DRAFT

REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

COMPARISON OF SC&A'S BLIND DOSE RECONSTRUCTION TO NIOSH'S DOSE RECONSTRUCTION OF CASE #[REDACT] FROM THE HANFORD SITE

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COMPARISON OF SC&A'S BLIND DOSE RECONSTRUCTION TO NIOSH'S DOSE RECONSTRUCTION OF #[REDACT] FROM THE HANFORD SITE	Page 2 of 16
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TABLE OF CONTENTS

Abbreviations and Acronyms 4

1.0 Relevant Background Information 5

2.0 Comparison of Methodology/Doses used by NIOSH and SC&A for Case #[ ] 7

2.1 Occupational External Dose Calculations 8
2.1.1 Recorded Photon and Neutron Doses 8
2.1.2 Missed Photon and Neutron Doses 9
2.1.3 Occupational Medical Doses 10
2.1.4 Onsite Ambient External Doses 11
2.1.5 Dose from Hot Particle Releases 11
2.2 Occupational Internal Doses 12
2.2.1 Internal Dose from Plutonium and Americium 12
2.2.2 Internal Dose from Fission Products 12
2.2.3 Internal Dose based on Coworker Intakes 13
2.2.4 Internal Environmental Dose 13

3.0 Summary Conclusions 14

References 15

Addendum A: SC&A's Blind Dose Reconstruction Report of Case #[ ] 16

LIST OF TABLES

Table 1-1. Comparison of NIOSH's Assigned Doses to SC&A's Blind DR Doses 6

Table 2-1. Comparison of Data and Assumptions Used by NIOSH and SC&A 7

Table 2-2. Comparison of Recorded Photon and Neutron Doses 9

Table 2-3. Comparison of Missed Photon and Neutron Doses 10

Table 2-4. Comparison of Occupational Medical Doses 11

Table 2-5. Comparison of Onsite Ambient External Doses 11

Table 2-6. Comparison of Internal Doses 13

Table 3-1. Comparison of Total External and Internal Doses 14

ABBREVIATIONS AND ACRONYMS

Advisory Board	Advisory Board on Radiation and Worker Health
CADW	chronic annual dose workbook
CATI	Computer-Assisted Telephone Interview
CF	correction factor
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DOL	(U.S.) Department of Labor
dpm	disintegrations per minute
DR	dose reconstruction
EE	energy employee
GM	geometric mean
ICD	International Classification of Diseases
ICRP	International Commission on Radiological Protection
IMBA	Integrated Modules for Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
keV	kilo electron volt; 1,000 electron volts
LOD	limit of detection
MeV	million electron volts
nCi	nanocurie
NIOSH	National Institute for Occupational Safety and Health
OCAS	Office of Compensation Analysis and Support
ORAUT	Oak Ridge Associated Universities Team
PA	posterior-anterior
PFG	photofluorography
pCi	picocurie
POC	probability of causation
rem	Roentgen equivalent man
SCC	squamous cell carcinoma
SC&A	S. Cohen and Associates (SC&A, Inc.)
SD	standard deviation
TBD	technical basis document
WBC	whole body count
yr	year

1.0 RELEVANT BACKGROUND INFORMATION

Under Contract No. 211-2014-58081, SC&A was tasked by the Advisory Board on Radiation and Worker Health (Advisory Board) to perform six blind dose reconstructions (DRs) at the July 2014, 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 reconstructing doses in behalf of these cases. SC&A used an independent approach to reconstruct occupational external and internal doses for the cases using the available dosimetry records and current guidance from NIOSH, including the spreadsheets and other tools developed by NIOSH to calculate the doses.

On February 27, 2015, SC&A submitted to the Advisory Board and NIOSH, a memorandum containing the summary results of our blind DR in behalf of Case #[**redact**]. After submitting the memorandum and prior to completing this blind comparison report, SC&A realized that an error was made in running the Hanford external dose workbook, which resulted in an overestimate of total doses by approximately a factor of 3. This corrected reduction in dose changed the initially reported probability of causation (POC) of 61.96% to below the compensation threshold of 50%. The complete DR report titled, *Blind Dose Reconstruction of Case #*[**Redact**] *from the Hanford Site* (SCA-TR-BDR2015-CN[**redact**]), which provides the assumptions and methodologies used to derived occupational radiation doses and resultant POC, is included herein as Addendum A. In this report, SC&A presents a comparison between NIOSH's and SC&A's DR methodologies, doses, and resultant POC values for Case #[**redact**]. Table 1-1 summarizes the external and internal occupational doses calculated by SC&A and the NIOSH-assigned doses for the two squamous cell carcinomas (SCCs) and the colon cancer diagnosed in behalf of Case #[**redact**]. A detailed comparison of the two 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 where appropriate, 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 NIOSH's Assigned Doses to SC&A's Blind DR Doses

	NIOSH Chest SCC Dose (rem)	SC&A Chest SCC Dose (rem)	NIOSH Leg SCC Dose (rem)	SC&A Leg SCC Dose (rem)	NIOSH Colon Dose (rem)	SC&A Colon Dose (rem)
External Dose (Occupational)						
▪ Recorded:						
<30 keV Photons	0.282	0.394	0.282	0.394	0.007	0.009
30–250 keV Photons	1.496	1.496	1.496	1.496	1.207	1.117
0.1–2 MeV Neutrons	1.693	2.134	1.693	2.134	0.834	1.046
▪ Missed Dose:						
<30 keV Photons	NA	0.105	NA	0.105	0.003	0.003
30–250 keV Photons	6.305	3.130	6.305	3.130	2.673	2.337
0.1–2 MeV Neutrons	1.408	6.356	1.408	6.356	0.255	3.116
▪ Onsite Ambient Dose:						
30–250 keV Photons	2.616	2.904	2.616	2.904	2.616	1.138
▪ Occupational Medical Dose:						
PFG exam, 1959	0.045	2.060	0.000	0.000	0.007	0.007
30–250 keV Photons	0.015	0.749	0.001	0.001	0.006	0.006
▪ Hot Particles						
>15 keV electrons	0.462	NA	0.462	NA	NA	NA
Internal Dose:						
alpha	0.572	0.039	0.572	0.039	0.736	0.050
>250 keV photons	0.004	0.004	0.004	0.004	0.013	0.013
>15 keV electrons	0.626	0.215	0.626	0.215	0.611	3.367
<15 keV electrons	0.025	NA	0.025	NA	0.475	NA
Total	**15.550**	**19.587**	**15.490**	**16.779**	**9.443**	**12.210**
POC	**11.64%**	**8.71%**	**11.62%**	**7.07%**	**26.12%**	**25.07%**

NA = Not assessed

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

Case #[redact] represents an energy employee (EE) who worked at the Hanford Site from [redact], to [redact]. According to the DOL file, the EE was a [redact]/[redact]/[redact] at the Hanford Site for several work periods between [redact] and [redact].

The EE was monitored for both external and internal radiation exposure while employed at the Hanford Site. The EE was diagnosed with **squamous cell carcinoma (SCC) in situ, on the** [redact] **chest** (ICD-9 Code 232.5) on [redact], **SCC on the** [redact] **leg** (ICD-9 Code 173.72) on [redact], and **colon cancer** (ICD-9 Code 153.6) on [redact].

For calculating radiation doses from employment at the Hanford Site, both DR methods primarily relied on guidance in the Technical Basis Document (TBD) for Hanford (issued as six separate documents numbered ORAUT-TKBS-0006-1 through ORAUT-TKBS-0006-6), and ORAUT-OTIB-0005, *Technical Information Bulletin: Internal Dosimetry Organ, External Dosimetry Organ, and IREP Model Selection by ICD-9 Code.* NIOSH and SC&A used the guidance provided in the relevant technical documents, along with the EE's records to reconstruct the EE's radiation dose. NIOSH used efficiency measures and assumptions related to radiation exposure and intakes resulting in a **reasonable estimate** of the EE's total dose. SC&A employed a **best-estimate approach** for calculating annual organ doses.

A summary of the documents, assumptions, and dose parameters used by each DR method is provided in Table 2-1.

