No. of Workers Reported	Concentration (µg/L)		Concentration (µg/L)				
		Mean	Maximum	Median	GSD	5th	Median	95th
1959	214	4.125	52.60	2.642	2.675	1.05E+02	6.42E+02	3.92E+03
1960	281	36.58	140.	19.53	3.813	7.79E+02	4.75E+03	2.89E+04
1961	123	51.40	192.1	37.44	2.402	1.49E+03	9.10E+03	5.55E+04
1962	148	4.327	15.75	3.162	2.508	1.26E+02	7.69E+02	4.69E+03
1963	211	10.96	72.00	7.564	2.532	3.02E+02	1.84E+03	1.12E+04
1964	219	5.627	78.38	3.888	2.431	1.55E+02	9.46E+02	5.76E+03
1965	175	9.572	38.00	5.583	3.422	2.23E+02	1.36E+03	8.27E+03
1966	223	6.432	45.05	4.214	2.640	1.68E+02	1.02E+03	6.24E+03
1967	159	5.438	21.50	3.574	2.713	1.43E+02	8.69E+02	5.30E+03
1968	11	6.055	6.600	6.052	1.029	2.42E+02	1.47E+03	8.97E+03
1969	<10	0.15	0.150	0.150	1.000	5.99E+00	3.65E+01	2.22E+02
1970	59	11.64	45.00	7.576	2.686	3.02E+02	1.84E+03	1.12E+04
1971	47	0.03596	0.1000	0.02993	1.903	1.19E+00	7.28E+00	4.44E+01
ALL	**1,871**	**14.1**	**192.1**	**5.5**	**4.7**			

Source: This table is a slightly modified version of Table 12 in ORAUT-TKBS-0031.
(a) All bioassay measurements.
(b) The recorded annual sum of urine concentration is the sum of all bioassay results for the year. There is one sum for each person-year record. The listed statistics are based on the analysis of the data, which are the sums of all bioassay data for every person for that year.
(c) Chronic intakes that produce the urinary excretion per day on the 365th day of intakes corresponding to the median excretion from the lognormal fit and 5th and 95th percentile intakes using a GSD of 3. Assumes 5-µm AMAD particle size and absorption Type S; intakes for 1-µm AMAD particle size, 10.97 g/cm^3 density, and absorption Type S are smaller.

Table 6-4 of the SEC PER also provides a summary of bioassay data by worker category, where the concentration of uranium in urine ranged from below the MDL to 14.08 µg/L with an average of 9.44 µg/L. These data and the associated MDLs are not discussed here, but they are being addressed as part of the KCP site profile and SEC PER review.

Given these data, Section 7.1.1 discusses the pedigree of the data and the approach NIOSH has adopted to assign bounding internal doses to workers from handling uranium at the facility. As may be noted, there is a considerable body of air sampling and bioassay data beginning in 1958, but the data are limited for the time period from May 1, 1950, through February 28, 1955. In theory, the air sampling and bioassay data summarized in Tables 6-2 and 6-3 can be used to reconstruct internal exposures to uranium workers using worker-specific data or through the development of claimant-favorable coworker models. The degree to which internal doses to uranium can be reliably reconstructed for these time periods and using these data sources are being addressed as part of the overall review of the KCP site profile and SEC PER review.

EVALUATION

This section focuses on the use of TBD-6000 as a scientifically sound and claimant-favorable set of protocols, data, and assumptions to reconstruct the internal uranium doses to KCP workers during those time periods where air sampling and bioassay data are limited. It should be noted that the use of TBD-6000 as one of the methods adopted by NIOSH to reconstruct internal exposures to uranium at the KCP is not addressed in the KCP site profile. This review also addresses the use of ORAUT-OTIB-0070 as the basis for reconstructing the doses to workers during the residual period following the termination of the uranium machining operations period, which took place during the period 1950 to 1955.

