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REVIEW OF THE REVISED HUNTINGTON PILOT PLANT SITE PROFILE

Contract No. 200-2009-28555
SCA-TR-SP2013-0043

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June 2013

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S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation & Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-SP2013-0043 Effective Date: Draft – June 4, 2013
Review of the Revised Huntington Pilot Plant Site Profile	Page 2 of 25
Task Manager: _____ Date: _____ John Mauro, PhD, CHP	Supersedes: N/A
Project Manager: _____ Date: _____ John Stiver, MS, CHP	Reviewer: John Mauro John Stiver

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	06/04/2013	Initial issue.

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

BNL	Brookhaven National Laboratory
Ci	Curies
cm	centimeter
DOE	Department of Energy
DRSC	Dose Reconstruction Subcommittee
g	gram
g/cc	gram per cubic centimeter
HPP	Huntington Pilot Plant
keV	kiloelectron volts
MCNPX	Monte Carlo N-Particle eXtended
MeV	mega electron volts, million electron volts
mg Ni/m^3	milligrams of nickel per cubic meter
mrep/hr	milli-Röntgen equivalent physical per hour
nCi/g U	nanocurie per gram of uranium
NIOSH	National Institute for Occupational Safety and Health
NNDC	National Nuclear Data Center
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
pCi/mg	picocurie per milligram
ppm	part per million
R/hr	Roentgen per hour
rad/hr	radiation absorbed dose per hour
RADAR	RAdiation Dose Assessment Resource
RPP	Reduction Pilot Plant
RU	recycled uranium
SC&A	S. Cohen and Associates (SC&A, Inc.)
TBD	Technical Basis Document
UCNC	Union Carbide Nuclear Company

1.0 BACKGROUND AND INTRODUCTION

During the meeting of the Dose Reconstruction Subcommittee (DRSC) held on February 4, 2013, one of the topics discussed was SC&A's focused review of the Huntington Pilot Plant (HPP) exposure matrix (SC&A 2008, Attachment 3), as originally provided in ORAUT 2004a. During that meeting, NIOSH indicated that the original SC&A findings are now addressed in a revised version of the exposure matrix; i.e., *Technical Basis Document for the Huntington Pilot Plant, Huntington, West Virginia*, OCAS-TKBS-0004 (OCAS 2008). SC&A was thereby directed by the DRSC to review the revised exposure matrix to evaluate the degree to which our original findings have been addressed.

SC&A presented the results of that evaluation in a report dated March 21, 2013 (SC&A 2013). Because of the relatively short time period between authorization to perform the review and the fact that NIOSH developed "an entirely revised strategy for deriving the external penetrating and non-penetrating doses to workers during operations" (SC&A 2013), SC&A was not able to fully address the responsiveness of the revised site profile to each of its original 12 findings. However, we were able to recommend the following:

- Closing Findings 1, 4, 6, 9, and 10
- Withdrawing Findings 2 and 5
- Keeping open Findings 3, 7, 8, 11, and 12, because SC&A requires additional time to investigate the new strategies that NIOSH has incorporated into the revised site profile

In Section 3 of SC&A 2013, we summarized the new strategy that NIOSH adopted in its revised site profile. A summary of that strategy is repeated here because it serves as a useful introduction to the new material that is reviewed in this report:

> *…in the earlier version of the site profile, NIOSH assumed that the level of enrichment was 36%, because this was the contractual limit on the level of enriched uranium that was permitted at Huntington. SC&A concurred with NIOSH at the time that this was a very conservative assumption, because the actual data showed that the level of enrichment in the actual uranium processed at the facility was only a few percent. Because of this extremely conservative assumption, NIOSH concluded that it was not necessary to explicitly account for the internal exposures that were associated with recycled uranium (RU), which was handled at the plant. SC&A agreed with this simplifying assumption. In the revised site profile, NIOSH no longer assumes 36% enrichment, but instead uses the more realistic enrichment of 2%, and now the site profile explicitly addresses RU by employing the RU composition used in the K-25 Gaseous Diffusion Plant TBD (ORAUT 2006). As part of this review, we did not review the models and assumptions employed in the K-25 TBD, but leave that to the Gaseous Diffusion Plant Work group.*

This report presents the completion of our review of the revised site profile for HPP, including explicitly addressing the new material provided in the revised site profile and the five original findings that we identified as requiring additional review.

2.0 INDEPENDENT EVALUATION OF EXPOSURE ESTIMATES

2.1 INTERNAL DOSE DURING OPERATIONS

Section 5.2 of OCAS-TKBS-0004 (OCAS 2008) states, "Mass of 2% enriched uranium is estimated to be 1,200 pCi/mg (DOE 2004)." DOE (2004), Table 2-5, gives the specific activity of 2% enriched uranium as 1,000 pCi/mg (1×10^{-6} Ci/g). Alternatively, the DOE (2004) equation for calculating uranium specific activity (i.e., $[0.4 + 0.38E + 0.0034E^2] \times 10^{-6}$ Ci/g, where E = % U-235 by weight) gives 1,174 pCi/mg at 2% U-235 enrichment. The differences between these three values are all likely to be due to round-off.