Table 2-1. Comparison of Data and Assumptions Used by NIOSH and SC&A

Parameters	NIOSH	SC&A
	External Dose	
Recorded/Missed/Unmonitored:		
Records/Guidance Documents	DOE records, ORAUT-TKBS-0006-6	DOE records, ORAUT-TKBS-0006-6
Work Locations	300, 700, 3000 Areas as [redact], [redact], [redact], [redact], [redact]	300, 700, 3000 Areas as [redact], [redact], [redact]
Energy Range	Photons: 100% 30keV–250 keV <30 keV Neutrons: 100% 0.1–2 MeV	Photons: 100% 30keV–250 keV <30 keV Neutrons: 100% 0.1–2 MeV
DCF	Colon 0.024 (<30 keV) Skin 1.0 Colon 0.747 (30keV–250 keV) Skin 1.0 Colon 0.049 (0.1–2 MeV) Skin 1.0	Colon 0.024 (<30 keV) Skin 1.0 Colon 0.747 (30keV–250 keV) Skin 1.0 Colon 0.049 (0.1–2 MeV) Skin 1.0
Dose Distribution	Recorded – Constant, Lognormal, Triangular Missed – Lognormal	Recorded – Constant Missed – Lognormal
External Medical X-rays:		
Guidance Documents	ORAUT-TKBS-0006-3, ORAUT-OTIB-0079, ORAUT-PROC-0061	ORAUT-TKBS-0006-3

Table 2-1. Comparison of Data and Assumptions Used by NIOSH and SC&A

Parameters	NIOSH	SC&A
Frequency	PFG exam in [redact], PA chest examinations during most years of employment, with two such examinations in [redact]. (14 PA exams)	PFG exam in [redact], PA chest examinations during most years of employment, with two such examinations in [redact]. (14 PA exams)
Dose Data	Tables 3-6, 3-8, 3-10, 3-11 of ORAUT-TKBS-0006-3	Tables 3-6, 3-8, 3-10, 3-11 of ORAUT-TKBS-0006-3
Dose Distribution	Normal; SD = 30%.	Normal; SD = 30%.
Onsite Ambient Dose:		
Guidance Documents	ORAUT-PROC-0060, ORAUT-TKBS-0006-4	ORAUT-PROC-0060, ORAUT-TKBS-0006-4
Dose Data	ORAUT-TKBS-0006-4	Table 4-8 of ORAUT-TKBS-0006-4
Dose Distribution	Constant	Constant
Internal Dose		
Recorded/Missed:		
Records/Guidance Documents	DOE records, ORAUT-TKBS-0006-5	DOE records, ORAUT-TKBS-0006-5
Dose Determination Approach	Overestimate – chronic through [redact] based on fit of bioassay	Reasonable Estimate – chronic through [redact] based on fit of bioassay
Solubility Type	Various, see Section 2.1.1	Various, see Section 2.1.1
POC Program:		
NIOSH-IREP POC	Ver. 5.7	Ver. 5.7.1

2.1 OCCUPATIONAL EXTERNAL DOSE CALCULATIONS

2.1.1 Recorded Photon and Neutron Doses

The DOE records show that the EE was monitored while employed at the Hanford Site from [redact] through [redact]. Individual dosimeter results or summary dosimeter totals were used to assign recorded dose.

2.1.1.1 Photon Dose

Both SC&A and NIOSH used the EE's recorded photon dose values that were >LOD/2 to assign doses using a photon energy range of 100% 30–250 keV photons. Both SC&A and NIOSH applied a dose conversion factor (DCF) of 1.0 for the skin resulting in exactly the same skin doses from 30–250 keV photons. SC&A applied a DCF of 0.747 for the colon, representing the mode of the DCF distribution given in OCAS-IG-001. NIOSH used Monte Carlo techniques, as described in ORAUT-OTIB-0012, to calculate a specific colon DCF for each year.

To determine the doses from <30 keV photons, both SC&A and NIOSH applied DCFs of 1.0 for the skin and 0.024 for the colon to the annual recorded non-penetrating dose. SC&A and NIOSH also applied a correction factor (CF) of 0.6 to account for film over-response for years prior to [redact], as specified in Attachment C of ORAUT-TKBS-0006-6. However, NIOSH continued to apply the 0.6 CF through [redact].

2.1.1.2 Neutron Dose

SC&A assigned neutron doses from [redact] to [redact] based on the recorded penetrating photon readings, work location, and guidance in Section 6.7.3.4 of ORAUT-TKBS-0006-6. The neutron doses were calculated for 100 keV–2 MeV neutrons using the recorded gamma dose and applying the geometric mean (GM) neutron-to-photon ratio from Table 6-22 of ORAUT-TKBS-0006-6, as well as the applicable International Commission on Radiological Protection Publication 66 (ICRP 1994) and organ DCFs.

NIOSH and SC&A calculated the neutron doses using the same parameters. However, NIOSH assigned neutron doses for a shorter time period; from 1964 to 1969.

A comparison of NIOSH's and SC&A's recorded photon and neutron doses is shown in Table 2-2.

Table 2-2. Comparison of Recorded Photon and Neutron Doses

	NIOSH Skin (rem)	SC&A Skin (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
Total <30 keV Photon Dose	0.282	0.394	0.007	0.009
Total 30–250 keV Photon Dose	1.496	1.496	1.207	1.117
Total Recorded Neutron Dose	1.693	2.134	0.834	1.046

SC&A entered the photon and neutron doses into the Interactive RadioEpidemiological Program (IREP) as constant distributions with no uncertainty. NIOSH entered the photon doses to the skin as constant distributions with no uncertainty, and neutron doses as lognormal distributions with an uncertainty of 2.30. NIOSH entered the photon doses to the colon as normal, lognormal, or triangular distributions and the neutron doses as lognormal distributions.

2.1.2 Missed Photon and Neutron Doses

Both NIOSH and SC&A assigned missed photon and neutron doses based on information in ORAUT-TKBS-0006-6.

2.1.2.1 Missed Photon Dose

SC&A analyzed the number of actual zeros and potential zeros based on a biweekly badge exchange cycle prior to [redact] and a monthly exchange thereafter, and arrived at a total of 163 zeros (or <LOD/2 values) for photons. SC&A used the annual number of zeros, the LOD/2 value, the DR parameters as listed above, and the applicable DCFs to determine the annual missed photon doses. This resulted in the assignment of 3.130 rem to skin and 2.337 rem to the colon from 30–250 keV photons.

NIOSH calculated 240 zeros using a weekly badge exchange cycle prior to [redact] and a monthly exchange thereafter, to determine the missed photon dose for 30–250 keV photon, a DCF of 1.0 for the skin, and Monte Carlo techniques to calculate a specific colon DCF for each

year. This resulted in the assignment of 6.305 rem to skin and 2.673 rem to the colon from 30–250 keV photons.

Both SC&A and NIOSH applied a DCF of 0.024 for the colon resulting in exactly the same dose of 0.003 rem from <30 keV photons. SC&A used the same method with a DCF of 1.0 for the skin to assign a skin dose of 0.105 rem from <30 keV photons. NIOSH did not assign a dose to the skin from <30 keV photons.

2.1.2.2 Missed Neutron Dose

SC&A assigned missed neutron doses from [redact] to [redact] based on the EE's work location and number of zero dosimeter readings (150 zero readings). The missed neutron doses were calculated for 100 keV–2 MeV neutrons using the annual number of zeros and applying the GM neutron-to-photon ratio from Table 6-22 of ORAUT-TKBS-0006-6, as well as the applicable ICRP and organ DCFs.

NIOSH and SC&A calculated the neutron doses to the colon using the same parameters. For the skin, NIOSH multiplied their missed photon doses by the ICRP factor and an organ DCF of 1.0 to assign missed neutron doses. NIOSH assigned neutron missed doses only during the years of [redact] through [redact].

A comparison of the NIOSH and SC&A missed photon and neutron doses is shown in Table 2-3.

Table 2-3. Comparison of Missed Photon and Neutron Doses

	NIOSH Skin (rem)	SC&A Skin (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
Total <30 keV Photon Dose	NA	0.105	0.003	0.003
Total 30–250 keV Photon Dose	6.305	3.130	2.673	2.337
Total Recorded Neutron Dose	1.408	6.356	0.255	3.116

Both NIOSH and SC&A entered the photon and neutron missed doses into IREP as lognormal distributions with an uncertainty of 1.520.

2.1.3 Occupational Medical Doses

Both DR methods calculated an occupational medical dose from diagnostic x-ray procedures required as a condition of employment. NIOSH indicated that they followed guidance cited in ORAUT-OTIB-0079, ORAUT-PROC-0061, and ORAUT-TKBS-0006-3 in order to calculate their occupational medical doses.

SC&A used guidance provided in ORAUT-TKBS-0006-3.

Both NIOSH and SC&A assigned dose for one photofluorography (PFG) x-ray exam in [redact] and fourteen posterior-anterior (PA) x-ray exams from [redact]–[redact]. For the chest SCC, SC&A chose "[Redact] torso: base of neck to end of sternum," as the cancer location. NIOSH chose "Front torso: base of neck to end of sternum," as the cancer location. This difference in

cancer location selection resulted in SC&A's occupational medical dose to the chest being significantly higher than that assigned by NIOSH, as shown in Table 2-4.

Table 2-4. Comparison of Occupational Medical Doses

Site	NIOSH Chest SCC (rem)	SC&A Chest SCC (rem)	NIOSH Leg SCC (rem)	SC&A Leg SCC (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
[redact] PFG exam	0.045	2.060	0.000	0.000	0.007	0.007
[redact]– [redact] PA exams	0.015	0.749	0.001	0.001	0.006	0.006
Total	0.060	2.809	0.001	0.001	0.013	0.013

Each DR method entered the annual doses into the IREP Input tables with a normal distribution and a standard deviation (SD) of 30%.

2.1.4 Onsite Ambient External Doses

Both NIOSH and SC&A assigned ambient external dose from the beginning of employment until [redact] in accordance with ORAUT-PROC-0060. SC&A used the maximum external gamma dose for each year from Table 4-8 of ORAUT-TKBS-0006-4. SC&A also used the isotropic DCFs of 0.803 for the colon and 1.0 for the skin, and corrected for 2,600 hours/yr.

NIOSH also used the maximum external gamma dose for each year from Table 4-8. However, NIOSH used a DCF of 1.0 for each cancer and did not adjust the dose for 2,600 hours/yr**.**

Table 2-5 summarizes NIOSH's and SC&A's onsite ambient external dose assignments.

