Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

Idaho National Laboratory (INL)
Site Profile Review
Status Update, Revision 1

Contract No. 200-2009-28555
SCA-SP-IM2013-0005

Prepared by

Stephen L. Ostrow, PhD
S. Cohen & Associates
1608 Spring Hill Road, Suite 400
Vienna, VA 22182

February 2014

Disclaimer

S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-SP-IM2013-0005 Effective Date: February 24, 2014 Revision No. 1 – Draft
Idaho National Laboratory (INL) Site Profile Review Status Update, Revision 1	Page 2 of 75
Task Manager: _____ Date: _____ Stephen L. Ostrow, PhD	Supersedes: Rev. 0
Project Manager: _____ Date: _____ John Stiver, MS, CHP	Reviewer(s): John Mauro John Stiver

Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	10/23/13	Initial issue
1 (Draft)	02/24/14	General revision to reflect issue reviews subsequent to the Rev. 0 report and to correct errata.

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
AmBe	americium-beryllium
ANL-W	Argonne National Laboratory – West
ANP	Aircraft Nuclear Propulsion Facility
AP	anterior posterior
ATR	Advanced Test Reactor
CFR	U.S. Code of Federal Regulations
CPP	Chemical Processing Plant
DCAS	NIOSH Division of Compensation Analysis and Support (formerly called OCAS)
DFO	Designated Federal Official
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy Headquarters
DNFSB	Defense Nuclear Facility Safety Board
DU	Depleted Uranium
EDF	Engineering Design File
EE	Energy Employee
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
EPA	U.S. Environmental Protection Agency
ETR	Engineering Test Reactor
FNCF	Facility Neutron Correction Factor
GB	Gross Beta
GG	Gross Gamma
IAEA	International Atomic Energy Agency
ICPP	Idaho Chemical Processing Plant (formerly CPP and now INTEC)
ICRP	International Commission on Radiological Protection
INEL	Idaho National Engineering Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly ICPP and CPP)
IREP	Interactive RadioEpidemiological Program
keV	kiloelectron volts
L	Liter

μ_g	microgram
m^3	cubic meter
MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
MeV	Mega Electron Volts
mg/cm^2	milligram per square centimeter
mm	millimeter
mrem	millirem
MRL	Minimum Dose Reporting Level
MTR	Materials Test Reactor
NCRP	National Council on Radiological Protection and Measurements
NIOSH	National Institute for Occupational Safety and Health
NRF	Naval Reactor Facility
NTA	Nuclear Track Emulsion-Type A
OCAS	NIOSH Office of Compensation Analysis and Support (now known as DCAS)
ORAUT	Oak Ridge Associated Universities Team
OTIB	ORAUT Technical Information Bulletin
ORAUT	Oak Ridge Associated Universities Team
OW	Open Window (dosimeter)
PIC	Pocket Ionization Chamber
PoBe	polonium-beryllium
PoC	Probability of Causation
RAC	Risk Assessment Corporation
RWMC	Radioactive Waste Management Complex
S	slow
SC&A	S. Cohen and Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
SL-1	Stationary Low-Power Reactor Number One
SMC	Specific Manufacturing Capability Facility
SRDB	Site Research Database
SRS	Savannah River Site
TAN	Test Area North

TBD	Technical Basis Document
TIB	Technical Information Bulletin
TLD	Thermoluminescent Dosimeter
TREAT	Transient Reactor Test Facility
UO_2	uranium dioxide
WG	ABRWH Work Group
yr	year
ZPPR	Zero Power Plutonium Reactor

1.0 INTRODUCTION AND BACKGROUND

This report summarizes SC&A's understanding of the issues resolution status of the Idaho National Laboratory (INL)/Argonne National Laboratory-West (ANL-W) site profile, and also presents comprehensive background and review information for convenience. In short, 10 of the 38 issues are closed and, after two rounds of further evaluation, SC&A recommended closing 10 more in its Rev. 0 report (SC&A 2013) and recommends closing an additional 4 in this, its Rev. 1 report, for a total of 14 issues.

The Revision 0 of this report (SC&A 2013) was prepared at the request of the Designated Federal Official (DFO), who, in October 2013, asked SC&A to prepare for the INL/ANL-W Work Group (WG) a summary matrix showing the status of each issue, organized under each Technical Basis Document (TBD) of the site profile. That summary appears in this section. SC&A has also included, in Section 3.0, a more detailed discussion of each issue, drawn from several existing sources, showing the key steps in its resolution process. The material in the report represents a consolidation in one convenient document of the history and disposition status of each issue. It is hoped that this will be a useful living document for all interested parties, facilitating final resolution of all the site profile issues.

SC&A issued its status update report (SC&A 2013) on October 23, 2013, and NIOSH issued two brief status reports on November 7, 2013 (NIOSH 2013b, 2013c). Subsequently, the DFO, on November 13, 2013, requested that SC&A address the issues assigned to SC&A in the NIOSH updates. SC&A reviewed open issues in detail and produced this report (SCA-SP-IM2013-0005, Rev. 0), Revision 1 of its *Idaho National Laboratory (INL) Site Profile Review Status Update* report. This report is intended to support the deliberations of the WG at its next meeting, scheduled for March 25, 2014.

NIOSH first issued the six-volume TBD comprising the INL site profile in July 2004 and SC&A reviewed it in September 2005 (SC&A 2005), followed by a revised review in January 2006 (SC&A 2006). SC&A performed a supplemental review of the July 2007 TBD revisions in December 2008 (SC&A 2008). The Advisory Board on Radiation and Worker Health (ABRWH, or the Board) INL Work Group held its first meeting in June 2009 and decided to combine the INL and ANL-W (SC&A 2007) reviews, as the ANL-W facility is physically located within the INL site. SC&A produced a combined issues matrix for the two facilities in July 2009 (SC&A 2009). NIOSH subsequently revised all its TBDs over the period from December 2009 through April 2011, merging the INL and ANL-W material and making some other changes as well; these are the current versions of the TBDs (ORAUT 2009, 2010a, 2010b, 2010c, 2010d, 2011b). The WG held its second meeting in June 2011 and SC&A subsequently issued an issue status and action item list for the 38 issues that SC&A identified (SC&A 2011a), which was soon revised to include NIOSH comments received on the first draft of the list (SC&A 2011b).

Table 1 shows the current INL/ANL-W TBD volumes that constitute the site profile.

Table 1. INL/ANL-W Site Profile TBDs

TBD	Title	Rev.	Revision Date
1	Introduction	3	March 12, 2010
2	Site Description	4	August 2, 2010
3	Occupational Medical Dose	2	December 31, 2009
4	Occupational Environmental Dose	2	January 8, 2010
5	Occupational Internal Dose	3	March 2, 2010
6	Occupational External Dosimetry	3	April 19, 2011

Section 2 of this report presents a brief chronology for reference, listing key events that have taken place since NIOSH issued Rev. 0 of the TBDs in 2004. Section 3 consists of a detailed listing of all 38 issues along with their status and action (NIOSH and/or SC&A) determined at the June 2011 WG meeting; it is included for completeness and convenience in having all pertinent information in one place. It should be noted that the first 35 issues appeared in the 2006 SC&A review (SC&A 2006), which added Attachment 3, "Summaries of Site Expert Reviews" and Attachment 5, "Issue Resolution Matrix for Findings and Key Observations," neither of which were present in the 2005 review (SC&A 2005). In 2008, SC&A performed a brief supplemental review (SC&A 2008) of the latest revisions of the six INL TBD volumes, which were issued in 2007. The supplemental review corrected one issue (No. 2), expanded four issues (Nos. 25, 26, 29, 35), and added three new issues (Nos. 36, 37, 38), for the current total of 38 issues. The following summarizes the status of all the issues:

Closed: The WG closed 10 of the 38 issues at the June 21, 2011 meeting: Issues 3, 7, 10, 11, 12, 13, 22, 25, 37, and 38.

Recommended for Closure:[1] SC&A was authorized to perform a "quick" review of its assigned issues after that meeting to try to identify issues that it could recommend that the WG close. This led SC&A shortly thereafter to recommend closing an additional 10 issues: Issues 4, 8, 14, 17, 18, 20, 26, 29, 33, and 36.

Subsequent additional review of the open issues, as reported in Rev. 1 of this report, leads SC&A to also recommend closing an additional 4 issues: Issues 21, 30, 32, and 35, which brings the total number of issues recommended for closure to 14.

In addition, NIOSH stated in a presentation made at the July 2013 ABRWH meeting in Idaho (NIOSH 2013a), an October 1, 2013, communication from ORAUT, and in NIOSH 2013b and 2013c, that it is working on four white papers, which will address some of the issues. These are shown in Table 2, along with the issues that NIOSH stated each paper addresses.

[1] Note that alternative terminology for SC&A recommending closing an issue that it reviewed would be to recommend putting it in abeyance pending WG discussion and determination.

Table 2. Planned NIOSH White Papers

Issue	TBD	White Paper Topic
1	ORAUT-TKBS-0007-4 (Environmental)	INL Environmental Monitoring
2	ORAUT-TKBS-0007-4 (Environmental)	Aircraft Nuclear Propulsion Issue
9	ORAUT-TKBS-0007-5 (Internal)	Hot Particle Issue
23	ORAUT-TKBS-0007-6 (External)	Hot Particle Issue
28	ORAUT-TKBS-0007-6 (External)	Investigation of the NTA Film Dosimeter Limits of Detection Being Used for INL Dose Reconstructions

NIOSH is also currently developing an INL-specific Coworker Model, which is purported to address Issues 16 and 31. SC&A is not aware at this time of NIOSH submitting any of the above reports to the Board or SC&A for consideration or review. In addition, NIOSH noted in NIOSH 2013b that it had completed data capture efforts on June 14, 2013, and added the data to the Site Research Database (SRDB).

Table 3 is a comprehensive summary of all the issues, showing the ones already closed by the WG at its June 21, 2011, meeting; action items assigned to NIOSH and/or SC&A at that meeting; white papers and other material that NIOSH is producing to respond to some of the issues; and SC&A recommendations for issue dispositions (i.e., remain open or close) following further review of the action items assigned to it.

Table 3. Issue Status Summary

Issue No.	TBD[b]	Title	Status[a]	Assigned Action[c]	Note
1	4	Routine Airborne Releases	Open	N	NIOSH is working on a white paper to address this issue: *INL Environmental Monitoring*. SC&A will review it when it is available. SC&A recommends: Remain Open.
2	4	Episodic Airborne Releases	Open	N	NIOSH is working on a white paper to address this issue: *Aircraft Nuclear Propulsion Issue*. SC&A will review it when it is available. SC&A recommends: Remain Open.

Table 3. Issue Status Summary

Issue No.	TBD[b]	Title	Status[a]	Assigned Action[c]	Note
3	4	Direct Gamma Exposures	Closed	-	
4	5	Completeness & Quality of INL Internal Dosimetry Programs	Open	N, S	SC&A recommends: Close.
5	5	High-Risk Jobs (Internal Exposure)	Open	S	SC&A recommends: Remain Open.
6	5	Calibration of Internal Dosimetry Analytical & Monitoring Equipment	Open	S	SC&A recommends: Remain Open.
7	7	Changes of Internal Dose Limits	Closed	-	
8	5	High-Fired Plutonium and Uranium Intakes	Open	N, S	SC&A recommends: Close.
9[d]	5	Skin and Facial Contamination	Open	N, S	NIOSH is working on a white paper to address this issue: *Hot Particle Issue*. SC&A will review it when it is available. SC&A recommends: Remain Open.
10	5	Breathing Rates	Closed	-	
11	5	Non-Occupational Worker Elimination of DU Background	Closed	-	
12	5	Unmonitored Workers	Closed	-	
13	4,5,6	Naval Reactor Facility Workers	Closed	-	
14	5	Plutonium Monitoring	Open	N, S	SC&A recommends: Close.
15	4,5,6	SL-1 Accident Dose	Open	S	SC&A recommends: Remain Open.
16	6	Completeness and Quality of INL Beta/Gamma Dosimetry and Record Keeping Programs	Open	N, S	NIOSH is working on an INL-specific coworker model. SC&A will review it when it is available (see Issue 31). SC&A recommends: Remain Open.
17	6	Penetrating and Non-Penetrating Doses	Open	S	SC&A recommends: Close.
18	6	Correction for Beta Doses	Open	S	SC&A recommends: Close.