Section 5.2 of OCAS-TKBS-0004 states, "Pu-239 and Np-237 are the contaminants that are likely to have contributed to significant dose at the RPP" [Reduction Pilot Plant]. No basis or reference for making this statement is provided. Additionally, the site profiles for Paducah [ORAUT-TKBS-0019-5 (ORAUT 2012)], Portsmouth [ORAUT-TKBS-0015-5 (ORAUT 2004b)], and K-25 [ORAUT-TKBS-0009-5 (ORAUT 2006)] all indicated that Technetium-99 is the fission product of concern from a dosimetry standpoint for recycled uranium. Paducah also indicated that americium-241 was also "present in small amounts in the feed material produced from RU [recycled uranium]."

Section 5.2 of OCAS-TKBS-0004 indicates that the default isotopic ratios for Pu-239 and Np-237 were taken from the K-25 site profile (ORAUT 2006). SC&A assumes that ORAUT-TKBS-0009-5, Table 5-6, was the source for these ratios. Using the data from Table 5-6 of ORAUT-TKBS-0009-5 and the three uranium specific activities discussed above, SC&A attempted to match the Pu-239 and Np-237 contaminant activities presented in OCAS-TKBS-0004, Table 4. As shown in the table below, we were not able to exactly match the Table 4 values, although our values are close to and on either side of them.

Nuclide	ORAUT-TKBS-0009, Table 5-6 (nCi/g U)	Containment Activity (unit-less)			
		Table 4	Specific Activity (pCi/mg)		
			1,200	1,000	1,174
Pu-239	67.5	0.063	0.056	0.068	0.058
Np-237	5.4	0.0050	0.0045	0.0054	0.0046
Am-241	67.5	N.G.	0.056	0.068	0.058
U-236	0.93	N.G.	0.00078	0.00093	0.00079
U-235	43.9	N.G.	0.037	0.044	0.037
U-234	702	N.G.	0.59	0.70	0.60
U-238	337.5	N.G.	0.28	0.34	0.29
Th-230	18.9	N.G.	0.016	0.019	0.016
Tc-99	0.12	N.G.	0.00010	0.00012	0.00010

Based on the above discussion, the following two findings related to the internal dose have been generated.

Finding 1: Since the three diffusion plants (the source of the HPP nickel) had additional isotopes of concern, NIOSH should clearly provide the basis for only specifying Pu-239 and Np-237 as isotopes of concern for recycled uranium.

Finding 2: NIOSH should clearly state which uranium specific activity was used in the analysis and ensure that it was used consistently throughout the analysis.

2.2 EXTERNAL DOSE DURING OPERATIONS

2.2.1 Gamma Energy Spectrum

The external dose review focused on Attachment A. The first item to be checked was the Table A2 gamma ray spectra.

Finding 3: There is a unit conversion error in going from Table A2 column 3 (Photons per decay ^{238}U) to column 4 (Photons per second per Ci ^{238}[U]).

The values in column 4 are a factor of 3,600 larger than they should be. For example, for the 0.001 to 0.01 MeV row:

$$0.000087252\ \frac{photons}{disintegration} \times 3.7 \times 10^{10}\ \frac{disintegrations}{\sec - Ci} = 3.228 \times 10^{6}\ \frac{photons}{\sec - Ci}$$

When this calculated value is compared to the value from Table A2, column 4, the difference is a factor of 3,600, as shown:

$$\frac{1.162 \times 10^{10}}{3.228 \times 10^{6}} = 3{,}600$$

As will be demonstrated below, this unit conversion error only affects column 4 of Table A2 (and Table A3), but does not affect the calculated dose rates.

Next, SC&A checked the gamma energy spectra given in Table A2. First, MicroShield (Grove 2009) was used to generate gamma energy spectra from the decay of U-238, U-235, and U-234 and their decay products. MicroShield contains its own library of radionuclide decay data, including decay schemes and photon energies. It was initially assumed that the decay products were in full equilibrium with their uranium parents. The three uranium MicroShield spectrums were combined using the drum activities given in Table A1 (i.e., U-234: 1,420 Ci; U-235: 78 Ci; and U-238: 295 Ci), and then normalized to the U-238 activity. The results are shown in Figure 1 (the purple dashed line) and compared to the Table A2 spectra (the blue solid line).