Table 2-5. Comparison of Onsite Ambient External Doses

Site	NIOSH Chest SCC (rem)	SC&A Chest SCC (rem)	NIOSH Leg SCC (rem)	SC&A Leg SCC (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
Total Onsite Ambient Dose	2.616	2.904	2.616	2.904	2.616	1.138

2.1.5 Dose from Hot Particle Releases

Emissions of particles of greater than respirable size occurred from the REDOX Plant in March, April, June, and September of [redact]; August and September of [redact]; and in January, April, May, and June of [redact]. DOE records indicate the EE worked in the 300 Area during the time of some of these releases.

NIOSH calculated skin doses from hot particle releases based on Tables 4-11, 4-12 and 4-13 of ORAUT-TKBS-0006-4. NIOSH assigned 0.462 rem to each skin cancer as acute GM dose electrons greater than 15 keV.

SC&A did not assess doses from hot particles.

2.2 OCCUPATIONAL INTERNAL DOSES

The DOE records indicate the EE was monitored for internal exposures to plutonium via urine sampling from [redact] through [redact], and to fission products via one urine sample and one whole body count (WBC) in [redact]. Most measurement results for non-naturally occurring radionuclides showed an activity less than the minimum detectable activity in ORAUT-TKBS-0006-5 for the given radionuclides and bioassay method.

2.2.1 Internal Dose from Plutonium and Americium

Both SC&A and NIOSH used the EE's plutonium bioassay data to determine the plutonium and americium intakes. The DOE records indicate the EE submitted six in-vitro analyses for plutonium from [redact], to [redact], with all of the results reported as less than the limit of detection (LOD) of the analysis. NIOSH and SC&A calculated chronic plutonium intakes of 34.37 dpm/day and 3.5 dpm/day, respectively, of Type S plutonium. Both NIOSH's and SC&A's intakes were based on half the last urinalysis measurement's detection level, 0.025 dpm/sample. NIOSH and SC&A both used the Hanford Pu Mix Intake Rate Calculator Workbook 1.12 to determine the intake rates for Pu-239, Pu-238, Pu-241, and Am-241, assuming the plutonium material was 10-year-aged fuel-grade plutonium.

NIOSH and SC&A input the calculated intake rates into the Chronic Annual Dose Workbook (CADW) to calculate the internal doses. Each DR method entered the annual doses from plutonium and americium into the IREP Input tables with a lognormal distribution and an SD of 3.0.

NIOSH and SC&A corrected the doses to account for the longer lung clearance times of Type SS plutonium. Following the guidance in ORAUT-OTIB-0049, NIOSH and SC&A adjusted the dose to the skin by a factor of 4 for doses after the time of the last urine bioassay measurement and adjusted all of the colon doses by a factor of 4.

2.2.2 Internal Dose from Fission Products

The EE had a WBC on [redact], which was above the detection limits for Cs-137 and Na-24. The Cs-137 results were attributed to fallout that is ever-present in the United States as a result of foreign and domestic atmospheric weapons testing. Therefore, the Cs-137 exposure was not considered to be occupational exposure. NIOSH and SC&A evaluated the potential dose from Na-24 and other fission products.

2.2.2.1 Sodium-24 Dose

The EE had positive WBC results for Na-24 on [redact]. NIOSH and SC&A input this positive result into the Integrated Modules for Bioassay Analysis (IMBA) computer code to determine a chronic ingestion of 457 pCi/day of Na-24 for the entire period of employment, from [redact], through [redact]. NIOSH and SC&A calculated the skin and colon doses from the Na-24 intake using the CADW workbook. NIOSH and SC&A both assigned total doses from Na-24 of 0.004 rem to the skin and 0.013 rem to the colon.

2.2.2.2 Other Fission Products

SC&A used the Hanford Radionuclide Chooser Workbook and determined the most claimant-favorable radionuclide for the missed dose calculations from fission products would be Type S Ce-144 for the colon and Type M Ce-144 for the skin. The resulting chronic intake was 2,606 nCi/year for the colon and 1,409 nCi/year for the skin for the time period from [redact] until [redact]. The skin and colon doses from the Ce-144 intakes were then calculated using the CADW. The total doses from Ce-144 are 0.215 rem to the skin and 3.367 rem to the colon.

According to the DR report, NIOSH assigned the highest radiostrontium coworker intake rate from Attachment C of ORAUT-TKBS-0006-5. This intake rate was assigned for radiostrontium as the indicator radionuclide without the Table 7-1 fraction correction in ORAUT-OTIB-0054. NIOSH used a radiostrontium coworker intake rate of 90.47 dpm/day for the intake period of [redact] through [redact]. NIOSH's total assigned dose from fission/activation products was 0.157 rem to the skin and 0.597 rem to the colon.

2.2.3 Internal Dose based on Coworker Intakes

As an overestimating assumption, NIOSH assigned internal dose from coworker data as described in Section 5.6.2 and Attachment C of ORAUT-TKBS-0006-5 and ORAUT-OTIB-0054. NIOSH assigned a total internal coworker dose of 0.751 rem to the skin and 0.820 rem to the colon.

SC&A did not assess internal dose based on coworker intakes.

2.2.4 Internal Environmental Dose

Both SC&A and NIOSH assessed internal environmental dose while the EE was employed at Hanford. In both calculations, the dose from environmental intakes was determined to be less than 0.001 rem.

Table 2-6 summarizes NIOSH's and SC&A's internal dose assignments.

Table 2-6. Comparison of Internal Doses

	NIOSH Skin (rem)	SC&A Skin (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
Internal Dose:				
alpha	0.572	0.039	0.736	0.050
>250 keV photons	0.004	0.004	0.013	0.013
>15 keV electrons	0.626	0.215	0.611	3.367
<15 keV electrons	0.025	NA	0.475	NA
Total Internal Dose	1.227	0.258	1.835	3.430

3.0 SUMMARY CONCLUSIONS

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

Table 3-1. Comparison of Total External and Internal Doses

Total Dose	NIOSH Chest SCC (rem)	SC&A Chest SCC (rem)	NIOSH Leg SCC (rem)	SC&A Leg SCC (rem)	NIOSH Colon (rem)	SC&A Colon (rem)
External Dose:	14.322	19.328	14.263	16.520	7.608	8.779
Internal Dose:	1.227	0.258	1.227	0.258	1.835	3.430
Total Dose	15.550	19.587	15.490	16.779	9.443	12.210
POC	11.64%	8.71%	11.62%	7.07%	26.12%	25.07%

As shown in Table 3-1, NIOSH's and SC&A's methods resulted in individual cancer POCs, and a combined total POC, that were similar. NIOSH derived a total combined POC of **42.31%** compared to **36.43%** for SC&A.

The following summarizes/compares the methods used by NIOSH and SC&A to assign doses in this case:

Dose Reconstruction Methodology
- NIOSH used an overestimating approach and SC&A employed a reasonable-estimate approach to the dose reconstruction.

Assignment of External Dose
- NIOSH and SC&A methods were very similar. NIOSH assigned neutron doses for a shorter time period than SC&A.

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Assignment of Occupational Medical Dose
- NIOSH and SC&A used the same methodology in assigning medical doses except for the location of the chest SCC.

Assignment of Onsite Ambient External Doses
- SC&A also used the isotropic DCFs of 0.803 for the colon and 1.0 for the skin, and corrected for 2,600 hours/yr. NIOSH used a DCF of 1.0 for each cancer and did not adjust the dose for 2,600 hours/yr**.**

Assignment of Hot Particle Doses
- Only NIOSH assigned doses from hot particles to the skin.

Assignment of Internal Doses
- NIOSH and SC&A employed a best-estimate approach to assigning doses based on bioassay data. NIOSH also used an overestimating approach by assigning intakes from coworker data.

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ADDENDUM A: SC&A'S BLIND DOSE RECONSTRUCTION REPORT OF CASE #[REDACT]

DRAFT

REPORT TO THE ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute of Occupational Safety and Health

BLIND DOSE RECONSTRUCTION OF CASE #[REDACT] FROM THE HANFORD SITE

Contract No. 211-2014-58081
SCA-TR-BDR2015-CN[Redact]

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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-BDR2015-CN[Redact] Effective Date: Draft – February 27, 2015 Revision No. 0 (Draft)
BLIND DOSE RECONSTRUCTION OF CASE #[REDACT] FROM THE HANFORD SITE	Page 2 of 34
Task Manager: _____ Date: Douglas Farver, CHP	Supersedes: N/A
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TABLE OF CONTENTS

Abbreviations and Acronyms 4

1.0 Summary Background Information 6

1.1 SC&A Blind DR Approach 6

2.0 External Doses 8

2.1 Recorded Photon Dose 8
2.2 Missed Photon Dose 9
2.3 Recorded Neutron Dose 10
2.4 Missed Neutron Dose 10
2.5 Occupational Medical Dose 11
2.6 Onsite Ambient Dose 11

3.0 Internal Doses 13

3.1 Missed Dose from Plutonium/Americium 13
3.2 Internal Dose from Fission Products 13
3.2.1 Sodium-24 Dose 14
3.2.2 Other Fission Products 14
3.3 Environmental Dose 14