Table 3. Issue Status Summary

Issue No.	TBD[b]	Title	Status[a]	Assigned Action[c]	Note
19	6	Angular Dependence Correction Factor for Gamma Dose	Open	N	SC&A is waiting for NIOSH response. SC&A recommends: Remain Open.
20	6	Restating Beta Dose as Gamma Dose	Open	S	SC&A recommends: Close.
21	6	Photon Spectrum Split	Open	S	SC&A recommends: Close.
22	6	Immersion Dose	Closed	-	
23[d]	6	High-Risk Jobs (Beta/Gamma Exposure)	Open	N, S	NIOSH is working on a white paper to address this issue: *Hot Particle Issue*. SC&A will review it when it is available. SC&A recommends: Remain Open.
24	6	Extremity Dose	Open	N, S	SC&A recommends: Remain Open.
25	6	Discrepancies Between PIC and Film Reading	Closed	-	
26	6	Minimum Detection Limit	Open	S	SC&A recommends: Close.
27	6	Minimum Reporting Level (Beta/Gamma)	Open	S	SC&A recommends: Remain Open.
28	6	Minimum Reporting Level (Neutron)	Open	N, S	NIOSH is working on a white paper to address this issue: *Investigation of the NTA Film Dosimeter Limits of Detection Being Used for INL Dose Reconstructions*. SC&A will review it when it is available. SC&A recommends: Remain Open.
29	6	Failure to Properly Address Neutron Exposures	Open	S	SC&A recommends: Close.
30	6	Neutron Calibration Deficiencies	Open	S	SC&A recommends: Close.
31	6	Completeness and Quality of INL Neutron Dosimetry and Record Keeping Programs	Open	N	NIOSH is working on an INL-specific coworker model. SC&A will review it when it is available (see Issue 16). SC&A recommends: Remain Open.
32	6	Uncertainty Estimation for Neutron Doses	Open	S	SC&A recommends: Close.

Table 3. Issue Status Summary

Issue No.	TBD[b]	Title	Status[a]	Assigned Action[c]	Note
33	6	Neutron Organ Dose	Open	S	SC&A recommends: Close.
34	6	High-Risk Jobs (Neutron Exposure)	Open	N, S	NIOSH revisiting issue. SC&A recommends: Remain Open.
35	6	Multiplying Factors for Missed Neutron Dose	Open	S	SC&A recommends: Close.
36	6	Missed Low Energy Beta Dose	Open	S	SC&A recommends: Close.
37	6	Error in Reference	Closed	-	
38	6	Shallow Dose	Closed	-	

Notes:

(a) The WG closed Issues 3, 7, 10, 11, 12, 13, 22, 25, 37, and 38 at its June 21, 2011, meeting.

(b) The six volumes comprising the site profile are numbered ORAUT-TKBS-0007-1 to ORAUT-TKBS-0007-6. Their titles are:

1. Introduction
2. Site Description
3. Occupational Medical Dose
4. Occupational Environmental Dose
5. Occupational Internal Dose
6. Occupational External Dose

(c) Assignments made at the June 21, 2011, WG meeting. N – NIOSH; S – SC&A

(d) June 2011 WG meeting recommended combining issues 9 and 23.

2.0 SITE PROFILE REVIEW CHRONOLOGY

The following briefly summarizes the chronology of key events in the INL/ANL-W TBD review process.

July 2004: NIOSH issues Rev. 0 of TBD.

Sept 2005: SC&A issues review of Rev. 0 TBD (SC&A 2005).

Jan 2006: SC&A issues Rev. 1 of its September 2005 review adding worker interviews and Issues Resolution Matrix (SC&A 2006).

Apr-Aug 2007: NIOSH issues revised TBDs; notably, the ones for internal and external exposures were completely rewritten.

July 2007: SC&A issues *Review of ANL-W Site Profile* (SC&A 2007).

Dec 2008: SC&A issues a supplemental review—a "quick look" (no detailed review or comparison)—of the 2007 TBDs, concluding that the original January 2006 SC&A comments are still valid, as none of its findings appear to have been addressed in the 2007 TBDs. The SC&A supplemental review includes a revised Issues Resolution Matrix (SC&A 2008).

6/10/09: First INL WG meeting. WG decides to combine INL and ANL-W (physically located within the INL site) TBDs and review the two sites together.

7/15/09: SC&A produces a "Combined Issues Matrix for INL and ANL-W" (SC&A 2009).

Dec 2009–Apr 2011: NIOSH revises all TBDs to merge INL and ANL-W and to make other revisions (ORAUT 2009, 2010a, 2010b, 2010c, 2010d, 2011b). These are the current revisions.

5/31/11: NIOSH adds its responses to the Issues Resolution Matrix.

6/21/11: Second WG meeting. SC&A produces a memo entitled, "INL/ANL-W Work Group Meeting, June 21, 2011: Actions," including a table of action items (SC&A 2011a).

6/24/11: SC&A issues a revised table incorporating comments from June 21 meeting participants (SC&A 2011b).

7/16/13: NIOSH's status report on INL/ANL-W site profile issues resolution given at the ABRWH Meeting in Idaho Falls, Idaho (NIOSH 2013a).

10/23/13: SC&A issues its *Idaho National Laboratory (INL) Site Profile Review Status Update*, draft, Rev. 0 (SC&A 2013). This is a complete summary of the history and status of the issues.

11/7/13: NIOSH issues two brief status reports:

(a) *INL WG Issues Summary* (NIOSH 2013b).

(b) *Nov. 2013 Status on INL WG Issues* (this is the file name. The document has no report name). This is a NIOSH markup of an SC&A table entitled: "October 2013 Status & Update in INL TBD WG Issues" (NIOSH 2013c).

2/28/14: SC&A issues its revised *Idaho National Laboratory (INL) Site Profile Review Status Update*, draft, Rev. 1 (SCA-SP-IM2013-0005, Rev. 1). This is a complete summary of the history and status of the issues, updating the Rev. 0, SC&A 2013 report.

3.0 TBD ITEM STATUS AND DISCUSSION

This section contains a comprehensive listing of the 38 issues by TBD, including, for each issue, the TBD section (at the time of the SC&A 2006 review); the page number of the full comment made in SC&A 2006 and SC&A 2008; NIOSH responses to SC&A comments made just prior to the June 21, 2011, WG meeting; the WG Action Item or determination from the June 21st meeting; and SC&A's subsequent response to the items assigned to it (SC&A 2011b) performed in a quick review (SC&A 2013) after the meeting; and SC&A's latest response after a subsequent thorough review (SCA-SP-IM2013-0005, Rev. 0). Note that this report presents the information in a linear fashion rather than the more traditional spreadsheet matrix in the interests of easier readability, as the matrix would have several very long and narrow columns. In addition, SC&A took the liberty in a few places to slightly edit the previously expressed findings and responses to clarify them.

3.1 ISSUE 1: ROUTINE AIRBORNE RELEASES

ORAUT-TKBS-0007-4, Occupational Environmental Dose, TBD Sect. 5.1.1.1, SC&A p. 45

Issue: Source terms provided require improvement for use in determining the worker intake from airborne releases at different INL facilities. The data NIOSH uses do not take into account the deficiencies in the environmental monitoring equipment and their locations, and, in addition, NIOSH does not assess the uncertainties associated with the meteorological dispersion model used for the INL site. Most importantly, the source terms do not account for worker inhalation of resuspended contaminated soils and materials around the INL facilities.

NIOSH Response: The SC&A comments are directly related to the Tiger Team report DOE/EH-0178 (DOE 1991). That report cites 40 CFR 50 and 40 CFR 58, both of which are EPA regulations concerning primary ambient air quality standards. The equipment type, location requirements, and uncertainties referred to in those standards are designed for purposes other than those for which NIOSH is using this data. The dose calculations made by NIOSH are independent of the requirements in those standards. NIOSH requests the reference SC&A used to determine that the uncertainties not accounted for in the meteorological dispersion model.

WG Action Items:

- **NIOSH:** Revisit meteorological dispersion model, especially for relatively close proximity to release points.

Note: (Oct. 2013 update) NIOSH is working on a white paper to address this issue: *INL Environmental Monitoring.*

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH is working on a white paper to address this issue.

SC&A Further Review: SC&A is waiting for the NIOSH white paper. Hence, SC&A recommends that this issue remain Open.

3.2 ISSUE 2: EPISODIC AIRBORNE RELEASE

ORAUT-TKBS-0007-4, Occupational Environmental Dose, Sect. 5.1.1.2, SC&A p. 55

Issue: The airborne releases associated with several of the Initial Engine Tests of the Aircraft Nuclear Propulsion (ANP) Program were likely to have been underestimated by factors ranging from 2 to 16. Also, NIOSH did not evaluate the uncertainties associated with the deficiencies in air monitoring equipment.

NIOSH Response: Please provide a basis for the "factors ranging from 2 to 16." Please see response to number 1 regarding uncertainties.

WG Action Items:

- **NIOSH:** Review SC&A report: *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program and INEL*, 2003, on the RAC modeling approach. [SC&A 2003]

Note: (Oct. 2013 update) NIOSH is working on a white paper to address this issue: *Aircraft Nuclear Propulsion Issue.*

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH is working on a white paper to address this issue.

SC&A Further Review: SC&A is waiting for the NIOSH white paper. Hence, SC&A recommends that this issue remain Open.

3.3 ISSUE 3: DIRECT GAMMA EXPOSURES

ORAUT-TKBS-0007-4, Occupational Environmental Dose, Sect. 5.1.1.3, SC&A p. 57

Issue: The fence-line thermoluminescent dosimeter (TLD) measurements are not adequate for reconstructing direct gamma doses to personnel working outdoors at and around a specific INL facility inside the fence-line boundary, because they do not take into account the most bounding scenarios.

NIOSH Response: Personnel within the various facilities were monitored and access was controlled. Dosimetry was required to enter the various "fenced" facilities on site. TLDs were placed on the fences enclosing the various facilities. The dose from these TLDs represents the bounding condition at the closest point an unmonitored individual could get to a facility.

WG Action Items: None. Issue closed based on NIOSH's response at the June 21, 2011, WG meeting.

ISSUE CLOSED

3.4 ISSUE 4: COMPLETENESS AND QUALITY OF INL INTERNAL DOSIMETRY PROGRAMS

ORAUT-TKBS-0007-4, Occupational Environmental Dose, Sect. 5.1.2.1, SC&A p. 73.

Issue: The identification and determination of missed internal dose for workers are heavily influenced by the assumption of confidence, but SC&A found this premise to be unsupported after examining several critical DOE-HQ Tiger Team and DNFSB site audit reports. In addition, many site experts interviewed by SC&A indicated that there were significant deficiencies and inconsistencies in radiation work practices throughout the operating history of the INL facilities. These observations jeopardize the validity of the TBD approaches in reconstructing missed worker internal doses.

NIOSH Response: The default table for missed dose (5-24) does not have a basis in the "confidence" of the INL radiological program. The table is based on monitoring results, favorable ratios, and other claimant-favorable assumptions.

However, in resolving the issue associated with SC&A's Finding 3.5-1 for the ANL-W Site Profile, the previous approaches used to calculate missed and unmonitored internal doses have been completely replaced. The missed and unmonitored doses for activation and fission products are now based on the approach described in OTIB-0054 (ORAUT 2007b). The unmonitored actinide doses are now being calculated using a new site-specific approach based on source term information and a broader list of radionuclides.

WG Action Items:

- **NIOSH:** Report the number of people sampled and the time periods when the samples were taken.
- **SC&A:** Review applicable portions of the current version of the Internal Exposure TBD and reassess the issue.

SC&A Reassessment: Upon reviewing TBD Section 5, Revision 3, SC&A observes that Section 5.8 "Default for Missed Dose" has been deleted and a new Section 5.6 "Intake and Internal Dose Assessment for Unmonitored Workers" has been added. New Section 5.6 refers to OTIB-0018 (ORAUT 2005a) and OTIB-0033 (ORAUT 2005c) for assigning a default missed internal dose. Additionally, in Section 5.5.1, missed and unmonitored doses for activation and fission products are now based on the approach described in OTIB-0054 (ORAUT 2007b), as stated by NIOSH in their response. OTIB-0018, OTIB-0033, and OTIB-0054 have each been reviewed by SC&A, under the Procedures Review Subcommittee [N.B., SC&A is currently (Oct. 2013) reviewing OTIB-0054, Rev. 1]. Outstanding issues with these three OTIBs are being resolved within that Subcommittee.

SC&A is satisfied with the manner in which NIOSH has resolved this issue, and recommends to the WG that this issue be closed.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.5 ISSUE 5: HIGH-RISK JOBS (INTERNAL EXPOSURE)

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.2, SC&A p. 77

Issue: NIOSH did not evaluate comprehensively the facility and field data to identify and separate out the high-risk or high-dose jobs for worker internal exposures. This information is essential for dose reconstructors to fill in the data gap when dose records in a claimant's file are not complete.

NIOSH Response: NIOSH has monitoring records for internal dose and NIOSH feels the records are fairly comprehensive for "high-risk" jobs. The TBD contains requirements for reconstructing internal doses and for missed doses.

WG Action Items:

SC&A: Review applicable portions of the current version of the Internal Exposure TBD and reassess the issue.

SC&A Reassessment: Revision 3 of the TBD does not explicitly address this finding; rather, the NIOSH response argues that the dose reconstruction methodology contained within the TBD is sufficient. A similar concern was raised by SC&A during the review of OTIB-0052 (ORAUT 2011a) regarding "high-risk" construction jobs. With regard to the OTIB-0052 concern, SC&A suggested (and we believe that NIOSH concurred) that wording be provided in OTIB-0020 (ORAUT 2008a) to instruct the dose reconstructor to modify the dose reconstruction and/or perform additional research if a claimant expresses a specific concern (either verbally or in writing) and the dose reconstructor is able to confirm that concern. SC&A suggests that a similar statement be provided in the INL TBD.

SC&A recommends to the WG that this finding remain open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the statement above, shown under WG Action Items: SC&A.

