DRAFT

REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

COMPARISON OF SC&A'S BLIND DOSE RECONSTRUCTION TO NIOSH'S DOSE RECONSTRUCTION OF CASE #[REDACTED] FROM THE HANFORD AND THE GRAND JUNCTION OPERATIONS OFFICE

Contract No. 211-2014-58081
SCA-TR-DRC2015-CN[Redacted]

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ABBREVIATIONS AND ACRONYMS

Advisory Board	Advisory Board on Radiation and Worker Health
BCC	basal cell carcinoma
CADW	Chronic Annual Dose Workbook
CATI	Computer-Assisted Telephone Interview
CF	correction factor
CW	coworker
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DOL	(U.S.) Department of Labor
DR	dose reconstruction
EE	Energy Employee
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
FAP	fission and activation products
FP	fission product
GJOO	Grand Junction Operations Office
GSD	geometric standard deviation
HTO	tritiated water
IMBA	Integrated Modules of Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
keV	kiloelectron volts
LOD	Limit of Detection
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
OW	open window
PA	posterior/anterior
POC	probability of causation
rem	Roentgen equivalent man
REMS	Radiation Exposure Monitoring System
S	shielded

SC&A	S. Cohen and Associates (SC&A, Inc.)
TBD	technical basis document
TIB	technical information bulletin

1.0 RELEVANT BACKGROUND INFORMATION

Under Contract No. 200-2009-28555, SC&A was tasked by the Advisory Board on Radiation and Worker Health (Advisory Board) to perform six blind dose reconstructions (DRs) at the May 21, 2013, DR Subcommittee meeting. SC&A was provided all of the Department of Energy (DOE) dosimetry records; the Department of Labor (DOL) correspondence, forms, and medical records; and the Computer-Assisted Telephone Interview (CATI) Reports that were made available to the National Institute for Occupational Safety and Health (NIOSH) for constructing doses in behalf of these cases. SC&A used two independent approaches to reconstruct occupational external and internal doses for the cases. Both approaches used the available dosimetry records and current guidance from NIOSH. The first approach, which is referred to as DR–Method A, used the spreadsheets and other tools developed by NIOSH to calculate the doses, whereas the second approach, referred to as DR–Method B, manually calculated the doses using a deterministic model that is based on central values and first principles.

One of the six draft blind DR reports [*Blind Dose Reconstruction of Case #035096 from the Hanford and the Grand Junction Operations* Office, SCA-TR-BDR2014-CN[Redacted] (SC&A 2014)], was submitted to the Advisory Board and NIOSH on January 21, 2014. In this report, SC&A presents a comparison between SC&A's and NIOSH's DR methodologies, doses, and resultant Probability of Causation (POC) values for Case #[Redacted]. Table 1-1 summarizes the external and internal occupational doses calculated by SC&A (using two independent methods) and the NIOSH-assigned doses for the nine basal cell carcinoma (BCCs) diagnosed in behalf of Case #[Redacted]. A detailed comparison of the three methodologies used to calculate doses in behalf of this case is presented in Section 2. Section 3 of this report provides Summary Conclusions.

It should be noted that an explanation is provided regarding the differences in doses and why they occurred; however, SC&A does not make any value judgments regarding which among them may be the more preferred approach. It is our position that further discussions are best addressed by the DR Subcommittee.

Table 1-1. Comparison of SC&A's Blind Dose Reconstruction to NIOSH's Dose Reconstruction for Case #[Redacted]