Airborne Uranium Dust Loadings during Machining Operations

Section 7.2.3.1, Natural Uranium Operations from May 1, 1950, through February 28, 1955, is where the SEC PER begins to describe the use of TBD-6000 to reconstruct internal doses to uranium for that time period. It should be noted that the machining operations as described and referenced in the SEC PER are more detailed than we have seen for most other Atomic Weapons Employer (AWE) operations, which allows us to better evaluate the degree to which TBD-6000, including its supporting source document, Harris and Kingsley 1959 (see also Harris 1951 and Harris and Kingsley 1958), can be used as a surrogate for the early uranium operations at KCP. The endnote of Harris and Kingsley describes how the data and other descriptive information provided in the report were compiled:

> *The investigations which resulted in the data contained in this report were performed mainly by members of the Industrial Hygiene Branch of the Health and Safety Laboratory, especially by Paul Klevin, A.J. Breslin, and Martin Weinstein. Assistance was provided by the analytical branch of the laboratory in processing the enormous number of samples involved in these studies.*
>
> *Assistance was also provided by the following persons and industrial concerns: Dr. Joseph Quigley and Mr. R.C. Heatherton and the Feed Materials Processing*

Center, Fernald Ohio; Mr. Mont Mason and the Mallinckrodt Chemical Works; Simonds Saw and Steel; Bridgeport Brass Company; and Sylvania-Corning Nuclear. Most photographs were supplied by the Fernald plant.

At the time, the HASL was one of the foremost radiological laboratories in the world. Because of the importance of this report, SC&A and NIOSH have been assigned on numerous occasions to further investigate and validate the completeness and reliability of the data (see SC&A 2013 and 2007; also see Allen 2009a and 2009b), and it is SC&A's position that the Harris and Kingsley report establishes a scientifically sound basis upon which to build a matrix of coworker models (as was done in TBD-6000) for reconstructing internal exposures to workers involved in the handling of uranium during the late 1940s and early 1950s, a time when the Manhattan Engineering District (MED) and the Atomic Energy Commission (AEC) relied heavily on selected private industries to support the weapons complex before uranium handling facilities, such as those at Fernald and Hanford, became available. In fact, it was the experience gained at these AWE facilities that established the scientific and engineering underpinning for uranium handling employed by the weapons complex. Notwithstanding the level of excellence achieved by the Harris and Kingsley report, SC&A believes that care must be taken in each application of TBD-6000 (and by reference, Harris and Kingsley) to any particular uranium handling operation, such as the operations that took place at KCP during the early 1950s.

The SEC PER explains that NIOSH selected the airborne uranium dust loading for the job category "operator" from Table 7.5 of TBD-6000, specifically 5,480 dpm/m^3, for use as surrogate uranium air concentration for early uranium operations at KCP. Inspection of Table 7.5 reveals that a uranium dust loading of 5,480 dpm/m^3 represents the highest geometric mean (GM) dust loading concentration among the 20 different categories of uranium machining operations addressed in TBD-6000. In addition, this dust loading is characterized as the daily weighted average (DWA) for centerless grinding operations, which is recognized in the supporting documentation provided in Harris and Kingsley (1959) as the operation with the highest airborne dust loadings. Table 7.5 of TBD-6000 also provides the range of measured air dust loading concentrations for centerless grinding as 5,000-6,000 dpm/m^3. However, it should be pointed out that the image of the lathe provided in Figure 5-3 of the SEC PER is a turret lathe, and it appears that most of the uranium machining operations at KCP involved lathes, as opposed to centerless grinding. A turret lathe is designed to remove metal by moving the rotating work piece against a cutting tool which produces metal chips (not unlike the shavings from planing a piece of wood). In centerless grinding, an abrasive cutting wheel rotates against the work piece and removes metal by an abrasive action (not unlike sandpaper). The residues and uranium dust from centerless grinding involve much larger quantities of finer particles of uranium than a lathe. Hence, from the perspective of TBD-6000, NIOSH certainly selected the highest dust loading among the various categories of uranium machining operations that took place in the early to mid 1950s.