SC&A Further Review: SC&A repeated its review of the Internal Exposure TBD and believes that its earlier assessment, shown above under WG Action Items: SC&A Reassessment, remains valid and that the "action" is on NIOSH to respond. Hence, SC&A recommends that this issue remain Open.

3.6 ISSUE 6: CALIBRATION OF INTERNAL DOSIMETRY ANALYTICAL AND MONITORING EQUIPMENT

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.3, SC&A p. 78

Issue: The TBD does not provide any information on the calibration procedures, sensitivities, and standards of the internal dosimetry analytical equipment and monitoring instrumentation. The 1991 DOE Tiger Team findings (DOE 1991) show the deficiencies in these areas. NIOSH should evaluate the uncertainties and impacts on the internal dose assessment results associated with the deficient calibration programs at INL.

NIOSH Response: The references cited in the TBD provide information on the analytical equipment maintenance. Other facility audits find the program adequate.

The equipment type, location requirements, and uncertainties referred to in the Tiger Team report are designed for purposes other than those for which NIOSH is using this data. The dose calculations made by NIOSH are independent of the issues discussed in an old Tiger Team report. NIOSH did account for uncertainties associated with the radiological model.

WG Action Items:

SC&A: Review applicable portions of the current version of the Internal Exposure TBD and the Tiger Team report and reassess the issue.

SC&A Reassessment: There is no additional information provided in Revision 3 to address this observation. The only additional information is that provided in the NIOSH response. There is too little information provided in the response to allow SC&A to agree or disagree with it. SC&A would like to know, what were the different "designed for purposes" between the Tiger Team report and NIOSH data? Also, how are the NIOSH calculations independent of the issues discussed in the Tiger Team report? Finally, how did NIOSH account for uncertainties associated with the radiological model?

SC&A recommends to the WG that this issue remain open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the statement above, shown under WG Action Items: SC&A.

SC&A Further Review: SC&A reexamined the INL Tiger Team report (DOE 1991), the current site profile Internal Dosimetry TBD (ORAUT 2010d), the SC&A comment and background discussion in its 2006 site profile review (SC&A 2006) pertaining to Issue 6, and, additionally, Defense Nuclear Facilities Safety Board (DNFSB) reports (DNFSB 1994a, 1994b, 1995); the latter were found not germane to this issue and will not be discussed in the following.

The INL Tiger Team assessment was conducted as part of the overall DOE Tiger Team Independent Assessment Program across the DOE facilities complex, which begun in the late 1980s. The INL assessment was accomplished during the summer of 1991 and the comprehensive, multi-volume report (DOE 1991) was published in August 1991. The evaluation focused on several areas, notably environment, safety and health, management, and organization. Much of the evaluation and many of the findings are programmatic and procedural, such as organizational structure (multiple governmental and private organizations were involved simultaneously at INL), direction, and coordination, and compliance with federal, state, and local regulations and procedures. The assessment is quite critical overall, particularly with respect to management. With regard to radiation protection, the Executive Summary notes:

> *The radiation protection program at EG&G Idaho* [i.e., INL] *was found to be particularly deficient. The nuclear accident dosimetry program is not in compliance with performance requirements for fixed and personnel nuclear accident dosimeters. The personnel dosimeter program is not in compliance with applicable DOE Orders and there is no program to identify and resolve problems related to the response of radiation protection instrumentation.*

Section 5.1.2 of the original SC&A site profile review (SC&A 2006), which assessed Rev. 0 of the INL Internal Dose TBD (ORAUT 2004b), discusses several issues noted in the Tiger Team report and quotes portions of it. In particular, Section 5.1.2.1, Completeness and Quality of INL Internal Dosimetry Programs, concludes:

> *Given these deficiencies noted in the INL radiological protection and internal dosimetry programs, it is unlikely that the information and internal exposure records provided in the worker files are complete. It is also likely that many worker internal exposures associated with high-dose jobs were not monitored or documented.*

SC&A reviewed the current, Rev. 3, INL Internal Dose TBD (2010d) and finds that it addresses some of the areas raised in Issue 6. For example, Section 5.1.6 and subsequent sections discuss the INL internal dosimetry program throughout the years, including air monitoring and in-vitro and in-vivo radiobioassay techniques and programs. Those sections contain several tables on detection sensitivities, such as minimum detectable activities (MDAs) for different types of measurements over different periods of time. The TBD discusses uncertainties only for bioassays in Section 5.4.2, and states that:

> *The uncertainty values for all types of bioassay measurements are typically included in the INEL's* [i.e., INL's] *bioassay records that are provided by the DOE. When measurement-specific uncertainty values are available, those values are preferred for the data analysis over generic values. When the uncertainty values are not included with the bioassay records, the uncertainty values to be used for the data analysis should be determined in accordance with the recommendations in the "Technical Information Bulletin: Internal Dose Reconstruction"* [i.e., ORAUT-OTIB-0060, ORAUT 2007a].

However, the TBD still does not comment on how accurate the data are expected to be, given the aforementioned deficiencies in, among other factors, calibration of monitoring and assay equipment, found in the radiation protection program by the Tiger Team assessment. The reliability of NIOSH's dose calculations for claimants depends on the reliability of the underlying data. Hence, SC&A recommends that Issue 6 remain open pending an elaboration of the issue by NIOSH, subsequent review of the response by SC&A, and action of the WG.

3.7 ISSUE 7: CHANGES OF INTERNAL DOSE LIMITS

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.4, SC&A p. 78

Issue: Inconsistent work practices were prevalent in the early years of the INL operation and may have led to significant missed dose to workers. NIOSH should evaluate the impacts of these dose limit changes over the operating history of INL to see whether there were missed doses in the early years when the radiation protection policy was less protective and inconsistently implemented.

NIOSH Response: Dose limits have no impact on missed doses, since missed doses are solely the doses that would have gone undetected by a particular monitoring method because of the limit of detection. Whereas, unmonitored dose is that for which no monitoring was performed. Therefore, NIOSH's response assumed that this comment was applicable to the potential unmonitored doses, since the dose limits were functions of when internal dose monitoring was performed.

A review of 90,515 urine sample results indicates that over 98% of the gross beta (GB) and gross gamma (GG) in urine results were below the minimum detectable activity (MDA) values provided in this TBD. In addition, a significant number of those positive bioassay measurements were follow-up measurements to previously identified intakes. Given that an overwhelming majority of the GB and GG in urine bioassay results, which constitute most of the bioassay data in the early years of the INL's operations, were below the MDAs for those measurement methods, it is unlikely that the alleged inconsistent practices led to significant unmonitored internal doses.

WG Action Items: None. WG concurs with NIOSH. Issue closed at the June 21, 2011, WG meeting.

ISSUE CLOSED

3.8 ISSUE 8: HIGH-FIRED PLUTONIUM AND URANIUM INTAKES

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.5, SC&A p. 78

Issue: The TBD did not evaluate the hazard associated with high-fired plutonium and uranium at the INTEC (ICPP) and Radioactive Waste Management Complex (RWMC) facilities. High-fired Pu-238, Pu-239, and uranium are not easily dissolvable, nor do they readily break into very small particles. They also emit some gamma rays and neutrons. Similar to the treatment of recycled uranium, NIOSH should evaluate the lung dose for intake of high-fired uranium and plutonium oxide particulates (alveolar deposition).

NIOSH Response: The INL internal TBD has been revised to include super-S Pu as a potential material type at the INL.

Please define what you mean by high-fired uranium intakes.

WG Action Items:

- **NIOSH:** Revisit the issue; in particular, the applicability of ICRP-66. Produce a "white paper" on recycled uranium.
- **SC&A:** Review applicable portions of the current version of the Internal Exposure TBD.

SC&A Reassessment: To create ceramic pellets, uranium dioxide (UO_2) powder is fired in a high-temperature (about 1,700°C) sintering furnace. The pellets are then ground to a uniform size. Inhalation or ingestion of this sintered material is what is meant by "high-fired uranium intakes." High-fired uranium has an absorption classification of slow (S).

The SC&A review of Revision 3 confirms that super-S plutonium has been included in the determination of which solubility classification yields the highest dose (Section 5.1.4). Likewise, uranium class S representing high-fired uranium is also included (i.e., the "dose reconstructor should assume either type M or type S uranium to maximize the dose" (Section 5.5.5).

Therefore, SC&A believes that NIOSH has addressed this issue, considers this issue to be resolved, and recommends that the WG close it.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.9 ISSUE 9: SKIN AND FACIAL CONTAMINATION

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.6, SC&A p. 79

Issue: This TBD does not consider incidents with workers having skin contamination, facial contamination, and positive nasal swipes in the INL facilities. These kinds of problems would be compounded by the deficiencies in air sampling systems and ineffective respiratory protection programs. Guidance should be provided to a dose reconstructor to account for the missed dose due to the unaccounted uptake.

NIOSH Response: All versions of the internal TBD have indicated that the monitoring and analytical programs were designed to initiate, through *in vitro* and/or *in vivo* bioassay analysis, an investigation of any potential internal intake as indicated by positive air sampling, personnel contamination, etc… As a result, the skin and facial contamination incidents would have follow-up *in vitro* and/or *in vivo* bioassay measurement data when an intake was suspected. Therefore, the alleged deficiencies are of no consequence in NIOSH's dose reconstruction methods, since urine, fecal, whole body count, and lung count data would take precedence over air monitoring, contamination survey, and nasal smear data.

WG Action Items:

- **NIOSH:** Look at how the issue of shallow exposures to radioactive particles or flakes is addressed. Did the facilities where this may have been an issue have programs addressing it? What work controls were used on the site?
- **SC&A:** Look at ORAUT-OTIB-0017 (ORAUT 2005b) for how it addresses potential hot particle doses.

SC&A Reassessment: SC&A performed a review of OTIB-0017 (ORAUT 2005b), including the "hot particle" portions, in June 2006 under the direction of the Procedures Review Subcommittee. The review of OTIB-0017 resulted in 15 findings being identified by SC&A, including Findings 3 and 5, which were related to "hot particles." All 15 of the OTIB-0017 findings have been discussed among the Procedures Review Subcommittee, NIOSH, and SC&A, and closed. In regards to the "hot particle" findings, SC&A recommended closure of the findings because it is believed that the methodology in OTIB-0017 could not be improved upon, even though it was believed to be technically weak. Obviously, NIOSH disagreed that OTIB-0017 was technically weak.

SC&A cannot make a recommendation to the WG regarding this observation until we have reviewed the NIOSH response to their action item.

Note: (Oct. 2013 update) NIOSH is working on a white paper to address this issue: *Hot Particle Issue.*

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH is working on a white paper to address this issue and comments that this issue should be merged with Issue 23, High Risk Jobs (Beta/gamma Exposure). NIOSH also states that it is awaiting SC&A's response: "SC&A: Look at ORAUT-OTIB-0017 for how it addresses potential hot particle doses."

SC&A Further Review: SC&A is waiting for NIOSH's white paper before it will consider this issue further. Hence, SC&A recommends that this issue remain Open.

3.10 ISSUE 10: BREATHING RATES

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.7; SC&A p. 79

Issue: The TBD assumption appears less claimant favorable than the ICRP or NCRP assumptions.

NIOSH Response: Based on the Section 5.1.2.7 of SCA-TR-TASK1-0005, this comment is actually being made for ORAUT-TKBS-0007-4.

NIOSH was only able to find breathing rate information in Footnote c of Table 1 in ICRP 68, which also indicates that the information being provided was obtained from Table 6 of ICRP 66. The breathing rates in ICRP Reports 23, 66, and 68 for 8 hr of light work activity are all 9.6 m^3/workday. The INL Environmental TBD used an intake rate of 2,400 m^3/yr, which is equivalent to 9.6 m^3/workday times 250 workdays/yr. Therefore, the breathing rate used in the INL Environmental TBD is equivalent to the breathing rates recommended in ICRP Reports 23, 66, and 68.

WG Action Item: None. The WG accepted NIOSH's response and closed the issue at the June 21, 2011, WG meeting.

ISSUE CLOSED

3.11 ISSUE 11: NON-OCCUPATIONAL WORKER ELIMINATION OF DU BACKGROUND

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.8, SC&A p. 79

Issue: The derivation of the background value of 0.16 µg/L used for subtraction from each urinalysis result of uranium prior to assessment of occupational internal dose for Specific Manufacturing Capability (SMC) Facility radiation workers is not technically sound. The baseline background (population) intake value was determined by a study of urine samples submitted by non-radiation workers at the SMC facility. A better approach would be to use the urine excretion samples by non-INL people in the Idaho Falls area. NIOSH should consider this subtraction from urinalysis results as a missed internal dose.

NIOSH Response: The idea to collect background samples from non-INL personnel is not feasible and is unreasonable. ICRP 23 lists the daily intake of naturally occurring uranium as 1.9 µg per day. Assuming equilibrium, the daily excretion of uranium through urine would also be 1.9 µg. Applying the excretion volume for Reference Man of 1.4 liters per day, this results in a range of typical urinary concentration of 0.04 to 0.5 µg/L. Therefore, the INL's adjustment value of 0.16 µg/L is consistent with ICRP reference values for natural uranium.