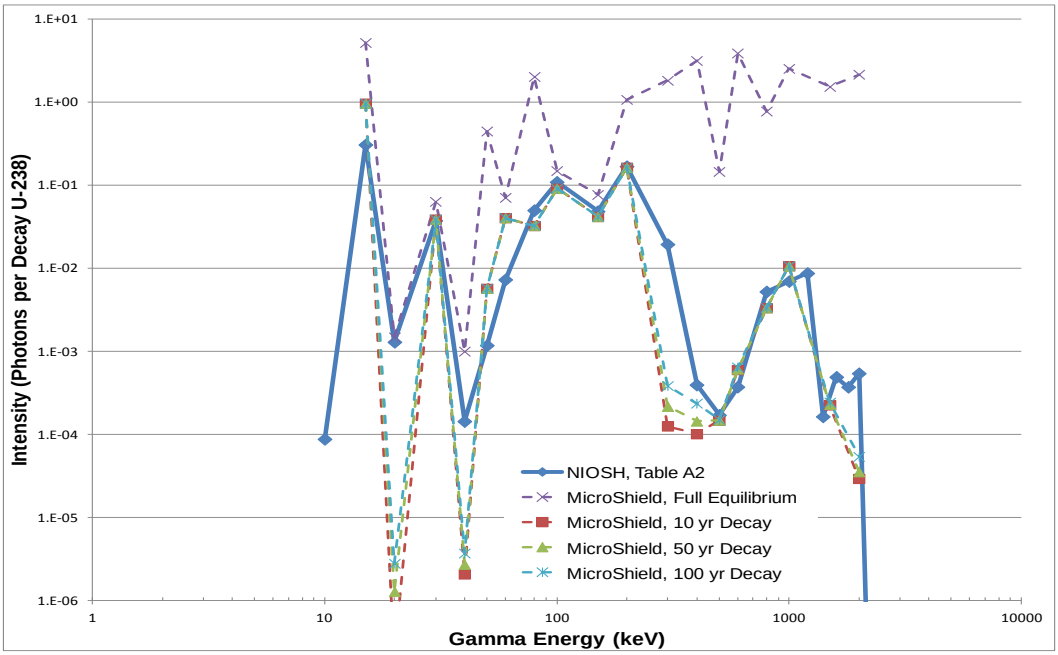

Figure 1: Uranium Gamma Spectrum, using MicroShield

As Figure 1 shows, when full equilibrium is assumed, there is considerable disagreement between the MicroShield and Table A2 gamma spectra. SC&A next used MicroShield to create gamma spectra at decay times of 10, 50, and 100 years. These would be the conditions before Th-230 and its progeny could grow in for the U-238 series and before any Pa-231 and its progeny could grow in the U-235 series. These would be the conditions one would expect from the types of uranium handled at HPP (not including any recycled uranium). The same procedure was followed to develop the gamma spectra, and the results are shown in Figure 1 as the red, green, and light blue dashed lines. Figure 1 now shows that there is much better agreement between the Table A2 and MicroShield gamma spectrums. Although there are differences between the Table A2 and MicroShield gamma spectrums, those differences are not considered significant. The differences are likely due to different decay times, different energy binning, etc.

Attachment A indicated that NIOSH utilized data from the National Nuclear Data Center [NNDC at Brookhaven National Laboratory (BNL 2013)] in the development of the Table A2 gamma energy spectrum. SC&A likewise went to the NNDC and attempted to reproduce the Table A2 spectrum. Figure 2 shows the results of that attempt.

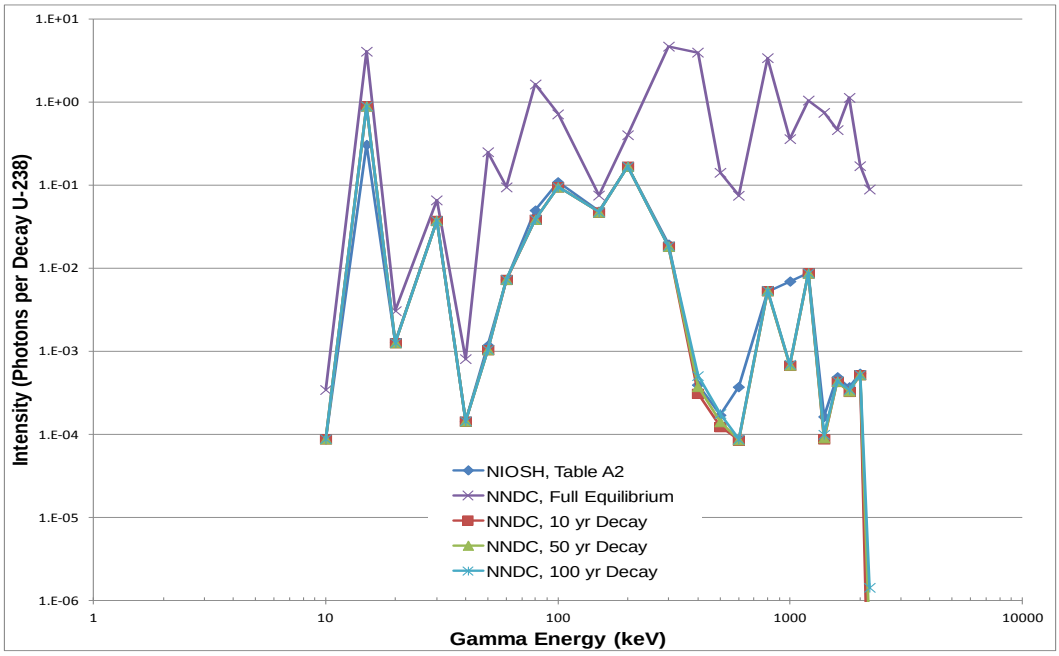

Figure 2: Uranium Gamma Spectrum, using the National Nuclear Data Center

With the possible exception of 600 and 1,000 keV, Figure 2 shows that SC&A was able to almost exactly match the Table A2 gamma spectrum with data from the NNDC. As with the MicroShield comparison, the Figure 2 agreement between the SC&A and Table A2 gamma spectrums is considered good. The differences are likely due to different assumed decay times, different energy binning, etc.

Observation 1: Consistent with HPP operations, the gamma energy spectrum used by NIOSH is not based on full equilibrium of U-238, U-235, and U-234 with their decay products; rather it is consistent with a decay period where only short-lived progeny of U-238 and U-235 would have had an opportunity to grow in.

2.2.2 Beta Energy Spectrum

Similar to Table A2, Table A3 presents the beta energy spectra. Since it does not include information on beta decay, SC&A could not use MicroShield to check the Table A3 beta spectrum. Attachment A indicates that NIOSH obtained the beta spectrum from the RADAR website (Stanford 2013). SC&A likewise obtained beta data from the RADAR website in order to check the Table A3 spectra.