	SC&A's DR – Method A							SC&A's DR – Method B			NIOSH						
	BCC (#1) [redact] (rem)	BCC (#2) [redact] (rem)	BCC (#3) [redact] (rem)	BCC (#4) [redact] (rem)	BCC (#5) [redact] (rem)	BCC (#6) [redact], BCC (#8) [redact], BCC (#9) [redact] (rem)	BCC (#7) [redact] (rem)	BCCs of [redact] (#1, #2, #5, #6, #8), [redact] (#4), [redact] (#9) (rem)	BCC (#3) [redact] (rem)	BCC (#7) [redact] (rem)	BCC (#1) [redact] (rem)	BCC (#2) [redact] (rem)	BCC (#3) [redact] (rem)	BCC (#4) [redact] (rem)	BCC (#5) [redact] (rem)	BCC (#6) [redact], BCC (#8) [redact], BCC (#9) [redact] (rem)	BCC (#7) [redact] (rem)
External Dose (Occ.)																	
▪ Recorded Photon Dose																	
30–250 keV Photons, Hanford	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.680	0.680	0.680	0.172	0.172	0.172	0.172	0.172	0.172	0.172
>250 keV Photons, Hanford	0.510	0.510	0.510	0.510	0.510	0.510	0.510	–	–	–	0.508	0.508	0.508	0.508	0.508	0.508	0.508
30–250 keV Photons, GJOO	0.370	0.370	0.370	0.370	0.370	0.370	0.370	–	–	–	0.400	0.400	0.400	0.400	0.400	0.400	0.400
▪ Missed Photon Dose																	
30–250 keV Photons, Hanford	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.090	0.090	0.090	0.120	0.120	0.120	0.120	0.120	0.120	0.120
30–250 keV Photons, GJOO CW	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
▪ Recorded Shallow Dose																	
e^- >15 keV, Hanford	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.009	–	–	–	–	–	–	–
e^- >15 keV, GJOO SC&A 30–250 keV, GJOO NIOSH	0.556	0.556	0.556	0.556	0.556	0.556	0.556	–	–	–	0.600	0.600	0.600	0.600	0.600	0.600	0.600
▪ Occupational Medical Dose																	
Hanford	0.008	0.008	0.008	0.032	0.008	0.008	0.324	0.031	0.053	0.530	0.008	0.008	0.008	0.032	0.008	0.008	0.324
GJOO	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Internal Dose (Occ.):																	
Th, U, & Ra GJOO (CW Intakes)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	–	–	–	0.048	0.050	0.052	0.052	0.055	0.058	0.058
Tritium, Hanford CW	0.079	0.079	0.079	0.079	0.079	0.079	0.079	–	–	–	0.079	0.079	0.079	0.079	0.079	0.079	0.079
E>15 keV, Hanford CW	0.005	0.005	0.005	0.005	0.005	0.005	0.005	–	–	–	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Pu, Hanford CW	0.043	0.045	0.047	0.047	0.049	0.051	0.051	–	–	–	0.042	0.045	0.047	0.047	0.049	0.051	0.051
U, Hanford CW	0.009	0.009	0.010	0.010	0.010	0.010	0.010	–	–	–	0.008	0.008	0.009	0.009	0.008	0.008	0.009
FAP, Hanford OTIB-0054	0.001	0.001	0.001	0.001	0.001	0.001	0.001	–	–	–	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total	**1.843**	**1.845**	**1.848**	**1.872**	**1.850**	**1.852**	**2.168**	**0.811**	**0.833**	**1.309**	**1.991**	**1.996**	**2.001**	**2.025**	**2.005**	**2.010**	**2.327**
POC	**43.18%**							**38.59%**			**45.27%**						

2.0 COMPARISON OF METHODOLOGY/DOSES USED BY SC&A AND NIOSH FOR CASE #[REDACTED]

Case #[Redacted] represents an energy employee (EE) who worked at Hanford from February 1974 through May 1987 and the Grand Junction Operations Office (GJOO) from [Redacted] through [Redacted]. According to the DOE records and the CATI Report, the EE worked in the [Redacted] and had a variety of job titles, such as [Redacted], [Redacted], and [Redacted] at both Hanford and GJOO. The EE was monitored for external photon and electron exposure during the employment period at Hanford; there were no external monitoring records provided for employment at GJOO. In addition, there were no recorded bioassay data from either facility. The EE was diagnosed with **nine basal cell carcinomas (BCCs)**, as shown in Table 2-1.

Table 2-1. Primary Cancers

#	Description	Diagnosis Date	ICD-9 Code
1	BCC, [Redacted]	[Redacted]	[Redacted]
2	BCC, [Redacted]	[Redacted]	[Redacted]
3	BCC, [Redacted]	[Redacted]	[Redacted]
4	BCC, [Redacted]	[Redacted]	[Redacted]
5	BCC, [Redacted]	[Redacted]	[Redacted]
6	BCC, [Redacted]	[Redacted]	[Redacted]
7	BCC, [Redacted]	[Redacted]	[Redacted]
8	BCC, [Redacted]	[Redacted]	[Redacted]
9	BCC, [Redacted]	[Redacted]	[Redacted]

For calculating radiation doses from employment at Hanford, all three DR methods primarily relied on guidance in the Technical Basis Document (TBD) for the Hanford (issued as six separate documents numbered ORAUT-TKBS-0006-01 through ORAUT-TKBS-006-6) and *Interpretation of Dosimetry Data for Assignment of Shallow Dose* (ORAUT-OTIB-0017). Since the EE was not monitored for radiation exposure at GJOO, SC&A's 'Method B' did not assign any dose for this period of employment. NIOSH and SC&A's 'Method A' assigned unmonitored external and internal doses based on a GJOO coworker dose model, which uses the 95th percentile doses, and dose methodology guidance provided in a DR draft template, entitled *DR Drafts GJOO_10-23-2013_5.0.docx*. NIOSH/Oak Ridge Associated Universities Team (ORAUT) have not published any TBDs for assessing worker doses in behalf of GJOO.

Using the guidance provided in the relevant documents, along with the employee's dosimetry records and the CATI report, each DR method calculated reasonable, claimant-favorable annual organ doses for each of the nine BCCs.