4.0 CATI Report and Radiological Incidents 15

5.0 Summary Conclusions 16

References 17

Appendix A-1: IREP Input – SCC on Chest 18

Appendix A-2: IREP Input – SCC on Leg 23

Appendix A-3: IREP Input – Colon 29

LIST OF TABLES

Table 1-1. Employment History 6

Table 1-2. Summary of SC&A-Derived External/Internal Dose Estimates 7

Table 2-1. External Dose Parameters 8

Table 3-1. Calculated Intake Rates 13

ABBREVIATIONS AND ACRONYMS

AP	anterior-posterior
CADW	chronic annual dose workbook
CATI	Computer-Assisted Telephone Interview
CF	correction factor
D.D.	deep dose
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DOL	(U.S.) Department of Labor
dpm	disintegrations per minute
DR	dose reconstruction
EE	energy employee
GM	geometric mean
ICD	International Classification of Diseases
ICRP	International Commission on Radiological Protection
IMBA	Integrated Modules for Bioassay Analysis
IREP	Interactive RadioEpidemiological Program
keV	kilo electron volt; 1,000 electron volts
LOD	limit of detection
MeV	million electron volts
nCi	nanocurie
NIOSH	National Institute for Occupational Safety and Health
NP.D.	non-penetrating dose
OCAS	Office of Compensation and Support
ORAUT	Oak Ridge Associated Universities Team
PA	posterior-anterior
PFG	photofluorography
pCi	picocurie
PNNL	Pacific Northwest National Laboratory
POC	probability of causation
rem	Roentgen equivalent man
SCC	squamous cell carcinoma

SC&A	S. Cohen and Associates (SC&A, Inc.)
TBD	technical basis document
WBC	whole body count
yr	year

1.0 SUMMARY BACKGROUND INFORMATION

This report presents the results of an independent blind dose reconstruction (DR) performed by SC&A for an energy employee (EE) who worked at the Hanford Site from [redact], to [redact]. The EE was diagnosed with **squamous cell carcinoma (SCC) in situ, on the** [redact] **chest** (ICD-9 Code 232.5) on [redact], **SCC on the** [redact] **leg** (ICD-9 Code 173.72) on [redact], and **colon cancer** (ICD-9 Code 153.6) on [redact].

According to Department of Labor (DOL) files and the Computer-Assisted Telephone Interview (CATI) report, the EE was a [redact]/[redact]/[redact] at the Hanford Site for several work periods, as shown in Table 1-1. The EE was monitored for both external and internal radiation exposure while at the Hanford Site.

Table 1-1. Employment History

Date	Employer	Occupation	Area
[redact]	General Electric Hanford	[redact]/[redact]	300 Area 321A; Bldg 3760; 700 Area
[redact]	General Electric Hanford	[redact]	300 Area; Bldgs 3706, 3760; 700 Area Bldg 703
[redact]	General Electric Hanford		300 Area
[redact]	General Electric Hanford		300 Area; Bldgs 3703, 3706
[redact]	General Electric Hanford	[redact]	300 Area, Bldg 326
[redact]	Battelle/PNNL	[redact]	300 Area Bldg 326; 700 Area
[redact]	Westinghouse Hanford	[redact]	300 Area, Bldg 309
[redact]	Westinghouse Hanford	[redact]	3000/3190 Area
[redact]	Westinghouse Hanford	[redact]	3000/3190 Area
[redact]	Westinghouse Hanford	[redact]	3000/3190 Area
[redact]	Westinghouse Hanford	[redact]	3000/3190 Area

1.1 SC&A BLIND DR APPROACH

SC&A reviewed all of the Department of Energy (DOE) records provided in behalf of this employee and the National Institute for Occupational Safety and Health (NIOSH) procedures relevant to this case, which included the Technical Basis Document (TBD) for the Hanford Site (issued as six separate documents numbered ORAUT-TKBS-0006-1 through ORAUT-TKBS-0006-6), ORAUT-OTIB-0005 for surrogate organs, OCAS-IG-001 for dose conversion factors (DCFs), and ORAUT-TKBS-0006-3 for occupational x-ray doses. Using the guidance provided in these documents, along with the employee's dosimetry records, SC&A calculated reasonable, claimant-favorable annual organ doses. Table 1-2 provides a summary of the total doses assigned for the cancer sites. Appendices A-1, A-2, and A-3 provide a list of SC&A's assigned annual organ doses and also includes the Interactive RadioEpidemiological Program (IREP) input parameters, such as energy range, distribution type, and uncertainty for each year.

Table 1-2. Summary of SC&A-Derived External/Internal Dose Estimates

	Appendix A-1 Entry No.	SCC Chest (rem)	Appendix A-2 Entry No.	SCC Leg (rem)	Appendix A-3 Entry No.	Colon (rem)
External Dose (Occupational)						
▪ Recorded:						
<30 keV Photons	26–31	0.394	26–31	0.394	26–31	0.009
30–250 keV Photons	1–15	1.496	1–15	1.496	1–15	1.117
0.1–2 MeV Neutrons	16–25	2.134	16–25	2.134	16–25	1.046
▪ Missed Dose:						
<30 keV Photons	66–71	0.105	66–71	0.105	66–71	0.003
30–250 keV Photons	32–52	3.130	32–52	3.130	32–52	2.337
0.1–2 MeV Neutrons	53–65	6.356	53–65	6.356	53–65	3.116
▪ Onsite Ambient Dose:						
30–250 keV Photons	86–101	2.904	86–101	2.904	86–101	1.138
▪ Occupational Medical Dose:						
PFG exam, 1959	85	2.060	85	0.000	85	0.007
30–250 keV Photons	72–84	0.749	72–84	0.001	72–84	0.006
Internal Dose:						
Alpha	102–158	0.039	102–158	0.039	102–164	0.050
>250 keV Photons	159–193	0.004	159–193	0.004	165–199	0.013
>15 keV Electrons	194–250	0.215	194–250	0.215	200–262	3.367
Total		**19.587**		**16.779**		**12.210**
POC		8.71%		7.07%		25.07%

SC&A determined the probability of causation (POC) for this case using the annual doses as input into the NIOSH POC program. The total doses and combined POCs shown in Table 1-2 produced a total POC of **36.43%**.

2.0 EXTERNAL DOSES

To perform the external DR, SC&A analyzed the EE's DOE files containing the dosimeter readings and x-ray examinations. Dosimetry and x-ray exam records were available for the time periods the EE was employed at the Hanford Site from [redact], to [redact]. Individual dosimeter results and annual dosimeter totals were available for the years worked.

SC&A used the DR parameters associated with work in the 300 Area as recommended in ORAUT-TKBS-0006-6, which consisted of an energy range of 100% 30–250 keV photons and 100% 0.1–2 MeV neutrons. Dose conversion factors (DCFs) from OCAS-IG-001 were used to calculate the external dose to the colon. A DCF of 1.0 was used for the skin dose calculations. To account for low-energy photons from plutonium, doses from <30 keV photons were also assigned based on the guidance in OCAS-IG-001, Table 4.1a, "Special Dose Conversion Factors (DCF's) for Plutonium," (page 38). The parameters used to calculate the external dose are shown in Table 2-1.

Table 2-1. External Dose Parameters

300 Area [redact]–[redact]			
	Photons		Neutrons
Energy Range	<30 keV	30–250 keV	30–250 keV
Energy Fraction	100%	100%	100%
Organ DCF (colon)	0.024	0.747	0.490
Organ DCF (skin)	1	1	1
ICRP 60 CF	NA	NA	1.91

2.1 RECORDED PHOTON DOSE

Dosimetry monitoring records for the EE were available beginning in [redact]. SC&A assumed 100% anterior/posterior (AP) exposures and used the recorded photon dose values that were ≥LOD/2 to assign photon doses using the parameters previously described.

Example of [redact] recorded photon dose calculations – SC&A calculated the recorded [redact] photon doses to the colon and skin as follows:

Records show in [redact] the EE received a deep dose of 0.340 rem. The photon dose was assumed to be 100% 30–250 keV. Dose conversion factors (DCFs) of 0.747 for the colon and 1.0 for the skin were applied.

30–250 keV photon dose (colon) = D.D. × DCF
= 0.340 × 0.747
= 0.254 rem

30–250 keV photon dose (skin) = D.D. × DCF
= 0.340 × 1.0
= 0.340 rem

The dose from <30 keV photons is calculated in a similar manner using the [redact] non-penetrating dose (NP.D.) of 0.080 rem and DCFs of 0.024 for the colon and 1.0 for the skin.

<30 keV photon dose (colon) = NP.D. × DCF
= 0.080 × 0.024
= 0.002 rem

<30 keV photon dose (skin) = NP.D. × DCF
= 0.080 × 1.0
= 0.080 rem

SC&A's calculated 30–250 keV doses are shown as IREP entry #6 in Appendices A-1, A-2, and A-3. SC&A assigned a total recorded 30–250 keV photon dose of 1.117 rem to the colon and 1.496 rem to the skin, as shown in IREP entries #1–#15 of all three appendices.

The <30 keV doses are shown as IREP entry #29 in Appendices A-1, A-2, and A-3. SC&A assigned a total recorded <30 keV photon dose of 0.009 rem to the colon and 0.394 rem to the skin, as shown in IREP entries #26–#31 of Appendices A-1, A-2, and A-3.

2.2 MISSED PHOTON DOSE

SC&A analyzed the number of physical zeros and potential zeros based on the EE's badge exchange cycle at the time (weekly or monthly) using the guidance in OCAS-IG-001 and a best-estimate reasonable approach to arrive at a total 163 zeros, or <LOD/2 values, for photons. SC&A used the annual number of zeros, the LOD/2 value of 0.020 rem ([redact]–[redact]) and 0.010 rem (after [redact]), the DR parameters as listed above, and the applicable DCF to determine the annual missed photon dose.

