NIOSH DOSE RECONSTRUCTION PROGRAM

Review of areas of professional judgement in the dose reconstruction process and

Approaches for assuring consistency

Submitted by

Mark A. Griffon

November 5, 2017

TABLE OF CONTENTS

Executive Summary

The issue of consistency for aspects of dose reconstruction that require professional judgements emerged as a question during the ABRWH dose reconstruction reviews. This review was conducted to consider areas where professional judgement is a factor in individual dose reconstruction. The review focused on example sites (one Department of Energy (DOE) site and one Atomic Weapons Employer (AWE) site to consider a range types of dose reconstructions. Most dose reconstruction completed in the NIOSH program involve one of three approaches: "underestimating approach", "overestimating approach" and "best estimate approach". The underestimating approach (calculating a portion of the dose the claimant received) is used for cases believed to definitely be compensable, the overestimating approach (assigning maximum values for at least one aspect of dose reconstruction), on the other hand, is used for cases believed likely not compensable, and finally, the best estimate approach is used for any cases that are near the cutoff for the compensation decision (nearing 50% probability of causation). While professional judgements are necessary in many aspects of dose reconstruction, when considering the question of consistency regarding professional judgements it is evident that this issue becomes most important when conducting best estimate dose reconstructions where different judgements made may affect the compensation decision. While this is a very important issue, it should be noted that of all the claims processed by NIOSH less than 5 percent of the claims require a best estimate approach for making a compensation decision.

This assessment was initiated to consider two sites, in detail, to determine what types of professional judgements were made for dose reconstructions done for the two sites and to gain insight into how possible inconsistencies in professional judgements may be reduced. Initially the focus of the review was to determine where an individual Dose Reconstruction (DR) staff person would need to make a professional judgement, the frequency of these judgements and the guidance available to make the judgement. It became evident, however, that there are a great deal of 'program judgements' that are quite important not only for these two specific sites but which likely effect many sites. These program judgements or assumptions, therefore, were also considered during this review.

The focus of these two site reviews was to consider the DR process from the initial claimant interview through internal review to final reworks if needed. This review required review of all relevant Technical Basis Documents (TBD), Implementation Guides (IG), Technical Information Bulletins (TIB) and procedures (both site specific as well as many of the overarching documents (e.g., OCAS-IG-001 – External Dose reconstruction, OCAS-IG-002 – Internal Dose reconstruction, ORAUT-OTIB-0060 – Internal Dose Reconstruction)) and review of Sanford Cohen and Associates (SC&A) review documents

(procedure review documents and case review documents). Additionally, the review involved a detailed examination of the internal guidance documents associated with the example sites (e.g. DR guidelines for SRS site).

In the course of this assessment dozens of cases were reviewed first to review calculations associated with the fairly complex dose reconstruction process and then to focus on areas where professional judgements are necessary and the measures which are being taken and can be improved on with regard to assuring consistency in these areas. The cases were selected from a query of primarily best estimate cases from the NOCTS database, from the Oak Ridge Associated Universities (ORAU) QA database (which identified cases with technical errors for cases completed after 2012), from findings from earlier internal reviews (2002-2003) and from cases reviewed by the Advisory Board on Radiation and Worker Health (ABRWH). The majority of the cases, especially for the SRS review, were best estimate type cases since it was evident that the individual professional judgements would be most relevant for these cases.

The observations and recommendations in this report are based on the review of two sample sites –the Savanah River Site (SRS) and the Linde Ceramics site. These types of sites tend to be very different in the nature of the dose reconstruction. The larger DOE sites often have an extensive amount of data including individual claimant monitoring data while the AWE sites often have very little if any personal monitoring data and the dose reconstructions often rely on other types of information to supplement or substitute for individual monitoring data (e.g., co-worker data, survey data, source term data, etc.).[1] [2]

In the course of this assessment several professional judgements were identified, some were judgements which would have to be made by the staff person doing the individual dose reconstruction while other judgments are what can be considered program judgements. The program judgements are professional judgements but they are dealt with directly in procedures, technical basis documents or DR guidelines. In the Linde Ceramics site, for example, a matrix is established which defines the dose to be assigned for a given time period – the program assumptions are associated with the assumptions involved in the development of the matrix. For SRS, the decision to use coworker data to estimate dose for periods of time when no records are available is a judgement made by the individual dose reconstructor while the construction of the coworker model and the assumption that it is appropriate for use for all site workers is a program judgement.