Page 101 of Harris and Kingsley (1959) describes uranium machining operations, explaining that uranium fires can occur frequently during machining unless a few rules are followed, including:

(1) Applying 8- to 15-gal/minute of coolant to the uranium undergoing machining, using a variety of different types of oils. As indicated on page 41 of the SEC PER, Texaco

soluble oil "C" was used, which is one of the coolant types recommended by Harris and Kingsley.

(2) Low cutting rates; e.g., below 100 surface feet per minute.

(3) Carbide-tipped tools.

(4) Use a chip breaker, which enhances coolant quenching.

The report goes on to describe other good practices that would help to reduce airborne uranium dust loading and fires and specifically addresses good practices associated with lathe operations. Page 102 of Harris and Kingsley goes on to describe the range of airborne uranium dust breathing zone concentrations observed during a variety of lathe operating conditions, ranging from 3 to 90 dpm/m^3 with optimal operating speeds but no ventilation. At higher than optimum cutting speeds (e.g., 200 ft/min), the breathing zone dust concentrations were as high as 1,750 dpm/m^3. However, with appropriate local ventilation, the dust loadings were reduced to <1 dpm/m^3. Figure 5 in Harris and Kingsley (1959) shows a canopy hood over a turret lathe that was effective in reducing dust to the indicated levels.

Our review of the supporting documentation for lathe operations at the KCP reveals that, in addition to the abundant use of cooling oil and ventilation, the fastest rpm stated was 402 rpm (Stowers 1951a; Williams 1951) and the smallest finished piece diameter was 0.750 in (Stowers 1951a; Stowers 1951b; Stowers 1951c); therefore, (0.750 in) × π × (1 ft/12 in) × (402 rev/min) ≈ 78.9 surface feet per minute. Also, the following carbide-tipped cutting tools were used (Stowers 1951a; Paine 1951; Mahaffey 1952):

- Garmet CA-1
- Kennametal K3H
- Kennametal K6
- Vascoloy

Finally, a safety survey was conducted at KCP (Johnson 1952). Attachment II of the Johnson memo provided the safety survey report of W.H. Kingsley. With respect to the machining of uranium metal, Kingsley stated the following:

> *Atmospheric dust analyses and general observation within the subject area indicated that personnel are being properly safeguarded. The dust count in the lathe area during cutting operations was well below any limit wherein toxicity might be considered. Some smoke and oxides were noticed, but hood ventilation appeared to be adequate.*
>
> *I should also like to comment here on the efficiency of the film badge system throughout the areas visited. It was quite evident that the contractor personnel have the problem well in hand. The 3A-Assembly Area dust analyses were negative and the neatness of the area was impressive.*

This information would seem to indicate that the lathe operations employed many of the techniques and systems that would help to reduce airborne dust loading of uranium. Hence, the dust loading at the KCP during uranium machining operations in 1950 to 1955 likely was associated with dust loading that was within the bounding values for lathe operations as reported by Harris and Kingsley and adopted in TBD-6000. In addition, as discussed below, NIOSH used bounding dust loadings that are applicable to centerless grinding, which adds additional conservatism to the analysis.

Page 104 of Harris and Kingsley provides a fairly detailed description of a centerless grinder and its potential to generate airborne uranium dust. The section explains that a centerless grinder needs to be enclosed as completely as possible in a leak-proof head and ventilated with a velocity through all openings of 500 feet/min; without such controls, breathing zone concentrations as high as 13,000 dpm/m^3 have been observed.