The SC&A-developed beta spectra are shown in Figure 3 (green line). Similar to the gamma spectra, there are significant differences between the SC&A-developed beta spectra and the Table A3 spectra (shown as the blue line in Figure 3).

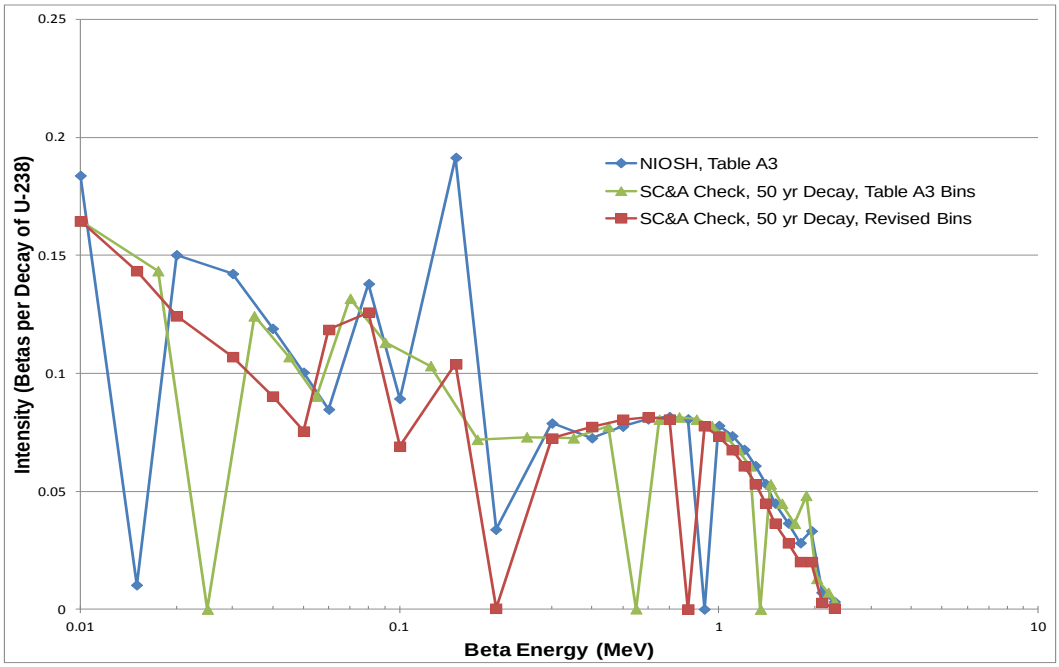

Figure 3: Uranium Beta Spectrum, using the National Nuclear Data Center

As a further check, SC&A performed a second beta spectrum analysis, only this time the upper energy range was selected as the mid-point between the upper limits given in Table A3. For example, Table A3 has upper energy bins from 0.02 to 0.03 and from 0.03 to 0.04; instead of these bins, SC&A used 0.025 to 0.035 and 0.035 to 0.045, i.e., the revised SC&A bins were centered on the Table A3 upper energy. The results of this revised binning are shown in Figure 3 (red line). What this exercise demonstrates is the effect that simple changes in assumptions can have on the resulting energy spectrum.

Regardless of the manner in which the beta energy bins are defined, the agreement between the two SC&A-calculated beta energy spectra and the Table A3 energy spectra is considered good.

Observation 2: Consistent with HPP operations, the beta energy spectrum used by NIOSH is not based on full equilibrium of U-238, U-235, and U-234 with their decay products; rather, it is consistent with a decay period where only short-lived progeny of U-238 and U-235 would have had an opportunity to grow in.

2.2.3 Penetrating Dose Rate

Observation 3: In the current site profile (OCAS 2008), NIOSH assumed that residues were stored in 20 gallons drums, while in the previous site profile (ORAUT 2004a), it was assumed that the residues were stored in "birdcages." The basis for this change in assumption is not provided in OCAS 2008.

To calculate the penetrating dose rate, NIOSH assumed that the "residues were placed into 20 gallon drums and then stored on the ground floor of the plant spaced over a 40 ft. by 105 ft. area" (OCAS 2008, page 8), which is consistent with the information provided in UCNC 1958:

"The residue from 150,000 lb. of feed material is spaced uniformly on the ground floor over an area 45 ft. × 105 ft. with the residue from each batch being in a single 20-gal. drum." These assumptions regarding the configuration of the residues differ from what had previously been assumed, i.e., "This process residue was most likely decanted into storage units known as 'birdcages,'" and "'Birdcage' container most likely used for storage and shipping of enriched uranium at the Huntington Pilot Plant" (ORAUT 2004a). Notice that the previous site profile (ORAUT 2004a) never presents documentation that the "birdcages" were used at the HPP, it only asserts that they were *most likely used*, as opposed to the current site profile (OCAS 2008), which based the use of 20-gallon drums on a document that is contemporary with HPP operation (i.e., UCNC 1958).

SC&A used MicroShield (Grove 2009) to perform a simple check on the MCNPX (LANL 2008) calculation that was performed by NIOSH and explained in Attachment A of OCAS 2008. Rather than attempt to model an array of 20-gallon residue drums, SC&A modeled a single drum. Therefore, it is expected that the SC&A MicroShield dose rates should be smaller than those presented in Table A4.

The SC&A MicroShield model was an 18.25-inch diameter by 14-inch high cylindrical source composed of nickel with a density of 0.4 g/cc, as described in Attachment A (OCAS 2008, page 23). The dose receptor position was 30 cm from the center of the drum, and 77.9 cm above the surface.