---

[1] 42 CFR 82.17 describes the types of information that could be used to supplement or substitute for individual monitoring data. Three types of information could be used:

(a) Monitoring data from co-workers, if NIOSH determines they had a common relationship to the radiation environment; or,
(b) A quantitative characterization of the radiation environment in which the covered employee worked, based on an analysis of historical workplace monitoring information such as area dosimeter readings, general area radiation and radioactive contamination survey results, air sampling data; or,
(c) A quantitative characterization of the radiation environment in which the employee worked, based on analysis of data describing processes involving radioactive materials, the source materials, occupational tasks and locations, and radiation safety practices.

[2] The ABRWH developed criteria for use of surrogate data for dose reconstruction. "CRITERIA FOR THE USE OF SURROGATE DATA", Prepared by the ABRWH Work Group on Use of Surrogate Data May 14, 2010

This assessment attempted to identify areas of personal and program judgements associated with dose reconstructions for the two specific sites (SRS and Linde Ceramics). While the assessment was focused on these two sites it is quite apparent that many of the personal as well as program judgements will be broadly applicable across the other sites covered under the EEOICPA program.

Personal dose reconstructor judgements

Several areas were identified where personal dose reconstructor judgements could potentially result in inconsistent assessment of a portion of an individual's dose. These judgements, which are detailed in the body of this report, include:

a. Judgements regarding worker location for purposes of internal dose estimates and external dose estimates,
b. Judgements regarding job title and the associated potential for exposure,
c. Judgements in the calculation of missed external and internal dose,
d. Judgements required in reconciling discrepancies in available dosimetry data (e.g., annual external summary data versus cycle data),
e. Judgements in calculating internal dose based on in-vivo and/or in-vitro measurements for best estimate cases, and
f. Judgements regarding calculating dose associated with incidents / events noted in the claimant interview or DOE records.

Recommendation

Assessments should be performed in the areas identified where personal professional judgements were made by individual dose reconstruction staff to determine consistency of judgements or assumptions. There are several means of assessment which may be useful in achieving the goal of determining whether there are inconsistencies in the areas of professional judgement including:

1. ORAU blind reviews – one case done by two different dose reconstructors (for SRS two different staff that work on SRS cases).
2. ORAU focused reviews – select areas of one case (or multiple cases) compared to determine if judgements were consistent. These type of reviews could lead to the identification of areas where procedures or guidance is ambiguous.
3. NIOSH blind reviews – similar blind review as described in item 1 conducted by NIOSH staff rather than ORAU.
4. NIOSH focused reviews – similar reviews as described in item 2 above.
5. ABRWH blind reviews – Board review (with Board contractor). Could be particularly useful for AWE sites that do not have a technical basis document.
6. ABRWH focused reviews – Board review (with Board contractor). The external Board review may be difficult if the cases do not include detailed documentation and basis for the professional judgement.
7. Refine current peer review conducted by NIOSH to assure a greater percentage of best estimate cases undergo a comprehensive review. The current procedure provides for 5% random sample of all completed cases undergo extensive peer review by NIOSH. NIOSH should consider biasing the sampling to select a greater percentage of best estimate cases for the comprehensive review.

The focused assessments described above involve the following challenges: 1) need to identify a sufficient number of cases involving 'similar' types of judgements and 2) need to be able to interpret what judgements were made (cases with more documentation and even timelines make this process most efficient). The author's opinion is that this type of focused review would not necessarily require cases that involved workers in same areas, same jobs, same years, etc. since the focus of such a review should be to determine what basis is used to support the judgement and, in cases of greater uncertainty, assurance that guidance available for the DR staff assure consistency in their approach. The focus should be on assuring that the decision making logic is adequate and is implemented consistently. The purpose of such a review should not be to evaluate or judge individual performance but rather to determine if there are significant discrepancies and if so to determine what system (e.g., procedure, guidance, Quality Assurance review) can be modified to improve consistency.

The focus should be on trying to understand why there was a difference in judgement and whether possible improvements / clarifications are necessary in policy or procedures to reduce the inconsistency in the approach. In conducting the review the ABRWH should consider a blend of the approach used in conducting the review of individual cases and the approach used in reviewing the dose reconstruction procedures[3]. The process currently in place for dose reconstruction reviews is focused on the outcome, which is certainly of utmost importance, however more attention to the process – what lead to the discrepancies or mistakes – should be useful in assuring consistency. Of course, training and lessons learned are important elements of an effective program however, if recurrent 'mistakes' are identified it is more likely that the system (e.g., procedures, guidance) needs to be improved.