Example of [redact] missed photon dose calculations – SC&A calculated the missed [redact] photon dose to the colon and skin as follows:

Records show in [redact], the EE's dosimeter results show 1 zero. The photon dose was assumed to be 100% 30–250 keV. Dose conversion factors (DCFs) of 0.747 for the colon and 1.0 for the skin were applied.

Missed Photon Dose (colon) = (# zeros × LOD/2) × DCF
= (1 × 0.020 rem) × 0.747
= 0.015 rem

Missed Photon Dose (skin) = (# zeros × LOD/2) × DCF
= (1 × 0.020 rem) × 1.0
= 0.020 rem

SC&A's calculated 30–250 keV missed doses are shown as IREP entry #40 in Appendices A-1, A-2, and A-3. SC&A assigned a total 30–250 keV photon missed dose of 2.337 rem to the colon and 3.130 rem to the skin, as shown in IREP entries #32–#52 of all three appendices.

The missed dose from <30 keV photons was assessed per the guidance in Attachment C of ORAUT-OTIB-0017. Accordingly, missed dose would be assessed when the non-penetrating reading is zero and the penetrating reading is non zero. The EE's records shows seven dosimeter cycles where this occurs. An LOD/2 of 0.015 rem and DCFs of 0.024 for the colon and 1.0 for the skin were applied.

SC&A assigned a total missed dose from <30 keV photons of 0.003 rem to the colon and 0.105 rem to the skin, as shown in IREP entries #66–#71 of all three appendices.

2.3 RECORDED NEUTRON DOSE

The EE was not specifically monitored for neutrons. SC&A assigned neutron doses based on the EE's work location and guidance in Section 6.7.3.4 of ORAUT-TKBS-0006-6. The neutron doses were calculated for 30–250 keV neutrons using the recorded gamma dose and applying the geometric mean (GM) neutron-to-photon ratio from Table 6-22 of ORAUT-TKBS-0006-6, as well as the applicable ICRP and organ DCFs.

Example of [redact] neutron dose calculations – SC&A calculated the [redact] neutron doses to the colon and skin as follows:

> Records show in [redact] the EE received a deep dose of 0.340 rem. The neutron dose was assumed to be 100% 30–250 keV. The ICRP-60 CF of 1.91, a neutron-to-photon ratio of 1.1, and DCFs of 0.490 for the colon and 1.0 for the skin were applied.

Colon η dose (0.1–2 MeV) = (0.340 rem)(ICRP-60 CF)(DCF)(η/photon ratio)
= (0.340 rem)(1.91)(0.490)(1.1)
= 0.350 rem

Skin η dose (0.1–2 MeV) = (0.340 rem)(ICRP-60 CF)(DCF)(η/photon ratio)
= (0.340 rem)(1.91)(1.0)(1.1)
= 0.714 rem

SC&A's calculated values of 0.350 rem to the colon and 0.714 rem to the skin are shown as IREP entry #21 of Appendices A-1, A-2, and A-3. SC&A assigned a total neutron dose from 30–250 keV neutrons of 1.046 rem to the colon and 2.134 rem to the skin, as shown in IREP entries #16–#25 of all three appendices.

2.4 MISSED NEUTRON DOSE

SC&A assigned missed neutron doses based on the EE's work location and number of zero dosimeter readings. The missed neutron doses were calculated for 30–250 keV neutrons using the annual number of zeros and applying the GM neutron-to-photon ratio from Table 6-22 of ORAUT-TKBS-0006-6, as well as the applicable ICRP and organ DCFs.

Example of [redact] missed neutron dose calculations – SC&A calculated the [redact] neutron doses to the colon and skin as follows:

Colon missed η dose = (1 zero reading)(0.040 rem/2)(ICRP-60 CF)(DCF)(η/photon ratio)
= (0.020 rem)(1.91)(0.490)(1.1)
= 0.021 rem

Skin missed η dose = (1 zero reading)(0.040 rem/2)(ICRP-60 CF)(DCF)(η/photon ratio)
= (0.020 rem)(1.91)(1.0)(1.1)
= 0.042 rem

SC&A's calculated missed neutron doses of 0.021 rem to the colon and 0.042 rem to the skin are shown as IREP entry #61 of Appendices A-1, A-2, and A-3. SC&A assigned a total missed neutron dose from 30–250 keV neutrons of 3.116 rem to the colon and 6.356 rem to the skin, as shown in IREP entries #53–#65 of all three appendices.

2.5 OCCUPATIONAL MEDICAL DOSE

The DOE records show that the EE received 1 photofluorography (PFG) x-ray exam in [redact] and 14 posterior-anterior (PA) x-ray exams from [redact]–[redact].

SC&A used the organ dose values recommended in Tables 3-6, 3-8, 3-10, and 3-11 of ORAUT-TKBS-0006-3 as a function of the year the exam was performed to calculate the occupational medical dose. SC&A assigned doses for the PFG exam of 0.007 rem to the colon, 2.060 rem to chest, and <0.001 rem to the leg as shown in entry #85 of the IREP Input tables in the appendices. SC&A also assigned a total dose from the PA exams of 0.006 rem to the colon, 0.749 rem to chest, and 0.001 rem to the leg, as shown in entries #72–#84 of the IREP Input tables in the appendices. These doses are summarized in Table 1-2 above, and detailed in Appendices A-1, A-2, and A-3.

2.6 ONSITE AMBIENT DOSE

SC&A assessed onsite ambient dose from the beginning of the EE's employment until [redact] in accordance with ORAUT-PROC-0060.

Table 4-8 of ORAUT-TKBS-0006-4 shows the 0.055 rem/yr as the maximum external gamma dose for [redact]. Using the isotropic DCFs of 0.803 for the colon and 1.0 for the skin, and correcting for 2,600 hours/yr, an ambient dose was calculated as follows:

1950 Ambient dose (colon) = Annual Dose × DCF × 2,600/2,000
= 0.055 rem/yr × 0.392 × 1.3
= 0.028 rem

1950 Ambient dose (skin) = Annual Dose × DCF × 2,600/2,000
= 0.055 rem/yr × 1.0 × 1.3
= 0.072 rem

SC&A's calculated ambient doses of 0.028 rem to the colon and 0.072 rem to the skin are shown as IREP entry #86 of Appendices A-1, A-2, and A-3. SC&A assigned a total ambient dose of 1.138 rem to the colon and 2.904 rem to the skin, as shown in IREP entries #86–#101 of all three appendices.

3.0 INTERNAL DOSES

The EE's internal dose monitoring records were reviewed and showed the EE was monitored for internal exposures while at Hanford from [redact] until [redact]. The EE was monitored for potential plutonium exposure via urine samples and fission product exposure via a whole body count (WBC).

3.1 MISSED DOSE FROM PLUTONIUM/AMERICIUM

The DOE records indicate the EE was monitored in six in-vitro analyses for plutonium from [redact], to [redact], with all of the results reported as less than the level of detection of the analysis. SC&A calculated a chronic plutonium intake based on 0.025 dpm/ sample, half the detection level of the bioassay. Then, assuming the plutonium material was 10-year-aged fuel-grade plutonium and using the Hanford Pu Mix Intake Rate Calculator Workbook 1.0, determined the intake rates for Pu-239, Pu-238, Pu-241, and Am-241.

Table 3-1. Calculated Intake Rates

Radionuclide	Type	Time Period	Intake Rate (dpm/day)
Pu-238	S	[redact]–[redact]	0.69
Pu-239/240	S	[redact]–[redact]	3.5
Pu-241	S	[redact]–[redact]	83.77
Am-241	S	[redact]–[redact]	1.71

These intake rates and time period were input in the Chronic Annual Dose Workbook (CADW) to calculate the internal doses.

Some forms of plutonium exhibit longer lung clearance times than those used in the International Commission on Radiological Protection Publication 66 (ICRP 1994) model for insoluble (Type S) plutonium. This can result in higher doses to some organs, so dose modification factors were developed, as described in ORAUT-OTIB-0049, *Technical Information Bulletin: Estimating Doses for Plutonium Strongly Retained in the Lung.* The EE's dose is estimated to the skin and colon.

Following the guidance in ORAUT-OTIB-0049, the dose to the skin was adjusted by a factor of 4 for doses after the time of the last urine bioassay measurement. All of the colon doses were increased by a factor of 4.

The total doses from plutonium/americium are 0.039 rem to the skin and 0.050 rem to the colon.

3.2 INTERNAL DOSE FROM FISSION PRODUCTS

The EE had one WBC on [redact], which was above the limits of detection (LOD) for Cs-137 and Na-24. The Cs-137 results were attributed to fallout that is ever-present in the United States as a result of foreign and domestic atmospheric weapons testing. Therefore, the Cs-137 exposure was not considered to be occupational exposure. The Na-24 results are evaluated below.

3.2.1 Sodium-24 Dose

The EE had positive WBC results for Na-24 on [redact]. This positive result was used with the Integrated Modules for Bioassay Analysis (IMBA) computer code to determine a chronic ingestion of 457 pCi/day of Na-24 for the entire period of employment, from [redact], through [redact]. The skin and colon doses from the Na-24 intake were then calculated using the CADW. The total doses from Na-24 are 0.004 rem to the skin and 0.013 rem to the colon.