In the first MicroShield run, SC&A entered the gamma spectrum from Table A2, column 4 of OCAS 2008. The resulting dose rate, when adjusted for the amount of U-238 present in the drum, was 0.044 R/hr. Once the dose rate was corrected for the Table A2 unit conversion error (see Finding 3), the single drum MicroShield-calculated dose rate, integrated over the energy spectrum, was 1.2×10^{-5} R/hr, which agrees well with the 2.56×10^{-5} rad/hr drum array dose rate given in Table A4. This is considered confirmation that NIOSH did not include the unit conversion error in the MCNPX calculation. It is also considered confirmation of the MCNPX-calculated dose rate, with the difference between 1.2×10^{-5} R/hr and 2.56×10^{-5} rad/hr attributed to the difference between a single drum and an array of drums.

SC&A made a second MicroShield run, but instead of entering the Table A2 gamma spectra, SC&A allowed MicroShield to calculate the gamma spectra from its internal library and the entered Table A1 drum U-238, U-235, and U-234 inventory. The dose rate from the second MicroShield run was 1.4×10^{-5} R/hr, which also agrees with the Table A4 dose rate.

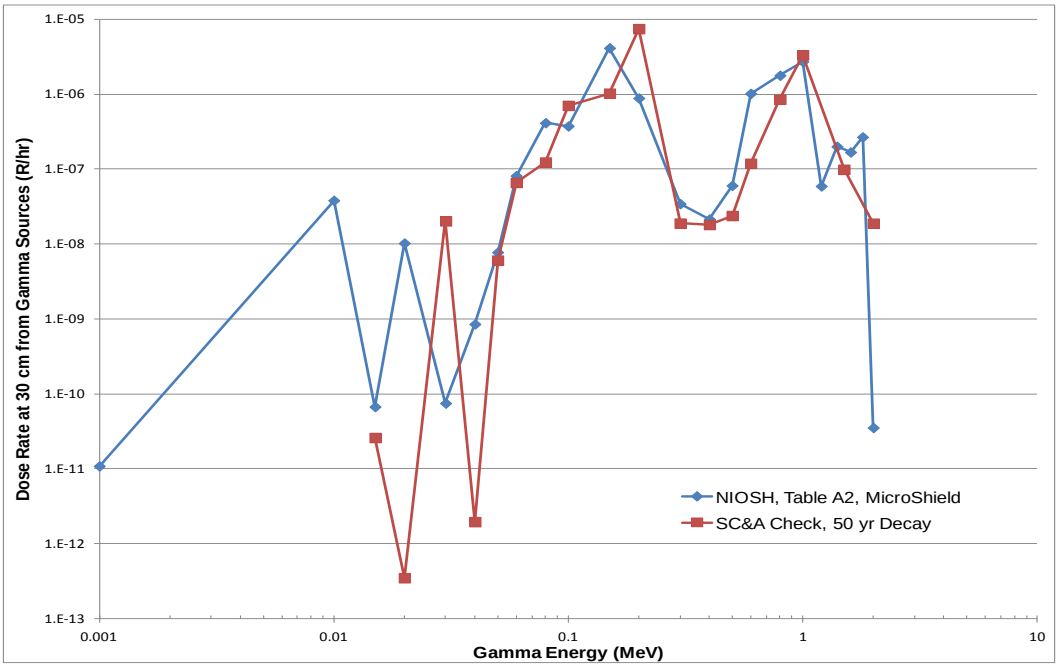

Figure 4: MicroShield Dose Rate from a 20-Gallon Drum by Gamma Energy

Figure 4 shows the dose rate as a function of the gamma energy spectrum, while Figure 5 shows the cumulative dose rate as a function of the spectrum. As expected based on the above discussion, there is good agreement between the calculated dose rates.

Figure 5 also shows the Table A4 dose rate of 2.56×10^{-5} rad/hr (the dashed blue line). If it is assumed that the difference between the MicroShield dose rate and the Table A4 dose rate is due to a single drum versus an array of drums, and if it is assumed that this same difference will be maintained for the MicroShield-generated gamma spectrum, then the resulting dose rate due to an array of drums is estimated to be 2.9×10^{-5} R/hr (the dashed red line on Figure 5). Considering the differences between MicroShield and MCNPX, the gamma spectrums, one drum versus an array of drums, is considered to be good agreement.