Program judgements

During this review it became clear that there were many professional judgements that are not individual judgements but rather judgements made by the program. These judgements include treatment of broad dosimetric issues (e.g., how to consider reconstructing dose from 'residual' contamination (contamination remaining after the operational period for AWE sites, how to reconstruct dose due to highly insoluble plutonium, how to estimate uncertainty for internal and external doses) as well as site specific judgements (e.g., models for estimating exposures at sites lacking individual monitoring records, neutron / photon ratio used to estimate neutron doses). It should be noted that the documents detailing these program judgements (Technical Basis documents, Technical Information Bulletins, etc.) have gone through extensive review by the ABRWH during the procedures review process, the site profile review process and in many cases during the Special Exposure Cohort petition process. Nonetheless the following recommendations may be useful to consider for assurance of consistency, fairness and transparency.

Recommendations

NIOSH should consider developing summary documents for some key program judgements that outline the basis for the assumption as well as the review and agreement of internal and external reviews. Some

[3] Note that SC&As review protocol, "A Protocol for the Review of Procedures and Methods Employed by NIOSH for Dose Reconstruction" (SCA-PR-Task3, Rev. 1, Final, April 29, 2004)," includes two metrics related to consistency and fairness. Specifically, item 4 "Assess procedure for providing a consistent approach to dose reconstruction regardless of claimants' exposures by time and employment locations," and item 5 "Evaluate procedure with regard to fairness and giving the benefit of the doubt to the claimant."

areas where this may be useful is the approach for estimating doses from residual contamination, the approach for estimating dose uncertainties, and the approach for addressing potential exposures from undocumented incidents.

For certain program judgements NIOSH should consider review and comparison of relevant site profile (or matrices) to assure consistency in the application of program wide methods. One specific area where this could be useful is the use of surrogate data for AWE sites to assure that they are consistent with regulatory requirements, the ABRWH policy and approaches are consistently applied. Another area is the interpretation of internal doses based on measured data (comparing approaches used at different sites for consistency).

Additional Recommendations

During the course of this review a few additional observations related to case documentation, quality assurance, and use of interview information lead to additional recommendations related to professional judgement in dose reconstruction. These are as follows:

- NIOSH / ORAU should consider requiring more detailed documentation in case files (especially for best estimate cases). While documentation within the DR case files has improved over the course of this program NIOSH / ORAU should consider more detailed documentation including detailed work 'timelines' and documentation where a professional judgement was required. NIOSH / ORAU should consider standardized requirements for what should be included in this documentation.
- It is recommended that a tracking mechanism should be developed, to the extent possible, to consider findings / comments from all reviews (Peer review, NIOSH review, ABRWH review, other?), in an aggregate fashion, for purposes of improving dose reconstruction methods and particularly, as it relates to this report, for improvements in assuring consistency in areas of professional judgement.
- For cases where a 'significant' amount of professional judgements were necessary, it may be useful to have additional level of review prior to finalizing the case. ORAU has indicated that since 2012 they have required a second peer review for all cases with POC between 40% and 52%. Based on PROC-0077 NIOSH conducts an extensive review on 5% of all cases (randomly selected from NOCTS). NIOSH may want to consider a biased sampling approach to select a greater percentage of the best estimate type cases.
- NIOSH should consider the use of incident / accident information provided in the CATI interviews in aggregate form. Perhaps a pilot study should be conducted to explore the feasibility and usefulness of a site specific incident database being developed based on CATI and expert interview information.

Background

The Energy Employees Occupational Illness Compensation Program Act (EEOICPA) of 2000 established a compensation program for eligible workers who worked for the U.S. Department of Energy (DOE), DOE contractors or subcontractors, or DOE predecessor agencies. Eligibility under Part B for cancers which may have been caused by radiation exposure is based on an individuals estimated radiation exposure. NIOSH developed regulations (42 CFR Part 82) describing the methods to be used to reconstruct an individual's radiation dose for purposes of determining eligibility for compensation. The exposure estimates are necessary for science-based decisions regarding the probability that the developed cancer was caused by the radiation exposure. Over more than 15 years NIOSH has completed more than 40,000 dose reconstruction reports.