A summary of the documents, assumptions, and dose parameters used by each DR method is provided in Table 2-2 below:

Table 2-2. Comparison of Data and Assumptions Used by NIOSH and SC&A

Dose Element	NIOSH	SC&A's DR–Method A	SC&A's DR–Method B
Hanford Recorded Photon Dose	Used DOE records, Hanford TBD, and Hanford B.E. Calculation Workbook 3.26. Assumed EE worked N-Reactor all years of employment. 25% 30–250 keV 75% >250 keV Organ DCF = 1.0 IREP = Constant distribution.	Used DOE records and Hanford TBD. Assumed EE worked in the Reactor Area all years of employment. 25% 30–250 keV 75% >250 keV Organ DCF = 1.0 IREP = Constant distribution.	Used DOE records, Hanford TBD, OCAS-IG-001. Assumed EE worked throughout facility. 100% 30–250 keV Organ DCF = 1.0 IREP = Normal distribution; 30% uncertainty.
GJOO Unmonitored Photon Dose	Used GJOO coworker dose. Assumed "Administrative" category. Assumed full year of employment for partial years. DCF = 1.0; 100% 30–250 keV IREP = Constant distribution.	Used GJOO coworker dose. Assumed "Administrative" category. Assumed partial years of employment for [Redacted] & [Redacted]. DCF = 1.0; 100% 30–250 keV IREP = Constant distribution	Not Considered
Hanford Missed Photon Dose	Used DOE records, Hanford TBD and ORAUT-OTIB-0017 to identify 8 zero or <LOD/2 values. LOD = 30 mrem. DCF = 1; 100% 30–250 keV. IREP = Lognormal with GSD of 1.52 based on OCAS-IG-001 guidance.	Used DOE records, Hanford TBD and ORAUT-OTIB-0017 to identify 8 zero or <LOD/2 values. LOD = 20 mrem. DCF = 1; 100% 30–250 keV. IREP = Lognormal with GSD of 1.52 based on OCAS-IG-001 guidance.	Used DOE records, and OTIB-0017 to identify 6 zero or <LOD/2 values. LOD = 30 mrem. DCF = 1; 100% 30–250 keV. IREP = Lognormal with GSD of 1.52 based on OCAS-IG-001 guidance.
Hanford Recorded Shallow Dose	DR Report states it used DOE records and ORAUT-OTIB-0017 guidance. Shallow minus Deep dose. No clothing attenuation applied. No IREP entries were identified for the one recorded shallow dose in 1982.	Used DOE records and ORAUT-OTIB-0017 guidance. Shallow minus Deep dose. No clothing attenuation applied. Assumed 100% E>15 keV. IREP = Constant distribution for one recorded shallow dose in 1982.	Used DOE records and ORAUT-OTIB-0017 guidance. Shallow minus Deep dose. Applied clothing attenuation to BCC on [Redacted]. Assumed 100% E>15 keV. IREP = Normal distribution with 30% uncertainty for 1982 recorded shallow dose.
GJOO Unmonitored Shallow Dose	Used GJOO coworker dose. Assumed "Administrative" category. Used beta/photon value of 1.5 as cited in GJOO DR template. Assumed full year of employment for partial years. DCF = 1.0; 100% 30-250 keV IREP = Constant distribution.	Used GJOO coworker dose. Assumed "Administrative" category. Used beta/photon value of 1.5 as cited in GJOO DR template. Assumed partial years of employment for [Redacted] & [Redacted]. DCF = 1.0; 100% electrons >15 keV. IREP = Constant distribution.	Not Considered

Table 2-2. Comparison of Data and Assumptions Used by NIOSH and SC&A

Dose Element	NIOSH	SC&A's DR–Method A	SC&A's DR–Method B
Hanford Occupational Medical Dose	Assigned medical dose for years with documented x-rays and based on ORAUT-OTIB-0079. Dose based on Hanford TBD & ORAUT-PROC-0061. IREP = Normal distribution with 30% uncertainty.	Assigned medical dose for years with documented x-rays in DOE file. Dose based on Hanford TBD. IREP = Normal distribution with 30% uncertainty.	Assigned medical dose based on documented x-rays plus frequency cited in Hanford TBD plus x-rays in DOE file. Dose based on Hanford TBD. IREP = Normal distribution with 30% uncertainty.
Hanford Environmental Internal Dose	Assessed environmental internal dose using maximum annual intakes from Hanford TBD. Resulted in doses of <1 mrem.	Assessed environmental internal dose using maximum annual intakes from Hanford TBD. Resulted in doses of <1 mrem.	Assessed environmental internal dose using maximum annual intakes from Hanford TBD. Resulted in doses of <1 mrem.
Hanford Unmonitored Internal Dose	Assigned internal dose based on coworker intakes cited in Hanford TBD. Assigned fission/activation product dose based on ORAUT-OTIB-0054.	Assigned internal dose based on coworker intakes cited Hanford TBD. Assigned fission/activation product dose based on ORAUT-OTIB-0054.	Not considered. Only considered doses from environmental internal dose.
GJOO Unmonitored Internal Dose	Used GJOO coworker intakes from GJOO DR Template. Assumed "General Labor" job category.	Used GJOO coworker intakes from GJOO DR Template. Assumed "Administrative" job category.	Not considered