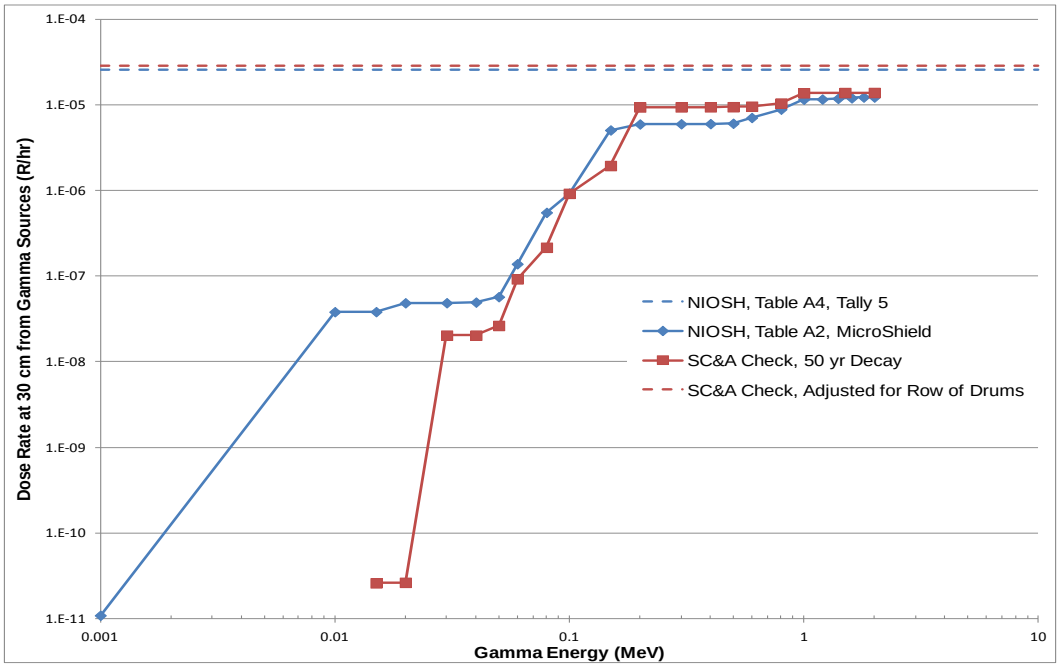

Figure 5: MicroShield Dose Rate from a 20-Gallon Drum – Cumulative over Gamma Energy

Observation 4: The penetrating dose rate calculated by NIOSH using MCNPX and modeling an array of drums is consistent with the dose rate calculated by SC&A using MicroShield and modeling a single drum. Furthermore, the MicroShield-calculated dose rate using the Table A2 gamma energy spectrum is consistent with the dose rate calculated using the gamma energy spectrum from the MicroShield radionuclide decay library.

2.2.4 Dose Rate Energy Distribution

Finally, Figure 6 is an attempt to reproduce OCAS-TKBS-0004, Figure A1. As shown, when the Table A2 Gamma energy spectrum is used, there is good agreement between Figure 6 and Figure A1, and the dose breakdown is approximately a 50/50 split for 0–250 keV/>250keV. However, when the MicroShield spectrum is used, the dose breakdown is ~70% for 0–250 keV and ~30% for >250 keV.

Finding 4: The dose breakdown between 0–250 keV and >250 keV varies from 50/50 to about 70/30, depending on the gamma spectrum.

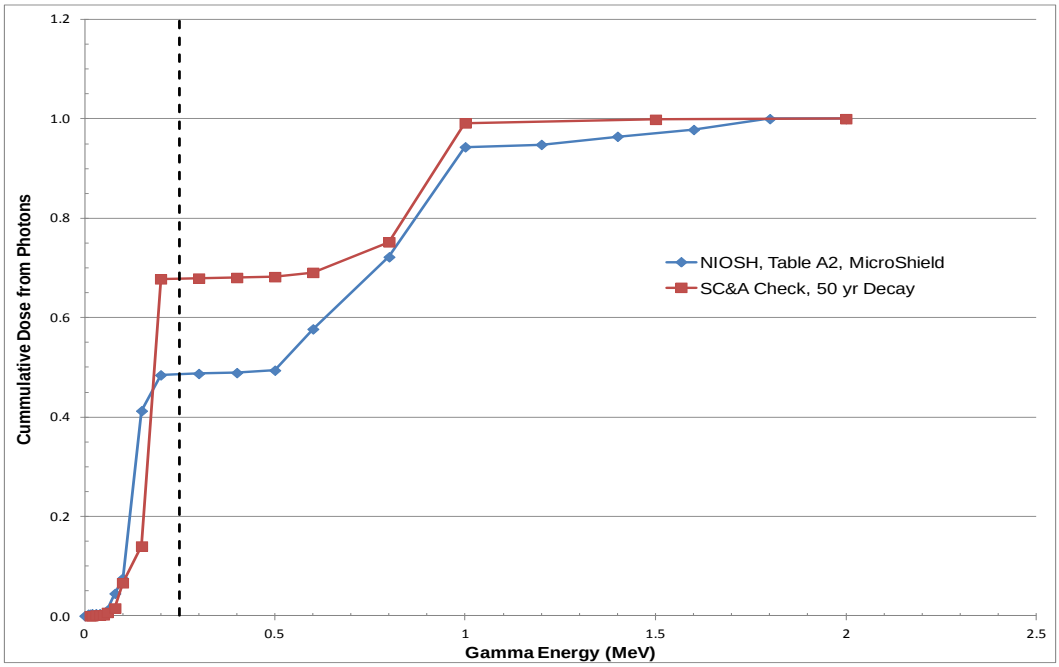

Figure 6: Energy Distribution for Photon Emissions

(OCAS-TKBS-004, Figure A1)

3.0 AIRBORNE NICKEL CONCENTRATION

In our March 21, 2013, evaluation report (SC&A 2013), SC&A questioned the use of modern sample data to estimate historical airborne nickel concentrations. In brief, Enterline and Marsh (1982) presented airborne nickel concentrations for various areas of the HPP (see Enterline and Marsh 1982, Table 8). These nickel concentrations were a combination of both modern and historical measurements. Enterline and Marsh recognize that the modern data are not directly compatible with historical conditions and made an attempt to correct for that fact, i.e., "Whenever possible and/or applicable, the modern data were adjusted on the basis of a knowledge of process changes and environmental controls that were implemented over the years." However, Enterline and Marsh further recognize that, "extrapolation of modern sample data to historical exposures is imperfect, but it can be assumed that the historical exposures were the same or, in most cases, of greater magnitude." In other words, the modern nickel concentrations given in Enterline and Marsh 1982, Table 8, are likely smaller than what the historical concentrations would be.