Reference: King, V.A., 2001, *Technical Basis for Internal Dosimetry at SMC*, EDF No. SMC-2001-02, Rev. 3, Idaho National Environmental and Engineering Laboratory, Idaho Falls, Idaho, May 31. [SRDB Ref ID: 8479, p. 67]

WG Action Item: None. The WG accepted NIOSH's response and closed the issue at the June 21, 2011, WG meeting.

CLOSED

3.12 ISSUE 12: UNMONITORED WORKERS

ORAUT-TKBS-0007-5, Occupational Internal Dose, TBD Sect. 5.1.2.9, SC&A p. 80

Issue: The potential missed doses for unmonitored workers would be from inhaling resuspended contaminated soils and ingesting contaminated materials while eating in a contaminated, previously considered uncontaminated, area (such as office and cafeteria). NIOSH should evaluate these potential missed doses.

NIOSH Response: These scenarios are considered in the development of unmonitored doses.

WG Action Items: None. The WG accepted NIOSH's response and closed the issue at the June 21, 2011, WG meeting.

CLOSED

3.13 ISSUE 13: NAVAL REACTOR FACILITY WORKERS

ORAUT-TKBS-0007-4 (Environmental), -5 (Internal), -6 (External), SC&A p. 80

Issue: As the internal dose TBD indicates, "some workers' internal dose could have resulted from their support work at the NRF." NIOSH should evaluate the potential missed dose at the Naval Reactor Facility (NRF) for these workers.

NIOSH Response: Workers assigned to the NRF are not covered as required by EEOICPA. However, doses received by NRF workers while responding to the Stationary Low-Power Reactor Number One (SL-1) accident are covered.

WG Action Items: None. The WG found the NIOSH response acceptable and closed the issue at the June 21, 2011, WG meeting.

CLOSED

3.14 ISSUE 14: PLUTONIUM MONITORING

ORAUT-TKBS-0007-5, Occupational Internal Dose, Sect. 5.1.2.11, SC&A p. 80

Issue: The TBD does not provide any historical information on the plutonium analysis methods used at INL. It is entirely possible that selective plutonium monitoring on workers was used at INL until 1980, but without this information, the dose reconstructors would not be able to assign missed internal dose due to plutonium intakes in the time period before 1980. NIOSH should provide information on plutonium monitoring.

NIOSH Response: Because plutonium was not separated from the spent nuclear fuel at the INL, the plutonium was always present with the more readily detectable mixed fission products that were also in the spent nuclear fuel. Therefore, in the vast majority of the plutonium exposure scenarios, the plutonium would have been present with the product and waste streams containing mixed fission products, and any intakes of radioactivity would have been more readily detectable by performing bioassay measurements for mixed fission products. Exceptions to these exposure scenarios may have included exposures to laboratory workers that may have separated and/or handled laboratory quantities of plutonium and the limited number of workers that may have somehow received a plutonium intake from the plutonium that was plated out on the surfaces inside a decontaminated hot cell at the ICPP. Performing bioassay measurements for these few types of scenarios and possibly just as experimental bioassay procedures, would explain the sporadic plutonium bioassay data. Because the INL appears to have routinely performed bioassay measurements for mixed fission products when it thought there was any potential for exposure, and because the intakes of mixed fission products can be correlated to intakes of plutonium, the dose reconstruction process for the INL involves assigning missed plutonium doses based on either Pu:Sr-90 or Pu:Cs-137 ratios that get applied to intakes that were estimated for those fission products.

WG Action Items:

- **NIOSH:** Provide SC&A with the source documents used.
- **SC&A:** Review applicable portions of the current version of the Internal Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A's review of Revision 3 indicates that the text of TKBS-0007-5 has been revised to incorporate a discussion on bioassay monitoring in Section 5.1.6.3.

Therefore, SC&A believes that NIOSH has addressed this issue, considers this issue to be resolved, and recommends that the WG close this issue.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.15 ISSUE 15: SL-1 ACCIDENT DOSE RECONSTRUCTIONS

ORAUT-TKBS-0007-4/5/6, Occupational Environmental Dose, Occupational Internal Dose, Occupational External Dose, TKBS-5 Section 5.1.3, SC&A p. 80

Issue: The TBDs do not evaluate the potential missed internal and external doses or the associated uncertainties for the over 1,000 rescue and cleanup workers involved with the SL-1 accident that occurred in January 1961. There was a high potential for significant exposures, because the equipment used and the radiological control policies in place in that era were not as advanced and protective as those in current use. The TBDs should develop adjustment factors related to stay time, dose field estimates, internal dose results, external dose readings, and contamination level estimates.

NIOSH Response: NIOSH has a significant dosimetry history for first-responder and recovery workers at the SL-1 facility. The dosimetric records provide enough data to accurately reconstruct doses. In some instances, SL-1 specific coworker dose is used. SL-1 dose reconstruction data are addressed in the TBD.

WG Action Items:

- **SC&A:** Review applicable portions of the current versions of the TBDs and reassess the issue.

SC&A Reassessment: SC&A's review of Revision 3 indicates that NIOSH did not make any changes to TKBS-5 as a result of this finding. NIOSH provided additional information in its issue response; however, SC&A would like to see more specifics before recommending that this finding be closed. For example, what constitutes "a significant dosimetry history?" How was it determined that the "dosimetric records provide enough data to accurately recalculate doses?" An example of an instance when SL-1-specific coworker dose was used would be appreciated.

SC&A recommends that this finding remain open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the content of the WG Action Items: SC&A, shown above.

SC&A Further Review: SC&A revisited the current versions of the INL TBDs that address the SL-1 accident: Occupational Environmental Dose (ORAUT 2010c), Occupational Internal Dose (ORAUT 2010d), and Occupational External Dosimetry (ORAUT 2011b). SC&A would still like to see a NIOSH discussion of the personnel exposures and underlying data associated with the SL-1 criticality accident. Hence, SC&A recommends that the WG keep this issue open.

3.16 ISSUE 16: COMPLETENESS AND QUALITY OF INL BETA/GAMMA DOSIMETRY AND RECORD KEEPING PROGRAMS

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.1, SC&A p. 96

Issue: The identification and determination of missed external dose for workers are heavily influenced by this assumption of confidence, but SC&A found this premise to be unsupported after examining several critical DOE-HQ Tiger Team and DNFSB site audit reports. In addition, many site experts interviewed by SC&A indicated that there were significant deficiencies and inconsistencies in radiation work practices throughout the operating history of the INL facilities. These observations jeopardize the validity of the TBD approaches in reconstructing missed worker external doses.

NIOSH Response: Please provide the reports of "significant deficiencies and inconsistencies in radiation work practices" and provide how the NIOSH-derived missed dose calculations are subject to the results of the Tiger Team report.

WG Action Items:

- **NIOSH/SC&A:** SC&A will clarify its concerns with respect to the Tiger Team reports and NIOSH will respond to those concerns and identify any additional relevant issues.

SC&A Reassessment: None at this time.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the statement above, shown under WG Action Items: SC&A.

SC&A Further Review: SC&A re-examined the INL Tiger Team report (DOE 1991), the current site profile External Dose TBD (ORAUT 2011b), the original External Dose TBD (ORAUT 2004a), the original SC&A comment and background discussion, as well as the site expert interview summary, in its 2006 site profile review (SC&A 2006) pertaining to Issue 16, and, additionally, the Defense Nuclear Facilities Safety Board (DNFSB) reports (DNFSB 1994a, 1994b, 1995); the latter were found not germane to this issue and will not be discussed in the following.

The INL Tiger Team assessment was conducted as part of the overall DOE Tiger Team Independent Assessment Program across the DOE facilities complex, which begun in the late 1980s. The INL assessment was accomplished during the summer of 1991 and the comprehensive, multi-volume report (DOE 1991) was published in August 1991. The evaluation focused on several areas, notably environment, safety and health, management, and organization. Much of the evaluation and many of the findings are programmatic and procedural, such as organizational structure (multiple governmental and private organizations were involved simultaneously at INL), direction, and coordination, and compliance with federal, state, and local

regulations and procedures. The assessment is quite critical overall, particularly with respect to management. With regard to radiation protection, the Executive Summary notes:

> *The radiation protection program at EG&G Idaho* [i.e., INL] *was found to be particularly deficient. The nuclear accident dosimetry program is not in compliance with performance requirements for fixed and personnel nuclear accident dosimeters. The personnel dosimeter program is not in compliance with applicable DOE Orders and there is no program to identify and resolve problems related to the response of radiation protection instrumentation.*

The Tiger Team report also mentions in several places that not everyone who should have had personal monitoring actually had it.

Section 5.1.4.1.1 of the SC&A site profile review (SC&A 2006), which assessed Rev. 0 of the INL External Dose TBD (ORAUT 2004a), cites several issues noted in the Tiger Team report, as well as site interviews SC&A had conducted. In particular, in reference to missed dose:

> *(3) During the site expert interviews, past and current workers at INL facilities provided first-hand information about potential missed dose scenarios and deficiencies in personnel protection programs and dosimetry record keeping. Even though there is a sentiment that the INL radiological protection programs and the advancement of equipment and techniques have made dramatic improvements over the past two decades, the missed dose problems due to these deficiencies in the early days must be addressed in a fair and reasonable manner.*

SC&A reviewed the current, Rev. 3, INL External Dose TBD (ORAUT 2011b) as well as the Rev. 0 External Dose TBD (ORAUT 2004a) and found that the issue is addressed in Section 6.5 of the former, Missed Dose, with subsections; dosimeter not worn, missed photon dose, missed electron dose, and missed neutron dose. The first two subsections are applicable to this issue. For the situation of a worker claiming exposure to radiation while not wearing a dosimeter (Section 6.5.1, dosimeter not worn), the TBD refers the dose reconstructor to ORAUT-OTIB-020, *Use of Coworker Dosimetry Data for External Dose Assignment* (ORAUT 2011c). The OTIB gives generic guidance, but NIOSH has indicated that it is currently preparing an INL-specific coworker model, which SC&A will review when it is available. The other subsections of Section 6.5 provide guidance for other missed dose situations that might be applicable to a particular dose reconstruction.

SC&A recommends that the WG keep this issue open pending receipt and review of the INL-specific coworker model under development by NIOSH.

3.17 ISSUE 17: PENETRATING AND NON-PENETRATING DOSES

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.2, SC&A p. 96

Issue: NIOSH should re-evaluate the missed gamma dose, due to the deficiencies in the procedures and algorithms.

NIOSH Response: The under-reporting of the penetrating photon doses at the INL, due to the two-element film dosimeter's limitation for measuring low-energy photon doses, is much less of a significant situation for the majority of exposure scenarios than what is being indicated by SC&A.

INL Health Physics personnel have been aware of the dosimeter response issues associated with low energy photons for many years, including at least some of the years when the two-element film dosimeters were being used. However, there were ways for the dosimetry personnel to determine whether a non-penetrating dose was likely attributable to beta or low-energy photon radiation. One such way was noting the ratio of the Open Window (OW) and S readings from the dosimeter, since this ratio should be relatively consistent for similar radiation fields (i.e., in terms of radiation type and energy distribution). Because the OW reading for the two-element film dosimeters being used at the INL had a significant over-response to low-energy photons, an unusual amount of blackening on the OW film would be observed when the dosimeter was exposed to low-energy photons. Therefore, an OW to S reading ratio that was significantly higher than usual would be an indication that the worker's non-penetrating dose contained a significant contribution from low-energy photon exposure. Also, using such dosimeter readings as is would potentially result in a significant overestimate of the non-penetrating dose that was being reported and could potentially have resulted in a dose limit being exceeded. Therefore, it was in the INL's best interest to at least be somewhat familiar with the OW to S reading ratios and the photon energy distributions for the various exposure scenarios and to adjust any doses that were too high because of the dosimeter's over-response to low-energy photons. In addition to the unusual amount of blackening that would have been observed on the OW dosimeter, the survey instrument readings would have indicated to the INL Health Physics personnel that the "beta" doses based on the dosimeter results were being significantly over-reported and that they were likely seeing the effect of the dosimeter's over-response to low energy photon radiation, since the hand held survey instruments that were carried during most hot jobs did not over-respond to the low-energy photons.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A's review of Revision 3 indicates that NIOSH did not make any changes to TKBS-0007-5 as a result of this finding. NIOSH provided additional information in their issue response. However, SC&A suggests that NIOSH incorporate the information provided above in the response into TKBS-0007-5 during its next revision, so that future

reviewers will have access to it. SC&A believes that the NIOSH response has adequately addressed this issue and recommends that the WG close it.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.18 ISSUE 18: CORRECTION FOR BETA DOSES

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.3, SC&A p. 97

Issue: NIOSH should develop a method to consistently account for uncertainties in dosimetry readings. Claimant-favorable correction factors should be developed for beta dose reconstruction.