3.2.2 Other Fission Products

The Hanford Radionuclide Chooser Workbook and the detection levels for the WBC were used to determine the most claimant-favorable radionuclide to use for the missed dose calculations from fission products. Ce-144 was found to be the most claimant-favorable assumption, so the intakes were assessed using Ce-144 (Type S) for the colon and Ce-144 (Type M) for the skin. The detection level for the Ce-144 WBC was assumed to be 200 nCi. The resulting chronic intake was 2,606 nCi/year for the colon and 1,409 nCi/year for the skin for the time period from 1950 until 1983. The skin and colon doses from the Ce-144 intakes were then calculated using the CADW. The total doses from Ce-144 are 0.215 rem to the skin and 3.367 rem to the colon.

3.3 ENVIRONMENTAL DOSE

While employed at Hanford, the EE was potentially exposed to environmental internal exposures. SC&A used the CADW tool and intake information from Table A-12 of ORAUT-TKBS-0006-4 to derive the environmental intakes and resulting doses. The annual doses from environmental intakes were less than 0.001 rem and not included in the final IREP Input table.

4.0 CATI REPORT AND RADIOLOGICAL INCIDENTS

SC&A reviewed the EE's DOE records and CATI report to determine if the EE was involved in any radiological incidents. SC&A did not find any documentation of radiological incidents that would impact the radiation doses assigned in this case.

5.0 SUMMARY CONCLUSIONS

This DR used best-estimate methods to obtain reasonable external and internal dose assignments. The derived total doses provided for a POC <50%.

The total POC for the SCC on the chest, SCC on the leg, and colon cancer was calculated using the NIOSH-Interactive RadioEpidemiological Program (v.5.7.1) and determined to be **36.43%**.

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APPENDIX A-1: IREP INPUT – SCC ON CHEST

EXPOSURE INFORMATION							
Number of exposures							
250							
Exp. #	**Exposure Year**	**Exposure Rate**	**Radiation Type**	**Dose Distribution Type**	**Parameter 1**	**Parameter 2**	**Parameter 3**
1	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
2	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
3	[redact]	acute	photons E=30–250 keV	Constant	0.040	0.000	0.000
4	[redact]	acute	photons E=30–250 keV	Constant	0.040	0.000	0.000
5	[redact]	acute	photons E=30–250 keV	Constant	0.046	0.000	0.000
6	[redact]	acute	photons E=30–250 keV	Constant	0.340	0.000	0.000
7	[redact]	acute	photons E=30–250 keV	Constant	0.240	0.000	0.000
8	[redact]	acute	photons E=30–250 keV	Constant	0.110	0.000	0.000
9	[redact]	acute	photons E=30–250 keV	Constant	0.070	0.000	0.000
10	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
11	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
12	[redact]	acute	photons E=30–250 keV	Constant	0.330	0.000	0.000
13	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
14	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
15	[redact]	acute	photons E=30–250 keV	Constant	0.020	0.000	0.000
16	[redact]	chronic	neutrons E=30–250 keV	Constant	0.105	0.000	0.000
17	[redact]	chronic	neutrons E=30–250 keV	Constant	0.063	0.000	0.000
18	[redact]	chronic	neutrons E=30–250 keV	Constant	0.084	0.000	0.000
19	[redact]	chronic	neutrons E=30–250 keV	Constant	0.084	0.000	0.000
20	[redact]	chronic	neutrons E=30–250 keV	Constant	0.097	0.000	0.000
21	[redact]	chronic	neutrons E=30–250 keV	Constant	0.714	0.000	0.000
22	[redact]	chronic	neutrons E=30–250 keV	Constant	0.504	0.000	0.000
23	[redact]	chronic	neutrons E=30–250 keV	Constant	0.231	0.000	0.000
24	[redact]	chronic	neutrons E=30–250 keV	Constant	0.147	0.000	0.000
25	[redact]	chronic	neutrons E=30–250 keV	Constant	0.105	0.000	0.000
26	[redact]	acute	photons E<30 keV	Constant	0.030	0.000	0.000
27	[redact]	acute	photons E<30 keV	Constant	0.048	0.000	0.000
28	[redact]	acute	photons E<30 keV	Constant	0.036	0.000	0.000
29	[redact]	acute	photons E<30 keV	Constant	0.080	0.000	0.000
30	[redact]	acute	photons E<30 keV	Constant	0.160	0.000	0.000
31	[redact]	acute	photons E<30 keV	Constant	0.040	0.000	0.000
32	[redact]	acute	photons E=30–250 keV	Lognormal	0.600	1.520	0.000
33	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
34	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
35	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
36	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
37	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
38	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
39	[redact]	acute	photons E=30–250 keV	Lognormal	0.080	1.520	0.000
40	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
41	[redact]	acute	photons E=30–250 keV	Lognormal	0.040	1.520	0.000
42	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
43	[redact]	acute	photons E=30–250 keV	Lognormal	0.080	1.520	0.000
44	[redact]	acute	photons E=30–250 keV	Lognormal	0.040	1.520	0.000
45	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
46	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
47	[redact]	acute	photons E=30–250 keV	Lognormal	0.030	1.520	0.000

Appendix A-1: IREP Input – SCC on Chest (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
48	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
49	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
50	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
51	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
52	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
53	[redact]	chronic	neutrons E=30–250 keV	Lognormal	1.271	1.520	0.000
54	[redact]	chronic	neutrons E=30–250 keV	Lognormal	1.102	1.520	0.000
55	[redact]	chronic	neutrons E=30–250 keV	Lognormal	1.102	1.520	0.000
56	[redact]	chronic	neutrons E=30–250 keV	Lognormal	1.102	1.520	0.000
57	[redact]	chronic	neutrons E=30–250 keV	Lognormal	1.102	1.520	0.000
58	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
59	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
60	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.169	1.520	0.000
61	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
62	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.085	1.520	0.000
63	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
64	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.169	1.520	0.000
65	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.085	1.520	0.000
66	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
67	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
68	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
69	[redact]	acute	photons E<30 keV	Lognormal	0.030	1.520	0.000
70	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
71	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
72	[redact]	acute	photons E=30–250 keV	Normal	0.108	0.032	0.000
73	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
74	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
75	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
76	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
77	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
78	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
79	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
80	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
81	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
82	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
83	[redact]	acute	photons E=30–250 keV	Normal	0.054	0.016	0.000
84	[redact]	acute	photons E=30–250 keV	Normal	0.047	0.014	0.000
85	[redact]	acute	photons E=30–250 keV	Normal	2.060	0.618	0.000
86	[redact]	chronic	photons E=30–250 keV	Constant	0.072	0.000	0.000
87	[redact]	chronic	photons E=30–250 keV	Constant	0.072	0.000	0.000
88	[redact]	chronic	photons E=30–250 keV	Constant	0.125	0.000	0.000
89	[redact]	chronic	photons E=30–250 keV	Constant	0.345	0.000	0.000
90	[redact]	chronic	photons E=30–250 keV	Constant	0.451	0.000	0.000
91	[redact]	chronic	photons E=30–250 keV	Constant	0.350	0.000	0.000
92	[redact]	chronic	photons E=30–250 keV	Constant	0.225	0.000	0.000
93	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
94	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
95	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
96	[redact]	chronic	photons E=30–250 keV	Constant	0.140	0.000	0.000
97	[redact]	chronic	photons E=30–250 keV	Constant	0.163	0.000	0.000
98	[redact]	chronic	photons E=30–250 keV	Constant	0.204	0.000	0.000

Appendix A-1: IREP Input – SCC on Chest (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
99	[redact]	chronic	photons E=30–250 keV	Constant	0.163	0.000	0.000
100	[redact]	chronic	photons E=30–250 keV	Constant	0.096	0.000	0.000
101	[redact]	chronic	photons E=30–250 keV	Constant	0.040	0.000	0.000
102	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
103	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
104	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
105	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
106	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
107	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
108	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
109	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
110	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
111	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
112	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
113	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
114	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
115	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
116	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
117	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
118	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
119	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
120	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
121	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
122	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
123	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
124	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
125	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
126	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
127	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
128	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
129	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
130	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
131	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
132	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
133	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
134	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
135	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
136	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
137	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
138	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
139	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
140	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
141	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
142	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
143	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
144	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
145	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
146	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
147	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
148	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
149	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000

Appendix A-1: IREP Input – SCC on Chest (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
150	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
151	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
152	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
153	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
154	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
155	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
156	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
157	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
158	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
159	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
160	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
161	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
162	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
163	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
164	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
165	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
166	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
167	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
168	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
169	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
170	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
171	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
172	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
173	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
174	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
175	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
176	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
177	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
178	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
179	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
180	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
181	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
182	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
183	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
184	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
185	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
186	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
187	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
188	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
189	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
190	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
191	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
192	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
193	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
194	[redact]	chronic	electrons E>15 keV	Lognormal	0.002	3.000	0.000
195	[redact]	chronic	electrons E>15 keV	Lognormal	0.005	3.000	0.000
196	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
197	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
198	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
199	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
200	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000