Tables 5 and 6 of Harris and Kingsley summarize the results of their comprehensive investigations, as follows:

Exhibit C. Reproduction of Table 5 – Machining Operations

(Daily Weighted Averages in d/m/M^3)

Operator	No. vent	Vent
Automatic lathe	200–300	30–70
*Turret lathe	150	40–50
*Facing (each)	100	–
*Cutoff (each)	100	20–30
*Milling (each)	100	20–30
*Slotting (each)	100	20–30
Drill	20	10
*Radius cutting	100–300	30
Milling	40	–
Shaping	<10	–
Planning	<10	–

*Values are for normal operations. With speeds less than 100 surface feet and adequate cooling, all results are less than 10 d/m/M^3.

Exhibit D. Reproduction of Table 6 – Abrasive Operations

(Daily Averages d/m/M^3)

Operator	No Vent	Vent
Cut-off	–*	<1
Surface grinder	2,000–5000	50–200
Portable grinder	400	50–200
Belt sander	3000	<10
Centerless grinder	5,000–6,000	50–300

*Never sampled, but very high.

It is apparent that by adopting a dust loading of 5,430 dpm/m^3 as the DWA uranium dust loading for uranium workers at KCP for the early 1950s, NIOSH is using the dust loading associated with a centerless grinder, the highest dust loading among all of the uranium machining and handling operations, and assumed no special ventilation controls. In fact, the KCP operations at the time appear to have primarily used various types of lathes. The implications are that the surrogate data adopted by NIOSH for these exposures is likely to be overestimated by at least a factor of 10. In fact, NIOSH would have been on solid scientific ground if it used the lathe operation data as the basis for dose reconstruction at the KCP. However, by using centerless grinding surrogate data, NIOSH is assured of meeting the surrogate data criteria discussed below.

In many reports of this type prepared by SC&A, we often conclude with a section that evaluates the surrogate data employed by NIOSH against the five surrogate data criteria adopted by the Advisory Board on Radiation and Worker Health (ABRWH 2010). The following presents that comparison.

Based on the information presented in this report, one can make a determination regarding whether or not the use of TBD-6000 surrogate data for the uranium machining operations that took place at the KCP in the early 1950s meets the Board criteria for surrogate data, as follows:

(1) Hierarchy of Data. *It should be assumed that the usual hierarchy of data would apply to dose reconstructions for that site (Individual worker monitoring data followed by co-worker data followed by workplace monitoring data such as area sampling followed by process and source term data.) This hierarchy should be considered when evaluating the potential use of surrogate data. Surrogate data should only be used to replace data if the surrogate data have some distinct advantages over the available data and then only after the appropriate adjustments have been made to reflect the uncertainty inherent in this substitution.*

There was limited air sampling or bioassay data available during the uranium machining operations at KCP during the early 1950s. In terms of hierarchy of data, generic air sampling data from TBD-6000 site was appropriately substituted for limited air sampling and bioassay data.

(2) Exclusivity Constraints. *In many cases, surrogate data are used to supplement the available monitoring data from a site. In those cases, the surrogate data is* [sic] *usually used to justify certain assumptions about the distribution or range of possible exposures or assumptions about the source terms. In those cases, no special justification is necessary beyond the usual scientific evaluation. This is akin to the Type II use described above. However, in other situations, there are no or very little monitoring data available. In those cases, the use of the surrogate data as the basis for individual dose reconstruction would need to be stringently justified. This judgment needs to take into account not only the amount of surrogate data being relied on relative to data from the site but also the quality and completeness of that surrogate data.*

The fact that TBD-6000 has been carefully vetted by a Work Group of the ABRWH is indicative of stringent justification of that document as a source of surrogate data. The selected surrogate data from TBD-6000 were based on the sampling work of HASL, which is regarded to be of high quality. The TBD-6000 data are composites from a number of sites and were selected from the source document (Harris and Kingsley 1959) using the most conservative groups of measurements. Consequently, the quality and quantity of the data used should satisfy this criterion.