Nevertheless, NIOSH utilized all of the nickel airborne concentration from Enterline and Marsh 1982, Table 8 (both modern and historical), to develop geometric mean (0.046 mg Ni/m^3) and 95^{th} percentile (0.44 mg Ni/m^3) concentrations. As stated above, SC&A took exception to utilizing the modern data, and recalculated the mean (0.242 mg Ni/m^3) and 95^{th} percentile (2.01 mg Ni/m^3) concentrations using only the 10 historical concentrations from Enterline and Marsh 1982, Table 8.

Finding 5: Provide justification for including modern airborne nickel concentrations in the concentration distribution, when Enterline and Marsh 1982 indicate that the historical concentrations were (in most cases) of greater magnitude.

Furthermore, at the beginning of their report, Enterline and Marsh state that the concentration of airborne nickel was estimated to range from 20 to 350 mg Ni/m^3 in areas where the matte was crushed, ground, and handled, and from 5 to 15 mg Ni/m^3 around the calciners. These concentrations are significantly larger than any of the values given in Enterline and Marsh 1982, Table 8, and no explanation is provided as to why they have not been included.

The NIOSH 95^{th} percentile concentration (0.44 mg Ni/m^3) implies that a worker spends only about 11 minutes per work-day in an area with a concentration of 20 mg Ni/m^3. If a worker spent more time in such an area, or if the concentration were 350 mg Ni/m^3, then use of the NIOSH 95^{th} percentile concentration would be claimant unfavorable.

Finding 6: Provide justification for excluding from the concentration distribution the airborne nickel concentration in the crushing, grinding, and handling areas and the area around the calciners reported by Enterline and Marsh (1982).

Finally, it should be noted that Enterline and Marsh do not use their Table 8 nickel airborne concentration to develop a single site distribution. Rather, they couple their Table 8 concentrations with an individual worker's work location and duration to develop a unique exposure concentration for each individual. For example, in Table 4 of their report, Enterline

and Marsh present exposure concentrations for four workers. The table below compares the Enterline and Marsh 1982, Table 4, average exposure concentrations to the NIOSH and SC&A concentration distributions.

Enterline and Marsh 1982, Table 4		Mean		95th Percentile	
		NIOSH	SC&A	NIOSH	SC&A
Hire	**mg Ni/m^3**	**0.046**	**0.242**	**0.44**	**2.01**
1924	0.03	<	<	<	<
1928	0.24	>	<	<	<
1940	0.20	>	<	<	<
1941	0.94	>	>	>	<

< indicates that the Table 4 value is less than the distribution value
> indicates that the Table 4 value is greater than the distribution value

As shown, the NIOSH mean concentration is favorable for only one of the four workers (or 25% of the time), while the SC&A mean and the NIOSH 95th percentile are favorable for three of the four workers (or 75% of the time). Only the SC&A 95th percentile concentration is favorable for all four of the Enterline and Marsh 1982, Table 4, average exposure concentrations.

Observation 5: When appropriately used, a site airborne nickel concentration distribution can be used to make favorable exposure estimates when compared to the individual worker location-specific estimates made by Enterline and Marsh (1982, Table 4).

4.0 SHALLOW DOSE – TYPOGRAPHICAL ERRORS

Finding 7: There are three typographical errors in the numerical values given in Section 6.2 of OCAS 2008. Despite the erroneous numerical values, the annual doses are reported correctly, thus SC&A has characterized them as "typographical," rather than "numerical" errors. Nonetheless, because the erroneous numerical values make it difficult to understand how the annual doses were calculated, SC&A has identified these three typographical errors as a finding rather than an observation.

Each of the numerical typographical errors is described below.

4.1 UCNC 1958 CONTACT BETA DOSE RATE

Section 6.2 states that UCNC (1958) "estimated an upper bound [beta] dose rate from the residues at 0.024 mrep/hour on contact". The full quotation from UCNC 1958 is:

> *The beta dose rate at the surface of an effectively infinite slab of normal uranium is 240 mrep/hr., and the dose rate at the surface of material with a uniform daughter-product concentration corresponding to 1000 ppm. of uranium (or 1 part per 1000) would accordingly be 1/1000 of this, or 0.24 mrep/hr.*
>
> *With the production of 50 pounds of residue from a 4000-lb. batch of material, the daughter products will be concentrated by a factor of 80, with a resulting dose rate of approximately 20 mrep/hr. This beta dose rate, which is the maximum that can be obtained from the material described, would be found only at the surface of the residue, and the beta radiation would be reduced to essentially zero by the shielding effect of the drum in which the material will be stored.*

Thus, Section 6.2 should indicate that UCNC (1958) "estimated an upper bound dose rate from the residues at 20. mrep/hour on contact." As described below, a contact beta dose rate of 20 mrep/hr produces the calculated annual doses reported elsewhere in Section 6.2 and Table 6, whereas a contact dose rate of 0.024 mrep/hr produces significantly different annual beta doses.

4.2 ANNUAL DOSE RATE TO HANDS AND FOREARMS

Next, the fourth sentence of the second paragraph of Section 6.2 states that "some workers could have had direct contact with the residues for fifty hours per year resulting in a shallow dose to the hands and forearms of 1.2 rem per year." Instead of 1.2 rem/yr, the correct product of 20 mrep/hr times 50 hr/yr is 1.0 rem/yr, as is correctly shown in Table 6 (OCAS 2008, page 17).