NIOSH Response: Table 6-9 in the TBD provides correction factors for under-reporting. Comment 18 quotes the following statement along with several others from OCAS-IG-001, which are quotes from Revision 1 (OCAS 2002) versus Revision 3 (OCAS 2007) of the OCAS-IG-001 and some of which is no longer in OCAS-IG-001. "If individual energy distribution information is not available for two-element film badges, the open window dose should be used as a claimant friendly estimate of the 30 to 250 keV dose." However, the comment didn't quote some statements that were in between the quoted statements. One such statement was, "When monitoring data do not indicate the relative energy distribution, the distribution can be estimated based upon either the site radionuclide inventory or the relative energy distribution which can be estimated for most facilities based upon a review of historical operations," which is still a statement in Revision 3 of OCAS-IG-001 (OCAS 2007) and is what was used for the INL TBD. The photon energy distribution of 25% 30–250 keV photons and 75% >250 keV photons in the INL TBD is claimant-favorable for the majority of exposure scenarios at the INL, based on the radioactivity in The Materials Test Reactor's (MTR's) spent reactor and the waste stream for the ICPP (see attached file). MicroShield calculations indicate that 88.9% of the photons in the spent MTR reactor fuel have an energy greater than 300 keV, and that percentage increases to 98.8% for the ICPP's waste stream that contains all of the fission products and transuranics. It should also be noted that these energy distributions do not account for the effect from any minimal shielding that would have been in place for most exposure scenarios and would have further reduced the amount of low-energy photons that the workers were being exposed to.

In addition, the potential under-reporting of the penetrating photon doses would have only been able to have occurred when the reported non-penetrating dose was significantly greater than the dosimeter's limit of detection, since the OW reading for the dosimeter would have been capable of detecting the low-energy photons and would have significantly over-responded to them. Therefore, this issue is only potentially applicable to the instances when a significant non-penetrating dose is reported for a specific dosimeter. Because reviews of the dosimetry data for a significant number of cases indicate that the majority of non-penetrating doses reported for most INL workers were either zero or insignificant, NIOSH expects that the number of potentially under-reported penetrating photon doses would have been very small. If SC&A has encountered any specific examples where an INL worker's penetrating dose was likely under-reported, NIOSH would be willing to investigate this potential issue further.

It should also be noted in Comment 18 that the reference to the correction factor used at the SRS (i.e., the factor of 1.119) is not applicable to other sites.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A's review of Revision 3 indicates that NIOSH did not make any changes to TKBS-0007-5 as a result of this observation. NIOSH provided additional information in their issue response. However, SC&A suggests that NIOSH incorporate the information provided above in the response into TKBS-0007-5 during its next revision, so that future reviewers will have access to it.

SC&A believes that the NIOSH response has addressed this issue, considers this issue to be resolved, and recommends that the WG close this issue.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.19 ISSUE 19: ANGULAR DEPENDENCE CORRECTION FACTOR FOR GAMMA DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, TBD Sect. 5.1.4.1.4, SC&A p. 99

Issue: NIOSH should provide angular dependence (anatomic geometry) correction factors for external gamma doses, particularly for low-photon energies, where the angular dependence of the sensitivity of the dosimeter is most pronounced. These correction factors are used to account for, for example, the bias introduced by a dosimeter worn at the neck level and the higher doses received by tissues/organs below the waist.

NIOSH Response: NIOSH DCAS-TIB-010 (DCAS 2011) provides angular correction factors for such exposure geometries that are usable for all sites. Also, NIOSH OCAS-IG-001 *External Dose Reconstruction Guideline*, Revision 3 (OCAS 2007), provides DCFs based on incident photon geometry. Therefore, no site-specific factors are needed. In addition, clamant-favorable AP geometry is typically assumed.

WG Action Items:

- **NIOSH:** Revise its response to correct a misstatement [clarification: that DCAS-TIB-010 contains angular correction factors in addition to geometric correction factors].

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH indicates that its response is available for WG and SC&A review.

SC&A Further Review: Communication (via email) with NIOSH's Pete Darnell on January 29, 2014, revealed that NIOSH is currently revisiting the issue and has not yet issued a response. SC&A will review that response when it is available; SC&A recommends that the issue remain open.

3.20 ISSUE 20: RESTATING BETA DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.5, SC&A p. 99

Issue: It is not claimant favorable to state that the entire dose measured in the open window is due to the beta dose.

NIOSH Response: Open window beta dose is discussed in OCAS-IG-001 (OCAS 2007). Please provide a basis for these opinions—where has SC&A found data supporting <30 keV photons?

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue (related to Issues 17 and 18).

SC&A Reassessment: SC&A's review of Revision 3 shows that NIOSH has revised Section 6.5.3 to address this issue. SC&A has reviewed the revised section, believes that it addresses this issue, considers it resolved, and recommends that the WG close this issue.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.21 ISSUE 21: PHOTON SPECTRUM SPLIT

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.6, SC&A p. 99

Issue: NIOSH should provide guidance assigning dose values for the 30 keV<E<250 keV and E>250 keV regions.

NIOSH Response: Photon energy ranges are based upon the predominant radionuclides found in the workplace. Scenarios like those discussed in the SC&A report would be reconstructed on a case-by-case basis. Please provide a basis for these statements and for the SC&A opinion that a 50/50 energy range is more appropriate.

WG Action Items:

- **SC&A:** Explain why it believes a 50:50 split between low- and high-energy photon energy groups is preferable to the 25:75 split assumed by NIOSH.

SC&A Reassessment: Not at this time.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats its statement under WG Action Items: SC&A above.

SC&A Further Review: When a penetrating dose is recorded on a film badge, the total dose is split into one to three different energy ranges: <30 keV for the x-rays emitted by transuranics, 3–250 keV for x-rays and many radionuclides, and >250 keV for the higher energy photon emitters. NIOSH uses its judgment regarding how to make this split. This split is made because the risk conversion factor (risk per rad) is energy dependent. We judge the reasonableness of this split on a case-by-case basis.

For INL, there is a very wide range of radionuclides, so we concur with NIOSH's response and recommend that the WG close this issue.

3.22 ISSUE 22: IMMERSION DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.7, SC&A p. 100

Issue: The dose recorded on a dosimeter due to a semi-infinite cloud irradiation would be approximately half of the actual dose received. NIOSH should, therefore, consider a weighting factor of 2 for immersion dose.

NIOSH Response: NIOSH does not use personnel whole-body or extremity dosimeter data to estimate internal doses. The comment listed in this matrix does not appear to coincide with the discussion in the SC&A review report. This comment may be an error, because there is no mention of semi-infinite cloud exposures in the TBD.

WG Action Items: None. The WG accepted NIOSH's response and closed the issue at the June 21, 2011, WG meeting.

CLOSED

3.23 ISSUE 23: HIGH-RISK JOBS (BETA/GAMMA EXPOSURE)

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.8, SC&A p. 100

Issue: Site experts interviewed by SC&A classified INL as an "acute dose" site, with a significant number of facilities, operations, experiments, and occurrences providing the possibility of personnel receiving dangerous levels of radiation. NIOSH did not evaluate comprehensively the facility and field data to identify and separate out the high-risk or high-dose jobs for worker external exposures. This information is essential for dose reconstructors to fill in the data gap when dose records in a claimant's file are not complete.

NIOSH Response: Please provide a basis for these statements regarding NIOSH evaluation of facility and field data. The referenced section of the SC&A report does not appear to relate to the comment provided. The report discusses beta dose and hot particles. NIOSH would only perform dose reconstruction for hot particles or unreported skin contamination that were documented. There is no reasonable way to estimate hot particle doses without monitoring data.

WG Action Items:

- **NIOSH/SC&A:** Merge with Issue 9 and see also Issues 5 and 34.

SC&A Reassessment: As the WG noted, this issue is similar to Issue 5 (internal exposure), Issue 9 (skin contamination), and Issue 34 (neutron exposure). The approach outlined in the response to Issue 5 could also be applied for high-risk gamma exposure jobs, i.e., wording could be provided in TKBS-0007-6 to instruct the dose reconstructor to modify the dose reconstruction and/or perform additional research if a claimant expresses a specific concern (either verbally or in writing) that he/she was inadequately monitored for gamma exposure, and the dose reconstructor is able to confirm that concern.

SC&A recommends that the WG keep this issue open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH is working on a white paper to address this issue and comments that this issue should be merged with Issue 9, Skin and Facial Contamination. NIOSH also refers to Issue 34, High-Risk Jobs (Neutron Exposure).

SC&A Further Review: SC&A is waiting for NIOSH's Hot Particle Issue white paper before it will consider this issue further. Hence, SC&A recommends that this issue remain Open.

3.24 ISSUE 24: EXTREMITY DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.9, SC&A p. 100

Issue: NIOSH should evaluate the potential for missed extremity dose for workers working in facilities where highly contaminated equipment, piping, instruments, valves, and systems resulted in exposures in confined spaces to hands.

NIOSH Response: INL assigned extremity dosimetry when needed. For other workers, NIOSH will address this on a case-by-case basis—we routinely use multiplication factors to account for geometry differences for cancer on extremities when the EE was a "hands-on" worker.

WG Action Items:

- **NIOSH/SC&A:** Look at interviews appearing in SC&A's site profile review for relevant anecdotal discussions on extremity exposures. NIOSH will report how many INL/ANL-W claimants have extremity cancers.

SC&A Reassessment: Discussion of extremity dose is provided in Attachment C, pages 190 to 191. Specific exposures to the hands and face are discussed on pages 171 and 206.

> *In the 1980s, the Specific Manufacturing Capability (SMC) facility was built in the TAN area. Operations at the SMC facility, which involved the machining of depleted uranium (DU), are considered classified. Chip fires occurred due to the pyrophoric nature of the uranium. An incident occurred when the elevated temperature resulting from a worker drilling a can containing DU reacted with the moisture inside the can to produce hydrogen gas. The hydrogen was ignited by the sparks, and flames shot up to the ceiling. This worker got burned all over his face and hands.* (SC&A 2006, p. 171)

> *In the ICPP Calciner Facility, workers had to use friction saws to cut off valves that were contaminated with high levels of Cs-137, Sr-90/Y, and U-235. When they were drilling into the valves, sometimes filters were burned through, spilling contaminants, which would get all over their hands or faces. This often resulted in skin contamination. The airborne radioactivity level was also very high and may have been responsible for significant uptakes of radionuclides.* (SC&A 2006, p. 206)

SC&A cannot make a recommendation to the WG regarding this observation until we have reviewed the NIOSH response to their portion of the action item.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the SC&A action item shown above, "Look at interviews appearing in SC&A's site profile review for relevant anecdotal discussions on extremity exposures," and also states that there are "no new data to report (NIOSH will report

how many INL/ANL-W claimants have extremity cancers. NIOSH response expected late 2013)."

SC&A Further Review: SC&A is waiting for the NIOSH response before it will consider this issue further. Hence, SC&A recommends that this issue remain Open.

3.25 ISSUE 25: DISCREPANCIES BETWEEN PIC AND FILM READING

ORAUT-TKBS-0007-6, Occupational External Dose, TBD Sect. 5.1.4.1.10, p. 100

Issue: NIOSH should compare PIC versus film badge data (i.e., shallow and deep), and ensure that all the dose has been captured by the film badge. It is important to note that some PICs were worn for only the length of the job, so the discrepancy between readings of the two-dosimeter systems cannot be explained by drifting.

Expanded: Many difficulties in comparing PIC readings and film badge results make agreement within a factor of two the best that can be expected.

NIOSH Response: The PIC is not a legal record and is a lower-preference for reconstructing dose. The PIC typically over-responded to site photon energies and was sensitive to shock. They are designed for use in the field to get a real-time exposure reading until the dosimeter could be read at a later time.

WG Action Items: None. The WG accepted NIOSH's response and closed the issue at the June 21, 2011, WG meeting.

CLOSED

3.26 ISSUE 26: MINIMUM DETECTION LIMIT

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.11, SC&A p. 101

Issue: NIOSH should re-evaluate the approach in determining the MDL of the dosimetry system by taking into account the system uncertainties.

Issue Expanded: The selection of 10 mrem as the MDL [minimum detection limit] for high-energy gamma is questionable. Even for modern densitometers and film, it is a challenge to achieve this level, as a single density "click" can correspond to greater than 10 mrem for high-energy gamma radiation; this is not a problem, however, for intermediate and low-energy x-rays. Rather, one click of the densitometry system may correspond to 15 or 20 mrem for 660 keV or 1.2 MeV gammas, for example. If the claim is made that 10 mrem is a valid choice for the MDL, then supporting materials should be provided, such as film dose-to-density curves and densitometer calibration data. Other sites [e.g., Savannah River Site (SRS)] have adopted 40 mrem as the high-energy gamma MDL for early film.

NIOSH Response: This observation is similar to finding 3 listed below (Issue 27). The response to the finding also satisfies this observation.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A believes that NIOSH has adequately addressed this issue and recommends that the WG close it.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.27 ISSUE 27: MINIMUM REPORTING LEVEL (BETA/GAMMA)

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.1.12, SC&A p. 103

Issue: NIOSH does not provide adequate information supporting the use of chosen detection threshold levels to represent the minimum dose reporting level (MRL) values for gamma film badges and TLDs. The use of MRL/2 as the missed external dose for dose reconstruction per OCAS-IG-001 (OCAS 2002) is not claimant favorable for claims where the probability of causation value is close to 50%. In addition, NIOSH should re-evaluate the MRL values used and provide more supportable default values.

NIOSH Response: The MRLs used in the INL TBD are based on peer-reviewed and published, scientific documents as referenced in Table 6-15 (see footnote b in Rev. 2 of the TBD).