2.1 OCCUPATIONAL EXTERNAL DOSE CALCULATIONS

2.1.1 Hanford External Doses

Hanford Recorded Photon Doses

The DOE records show that the EE was monitored on a yearly dosimeter exchange basis for the entire Hanford employment period during [Redacted]–[Redacted], and that the EE received a small amount of positive recorded photon and electron dose. All three DR methods calculated recorded photon doses using guidance provided in the Hanford Occupational External Dose TBD (ORAUT-TKBS-0006-6) and ORAUT-OTIB-0017, Rev. 01, and applied an organ dose conversion factor (DCF) of 1.00 in accordance with *External Dose Reconstruction Implementation Guideline* (OCAS-IG-001).

NIOSH and SC&A's 'Method A' assumed the EE worked in the [Redacted] throughout employment, and therefore, assigned photons based on 25% 30–250 keV and 75% >250 keV energy ranges. Both methods also applied an organ DCF of 1.0 and entered the annual dose values into the Interactive RadioEpidemiological Program (IREP) as a constant distribution with no uncertainty.

SC&A's 'Method B' assumed the EE worked throughout the Hanford site, and assigned 100% of the photons as 30–250 keV. 'Method B' also applied an organ DCF of 1.0. However, annual doses were entered as a mean value (i.e., normal distribution) with an uncertainty of 30%.

All three methods calculated the identical total recorded photon dose of 0.680 rem for the EE's employment at Hanford.

Hanford Missed Photon Doses

Missed dose was assigned by all DR methods for photon doses reported as zero or less than one-half the applicable limit of detection (LOD) value. NIOSH and SC&A's 'Method A' counted eight missed photon readings, and SC&A's 'Method B' counted six missed readings.

NIOSH's DR and SC&A's 'Method B' used guidance in ORAUT-OTIB-0017, which cites the following for the assignment of missed photon dose to the skin.

1. If only the OW (shallow) reading was reported as zero, the missed dose assigned should be the appropriate OW LOD (divided by 2, treated as lognormal) and considered >15 keV electrons.

2. If only the S (deep) reading was reported as zero, the missed dose assigned should be the appropriate S LOD (divided by 2, treated as lognormal) and considered 30–250 keV photons.

3. If both the OW and S readings were reported as zero, the missed dose assigned should be the appropriate OW LOD (divided by 2, treated as lognormal) and considered 30–250 keV photons."

Based on the above-cited ORAUT-OTIB-0017 guidance, NIOSH and SC&A's 'Method A' found that there were no instances when the photon (or S) reading was positive and the beta (or OW) reading was zero. Therefore, all missed doses were entered into IREP as 30–250 keV photons. Both NIOSH and SC&A's 'Method B' assumed an LOD value of 0.030 rem; however, NIOSH based their assumption regarding the LOD value on guidance in the *External Dose Reconstruction Implementation Guideline*, Rev. 03 (OCAS-IG-001) while SC&A's 'Method B' used the LOD value cited in ORAUT-OTIB-0017.

SC&A's 'Method A' assigned the missed doses as 100% 30–250 keV. An LOD value of 0.020 rem was assumed, based on guidance in the Hanford TBD (ORAUT-TKBS-0006-6, Table 6-13).

A comparison of total missed photon dose calculated by the three DR methods is shown in Table 2-3. The slight difference in total missed photon doses was due to (1) the counting of eight missed doses by NIOSH and SC&A's 'Method A' as opposed to six missed doses assigned by SC&A's 'Method B,' and (2) 'Method A' used an LOD value of 0.020 rem, while NIOSH and 'Method B' assumed an LOD value of 0.030 rem.

Table 2-3. Comparison of Hanford Missed Photon Doses

Recorded Photon Doses	SC&A-Method A (rem)	SC&A-Method B (rem)	NIOSH (rem)
All 9 BCCs	0.080	0.090	0.120

All three DR methods entered annual missed photon doses into IREP as a lognormal distribution with an uncertainty of 1.520.

Hanford Recorded Electron (Shallow) Doses

DOE records showed only 1 year (i.e., [Redacted]) where the reported beta dose was positive. Both SC&A DR methods used guidance in ORAUT-OTIB-0017 for assigning non-penetrating dose to the skin and entered these doses into IREP as >15 keV electrons. SC&A's 'Method A' did not apply any correction factor (CF) for clothing; however, 'Method B' did apply a clothing attenuation CF of 0.855 for the BCC on the [Redacted].