4.3 HOURLY DOSE RATE AT 30 CENTIMETERS

The third sentence of the third paragraph of Section 6.2 states that the "contact dose rate estimated for the residues is … divided by 75 to determine beta dose rates at 30 cm from the surface of the residues, resulting in a beta dose rate of 0.00027 mrem per hour." The quotient of dividing 20 mrep/hr by 75 is 0.27 mrem/hr, rather than 0.00027 mrem/hr. Although the 30-cm

beta dose rate given in the text is 3 orders of magnitude too small, the calculated annual beta doses are correct. For example, with an exposure duration of 2,000 hours per year, the annual beta dose would be [0.27 mrem/hr × 2,000 hr/yr × 0.001 rem/mrem] = 0.54 rem/yr, as reported in both Section 6.2 and Table 6.

5.0 SUMMARY OF FINDINGS AND OBSERVATIONS

The findings and observations that have been made in the preceding discussion are summarized in the following subsections. Generally, in order to resolve a finding, SC&A expects that NIOSH will need to make a change or correction or provide an explanation to OCAS-TKBS-0004 (OCAS 2008). However, an observation does not necessarily require any action or response by NIOSH.

5.1 FINDING 1 – RECYCLED URANIUM ISOTOPES OF CONCERN

Since the three diffusion plants (the source of the HPP nickel) had additional isotopes of concern, NIOSH should clearly provide the basis for only specifying Pu-239 and Np-237 as isotopes of concern for recycled uranium.

5.2 FINDING 2 – URANIUM SPECIFIC ACTIVITY

NIOSH should clearly state which uranium specific activity was used in the analysis and ensure that it was used consistently throughout the analysis.

5.3 FINDING 3 – UNIT CONVERSION

There is a unit conversion error in going from Table A2 column 3 (Photons per decay ^{238}U) to column 4 (Photons per second per Ci ^{238}[U]). This same unit conversion error also appears in Table A3 for the beta spectrum.

As explained above, this unit conversion error only affects the values presented in Tables A2 and A3, and is not carried through to the dose rate calculations.

5.4 OBSERVATION 1 – GAMMA ENERGY SPECTRUM

Consistent with HPP operations, the gamma energy spectrum used by NIOSH is not based on full equilibrium of U-238, U-235, and U-234 with their decay products. Rather it is consistent with a decay period where only short-lived progeny of U-238 and U-235 would have had an opportunity to grow in.

Although SC&A found that the Table A2 gamma energy spectrum is consistent with a decay period of 50 to 100 years, NIOSH may want to consider identifying in OCAS-TKBS-0004 (OCAS 2008) the specific decay period that was used, with an explanation as to why that period was selected.

5.5 OBSERVATION 2 – BETA ENERGY SPECTRUM

Consistent with HPP operations, the beta energy spectrum used by NIOSH is not based on full equilibrium of U-238, U-235, and U-234 with their decay products. Rather it is consistent with a decay period where only short-lived progeny of U-238 and U-235 would have had an opportunity to grow in.

5.6 OBSERVATION 3 – RESIDUE STORAGE CONTAINER

In the current site profile (OCAS 2008), NIOSH assumed that residues were stored in 20 gallons drums, while in the previous site profile (ORAUT 2004a) it was assumed that the residues were stored in "birdcages". The basis for this change in assumption is not provided in OCAS 2008.

5.7 OBSERVATION 4 – PENETRATING DOSE RATE

The penetrating dose rate calculated by NIOSH using MCNPX and modeling an array of drums is consistent with the dose rate calculated by SC&A using MicroShield and modeling a single drum. Furthermore, the MicroShield calculated dose rate using the Table A2 gamma energy spectrum is consistent with the dose rate calculated using the gamma energy spectrum from the MicroShield radionuclide decay library.

5.8 FINDING 4 – DOSE ENERGY DISTRIBUTION

The dose breakdown between 0–250 keV and >250 keV varies from 50/50 to about 70/30, depending on the gamma spectrum.

5.9 FINDING 5 – INCLUDING MODERN AIRBORNE NICKEL CONCENTRATIONS

Provide justification for including modern airborne nickel concentrations in the concentration distribution, when Enterline and Marsh 1982 indicate that the historical concentrations were (in most cases) of greater magnitude.

5.10 FINDING 6 – EXCLUDING DATA FROM THE CRUSHING, GRINDING, HANDLING, AND CALCINER AREAS

Provide justification for excluding from the concentration distribution the airborne nickel concentration in the crushing, grinding, and handling areas and the area around the calciners reported by Enterline and Marsh (1982).

5.11 OBSERVATION 5 – USE OF SITE CONCENTRATION DISTRIBUTIONS

When appropriately used, a site airborne nickel concentration distribution can be used to make favorable exposure estimates when compared to the individual worker location-specific estimates made by Enterline and Marsh (1982, Table 4).

5.12 FINDING 7 – NUMERICAL TYPOGRAPHICAL ERRORS

There are three typographical errors (identified above in Section 4) in the numerical values given in OCAS-TKBS-0004 (OCAS 2008), Section 6.2. Despite the erroneous numerical values, the annual doses are reported correctly, thus SC&A has characterized them as "typographical," rather than "numerical" errors. Nonetheless, because the erroneous numerical values make it

difficult to understand how the annual doses were calculated, SC&A has identified these three typographical errors as a finding rather than an observation.

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