In undertaking such an enormous effort NIOSH put in place certain efficiency measures to improve timeliness of completing dose reconstructions. An 'underestimating' approach is used for some compensable cases. An overestimating approach is used for cases considered not likely to be compensable[4]. A best estimate approach is used for cases where a complete, best estimate of radiation dose is necessary to make a determination on causation. It should be noted that only about 5 percent of all cases have required a best estimate approach. This is important to consider with regard to the focus of this report since the effect that professional judgements can have on the DRs are magnified in these cases closer to the decision point (near 50% probability of causation[5]).

Given the importance of making the correct decision on compensation the Advisory Board on Radiation and Worker Health, which has as part of their statutory duties, the review of dose reconstructions, has focused their review efforts on cases just below the 50% cutoff, the best estimate cases. Over several years of review by the Advisory Board on Radiation and Worker Health there have been a significant percentage of findings related to what can be classified as professional judgements. These judgments can be very important when they involve cases that may be near the compensation level (a probability of causation near 50%). These necessary professional judgements are particularly important because relatively small differences in dose reconstruction could influence the outcome of the claim.

As is noted by Daniels and Spitz[6] NIOSHs goal is to obtain reasonable estimates of a claimant's radiation exposure which should be done in a timely and fair manner. They point out that where there is uncertainty the goal of the program is to make claimant favorable estimates of the dose. They also make the point that "scientifically based estimates include assurances of objectivity, reliability and validity in the methods used." These principles certainly apply to the professional judgments as well as to the prescribed methods

[4] NIOSH reviewed the issue of using an overestimating approach as part of the Ten Year Review and determined that for some cases there is an efficiency gained in the DR process by using an overestimating approach. NIOSH modified their policy to only use the overestimating approach for cases where it is clearly more efficient. NIOSH reported to the ABRWH that "A cost benefit analysis was completed and presented to the DR SC on August 6, 2012. The analysis concluded that eliminating all efficiency measures would be cost prohibitive." (Ten Year Review Follow-up Action Items talking points for Board Meeting 9/7/2014).

[5] 50% at the 99th percentile as defined in 42 CFR Part 82

[6] Quality of Science report, page 3

for calculating dose. Consistency of dose reconstruction is an important factor related to both fairness and reliability. Since the beginning of the program many improvements have been made related to assuring consistency in dose reconstructions including the development and use of standardized workbooks used for dose calculations and an enhanced quality assurance and quality control program (described further in Attachment 1).

Ideally, if all individual claimants had complete monitoring records, the dose reconstruction process could be relatively straight forward. However, it is often the case that individual monitoring records are incomplete or non-existent and in these cases the regulations (42 CFR 82, § 82.17) allow for other estimation methods including the use of 'monitoring data from coworkers", an estimation based on area monitoring records or survey records, and process or source specific estimates of radiation exposure. The last two methods become particularly important in many of the Atomic Weapons Employer (AWE) sites where fewer individual monitoring records are available. The sites with limited individual monitoring records require professional judgement to estimate individual exposures from process, source or survey information. The National Resource Council (NRC) review of the dose reconstruction approach used in the Nuclear Test Personnel Review (NTPR) program made recommendations related to dose reconstruction consistency which are relevant to the NIOSH program and should be considered in the analysis of consistency as it pertains to areas of professional judgement. Perhaps most relevant to the NIOSH program were the recommendations made by NRC regarding a quality management program and documentation of standard operating procedures and individual case files ('showing all work').[7] The report noted that "some of the case files contained no narrative discussions of the dose assessments"[8].

"An unusual aspect of the NTPR program is that it has been going on for 25 years. This can place special demands on the dose reconstruction process with regard to consistency in the technical approach, nondiscriminatory methods of estimating dose, and implementation of changes in methods of estimating dose based on improvements in science."[9] The EEOICPA program faces a similar challenge since it has been in effect for 17 years.

Additionally the report noted that "it can be difficult to achieve consistency in methods of dose reconstruction when analyses are performed by different people and over an extended period during which the scientific basis of dose reconstruction has been evolving. Preparation of a detailed manual of procedures for the conduct of dose reconstructions can be an important means of achieving the desired degree of consistency among different analysts and over time.[10]"

All of these points raised by the NRC would seem to apply to the EEOICPA program. From the beginning of this program NIOSH has paid close attention to these issues including the preparation and review of detailed technical basis documents and procedures (SOPs), the development and implementation of a

[7]NRC [2003]. A Review of the Dose Reconstruction Program of the Defense Threat Reduction Agency. Committee to Review the Dose Reconstruction Program of the Defense Threat Reduction Agency, Board on Radiation Effects Research, Division on Earth and Life Studies, National Research Council (NRC) Washington DC: The National Academies Press (399 pgs).