(3) Site or Process Similarities. *One of the key criteria for judging the appropriateness of the use of surrogate data would be the similarities between the site (or sites) where the data were generated and the site where the surrogate data are being utilized. The application of any surrogate data to an individual dose reconstruction at a site should include a careful review of the rationale for utilizing that source of data.*

The uranium machining operations at the KCP during the early 1950s are thoroughly described in the SEC PER, and it is clear that those operations fall within the scope of machining operations described in TBD-6000 and also its supporting documentation provided in Harris and Kingsley (1959). In fact, if anything, the surrogate data adopted by NIOSH likely overestimate the inhalation exposures to uranium that might have occurred at the KCP during the early 1950s, because it appears that most machining operations involved the use of lathes, while NIOSH elected to use TBD-6000 data for centerless grinding as the surrogate for all machining operations, which likely overestimates the exposures. By adopting this strategy, NIOSH ensures that Criterion 2 is satisfied. As may be noted, a delicate balance must be struck between the requirements of Criterion 2, Exclusivity Constraints, and Criterion 5, Plausibility. We believe that NIOSH has struck this balance, with greater emphasis given to meeting Criterion 2.

(4) Temporal Considerations. *Consideration also needs to be given to the period in question, since working conditions and processes varied in different periods. Surrogate data should belong in the same general period as the period for which doses are sought to be reconstructed unless it can be demonstrated that the working conditions, procedures, monitoring methods, and (perhaps) legal requirements were comparable to the period in question.*

The data gathered by the HASL and reported in Harris and Kingsley (1959) and used as the basis for TBD-6000, were collected at time periods that were contemporaneous with the KCP operations in the early 1950s. Hence, this criterion is satisfied.

(5) Plausibility. *The plausibility criterion equates plausibility with the reasonableness of the assumptions made regarding surrogate data. The plausibility determination should address issues of:*

- Scientific plausibility. *Are the assumed models (e.g., bioassay, concentration gradients) scientifically appropriate? Have the models been validated (where feasible) using actual monitoring data collected in a similar situation?*

- Workplace plausibility. *Are the assumed processes and procedures (including monitoring) plausible for the facility in question? Have all of the factors that could significantly impact exposure been taken into account? Is adequate information available about the facility in order to be able to make a fair assessment?*

With regard to scientific plausibility, as described previously, internal exposures were based on actual monitoring data collected under similar situations by a respected measurement laboratory. With regard to workplace plausibility, we described in Section 2.1 that the processes and procedures that underlie the TBD-6000 data are generally comparable and likely more conservative than the processes used at the KCP in the early 1950s. We have also noted that the methodology used in TBD-6000 was to select from air concentrations measured for several job descriptions. The particular operation (i.e., machining) that resulted in the highest exposure was selected and applied to all the operators involved in the uranium machining operation. Given this methodology, it is reasonable to assume all of the factors that could significantly impact exposure have been taken into account.

It is our opinion that use of surrogate data from TBD-6000 for dose reconstruction at the KCP during uranium machining operations in the early 1950s satisfies the ABRWH criteria.

Airborne Dust Loadings and Exposures Associated with the Residual Period following the Termination of Uranium Machining Operations in 1955

Section 7.2.3.1 describes the methods used to reconstruct internal exposures due to residual uranium deposited on surfaces following the termination of uranium machining operations in 1955. The section refers to TBD-6000 as the basis for the approach. However, it appears that NIOSH actually used the protocols described in ORAUT-OTIB-0070, which SC&A has previously reviewed and found to be scientifically sound and claimant favorable. The following is a description of the protocol used and any comments SC&A has regarding that protocol as applied to the KCP.

NIOSH assumes that the air concentration of uranium at the beginning of the residual period on March 1, 1955, was 5,480 dpm/m^3. This is the bounding concentration used during the uranium machining operations. Hence, this is the appropriate starting point for dose reconstruction during the residual period and is consistent with the guidance provided in OTIB-0070.