NIOSH's DR Report states the following with regard to the assignment of Hanford reported shallow dose:

> *Corrections to the reported shallow doses were applied in accordance with the Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose* [ORAUT-OTIB-0017]. *The electron dose was assumed to be the difference between the reported deep and shallow dose from* [the EE's] *Radiological Exposure Individual Dosimeter History document. A dose conversion factor of 1.000 was used for all dosimeter doses applied in this dose reconstruction. A reduction of the electron dose due to attenuation from clothing was not applied because the skin cancers evaluated in this dose reconstruction were diagnosed in locations in which the skin would not normally be covered.*

Although the DR Report states that reported shallow dose was assigned, an inspection of the IREP sheets for all nine BCCs did not identify any electron dose for [Redacted].

SC&A's 'Method A' and 'Method B' assigned a recorded shallow dose of 0.010 rem for all cancer sites, except the BCC on [Redacted], where 'Method B' assigned 0.009 rem due to the clothing attenuation correction. This single recorded electron dose was entered as 100% electrons >15 keV. SC&A's 'Method A' assumed a constant dose distribution with no uncertainty, and SC&A's 'Method B' entered the electron doses as a normal distribution with a 30% uncertainty.

Hanford Occupational Medical Doses

All three DR methods calculated an occupational medical dose from diagnostic x-ray procedures required as a condition of employment. NIOSH and SC&A's 'Method A' identified the following four guidance documents that were referenced/consulted in order to calculate their occupational medical doses:

1. ORAUT-TKBS-0006-3, *Technical Basis Document for the Hanford Site – Occupational Medical Dose*, Rev. 02.
2. ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures*, Rev. 04.

3. ORAUT-PROC-0061, *Occupational Medical X-Ray Dose Reconstruction for DOE Sites*, Rev. 03.
4. ORAUT-OTIB-0079, *Technical Information Bulletin: Guidance on Assigning Occupational X-Ray Dose under EEOICPA for X-Rays Administered Off Site*, Rev. 00.

SC&A's DR 'Method B' strictly used guidance provided in the Hanford TBD (ORAUT-TKBS-0006-3).

NIOSH and SC&A's 'Method A' assigned dose for only x-ray exams that were documented in the EE's DOE records. Both DR methods counted six PA chest x-rays and calculated doses based on values cited in Table 3-8 ("Organ Doses for Chest Projections for all Periods") and Table 3-9 ("Skin Dose Guidance for Various Chest Projections and Periods") of the Hanford TBD. This resulted in the assignment of identical doses for all nine BCCs, as shown in Table 2-4.

SC&A's 'Method B' identified six documented posterior/anterior (PA) chest x-ray exams for the years [Redacted], [Redacted], [Redacted], [Redacted], and [Redacted]. 'Method B' also used guidance cited in Table 3-3 of ORAUT-TKBS-0006-3 that states from [Redacted] through [Redacted], all employees at Hanford received annual conventional x-ray exams; and from [Redacted] through [Redacted], all employees less than 45 years of age were given x-ray exams every 5 years, and 1 exam at the termination of employment. Using this information, 'Method B' assumed that the EE received an x-ray exam every year between [Redacted] and [Redacted], plus the documented exam in [Redacted]. Method B also assumed the EE received an x-ray exam in [Redacted] (5 years after the last in [Redacted]) and one at termination in [Redacted], for a total of 10 x-rays. Occupational medical doses were assigned to the skin using the dose values in Tables 3-10 and 3-11 of ORAUT-TKBS-0006-3, which provide dose values for specific areas of the skin.

A comparison of medical doses derived by the SC&A and NIOSH DR methods is presented in Table 2-4.

Table 2-4. Comparison of Hanford Occupational Medical Doses

Cancer Sites	SC&A-Method A (rem)	SC&A-Method B (rem)	NIOSH (rem)
BCC, [Redacted]	0.008	0.031	0.008
BCC, [Redacted]	0.008	0.031	0.008
BCC, [Redacted]	0.008	0.053	0.008
BCC, [Redacted]	0.032	0.031	0.032
BCC, [Redacted]	0.008	0.031	0.008
BCC, [Redacted]	0.008	0.031	0.008
BCC, [Redacted]	0.324	0.530	0.324
BCC, [Redacted]	0.008	0.031	0.008
BCC, [Redacted]	0.008	0.031	0.008

Each DR method entered the annual doses into IREP as a mean value with a standard deviation of 30%.

SC&A's 'Method B' doses are higher since this DR method assigned dose for 10 x-rays as opposed to 6 x-ray exams assigned by NIOSH and SC&A's 'Method A.' In addition, Method B used Tables 3-10 and 3-11 of ORAUT-TKBS-0006-3, which provide doses from specific areas of the skin.