Comments on OCAS-IG-001 are usually more programmatic in nature and not part of a specific site. In this case, the reviewer's comment is not accurate. MRL/2 is assigned a lognormal distribution as required in OCAS-IG-001 and discussion of uncertainty may be found therein. Additionally, when the PoC is between 45 and 52%, the IREP sample size increases from 2,000 to 10,000, the random seed (which is normally 99) is selected by chance, and IREP is run 30 times at the 99^{th} percentile versus the 50^{th} percentile. These methods provide a more claimant-favorable dose reconstruction and ensure that the PoC is not underestimated.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: In order to confirm the MRLs, SC&A requests that NIOSH identify which MRLs were obtained from which documents, and since some of these documents are large (over 250 pages), please identify the page(s) from which they were taken. If instead of being taken directly from the reference documents, the MRLs were derived from information provided in the documents, please indicate the source (and page) of the information and the methodology used to calculate the MRLs. SC&A has also reviewed the above NIOSH response as regarding OCAS-IG-001, and we concur.

SC&A recommends to the WG that this observation remain open until we are able to confirm the MRLs.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the SC&A action item shown above: "Review applicable portions of the current version of the External Exposure TBD and reassess the issue."

SC&A Further Review: SC&A reviewed Rev. 3 of the site profile to check on how MDLs are addressed. Section 6.3 provides useful background information and examples of the early personnel dosimetry program, indicating an MDL of 30 mR as the MDL for penetrating photon dose for the 1958 time frame for DuPont 552 film (page 12). This is not an unreasonable MDL for that time period, based on our experience with MDLs for other sites. However, Section 6.3.2.1 (page 18) indicates an MDL of 10 mR per change-out for DuPont 558 film for the 1958 time frame. This is an unusually low MDL for that time frame. Section 6.3 provides considerable discussion of the film badges used at the time and their calibration methods, along with recommended correction factors.

Section 6.3.2.3 describes the LiF badges used beginning in late 1966 and goes on to describe the evolution of the different types of TLDs used at the facility over time, providing LODs 15 mrem beta and gamma from January to July 1986 (Gesell 1986), 10 mrem gamma and 30 mrem beta from July 1986 to September 1989, and 15 mrem for gamma and 30 mrem for beta until 1993 (Perry et al. 1993), when it returned to 10 mrem gamma.

Section 6.3.2.7 describes the NTA film used for neutron dosimetry in the 1950s with an LOD of 14 mrem (on page 21) for neutron energies above 500 to 800 keV, and 20 mrem on page 22, followed by discussions of albedo dosimetry and associated correction factors.

Section 6.3.4.2 presents a detailed discussion of non-penetrating radiation at the facility (>15 keV electrons and <30 keV photons and x-rays), along with correction factors for energy ranges not detected by the dosimeters. This is followed by extensive discussion of neutron sources and energy distribution at many of the different INL facilities, including adjustment factors and weighting factors for different energy groups (W_R).

Table 6-15 provides recommended LODs of 30 or 10 mrem for photons (depending on time period and location), 30 mrem for electrons in general, but 15 mrem for LiF TLDs. Table 6-16 presents neutron LODs ranging from 14 to 20, depending on time period. These values seem quite low compared to the LODs adopted in other site profiles. See the following table.

Facility	Dosimeter Type and Dates	LODs	Source
Hanford	Film dosimeters 1950s–1971	30–40 mrem	ORAUT-TKBS-0006-6
	TLDs 1970s–present	10–20 mrem	
Savannah River	Film 1952–1970	40 mrem	ORAUT-TKBS-0003
	TLD 1970s–present	5–15 mrem	
Rocky Flats	1951–1968 40mR	40 mR	ORAUT-TKBS-0011-6
	1968–1982 20mR	20 mR	
	1980s–present	5–20 mrem	
Fernald	1950s–1980s	30–40 mrem	ORAUT-TKBS-0017-6
	1995–present	20 mrem	
ORNL	1944–1974	30 mrem	ORAUT-TKBS-0012-6
	1975–present	10 mrem	
LANL	Film 1945–1979	40 mrem	ORAUT-TKBS-0010-6
	TLD 1980–present	10 mrem	
LLNL	Film 1952–1968	30 mrem	ORAUT-TKBS-0035-6
	TLD 1969–present	10–20 mrem	

We believe that some explanation is needed regarding why INL LODs are considerably lower for photon external radiation compared to those reported in other site profiles. Hence, SC&A recommends that this issue remain open.

3.28 ISSUE 28: MINIMUM REPORTING LEVEL (NEUTRON)

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.1, SC&A p. 108

Issue: NIOSH's approach for determining the MRL values for NTA emulsion film is not thorough or supported. For example, NIOSH uses 10 neutron readings in 1 data sheet from March 1958 to determine the MRL values for the period between 1951 and 1957, and 6 neutron readings to represent all neutron measurements between 1959 and 1976. Furthermore, the use of MRL/2 as the missed external dose for dose reconstruction per OCAS-IG-001 is not claimant favorable for claims where the probability of causation value is close to 50%. In addition, NIOSH's MRL values of 14 mrem and 20 mrem appear low and are inconsistent with generic values given for NTA dosimeters, as well as values cited by other DOE facilities with similar neutron source terms and detectors. NIOSH should re-evaluate the MRL values used and provide more supportable default values.

NIOSH Response: Comments on OCAS-IG-001 are usually more programmatic in nature and not part of a specific site. In this case, the reviewer's comment is not accurate. MRL/2 is assigned a lognormal distribution as required in OCAS-IG-001 and discussion of uncertainty may be found therein. The MRLs used in the INL TBD are based on peer-reviewed and published, scientific documents as referenced on page 22. The MRL of 14 is cited on page 6 of Cipperly 1958. Additionally, when the PoC is between 45 and 52%, the IREP sample size increases from 2,000 to 10,000, the random seed (which is normally 99) is selected by chance, and IREP is run 30 times at the 99^{th} percentile versus the 50^{th} percentile. These methods provide a more claimant-favorable dose reconstruction and ensures that the PoC is not underestimated.

WG Action Items:

- **NIOSH:** Revisit its response about detection limits.
- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A has also reviewed the above NIOSH response regarding OCAS-IG-001, and we concur. The SC&A review of Revision 3 found that attribution [41] needs to be changed to indicate that 14 mrem is from Cipperly. Finally, the NIOSH response above provided no rationale for the 28 or 15 mrem missed neutron dose given in Table 6-16.

SC&A cannot make a recommendation to the WG regarding this issue until we have reviewed the NIOSH response to their portion of the action item.

Note: (Oct. 2013 update) NIOSH is working on a white paper to address NTA film dosimeter issues: *Investigation of the NTA Film Dosimeter Limits of Detection Being Used for INL Dose Reconstructions.*

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH notes that it is still working on a white paper to address this issue.

SC&A Further Review: SC&A is waiting for the NIOSH white paper. Hence, SC&A recommends that this issue remain Open.

3.29 ISSUE 29: FAILURE TO PROPERLY ADDRESS NEUTRON EXPOSURES

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.2, SC&A p. 109

Issue: INL had a total of 52 reactors, most of which were experimental/prototype in design, which typically operated with high-power densities and with minimum shielding and neutron moderation. It is unjustified to presume that there are no missed neutron doses. In addition, there are deficiencies associated with neutron calibrations. Due to the use of the PoBe source for neutron calibration, dosimeters would significantly under-measure neutron doses from sources with lower-energy spectra. NIOSH should re-evaluate the entire approach in the TBD to account for potential missed neutron doses.

Issue Expanded: The method presented in the TBD of determining who needs to be assigned a missed neutron dose is circular: Section 6.5.4 states, "If no neutron dose was assigned to the worker or coworkers for several months, the dose reconstructor should assume that the person was not exposed to neutrons." Clearly this does not allow for individual workers having temporary or varying assignments. Also, if the program failed to correctly identify that they should have been monitored, the record will show no assigned neutron dose.

In addition, the TBD makes the assumption that high Z materials, such as iron and lead, were never used (e.g., for shield penetrations) in place of hydrogenous materials, such as water and concrete. However, no attempt is made to validate or qualify this assumption.

ORAUT-OTIB-0051, *Effect of Threshold Energy and Angular Response of NTA Film on Missed Neutron Dose at the Oak Ridge Y-12 Facility* (ORAUT 2006), was issued after the 2004 site profile and has a bearing on neutron dosimetry issues; hence, it should be considered in this TBD.

NIOSH Response: The inappropriate instructions to discount an INL worker's missed neutron doses has been eliminated from the Missed Neutron Dose Section of the external dosimetry TBD. Because it was impossible to determine who a worker's coworkers were from the redacted dosimetry records, the guidance in Revision 02 of that TBD was not being used to eliminate missed neutron doses. However, it should be noted that ORAUT-OTIB-0023 (ORAUT 2008b) is still considered an appropriate basis for eliminating unreasonably high missed neutron doses for some INL claims. In addition, neutron dosimeters at the INL were only assigned and read when there was a potential for exposure. Given that most of the reported neutron dosimeter results were reported as zero, the INL's process to determine who had the potential to receive neutron exposures appears to have been appropriate and adequate.

The guidance provided in Revision 03 of the external TBD now requires missed neutron doses to be assessed for every worker using the reported neutron dosimeter results, unless the missed neutron doses are unreasonably high per the guidance in ORAUT-OTIB-0023 (ORAUT 2008b).

NIOSH is not clear what SC&A's issue is regarding the potential under-measurement of neutron doses to lower-energy neutrons, since Revision 00 through Revision 03 of the INL's external dosimetry TBD have included facility-specific adjustments to the reported neutron doses to

account for the dosimeters' poor energy response to lower-energy neutrons. The NTA film corrections for energy response in the INL TBD are comparable to the energy response corrections in ORAUT-OTIB-0051 (ORAUT 2006), which range from 1.0 to 2.2. Because the need to apply a correction to NTA film results to account for angular response is being discussed as an overarching issue, no angular response corrections were added in the latest revision of this TBD. Also, the assumption of AP geometry would negate the need to adjust for angular response.

WG Actions:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A has reviewed and agrees with the NIOSH response provided above. Also, SC&A has reviewed Revision 3 and agrees that the TKBS-0007-6 (Table 6-5) neutron correction factors are comparable to the OTIB-0051 (Table 8-1) factors. Finally, SC&A has reviewed OTIB-0023 under the direction of the Procedures Review Subcommittee, and identified eight findings. All eight of the OTIB-0023 findings have been discussed among the Procedures Review Subcommittee, NIOSH, and SC&A; agreement was reached, and all are closed.

SC&A considers this issue to be resolved, and recommends that the WG close it.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.30 ISSUE 30: NEUTRON CALIBRATION DEFICIENCIES

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.3, SC&A p. 110

Issue: Due to the use of the PoBe source for neutron calibration, dosimeters would significantly under-measure neutron doses from sources with lower energy spectra. NIOSH should re-evaluate the approach in the TBD to account for potential missed neutron doses.

NIOSH Response: Section 6.3.3.2 indicates that the recorded dose is 11% high based on this calibration.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: As SC&A understands Section 6.3.3.2, the 11% refers to the difference between the AmBe dose conversion factor used by INL (4.17×10^{-8} rem-cm^2/n) and the AmBe dose conversion factor recommended by the IAEA (3.8×10^{-8} rem-cm^2/n). Both dose conversion factors are specific to the AmBe energy spectrum. However, the issue is concerned with whether neutron sources with energy spectra lower than the AmBe spectra are significantly under-recorded or missed entirely.

Since the NIOSH response does not appear to address the issue, SC&A recommends that the WG keep this issue open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the WG Action Items: SC&A entry shown above.

SC&A Further Review: SC&A revisited Section 6.3.3.2, Neutron Calibration, of the current External Dose TBD (ORAUT 2011b). NIOSH notes that "the initial NTA neutron badges were calibrated using a PoBe neutron source…[and that] in 1982, an AmBe source was used." SC&A further investigated the issue that it had raised previously about possibly significant differences in the neutron source energy spectra from the two neutron sources.

In both cases, neutrons are produced via the (α,n) reaction in Be, following decay of the parent radioisotope by α-particle emission:

$^{241}_{95}Am \rightarrow {}^{237}_{93}Np + \alpha,$ $T_{1/2}$ = 432.6 y, E_α = 5.486 MeV (85%), 5.443 MeV (13%) (BNL 2014)

$^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + \alpha,$ $T_{1/2}$ = 138 d y, E_α = 5.304 MeV (100%) (BNL 2014)

$^{4}_{2}\alpha + {}^{9}_{4}Be \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$ (Q = 5.71 MeV),

where the resulting broad neutron energy spectra for different parent nuclide decays and the average neutron energies emitted (4–5 MeV range) are quite similar and somewhat dependent on E_α (Knoll 2000).

Since the neutron energy spectra resulting from the AmBe and PoBe sources are quite similar, SC&A withdraws its previous comments and recommends that the WG close this issue.