Appendix A-1: IREP Input – SCC on Chest (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
201	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
202	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
203	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
204	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
205	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
206	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
207	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
208	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
209	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
210	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
211	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
212	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
213	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
214	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
215	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
216	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
217	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
218	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
219	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
220	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
221	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
222	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
223	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
224	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
225	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
226	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
227	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
228	[redact]	chronic	electrons E>15 keV	Lognormal	0.004	3.000	0.000
229	[redact]	chronic	electrons E>15 keV	Lognormal	0.002	3.000	0.000
230	[redact]	chronic	electrons E>15 keV	Lognormal	0.001	3.000	0.000
231	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
232	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
233	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
234	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
235	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
236	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
237	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
238	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
239	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
240	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
241	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
242	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
243	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
244	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
245	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
246	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
247	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
248	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
249	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
250	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000

APPENDIX A-2: IREP INPUT – SCC ON LEG

EXPOSURE INFORMATION							
Number of exposures							
250							
Exp. #	**Exposure Year**	**Exposure Rate**	**Radiation Type**	**Dose Distribution Type**	**Parameter 1**	**Parameter 2**	**Parameter 3**
1	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
2	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
3	[redact]	acute	photons E=30–250 keV	Constant	0.040	0.000	0.000
4	[redact]	acute	photons E=30–250 keV	Constant	0.040	0.000	0.000
5	[redact]	acute	photons E=30–250 keV	Constant	0.046	0.000	0.000
6	[redact]	acute	photons E=30–250 keV	Constant	0.340	0.000	0.000
7	[redact]	acute	photons E=30–250 keV	Constant	0.240	0.000	0.000
8	[redact]	acute	photons E=30–250 keV	Constant	0.110	0.000	0.000
9	[redact]	acute	photons E=30–250 keV	Constant	0.070	0.000	0.000
10	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
11	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
12	[redact]	acute	photons E=30–250 keV	Constant	0.330	0.000	0.000
13	[redact]	acute	photons E=30–250 keV	Constant	0.050	0.000	0.000
14	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
15	[redact]	acute	photons E=30–250 keV	Constant	0.020	0.000	0.000
16	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.105	0.000	0.000
17	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.063	0.000	0.000
18	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.084	0.000	0.000
19	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.084	0.000	0.000
20	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.097	0.000	0.000
21	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.714	0.000	0.000
22	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.504	0.000	0.000
23	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.231	0.000	0.000
24	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.147	0.000	0.000
25	[redact]	chronic	neutrons E=100 keV–2 MeV	Constant	0.105	0.000	0.000
26	[redact]	acute	photons E<30 keV	Constant	0.030	0.000	0.000
27	[redact]	acute	photons E<30 keV	Constant	0.048	0.000	0.000
28	[redact]	acute	photons E<30 keV	Constant	0.036	0.000	0.000
29	[redact]	acute	photons E<30 keV	Constant	0.080	0.000	0.000
30	[redact]	acute	photons E<30keV	Constant	0.160	0.000	0.000
31	[redact]	acute	photons E<30keV	Constant	0.040	0.000	0.000
32	[redact]	acute	photons E=30–250 keV	Lognormal	0.600	1.520	0.000
33	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
34	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
35	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
36	[redact]	acute	photons E=30–250 keV	Lognormal	0.520	1.520	0.000
37	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
38	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
39	[redact]	acute	photons E=30–250 keV	Lognormal	0.080	1.520	0.000

Appendix A-2: IREP Input – SCC on Leg (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
40	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
41	[redact]	acute	photons E=30–250 keV	Lognormal	0.040	1.520	0.000
42	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
43	[redact]	acute	photons E=30–250 keV	Lognormal	0.080	1.520	0.000
44	[redact]	acute	photons E=30–250 keV	Lognormal	0.040	1.520	0.000
45	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
46	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
47	[redact]	acute	photons E=30–250 keV	Lognormal	0.030	1.520	0.000
48	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
49	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
50	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
51	[redact]	acute	photons E=30–250 keV	Lognormal	0.010	1.520	0.000
52	[redact]	acute	photons E=30–250 keV	Lognormal	0.020	1.520	0.000
53	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	1.271	1.520	0.000
54	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	1.102	1.520	0.000
55	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	1.102	1.520	0.000
56	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	1.102	1.520	0.000
57	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	1.102	1.520	0.000
58	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.042	1.520	0.000
59	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.042	1.520	0.000
60	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.169	1.520	0.000
61	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.042	1.520	0.000
62	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.085	1.520	0.000
63	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.042	1.520	0.000
64	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.169	1.520	0.000
65	[redact]	chronic	neutrons E=100 keV–2 MeV	Lognormal	0.085	1.520	0.000
66	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
67	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
68	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
69	[redact]	acute	photons E<30 keV	Lognormal	0.030	1.520	0.000
70	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
71	[redact]	acute	photons E<30 keV	Lognormal	0.015	1.520	0.000
72	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.032	0.000
73	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
74	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
75	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
76	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
77	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
78	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
79	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
80	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
81	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000

Appendix A-2: IREP Input – SCC on Leg (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
82	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
83	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.016	0.000
84	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.014	0.000
85	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.618	0.000
86	[redact]	chronic	photons E=30–250 keV	Constant	0.072	0.000	0.000
87	[redact]	chronic	photons E=30–250 keV	Constant	0.072	0.000	0.000
88	[redact]	chronic	photons E=30–250 keV	Constant	0.125	0.000	0.000
89	[redact]	chronic	photons E=30–250 keV	Constant	0.345	0.000	0.000
90	[redact]	chronic	photons E=30–250 keV	Constant	0.451	0.000	0.000
91	[redact]	chronic	photons E=30–250 keV	Constant	0.350	0.000	0.000
92	[redact]	chronic	photons E=30–250 keV	Constant	0.225	0.000	0.000
93	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
94	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
95	[redact]	chronic	photons E=30–250 keV	Constant	0.153	0.000	0.000
96	[redact]	chronic	photons E=30–250 keV	Constant	0.140	0.000	0.000
97	[redact]	chronic	photons E=30–250 keV	Constant	0.163	0.000	0.000
98	[redact]	chronic	photons E=30–250 keV	Constant	0.204	0.000	0.000
99	[redact]	chronic	photons E=30–250 keV	Constant	0.163	0.000	0.000
100	[redact]	chronic	photons E=30–250 keV	Constant	0.096	0.000	0.000
101	[redact]	chronic	photons E=30–250 keV	Constant	0.040	0.000	0.000
102	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
103	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
104	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
105	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
106	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
107	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
108	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
109	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
110	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
111	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
112	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
113	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
114	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
115	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
116	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
117	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
118	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
119	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
120	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
121	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
122	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
123	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000

Appendix A-2: IREP Input – SCC on Leg (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
124	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
125	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
126	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
127	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
128	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
129	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
130	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
131	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
132	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
133	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
134	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
135	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
136	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
137	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
138	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
139	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
140	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
141	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
142	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
143	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
144	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
145	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
146	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
147	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
148	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
149	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
150	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
151	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
152	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
153	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
154	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
155	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
156	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
157	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
158	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
159	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
160	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
161	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
162	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
163	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
164	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
165	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000

Appendix A-2: IREP Input – SCC on Leg (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
166	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
167	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
168	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
169	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
170	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
171	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
172	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
173	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
174	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
175	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
176	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
177	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
178	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
179	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
180	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
181	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
182	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
183	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
184	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
185	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
186	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
187	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
188	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
189	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
190	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
191	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
192	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
193	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
194	[redact]	chronic	electrons E>15 keV	Lognormal	0.002	3.000	0.000
195	[redact]	chronic	electrons E>15 keV	Lognormal	0.005	3.000	0.000
196	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
197	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
198	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
199	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
200	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
201	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
202	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
203	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
204	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
205	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
206	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
207	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000

Appendix A-2: IREP Input – SCC on Leg (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
208	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
209	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
210	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
211	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
212	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
213	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
214	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
215	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
216	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
217	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
218	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
219	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
220	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
221	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
222	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
223	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
224	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
225	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
226	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
227	[redact]	chronic	electrons E>15 keV	Lognormal	0.006	3.000	0.000
228	[redact]	chronic	electrons E>15 keV	Lognormal	0.004	3.000	0.000
229	[redact]	chronic	electrons E>15 keV	Lognormal	0.002	3.000	0.000
230	[redact]	chronic	electrons E>15 keV	Lognormal	0.001	3.000	0.000
231	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
232	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
233	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
234	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
235	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
236	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
237	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
238	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
239	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
240	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
241	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
242	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
243	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
244	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
245	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
246	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
247	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
248	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
249	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
250	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000