2.1.2 GJOO External Doses

There were no records of external dosimetry for the EE's employment period at the GJOO. SC&A's 'Method B' concluded that there was no indication that the EE was exposed to any radioactive materials at GJOO and did not assign any dose for this employment period.

NIOSH and SC&A's 'Method A' determined that the EE should be assigned unmonitored dose for employment at GJOO. There is no site profile for the GJOO. However, more than 15,000 exposure records of personnel associated with Grand Junction between the years [Redacted] and [Redacted] have been compiled in the REMS database. These data were used to develop the 95th percentile coworker external doses for Operators, Laborers, Supervisors and Administrative workers. Guidance on the use of these data is provided in a DR template entitled, *DR Drafts GJOO_10-23-2013_5.0.docx*. Using this template, NIOSH and SC&A's 'Method A' assigned unmonitored external dose as described below.

GJOO Coworker Photon Doses

Since the EE's position was identified as an [Redacted], both NIOSH and SC&A's 'Method A' assigned coworker doses for each year of employment based on the 'Administrative' job category cited in the GJOO DR template. Both DR methods also assumed 100% 30–250 keV photons and a DCF of 1.0. The only difference between the two DRs was that NIOSH calculated claimant-favorable doses based on a full year of employment in [Redacted] and [Redacted], while SC&A's 'Method A' included an appropriate time fraction to account for a partial year of employment during those years. This resulted in NIOSH assigning a maximized dose of 0.400 rem to each cancer site, while SC&A's 'Method A' assigned 0.370 rem to each BCC.

GJOO Missed Photon Doses

Neither NIOSH nor SC&A's 'Method A' assigned missed photon dose since, according to the *DR Drafts GJOO_10-023-2013_5.0.docx* template, this dose was accounted for in the assigned 95th percentile coworker doses.

GJOO Coworker Electron (Shallow) Dose

Both NIOSH and SC&A's 'Method A' calculated an electron dose based on applying a beta-to-photon ratio of 1.5 for years post-[Redacted], as recommended in the GJOO DR template. As with the modeled photon doses, NIOSH did not account for partial years of employment, while SC&A's 'Method A' did apply an appropriate time fraction for the first and last years of employment. This resulted in NIOSH assigning a dose of 0.600 rem and SC&A assigning a slightly lower dose of 0.556 rem to each skin cancer location.

SC&A's 'Method A' entered annual dose values into IREP as electrons >15 keV with a constant dose distribution and no uncertainty. Although NIOSH appropriately calculated and refers to these doses as electrons, the annual dose values were entered into IREP as 30–250 keV photons.

GJOO Occupational Medical Doses

Neither NIOSH nor SC&A's 'Method A' assigned doses for occupational x-ray exams, since x-rays were performed offsite at a non-covered facility, as specified in ORAUT-OTIB-0079.

2.2 OCCUPATIONAL INTERNAL DOSES

2.2.1 Hanford Internal Doses

The EE's file contained no records for bioassay monitoring for employment at Hanford. However, considering the work locations (e.g., [Redacted]) identified by the EE in the CATI, NIOSH and SC&A's 'Method A' assigned internal doses based on coworker data and environmental intakes, while SC&A's 'Method B' only assessed internal dose based on environmental intakes. Details associated with the calculation of internal doses are provided below.

Internal Dose Based on Hanford Coworker Intakes

NIOSH and SC&A's 'Method A' calculated unmonitored internal doses using guidance in the Section 5.6.2 and Attachment C of the Hanford Occupational Internal TBD (ORAUT-TKBS-0006-5). Both DR methods considered radionuclides and intake parameters listed in Table 2-5 below.

Table 2-5. Hanford Coworker Intake Parameters (1974–1987)

Radionuclide	Solubility Types Compared	IREP Radiation Type
Pu-239, 240	M, S, **SS**	alpha
Uranium	F, M, **S**	alpha
H-3 as HTO	F	e^- <15 keV
I-131	F	e^- >15 keV
Cs-137	F	e^- >15 keV
Zn-65	S	p >250 keV
Na-24	F	p >250 keV

Solubility types that produced the highest dose (i.e., Type SS for plutonium and Type S for uranium) were used and radionuclides that produced doses of <0.001 (i.e., Zn-65 and Na-24) were not assigned. Both DR methods entered resultant doses into IREP as a lognormal dose with a geometric standard deviation (GSD) value as specified in the applicable table in the Hanford Occupational Internal TBD (ORAUT-TKBS-0006-5).

Dose from Fission and Activation Products

NIOSH and SC&A's 'Method A' also considered internal dose associated with fission and activation products. Both DR methods used guidance cited in *Technical Information Bulletin: Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses*, and implemented using ORAUT-OTIB-0054 Workbook, Version 1.60. It was determined by both methods that only Ru-106 resulted in a total measurable dose of 0.001 rem. This value was entered into IREP for each of the skin cancer sites as electrons >15 keV.