3.31 ISSUE 31: COMPLETENESS AND QUALITY OF INL NEUTRON DOSIMETRY AND RECORD KEEPING PROGRAMS

ORAUT-TKBS-0007-6, Occupational External Dose, TBD Sect. 5.1.4.2.4, SC&A p. 110

Issue: The identification and determination of missed neutron dose for workers are heavily influenced by this assumption of confidence, but SC&A found this premise to be unsupported after examining several critical DOE-HQ Tiger Team and DNFSB site audit reports. In addition, many site experts interviewed by SC&A indicated that there were significant deficiencies and inconsistencies in radiation work practices throughout the operating history of the INL facilities. These observations jeopardize the validity of the TBD approaches in reconstructing missed worker neutron doses.

NIOSH Response: Please provide the reports of "significant deficiencies and inconsistencies in radiation work practices" and provide how the NIOSH-derived missed dose calculations are subject to the results of the Tiger Team report.

WG Action Items:

- **NIOSH:** Review TIGER Team reports for applicable information [per discussions during June 21, 2011, WG meeting].

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH notes that this issue is related to Issue 16: Completeness and Quality of INL Beta/Gamma Dosimetry and Record Keeping Programs.

SC&A Further Review: SC&A reexamined the INL Tiger Team report (DOE 1991), the current INL site profile External Dose TBD (ORAUT 2011b), the original External Dose TBD (ORAUT 2004a), the original SC&A comment and background discussion, as well as the site expert interview summary, in its 2006 site profile review (SC&A 2006) pertaining to Issue 31, and, additionally, the Defense Nuclear Facilities Safety Board (DNFSB) reports (DNFSB 1994a, 1994b, 1995); the latter were found not germane to this issue and are not discussed further.

The INL Tiger Team assessment was conducted as part of the overall DOE Tiger Team Independent Assessment Program across the DOE facilities complex, which begun in the late 1980s. The INL assessment was accomplished during the summer of 1991 and the comprehensive, multi-volume report (DOE 1991) was published in August 1991. The evaluation focused on several areas, notably environment, safety and health, management, and organization. Much of the evaluation and many of the findings are programmatic and procedural, such as organizational structure (multiple governmental and private organizations were involved simultaneously at INL), direction, and coordination, and compliance with federal, state, and local regulations and procedures. The assessment is quite critical overall, particularly with respect to management. With regard to radiation protection, the Executive Summary notes:

> *The radiation protection program at EG&G Idaho* [i.e., INL] *was found to be particularly deficient. The nuclear accident dosimetry program is not in compliance with performance requirements for fixed and personnel nuclear accident dosimeters. The personnel dosimeter program is not in compliance with applicable DOE Orders and there is no program to identify and resolve problems related to the response of radiation protection instrumentation.*

The Tiger Team report also mentions in several places that not everyone who should have had personal monitoring actually had it.

Section 5.1.4.1.1 of the 2006 SC&A site profile review (SC&A 2006), which assessed Rev. 0 of the INL TBD (ORAUT 2004a), cites several issues noted in the Tiger Team report, as well as site interviews SC&A had conducted. In particular, in reference to missed dose:

> *(3) During the site expert interviews, past and current workers at INL facilities provided first-hand information about potential missed dose scenarios and deficiencies in personnel protection programs and dosimetry record keeping. Even though there is a sentiment that the INL radiological protection programs and the advancement of equipment and techniques have made dramatic improvements over the past two decades, the missed dose problems due to these deficiencies in the early days must be addressed in a fair and reasonable manner.*

SC&A reviewed the current, Rev. 3, INL External Dose TBD (ORAUT 2011b), as well as the Rev. 0 External Dose TBD (2004a), and found that the issue is addressed in Section 6.5 of the former, Missed Dose, with subsections: dosimeter not worn, missed photon dose, missed electron dose, and missed neutron dose. For the situation of a worker claiming exposure to radiation while not wearing a dosimeter (Section 6.5.1, dosimeter not worn), the TBD refers the dose reconstructor to ORAUT-OTIB-0020, *Use of Coworker Dosimetry Data for External Dose Assignment* (ORAUT 2011c). The OTIB gives generic guidance, but NIOSH has indicated that it is currently preparing an INL-specific coworker model, which SC&A will review when it is available. The other subsections of Section 6.5 provide guidance for other missed dose situations.

SC&A recommends that the WG keep this issue open pending receipt and review of the INL-specific coworker model under development by NIOSH. (See Issue 16 for beta/gamma).

3.32 ISSUE 32: UNCERTAINTY ESTIMATION FOR NEUTRON DOSES

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.5, SC&A p. 110

Issue: NIOSH should explain how the Facility Neutron Correction Factors (FNCFs) were obtained and provide instruction to dose reconstructors on how to apply them.

NIOSH Response: The latest revision to the TBD appears to adequately explain the FNCFs. The text indicates that this is a correction that INL applied to the dosimeter results to generate the reported dose (pg. 22 of TBD). Also, several references are cited in the TBD text to indicate how these FNCFs were obtained. The references also provide additional information on the methodology used.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: Since it appears that NIOSH did not develop the FNCFs, but rather obtained them from various references (primarily Cusimano 1981), SC&A agrees that providing only a summary of how they are developed is appropriate [i.e., "A FNCF … can be generated from the ratio of the dose equivalent measured with a 9-in.-diameter Eberline PNR-4 and the corresponding signal (in millirem but not dose equivalent) with the detector in the 3-in.-diameter PNR-4 insert" (page 22)]. SC&A considers that the NIOSH response addresses the first portion of the issue.

In a teleconference between SC&A and NIOSH held June 29, 2005 (SC&A 2006, Attachment 1, pp. 150 and 151), SC&A stated, "It is not clear from the accompanying text whether the data recorded in the workers' records were already adjusted based on the FNCFs or whether the dose reconstructor should make the adjustments." NIOSH replied, "The adjustments have been made in the recorded data. NIOSH stated that it would clarify this point in a future revision of the TBD." SC&A's review could not confirm that the clarification had been provided in Revision 3 of TBKS-0007-6.

Because the clarification on the use of the FNCFs has not been provided in TBKS-0007-6, Revision 3, SC&A recommends that the WG keep this issue open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the WG Action Items: SC&A item shown above.

SC&A Further Review: SC&A reviewed the current, Rev. 3, External Dose TBD (ORAUT 2011b) and notes that Facility Neutron Correction Factors (FNCFs) appear in Section 6.3.2.8, Neutron Albedo Dosimetry. Table 6-5 tabulates the FNCFs for different INL facilities, taken from Cusimano 1981. The accompanying text states: "This correction was applied to generate

the reported neutron dose." Hence, SC&A believes that all the points in this issue have been adequately addressed, and recommends to the WG that it close this issue.

3.33 ISSUE 33: NEUTRON ORGAN DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.6, SC&A p. 110

Issue: NIOSH should provide neutron spectrum information and guidance for organ dose reconstruction for workers at ZPPR and TREAT.

NIOSH Response: Guidance provided in Section 6.4, spectrum data in Table 6-14 of Revision 03.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: Upon reviewing Revision 3, SC&A agrees with NIOSH that the requested information has been provided in Section 6.4. SC&A considers this issue to be resolved, and recommends that the WG close this issue.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.34 ISSUE 34: HIGH-RISK JOBS (NEUTRON EXPOSURE)

ORAUT-TKBS-00007-6, Occupational External Dose, Sect. 5.1.4.2.7, SC&A p. 111

Issue: NIOSH did not evaluate comprehensively the facility and field data to identify and separate out the high-risk or high-dose jobs for worker neutron exposures. This information is essential for dose reconstructors to fill in the data gap when dose records in a claimant's file are not complete.

NIOSH Response: Please provide a basis for these statements regarding NIOSH's evaluation of facility and field data. The report discusses that there were potential higher dose neutron activities conducted, but no details are provided. NIOSH would only perform dose reconstruction for such activities if they were documented. These types of reconstructions would be done on a case-by-case basis.

WG Action Items:

- **NIOSH/SC&A:** Look at interviews appearing in SC&A's site profile review and elsewhere for relevant anecdotal discussions on neutron exposures.

SC&A Reassessment: SC&A reviewed the summary of site expert interviews of current and former workers contained in SC&A 2006, Attachment 3. While there is additional discussion on neutron sources and neutron monitoring, no specific incidents of high neutron exposures were found in the interview summary. However, the following excerpt on the potential for missed neutron exposures is provided.

> *Some site experts believe the neutron monitoring program at INL has been inconsistent. For example, although the work has not changed, monitoring for neutron*[s] *changed over the course of time. Workers noted that those outside the radiation boundary at RWMC do not participate in neutron monitoring, while those inside do. There are some disagreements between RadCon and other site experts as to whether neutron dosimetry was consistently used at ATR and ETR throughout the years. There was also some inconsistency between monitoring of permanent workers versus vendors, such as equipment handlers and excavators at RWMC. There was no routine neutron monitoring of some hands-on maintenance workers in ICPP.*
> …
> *There was a potential for missed neutron dose in the early days, due to incomplete monitoring of the exposed population. For example, many laboratory analysts and chemists did not have neutron dosimeters, as they were not aware that there was an issue with neutrons. This lack of neutron monitoring could be verified by evaluating ambient neutron sources and cross comparing this information with dosimetry processing data.* (SC&A 2006, Attachment 3, p. 189)

As the WG noted, this issue is similar to Issue 5 (Internal Exposure), Issue 9 (Skin Contamination), and Issue 23 (Gamma Exposure). The approach outlined in the response to

Issue 5 could also be applied for high-risk neutron exposure jobs; i.e., wording could be provided in TBKS-0007-6 to instruct the dose reconstructor to modify the dose reconstruction and/or perform additional research if a claimant expresses a specific concern (either verbally or in writing) that he/she was inadequately monitored for neutron exposure, and the dose reconstructor is able to confirm that concern.

SC&A recommends that the WG keep this issue open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH indicates that its response is available for WG and SC&A review.

SC&A Further Review: Private communication (via email) with NIOSH's Pete Darnell on January 29, 2014, revealed that NIOSH is currently revisiting the issue and has not yet issued a response. SC&A will review that response when it is available; hence, the issue remains open.

3.35 ISSUE 35: MULTIPLYING FACTORS FOR MISSED NEUTRON DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 5.1.4.2.8, SC&A p. 111

Issue: NIOSH should provide data to support the two multiplying factors (1.25 and 2) and the fixed missed neutron dose default value of 50 mrem.

Issue Expanded: See ORAUT-OTIB-0051 and Issue No. 29.

NIOSH Response: These values are based on weighting neutron spectra with dose conversion factors to determine the fraction of the dose below 0.8 MeV as referenced in footnote 37 of Revision 02. It should also be noted that the upper-bound for the factor of 2 ± 0.3 is being used (i.e., a factor of 2.3).

In regards to the 50 mrem of neutron dose, the TBD was not recommending that the dose reconstructors assign 50 mrem of unmonitored neutron doses to the affected workers. The TBD was merely describing an instance where unmonitored neutron doses were received by INL workers. The earlier versions of the external TBD neglected to indicate that the INL has already assigned unmonitored neutron doses for those workers based on the area dosimeter results, such that the dose reconstructors do not need to assign unmonitored neutron doses to the affected TAN workers. An additional clarifying statement was since added to Revision 02 of the external TBD that still subsists in Revision 03.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A notes that footnote 37 of Revision 02 is Attribution [46] of Revision 3. Attribution [46] states that the two multiplying factors "are based on weighting neutron spectra with dose conversion factors to determine the fraction of the dose below 0.8 MeV," but does not show the calculations. SC&A's review of Revision 03 (and Revision 02) confirms that the "fixed missed neutron dose default value of 50 mrem" has been removed, since the unmonitored office workers dose records were already corrected by INL.

Since the NIOSH response does not provide data to support the two missed neutron dose multiplying factors, SC&A recommends that the WG keep this issue open for further discussion.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH repeats the statement above, shown under WG Action Items: SC&A, and adds: "This issue is related to Issue 29 that SC&A has recommended for closure – previous NIOSH efforts were to respond with 1 reply for both issues – NIOSH recommends closure for this issue."

SC&A Further Review: NIOSH (NIOSH 2013b, 2013c) refers SC&A to the Issue 29 resolution. The NIOSH response in Issue 29 says:

> *…Revision 00 through Revision 03 of the INL's external dosimetry TBD have included facility-specific adjustments to the reported neutron doses to account for the dosimeters' poor energy response to lower-energy neutrons. The NTA film corrections for energy response in the INL TBD are comparable to the energy response corrections in ORAUT-OTIB-0051, which range from 1.0 to 2.2.*

SC&A reviewed Rev. 3 of the External Dose TBD (ORAUT 2011b), which notes in Section 6.5.4 that NTA dosimeters were used at INL before October 1976 and Hankins albedo TLDs thereafter. Section 6.5.4.1 states for the earlier period, "When the LOD for NTA film is used to estimate the missed neutron dose, it should be multiplied by 1.25 for most workers and by 2 for workers on the MTR experiment floor and on the TREAT or ZPPR experiment floor..." Data to support the correction factor is found in an extensive discussion in ORAUT-OTIB-0051 (ORAUT 2006). Although the OTIB is specifically for Y-12, the discussion on NTA film response to different energy neutrons is generic and applicable to INL as well. Hence, the range of NTA film response multiplication factors given in the INL External Dose TBD appears reasonable and consistent. SC&A recommends that the WG close this issue.