APPENDIX A-3: IREP INPUT – COLON

EXPOSURE INFORMATION							
Number of exposures							
262							
Exp. #	**Exposure Year**	**Exposure Rate**	**Radiation Type**	**Dose Distribution Type**	**Parameter 1**	**Parameter 2**	**Parameter 3**
1	[redact]	acute	photons E=30–250 keV	Constant	0.037	0.000	0.000
2	[redact]	acute	photons E=30–250 keV	Constant	0.022	0.000	0.000
3	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
4	[redact]	acute	photons E=30–250 keV	Constant	0.030	0.000	0.000
5	[redact]	acute	photons E=30–250 keV	Constant	0.034	0.000	0.000
6	[redact]	acute	photons E=30–250 keV	Constant	0.254	0.000	0.000
7	[redact]	acute	photons E=30–250 keV	Constant	0.179	0.000	0.000
8	[redact]	acute	photons E=30–250 keV	Constant	0.082	0.000	0.000
9	[redact]	acute	photons E=30–250 keV	Constant	0.052	0.000	0.000
10	[redact]	acute	photons E=30–250 keV	Constant	0.037	0.000	0.000
11	[redact]	acute	photons E=30–250 keV	Constant	0.037	0.000	0.000
12	[redact]	acute	photons E=30–250 keV	Constant	0.246	0.000	0.000
13	[redact]	acute	photons E=30–250 keV	Constant	0.037	0.000	0.000
14	[redact]	acute	photons E=30–250 keV	Constant	0.022	0.000	0.000
15	[redact]	acute	photons E=30–250 keV	Constant	0.015	0.000	0.000
16	[redact]	chronic	neutrons E=30–250 keV	Constant	0.051	0.000	0.000
17	[redact]	chronic	neutrons E=30–250 keV	Constant	0.031	0.000	0.000
18	[redact]	chronic	neutrons E=30–250 keV	Constant	0.041	0.000	0.000
19	[redact]	chronic	neutrons E=30–250 keV	Constant	0.041	0.000	0.000
20	[redact]	chronic	neutrons E=30–250 keV	Constant	0.047	0.000	0.000
21	[redact]	chronic	neutrons E=30–250 keV	Constant	0.350	0.000	0.000
22	[redact]	chronic	neutrons E=30–250 keV	Constant	0.247	0.000	0.000
23	[redact]	chronic	neutrons E=30–250 keV	Constant	0.113	0.000	0.000
24	[redact]	chronic	neutrons E=30–250 keV	Constant	0.072	0.000	0.000
25	[redact]	chronic	neutrons E=30–250 keV	Constant	0.051	0.000	0.000
26	[redact]	acute	photons E<30 keV	Constant	0.001	0.000	0.000
27	[redact]	acute	photons E<30 keV	Constant	0.001	0.000	0.000
28	[redact]	acute	photons E<30 keV	Constant	0.001	0.000	0.000
29	[redact]	acute	photons E<30 keV	Constant	0.002	0.000	0.000
30	[redact]	acute	photons E<30 keV	Constant	0.004	0.000	0.000
31	[redact]	acute	photons E<30 keV	Constant	0.001	0.000	0.000
32	[redact]	acute	photons E=30–250 keV	Lognormal	0.448	1.520	0.000
33	[redact]	acute	photons E=30–250 keV	Lognormal	0.388	1.520	0.000
34	[redact]	acute	photons E=30–250 keV	Lognormal	0.388	1.520	0.000
35	[redact]	acute	photons E=30–250 keV	Lognormal	0.388	1.520	0.000
36	[redact]	acute	photons E=30–250 keV	Lognormal	0.388	1.520	0.000
37	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
38	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
39	[redact]	acute	photons E=30–250 keV	Lognormal	0.060	1.520	0.000
40	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
41	[redact]	acute	photons E=30–250 keV	Lognormal	0.030	1.520	0.000
42	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
43	[redact]	acute	photons E=30–250 keV	Lognormal	0.060	1.520	0.000
44	[redact]	acute	photons E=30–250 keV	Lognormal	0.030	1.520	0.000
45	[redact]	acute	photons E=30–250 keV	Lognormal	0.007	1.520	0.000
46	[redact]	acute	photons E=30–250 keV	Lognormal	0.007	1.520	0.000
47	[redact]	acute	photons E=30–250 keV	Lognormal	0.022	1.520	0.000

Appendix A-3: IREP Input – Colon (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
48	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
49	[redact]	acute	photons E=30–250 keV	Lognormal	0.007	1.520	0.000
50	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
51	[redact]	acute	photons E=30–250 keV	Lognormal	0.007	1.520	0.000
52	[redact]	acute	photons E=30–250 keV	Lognormal	0.015	1.520	0.000
53	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.623	1.520	0.000
54	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.540	1.520	0.000
55	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.540	1.520	0.000
56	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.540	1.520	0.000
57	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.540	1.520	0.000
58	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.021	1.520	0.000
59	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.021	1.520	0.000
60	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.083	1.520	0.000
61	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.021	1.520	0.000
62	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
63	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.021	1.520	0.000
64	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.083	1.520	0.000
65	[redact]	chronic	neutrons E=30–250 keV	Lognormal	0.042	1.520	0.000
66	[redact]	acute	photons E<30 keV	Lognormal	0.000	1.520	0.000
67	[redact]	acute	photons E<30 keV	Lognormal	0.000	1.520	0.000
68	[redact]	acute	photons E<30 keV	Lognormal	0.000	1.520	0.000
69	[redact]	acute	photons E<30 keV	Lognormal	0.001	1.520	0.000
70	[redact]	acute	photons E<30 keV	Lognormal	0.000	1.520	0.000
71	[redact]	acute	photons E<30 keV	Lognormal	0.000	1.520	0.000
72	[redact]	acute	photons E=30–250 keV	Normal	0.002	0.001	0.000
73	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.000	0.000
74	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.000	0.000
75	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.000	0.000
76	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.000	0.000
77	[redact]	acute	photons E=30–250 keV	Normal	0.001	0.000	0.000
78	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
79	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
80	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
81	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
82	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
83	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
84	[redact]	acute	photons E=30–250 keV	Normal	0.000	0.000	0.000
85	[redact]	acute	photons E=30–250 keV	Normal	0.007	0.002	0.000
86	[redact]	chronic	photons E=30–250 keV	Constant	0.028	0.000	0.000
87	[redact]	chronic	photons E=30–250 keV	Constant	0.028	0.000	0.000
88	[redact]	chronic	photons E=30–250 keV	Constant	0.049	0.000	0.000
89	[redact]	chronic	photons E=30–250 keV	Constant	0.135	0.000	0.000
90	[redact]	chronic	photons E=30–250 keV	Constant	0.177	0.000	0.000
91	[redact]	chronic	photons E=30–250 keV	Constant	0.137	0.000	0.000
92	[redact]	chronic	photons E=30–250 keV	Constant	0.088	0.000	0.000
93	[redact]	chronic	photons E=30–250 keV	Constant	0.060	0.000	0.000
94	[redact]	chronic	photons E=30–250 keV	Constant	0.060	0.000	0.000
95	[redact]	chronic	photons E=30–250 keV	Constant	0.060	0.000	0.000
96	[redact]	chronic	photons E=30–250 keV	Constant	0.055	0.000	0.000
97	[redact]	chronic	photons E=30–250 keV	Constant	0.064	0.000	0.000
98	[redact]	chronic	photons E=30–250 keV	Constant	0.080	0.000	0.000

Appendix A-3: IREP Input – Colon (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
99	[redact]	chronic	photons E=30–250 keV	Constant	0.064	0.000	0.000
100	[redact]	chronic	photons E=30–250 keV	Constant	0.038	0.000	0.000
101	[redact]	chronic	photons E=30–250 keV	Constant	0.016	0.000	0.000
102	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
103	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
104	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
105	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
106	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
107	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
108	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
109	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
110	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
111	[redact]	chronic	alpha	Lognormal	0.000	3.000	0.000
112	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
113	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
114	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
115	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
116	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
117	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
118	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
119	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
120	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
121	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
122	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
123	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
124	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
125	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
126	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
127	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
128	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
129	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
130	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
131	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
132	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
133	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
134	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
135	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
136	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
137	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
138	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
139	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
140	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
141	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
142	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
143	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
144	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
145	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
146	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
147	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
148	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
149	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000

Appendix A-3: IREP Input – Colon (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
150	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
151	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
152	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
153	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
154	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
155	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
156	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
157	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
158	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
159	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
160	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
161	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
162	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
163	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
164	[redact]	chronic	alpha	Lognormal	0.001	3.000	0.000
165	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
166	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
167	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
168	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
169	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
170	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
171	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
172	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
173	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
174	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
175	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
176	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
177	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
178	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
179	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
180	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
181	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
182	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
183	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
184	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
185	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
186	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
187	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
188	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
189	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
190	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
191	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
192	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
193	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
194	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
195	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
196	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
197	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
198	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
199	[redact]	chronic	photons E>250 keV	Lognormal	0.000	3.000	0.000
200	[redact]	chronic	electrons E>15 keV	Lognormal	0.097	3.000	0.000

Appendix A-3: IREP Input – Colon (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
201	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
202	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
203	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
204	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
205	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
206	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
207	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
208	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
209	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
210	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
211	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
212	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
213	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
214	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
215	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
216	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
217	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
218	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
219	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
220	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
221	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
222	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
223	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
224	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
225	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
226	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
227	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
228	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
229	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
230	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
231	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
232	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
233	[redact]	chronic	electrons E>15 keV	Lognormal	0.099	3.000	0.000
234	[redact]	chronic	electrons E>15 keV	Lognormal	0.002	3.000	0.000
235	[redact]	chronic	electrons E>15 keV	Lognormal	0.001	3.000	0.000
236	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
237	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
238	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
239	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
240	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
241	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
242	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
243	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
244	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
245	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
246	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
247	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
248	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
249	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
250	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
251	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000

Appendix A-3: IREP Input – Colon (continued)

Exp. #	Exposure Year	Exposure Rate	Radiation Type	Dose Distribution Type	Parameter 1	Parameter 2	Parameter 3
252	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
253	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
254	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
255	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
256	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
257	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
258	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
259	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
260	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
261	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000
262	[redact]	chronic	electrons E>15 keV	Lognormal	0.000	3.000	0.000