Environmental Internal Dose

All three DR methods assessed environmental internal doses using guidance in the Hanford Occupational Environmental Dose TBD (ORAUT-TKBS-0006-4). Each method selected maximum annual intakes and default absorption types for assessing doses. NIOSH and SC&A's 'Method A' used the Chronic Annual Dose Workbook (CADW) (which allows for the evaluation of numerous radionuclides), and SC&A's 'Method B' used the Interactive RadioEpidemiological Program (IMBA) (which requires each radionuclide to be entered individually) for calculating doses to the nine BCCs. All methods determined that the resultant doses were <0.001 rem, and these values were not included in IREP.

A summary of the total internal dose assigned by each DR method for the EE's employment at Hanford is provided in Table 2-6.

Table 2-6. Comparison of Hanford Total Internal Doses

Cancer Sites	SC&A-Method A (U, Pu, HTO, I, FP) (rem)	SC&A-Method B (Env. Only) (rem)	NIOSH (U, Pu, HTO, I, FP) (rem)
BCC, [Redacted]	0.137	<0.001	0.136
BCC, [Redacted]	0.139	<0.001	0.138
BCC, [Redacted]	0.142	<0.001	0.141
BCC, [Redacted]	0.142	<0.001	0.141
BCC, [Redacted]	0.144	<0.001	0.142
BCC, [Redacted]	0.146	<0.001	0.144
BCC, [Redacted]	0.146	<0.001	0.145
BCC, [Redacted]	0.146	<0.001	0.144
BCC, [Redacted]	0.146	<0.001	0.144

As shown in Table 2-6, NIOSH and SC&A's 'Method A' calculated doses that are nearly identical.

2.2.2 GJOO Internal Doses

NIOSH and SC&A's 'Method A' calculated unmonitored internal dose in behalf of the EE using the guidance cited in the *DR Drafts GJOO_10-023-2013_5.0.docx* template. This guidance provides inhalation and ingestion intake rates for the period [Redacted]–[Redacted] for uranium, radium-226, and thorium-230. The intake rates were based on whether (1) the source term was ore or tailing samples, and (2) the EE's job category was operator, general labor,

supervisor, or administrative. NIOSH calculated doses based on the intake rate associated with the general labor job category, while SC&A's 'Method A' used the administrative position, since the EE's job function was [Redacted]. Both methods assumed the most claimant-favorable source terms and solubility types for deriving internal doses.

A comparison of total internal doses assigned for each of the nine BCCs by each DR methods is provided in Table 2-7.

Table 2-7. Comparison of GJOO Total Internal Doses

Cancer Sites	SC&A-Method A (rem)	SC&A-Method B (rem)	NIOSH (rem)
BCC, [Redacted]	0.002	Not considered	0.047
BCC, [Redacted]	0.002	Not considered	0.050
BCC, [Redacted]	0.002	Not considered	0.052
BCC, [Redacted]	0.002	Not considered	0.055
BCC, [Redacted]	0.002	Not considered	0.058
BCC, [Redacted]	0.002	Not considered	0.058
BCC, [Redacted]	0.002	Not considered	0.058
BCC, [Redacted]	0.002	Not considered	0.058
BCC, [Redacted]	0.002	Not considered	0.058

SC&A's 'Method A' GJOO internal doses are lower than the NIOSH-assigned doses due to the different job category selected by each method. SC&A assumed the EE was an administrative worker, while NIOSH assumed the general labor job category.

3.0 SUMMARY CONCLUSIONS

Total external and internal doses and resultant POCs calculated by SC&A's 'Method A,' SC&A's 'Method B,' and NIOSH in behalf of Case #[Redacted] are presented in Table 3-1 for comparison.

Table 3-1. Comparison of Total External and Internal Doses Estimated for the Nine BCCs

Total Doses	SC&A-Method A (rem)	SC&A-Method B (rem)	NIOSH (rem)
External Skin Doses:			
- BCC, [Redacted]	1.704	0.811	1.808
- BCC, [Redacted]	1.704	0.811	1.808
- BCC, [Redacted]	1.704	0.833	1.808
- BCC, [Redacted]	1.728	0.811	1.832
- BCC, [Redacted]	1.704	0.811	1.808
- BCC, [Redacted]	1.704	0.811	1.808
- BCC, [Redacted]	2.020	1.309	2.124
- BCC, [Redacted]	1.704	0.811	1.808
- BCC, [Redacted]	1.704	0.811	1.808
Internal Skin Doses:			
- BCC, [Redacted]	0.139	–	0.183
- BCC, [Redacted]	0.141	–	0.188
- BCC, [Redacted]	0.144	–	0.193
- BCC, [Redacted]	0.144	–	0.193
- BCC, [Redacted]	0.146	–	0.197
- BCC, [Redacted]	0.148	–	0.202
- BCC, [Redacted]	0.148	–	0.203
- BCC, [Redacted]	0.148	–	0.202
- BCC, [Redacted]	0.148	–	0.202
Total Skin Dose			
- BCC, [Redacted]	1.843	0.811	1.991
- BCC, [Redacted]	1.845	0.811	1.996
- BCC, [Redacted]	1.848	0.833	2.001
- BCC, [Redacted]	1.872	0.811	2.025
- BCC, [Redacted]	1.850	0.811	2.005
- BCC, [Redacted]	1.852	0.811	2.010
- BCC, [Redacted]	2.168	1.309	2.327
- BCC, [Redacted]	1.852	0.811	2.010
- BCC, [Redacted]	1.852	0.811	2.010
POC	43.18%	38.59%	45.27%