Also, in accordance with OTIB-0070, NIOSH assumes that the concentration of dust on surfaces at the beginning of the residual period reflects the buildup of residue associated with a deposition velocity of 0.00075 m/sec for a 30-day period, as follows:

$$5{,}480\ dpm/m^3 \times 0.00075\ m/sec \times 30\ days \times 86{,}400\ sec/day = 10{,}653{,}120\ dpm/m^2$$

Given this activity on surfaces, NIOSH applied a resuspension factor of 1E-5/m and derived an airborne dust loading at the beginning of the residual period of 106.5 dpm/m^3, which is consistent with guidance provided in OTIB-0070.

The SEC PER goes on to explain that this airborne dust loading will decline due to natural attenuation, because machining operations had ceased on March 1, 1955. There are basically two approaches that can be used to evaluate the rate of decline of this airborne concentration. One approach is to use a natural attenuation factor of 0.00067/day, as recommended in OTIB-0070 and which SC&A believes is a reasonably conservative value, or make use of airborne dust loading measurements made at a later date and derive the rate of decline in the airborne dust loading by fitting an exponentially declining function between the derived dust loading on March 1, 1955, and the dust loading measured at a later date, prior to the start-up of other uranium operations. The SEC PER explains that dust loading measurements were made on May 23, 1958, prior to the start of DU operations, and the maximum value was reported as 49 pCi/m^3 (or 108.9 dpm/m^3).

Note that the measured maximum dust loading of 108.9 dpm/m^3 on May 23, 1958, is comparable to the derived dust loading of 106.5 dpm/m^3 derived as representative of the dust loading at the beginning of the residual period. Because of this, NIOSH assumes that the dust loading during the residual period from March 1, 1955, until large scale DU operations began in 1958 remains constant at 108.9 dpm/m^3. This is an interesting outcome, because it raises a couple of questions: (1) is the 5,480 dpm/m^3 adequately conservative for the operations period, (2) is the deposition period of 30 days adequately long, and (3) is the resuspension factor of 1E-5/m sufficiently bounding. The reason we raise these questions is we believe that the airborne dust loadings should have declined from March 1, 1955, until 1958, but they did not. We believe that the assumed dust loading of 5,480 dpm/m^3 is certainly bounding as the starting point for the airborne uranium dust loadings on March 1, 1955. However, there is evidence from previous work performed by SC&A (SC&A 2013) that the time period for buildup of dust (i.e., 30 days) may be too short and the resuspension factor could be higher by perhaps a factor of 10 based on SC&A's previous reviews of resuspension factors, especially at sites where there is a lot of activity. However, it is also possible that NIOSH was overly conservative by using the highest dust loading observed in 1958 of 108.9 dpm/m^3. SC&A searched the Site Research Database (SRDB) to capture the air sampling data that were collected in the Main Manufacturing Building in 1958. We captured 36 samples, and summarized their distribution in the following plot (Exhibit E).