3.36 ISSUE 36: MISSED LOW-ENERGY BETA DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, Sect. 6.3.2.2 (subsequent to SC&A 2006)

Issue: Section 6.3.2.2 of the TBD discusses the 100 mg/cm^2 plastic dosimeter holder and the fact that betas of less than 360 keV will not penetrate the holder. (It is unclear if this density includes the film wrapper.) However, the TBD does not discuss allowance for or consideration of the possibility of the complete failure to detect these betas.

The general, averaging approach to missed beta is questionable. The concern is that beta exposure is always assumed to be due to a mix of energies and thus the dose component from low energies is known and can be corrected. Clearly this is not the case, as is stated in the attribution.

A specific concern is the Rare Gas Processing Facility (CPP-604), which harvested Kr-85. This nuclide is a pure beta emitter, with an endpoint energy of 670 keV. The film badges in use at the time were far from ideal for betas and failed to see any below 360 keV. NIOSH should determine if the maximum modifier recommended for betas of 2.8 is sufficient for this environment.

NIOSH Response: The current revision to the TBD (i.e., Revision 03) appears to address these concerns regarding the INL dosimeter responses to low-energy betas.

WG Action Items:

- **SC&A:** Review applicable portions of the current version of the External Exposure TBD and reassess the issue.

SC&A Reassessment: SC&A has reviewed Revision 03, including new Section 6.4.2 and Table 6-12. SC&A agrees with NIOSH that Revision 03 appears to address Issue 36, and recommends to the WG that this issue be closed.

Rev. 1 Status and Review Information

NIOSH Update (NIOSH 2013b, 2013c): NIOSH agrees with SC&A's recommendation to the WG to close this issue.

SC&A Further Review: None

3.37 ISSUE 37: ERROR IN REFERENCE

ORAUT-TKBS-0007-6, Occupational External Dose, TBD Sect. 6.5.4, (subsequent to SC&A 2006)

Issue: The second paragraph of page 41 of the 2007 External Dose TBD references Table 6-16 for IREP groups; it should refer to Table 6-14 instead.

NIOSH Response: Corrected in latest TBD revision.

WG Action Items: None. Issue closed at the June 21, 2011, WG meeting.

CLOSED

3.38 ISSUE 38: SHALLOW DOSE

ORAUT-TKBS-0007-6, Occupational External Dose, (subsequent to SC&A 2006)

Issue: NIOSH should consider making use of ORAUT-OTIB-0017, *Interpretation of Dosimetry Data for Assignment of Shallow Dose*, where appropriate. Additionally, contrary to the OTIB's claim (p. 15) that the assumption of undergarment and pants thicknesses of 2 mm each is claimant favorable, SC&A believes that measured thicknesses are about half that and, hence, the OTIB assumptions are not claimant favorable.

NIOSH Response: This is a complex-wide issue and not specific to INL.

WG Action Items: None. ORAUT-OTIB-0017 already reviewed by Procedures Review Subcommittee. Issue closed at the June 21, 2011, WG meeting.

CLOSED

REFERENCES

40 CFR 50. U.S. Code of Federal Regulations, 40 CFR Part 50, *National Primary and Secondary Ambient Air Quality Standards*.

40 CFR 58. U.S. Code of Federal Regulations, 40 CFR Part 58, *Ambient Air Quality Surveillance.*

BNL 2014. Brookhaven National Laboratory, National Nuclear Data Center, "Interactive Chart of the Nuclides," www.nndc.bnl.gov (accessed February 12, 2014).

Cipperly 1958. Cipperly, F.V., *Personal Metering Operating Techniques, Self-Service System, Effective August 20, 1951 through March 29, 1958*, IDO-12007, U.S. Atomic Energy Commission, Idaho Operations Office, 1958. [SRDB Ref. ID 8130]

Cusimano 1981. Cusimano, J.P., *Update of Facility Neutron Calibration Factor (FNCF)*, memo to Dosimetry File, U.S. Department of Energy, January 21, 1981. [SRDB Ref. ID 8145]

DCAS 2011. *Best Estimate Dose Reconstruction for Glovebox Workers*, DCAS-TIB-0010, Rev. 4, November 28, 2011.

DOE 1991. *Tiger Team Assessment of the Idaho National Engineering Laboratory*, DOE/EH-0178, U.S. Department of Energy, Office of Environment, Safety and Health, August 1991.

DNFSB 1994a. Memo from J.W. Troan to W. Cunningham, Technical Director, "Report on the Radiation Protection Program at the Idaho National Engineering Laboratory," July 29, 1994.

DNFSB 1994b. Memo from Timothy J. Dwyer, Technical Staff, to G. W. Cunningham, Technical Director, "Sitewide Training and Qualification Review at the Idaho National Engineering Laboratory (INEL), July 11-15, 1994," September 15, 1994.

DNFSB 1995. Letter from John T. Conway, Chairman DNFSB, to Thomas P. Grumbly, Assistant Secretary for Environmental Management Department of Energy, March 28, 1995. Attaching: Memo from Daniel G. Ogg, Program Manager, INEL, to G. W. Cunningham, Technical Director, "Radiological Controls and Conduct of Operations, Idaho National Engineering Laboratory, High Level Waste Tank Farm Replacement Project, Report of Site Visit, November 30 - December 2, 1994," January 17, 1995.

Gesell 1986. "Minimum Reporting Levels for the Panasonic Dosimetry Systems." Letter to Dosimetry Customers, Radiological and Environmental Sciences Laboratory, May 15, 1986.

ICRP-23. *Report of the Task Group on Reference Man*, International Commission on Radiological Protection, Publication, No. 23, 1975.

ICRP-66. *Human Respiratory Tract Model for Radiological Protection*, International Commission on Radiological Protection, Publication No. 66, 1994.

ICRP-68. *Dose Coefficients for Intake of Radionuclides by Workers*, International Commission on Radiological Protection Publication, No. 68, 1995.

King 2001. King, V.A., *Technical Basis for Internal Dosimetry at SMC*, EDF No. 2001-02, Rev. 3, Idaho National Laboratory. [SRDB Ref. ID 8479]

Knoll, G., *Radiation Detection and Measurement*, 3rd Ed., New York: John Wiley & Sons, Inc., 2000.

NIOSH 2013a. *Idaho National Laboratory (INL) Site Profile Update*, presentation at ABRWH Idaho Falls, Idaho meeting. National Institute for Occupational Safety and Health, Cincinnati, Ohio. July 16, 2013.

NIOSH 2013b. *INL WG Issues Summary*. National Institute for Occupational Safety and Health, Cincinnati, Ohio. November 7, 2013.

NIOSH 2013c. *Nov. 2013 Status on INL WG Issues* (file name), November 7, 2013. This is a NIOSH markup of an SC&A table entitled: "October 2013 Status & Update in INL TBD WG Issues." National Institute for Occupational Safety and Health, Cincinnati, Ohio.

OCAS 2002. *External Dose Reconstruction Implementation Guideline*, OCAS-IG-001, Rev. 1. Office of Compensation Analysis and Support, NIOSH, Cincinnati, Ohio. August 2002.

OCAS 2007. *External Dose Reconstruction Implementation Guideline*, OCAS-IG-001, Rev. 3. Office of Compensation Analysis and Support, NIOSH, Cincinnati, Ohio. November 21, 2007.

ORAUT 2004a. *Technical Basis Document for the Idaho National Engineering and Environmental Laboratory (INEEL) – Occupational External Dosimetry*, ORAUT-TKBS-0007-6, Rev. 0. Oak Ridge Associated Universities Team, Cincinnati, Ohio. April 6, 2004.

ORAUT 2004b. *Technical Basis Document for the Idaho National Engineering and Environmental Laboratory (INEEL) – Occupational Internal Dose*, ORAUT-TKBS-0007-5, Rev. 0, PC-1. Oak Ridge Associated Universities Team, Cincinnati, Ohio. October 12, 2004.

ORAUT 2005a. *Internal Dose Overestimates for Facilities with Air Sampling Programs*, ORAUT-OTIB-0018, Rev. 1. Oak Ridge Associated Universities Team, Cincinnati, Ohio. August 9, 2005.

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

ORAUT 2005c. *Internal Dosimetry Coworker Data for X-10*, ORAUT-OTIB-0033, Rev. 0. Oak Ridge Associated Universities Team, Cincinnati, Ohio. December 13, 2005.

ORAUT 2006. *Effect of Threshold Energy and Angular Response of NTA Film on Missed Neutron Dose at the Oak Ridge Y-12 Facility*, ORAUT-OTIB-0051. Oak Ridge Associated Universities Team, Cincinnati, Ohio. May 15, 2006.

ORAUT 2007a. *Technical Information Bulletin: Internal Dose Reconstruction*, ORAUT-OTIB-0060, Rev. 0. Oak Ridge Associated Universities Team, Cincinnati, Ohio. February 6, 2007.

ORAUT 2007b. *Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses*, ORAUT-OTIB-0054, Revision 0, PC-1. Oak Ridge Associated Universities Team, Cincinnati, Ohio. November 19, 2007.

ORAUT 2008a. *Use of Coworker Dosimetry Data for External Dose Assignment*, ORAUT-OTIB-0020, Rev. 02. Oak Ridge Associated Universities Team, Cincinnati, Ohio. December 4, 2008.

ORAUT 2008b. *Assignment of Missed Neutron Doses Based on Dosimeter Records*, ORAUT-OTIB-0023, Rev. 01. Oak Ridge Associated Universities Team, Cincinnati, Ohio. May 14, 2008.

ORAUT 2009. *Idaho National Laboratory and Argonne National Laboratory-West: Occupational Medical Dose,* ORAUT-TKBS-0007-3, Rev. 2. Oak Ridge Associated Universities Team, Cincinnati, Ohio. December 21, 2009.

ORAUT 2010a. *Idaho National Laboratory and Argonne National Laboratory-West: Introduction,* ORAUT-TKBS-0007-1, Rev. 3. Oak Ridge Associated Universities Team, Cincinnati, Ohio. March 12, 2010.

ORAUT 2010b. *Idaho National Laboratory and Argonne National Laboratory-West: Site Description,* ORAUT-TKBS-0007-2, Rev. 4. Oak Ridge Associated Universities Team, Cincinnati, Ohio. August 2, 2010.

ORAUT 2010c. *Idaho National Laboratory and Argonne National Laboratory-West: Occupational Environmental Dose,* ORAUT-TKBS-0007-4, Rev. 2. Oak Ridge Associated Universities Team, Cincinnati, Ohio. January 8, 2010.

ORAUT 2010d. *Idaho National Laboratory and Argonne National Laboratory-West: Occupational Internal Dose,* ORAUT-TKBS-0007-5, Rev. 3. Oak Ridge Associated Universities Team, Cincinnati, Ohio. March 2, 2010.

ORAUT 2011a. *Parameters to Consider When Processing Claims for Construction Trade Workers*, ORAUT-OTIB-0052, Rev. 1. Oak Ridge Associated Universities Team, Cincinnati, Ohio. February 17, 2011.

ORAUT 2011b. *Idaho National Laboratory and Argonne National Laboratory-West: Occupational External Dosimetry,* ORAUT-TKBS-0007-6, Rev. 3. Oak Ridge Associated Universities Team, Cincinnati, Ohio. April 19, 2011.

ORAUT 2011c. *Use of Coworker Dosimetry Data for External Dose Assignment*, Rev. 3. Oak Ridge Associated Universities Team, Cincinnati, Ohio. November 14, 2011.

Perry, O.R., B.L. Anderson, and P.E. Ruther, 1993. *Minimum Reporting Level for the Idaho National Engineering Laboratory (INEL) Thermoluminescent Dosimetry (TLD) Systems*, EGG-ESQ-10917, 1993.

SC&A 2003. *Critical Review of Source Terms for Select Initial Engine Tests Associated with the Aircraft Nuclear Propulsion Program and INEL*. SC&A, Inc., Vienna, Virginia. 2003

SC&A 2005. *Review of the NIOSH Site Profile for the Idaho National Laboratory, Idaho*, SCA-TR-TASK1-0005, Draft, Rev. 0. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. September 25, 2005.

SC&A 2006. *Review of the NIOSH Site Profile for the Idaho National Laboratory, Idaho*, SCA-TR-TASK1-0005, Draft, Rev. 1. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. January 25, 2006.

SC&A 2007. *Review of the NIOSH Site Profile for the Argonne National Laboratory-West, Idaho*, SCA-TR-TASK1-0021, Draft. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. July 27, 2007.

SC&A 2008. *Idaho National Laboratory (INL) Site Profile Review Update*, SCA-TR-TASK1-0005-S1, Draft. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. December 10, 2008.

SC&A 2009. Combined Issues Matrix for the Idaho National Laboratory and the Argonne National Laboratory-West. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. July 15, 2009.

SC&A 2011a. *INL/ANL-W Work Group Meeting, June 21, 2011, Actions*, June 24, 2011.

SC&A 2011b. *INL/ANL-W Work Group Meeting, June 21, 2011, Actions*, June 24, 2011 (incl. NIOSH comments).

SC&A 2013. *Idaho National Laboratory (INL) Site Profile Review Status Update*, SCA-SP-IM2013-0005, Rev. 0, Draft. SC&A, Inc., Vienna, Virginia, and Saliant, Inc., Jefferson, Maryland. October 23, 2013.