As shown in Table 3-1, NIOSH and SC&A's 'Method A' assigned total doses are in close agreement. SC&A's 'Method B' total doses are less than one-half of those assigned by NIOSH and SC&A's 'Method A,' because this DR method did not calculate any dose for the EE's GJOO employment and only assessed environmental internal dose for the EE's Hanford employment. It should also be noted that although doses assigned by SC&A's 'Method B' were significantly less than the other two DR methods, the POC was only modestly lower. This is primarily due to the fact that Method B entered the recorded photon and electron doses into IREP as a normal distribution with a 30% uncertainty, while NIOSH and SC&A's 'Method A' entered the recorded doses as a constant value with no uncertainty.

In instances when dose assignment among the three methods differed, they were linked to the following variables:

- Assignment of Missed Photon Dose
  - NIOSH and SC&A's 'Method B' assumed an LOD value of 0.030 rem; however, NIOSH counted eight missed doses and Method B counted six.
  - SC&A's 'Method A' counted eight missed doses, but assumed an LOD value of 0.020 rem.

- Assignment of Occupational Medical Dose
  - SC&A's 'Method A' and NIOSH assigned medical doses for the six documented x-ray exams based on values cited in the Hanford TBD; both DR methods calculated identical doses that ranged from 0.008 rem to 0.324 rem based on the BCC location.
  - SC&A's 'Method B' assigned occupational medical doses based on values in the Hanford TBD, but assigned doses for documented exams and based on the x-ray frequency cited in Hanford TBD, for a total of 10 x-rays, which resulted in doses ranging from 0.031 rem to 0.530 rem.

- Assignment of GJOO Internal Doses
  - NIOSH assigned unmonitored internal doses based on the job category of 'general labor,' which resulted in a dose ranging from 0.047 rem to 0.058 rem.
  - SC&A's 'Method A' assigned coworker internal doses based on the job category 'administrative,' which resulted in the assignment of 0.002 rem to each of the 9 BCCs.

4.0 REFERENCES

OCAS-IG-001. 2007. *External Dose Reconstruction Implementation Guideline*, Rev. 3, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio. November 21, 2007.

ORAUT-OTIB-0006. 2005. *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures,* Rev 04, Oak Ridge Associated Universities Team, Cincinnati, Ohio. June 20, 2011.

ORAUT-OTIB-0017. 2005. *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose,* Rev. 01, Oak Ridge Associated Universities Team, Cincinnati, Ohio. October 11, 2005.

ORAUT-OTIB-0054. 2007. *Technical Information Bulletin: Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses,* Rev. 00 PC-1, Oak Ridge Associated Universities Team, Cincinnati, Ohio. November 19, 2007.

ORAUT-OTIB-0079. 2011. *Technical Information Bulletin: Guidance on Assigning Occupational X-Ray Dose under EEOICPA for X-Rays Administered Off Site,* Rev. 00, Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 3, 2011.

ORAUT-PROC-0061. 2010. *Occupational Medical X-Ray Dose Reconstruction for DOE Sites,* Rev. 03, Oak Ridge Associated Universities Team, Cincinnati, Ohio. March 3, 2010.

ORAUT-TKBS-0006-3. 2010. *Technical Basis Document for the Hanford Site – Occupational Medical Dose,* Rev. 02, Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 7, 2010.

ORAUT-TKBS-0006-4. 2010. *Technical Basis Document for the Hanford Site – Occupational Environmental Dose*, Rev 03. Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 7, 2010.

ORAUT-TKBS-0006-5. 2012. *Technical Basis Document for the Hanford Site – Occupational Internal Dose*, Rev. 05. Oak Ridge Associated Universities Team, Cincinnati, Ohio. November 5, 2012.

ORAUT-TKBS-0006-6. 2010. *Technical Basis Document for the Hanford Site – Occupational External Dose*, Rev. 04. Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 7, 2010

SC&A 2014. *SC&A's Blind Dose Reconstruction of Case #[Redacted] from Hanford and the Grand Junction Operations Office,* SCA-TR-BDR2014-CN[Redacted], Rev. 0, SC&A, Inc., Vienna, Virginia. January 21, 2014.