Exhibit E. Plot of 1958 Air Sampling Data for KCP Main Manufacturing Building

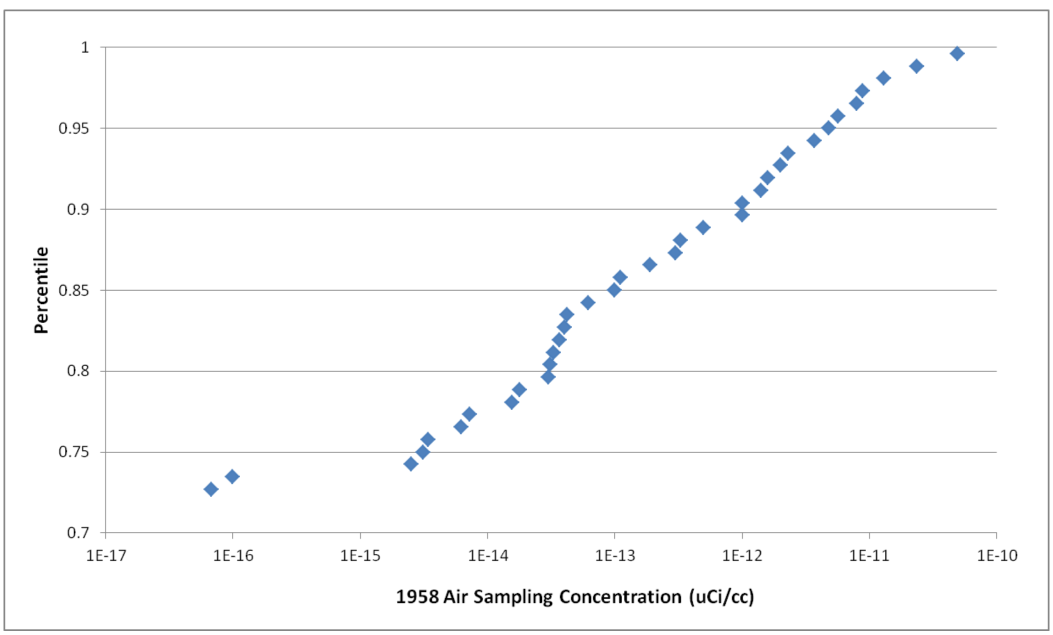

Exhibit F. Summary Table of 1958 Air Sampling Data for KCP

Metric	Value	Units
# Positive Samples	36	Samples
GM	1.086E-16	µCi/cc
GSD	426.36	-
GM*GSD	4.639E-14	µCi/cc

As previously described, NIOSH selected 49 pCi/m^3 as the airborne dust loading due to resuspension at the end of the residual period in 1958. This corresponds to a concentration of 4.9E-11 µCi/cc, which appears to be the highest measured concentration. The GM is 1.09E-16 µCi/cc, or 1.1E-4 pCi/m^3, which would be a more appropriate value for deriving the slope of the attenuation factor. Accordingly, the approach used by NIOSH in the SEC PER to estimate the airborne uranium dust loading during the residual period from March 1, 1955, to 1958 is extremely claimant favorable. A strategy that would be more in keeping with OTIB-0070 would have been to use the GM concentration as the airborne dust loading at the end of the residual period. Again, it appears that NIOSH is sacrificing plausibility in favor of ensuring that they meet the Criterion 2 (exclusivity) requirements. These are judgment calls, which, in this application, appear to greatly favor the claimants.

Given the uranium dust loading, NIOSH assumes that workers in the Main Manufacturing Building were exposed to this airborne dust loading for 2,000 hours per year. Other general laborers are assumed to spend 50% of their time in the Main Manufacturing Building, as per TBD-6000, page 49. Of course, this assumption is somewhat arbitrary, but given the conservatism inherent in the average dust loading during the residual period, this assumption is not unreasonable. In addition, it might be difficult to determine who should be assigned 2,000 hrs/yr versus 1,000 hrs/yr exposure duration. However, this is an implementation issue that is appropriately evaluated as part of dose reconstruction reviews.

The SEC PER states that ingestion exposures to uranium should be based on OCAS-TIB-009 (OCAS 2004) protocols; SC&A has reviewed this protocol and has found it acceptable.

CONCLUSIONS

We conclude that the approach adopted in the SEC PER to reconstruct internal exposures to uranium during the uranium machining operations from 1950 to 1955 and during the residual period, from March 1, 1955, to the beginning of the DU operations in 1958, is scientifically sound and extremely claimant favorable (as long as there were no other radiological operations taking place in the Main Manufacturing Building during this time period), but is deemed to be acceptable as a means to ensure compliance with the Criterion 2 Exclusivity Requirements.

REFERENCES

ABRWH 2010. *Criteria for Use of Surrogate Data*. Draft. Prepared by ABRWH Work Group on Use of Surrogate Data. May 2010.

Allen 2009a. BATTELLE-TBD-6000 ISSUE 5 WHITE PAPER. Comparison to Adley and Simonds Saw Contamination Data. Prepared by Dave Allen, OCAS. October 9, 2009.

Allen 2009b. BATTELLE-TBD-6000 ISSUE 4 WHITE PAPER. Comparison to Adley Air Data also Simonds. Prepared by Dave Allen, OCAS. October 9, 2009.

Battelle 2011. *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals*. Battelle-TBD-6000. Revision 1.

Harris, W.B., 1951. Recommended Practices for Uranium Finishing, NYO-1516, USAEC New York Operations Office, May 17, 1951. USDOE OSTI (http://www.osti.gov) Ref ID: 4377963.

Harris, W.B., and I. Kingsley, 1958. *The Industrial Hygiene of Uranium Fabrication*, HASL-39, USAEC New York Operations Office, June 6, 1958, SRDB Ref ID: 15785.

Harris, W.B., and I. Kingsley, 1959. *The Industrial Hygiene of Uranium Fabrication*, Reprinted from the A. M. A. Archives of Industrial Health, May 1959, Volume 19, pp 540-565.

Johnson, W. M., 1952. *Safety Survey - August 4-7, 1952*, correspondence to W. B. Paine, August 28, 1952, SRDB Ref ID: 128316.

KCP 1950–1963. *Chronological List of Radioactive Materials in the Plant*; dates in document ranging from January 1950 through January 8, 1963; SRDB Ref ID: 128349, pdf pp. 2-17.

Mahaffey, J. W., 1952. *History of Production Machining of Uranium*, FMPC-28, Production Division National Lead Company of Ohio, June 16, 1952, SRDB Ref ID: 44238.

OCAS 2004. *Estimation of Ingestion Intakes*, OCAS-TIB-009, Rev. 0; Office of Compensation Analysis and Support; effective April 13, 2004; SRDB Ref ID: 22397.

ORAUT 2006. *Site Profile for the Kansas City Plant*, ORAUT-TKBS-0031, Rev. 00 PC-1, Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 6, 2006.

ORAUT 2012. *Dose Reconstruction during Residual Radiation Periods at Atomic Weapons Employer Facilities*. ORAUT-OTIB-0070, Rev. 1. Oak Ridge Associated Universities Team, Cincinnati, Ohio.

Paine, W.B., 1951. *Machining of U-238*, September 13, 1951, SRDB Ref ID: 75263.

Safety Survey 1952. *Safety Survey for August 4-7, 1952*; Survey write-up dated August 28, 1952; SRDB Ref ID: 128316.

SC&A 2007. *Draft Review of Battelle-TBD-6000, Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals*, Rev. 0. September 14, 2007.

SC&A 2012. *Review of the NIOSH Site Profile for the Kansas City Plant*, Contract No. 200-2009-28555, SCA-TR-SP2012-0006, Prepared by Ron Buchanan, Joyce Lipsztein, John Mauro, Joseph Porrovecchio, S. Cohen & Associates, 1608 Spring Hill Road, Suite 400, Vienna, VA 22182.

SC&A 2013. *Supplementary Comments on Revision 01 of Battelle-TBD-6000*. Contract No. 200-2009-28555, Prepared by William C. Thurber, S. Cohen & Associates, 1608 Spring Hill Road, Suite 400, Vienna, VA 22182, May 2013.

SEC PER 2014. Special Exposure Cohort Petition Evaluation Report, Petition SEC-00210, Rev. 0, January 7, 2014.

Stowers, J. C., 1951a. *Machining of U-238*, correspondence to W. B. Paine, April 23, 1951, SRDB Ref ID: 128332.

Stowers, J. C., 1951b. *Machining of U-238*, correspondence to W. B. Paine, May, 11, 1951, SRDB Ref ID: 128335.

Stowers, J. C., 1951c. *Procedures Pertaining to Work Performed in Area X*, correspondence to W. B. Paine, June 8, 1951, SRDB Ref ID: 128333.

Williams, H. E., 1951. *Report on Trip to the Hanford Works, Richland Washington*, correspondence to R. E. Batty, May 1, 1951, SRDB Ref ID: 128331.