[8] NRC, page 232.

[9] NRC, page 40.

[10] NRC, page 40.

QA/QC program, technical review of all elements of the program (procedures, methods, and a sampling of dose reconstruction cases) by the ABRWH and in some cases other outside peer reviewers and the continual improvement of all elements of the programs based on review comments (internal and external) as well as updates to meet most current scientific methods (which can necessitate re-evaluation of some past cases).

This assessment is designed to look a particular challenging area with regard to consistency. In cases nearing the compensation cut-off (probability of causation of 50%) that involve some professional judgements in determining at least a portion of the assigned dose it is important that consistent, defensible approaches (judgements) are used and that uncertainty in the judgement is biased in favor of the claimant. Many of the measures put in place by NIOSH are designed to achieve this goal. Based on the review of two specific sites (Savanah River Site and Linde Ceramics site) this report considers certain specific professional judgements, the possible approach in reviewing to assure consistency in these judgements and recommendations for possible enhancement in current approaches for assuring consistency.

Overview of Assessment

The issue of dose reconstruction consistency emerged as a question during the ABRWH dose reconstruction reviews. Most dose reconstruction completed in the NIOSH program involve one of three approaches: "underestimating approach", "overestimating approach" and "best estimate approach". The underestimating approach (calculating a portion of the dose the claimant received) is used for cases believed to definitely be compensable, the overestimating approach (assigning maximum values for at least one aspect of dose reconstruction), on the other hand, is used for cases believed likely not compensable, and finally, the best estimate approach is used for any cases that are near the cutoff for the compensation decision (nearing 50% probability of causation). When considering the question of consistency regarding professional judgements it is evident that this issue becomes most important when conducting best estimate dose reconstructions where different judgements made may affect the compensation decision. While this is a very important issue, it should be noted that of all the claims processed by NIOSH less than 5 percent of the claims require a best estimate approach for making a compensation decision.

The Board contractor, Sanford Cohen and Associates (SC&A), was asked to consider this issue and to outline possible ways in which this issue could be assessed through the dose reconstruction review process (the Advisory Board on Radiation and Worker Health (ABRWH) review). In March 2016 SC&A issued a memo (Attachment 2) to the Board outlining some of the areas involving the potential for inconsistencies and some possible approaches to assess these issues through the dose reconstruction review process.

This assessment was initiated to consider two sites, in detail, to determine what types of professional judgements were made for dose reconstructions done for the two sites and to consider possible ways to assess these issues through an audit process. Two sites were selected (one DOE site and one AWE site) to consider in a more specific way the areas where professional judgements occur within the dose reconstruction process and to gain insight into how potential inconsistencies due to differences in professional judgements may be reduced possibly through QA/QC review mechanisms (internal or external – ABRWH).

Initially the focus of the review was to determine where an individual DR staff person would need to make a professional judgement, the frequency of these judgements and the guidance available to make the judgement. It became evident, however, that there are a great deal of 'program assumptions' that are quite important not only for these two specific sites but which likely effect many sites. These program assumptions, therefore, were also considered during this review.

Approach for Assessment

The focus of these two site reviews was to consider the DR process from the initial claimant interview through internal review to final reworks if needed. This review required review of all relevant TBDs, TIBs and procedures (both site specific as well as many of the overarching documents (e.g., OCAS-IG-001 – External Dose reconstruction, OCAS-IG-002 – Internal Dose reconstruction, ORAUT-OTIB-0060 – Internal Dose Reconstruction)) and review of SC&A review documents for the site specific procedures and TBDs. Additionally, the review involved a detailed examination of the internal guidance documents associated with the example sites (e.g. DR guidelines for SRS site).

In the course of this assessment dozens of cases were reviewed first to review calculations associated with the fairly complex dose reconstruction process and then to focus on areas where professional judgements are necessary and the measures which are being taken and can be improved on with regard to assuring consistency in these areas. The cases were selected from a query of primarily best estimate cases from the NOCTS database, from the ORAU QA database (which identified cases with technical errors – 2012 – 2016), from findings from earlier reviews (2002-2003) and from cases reviewed by the Advisory Board on Radiation and Worker Health (ABRWH). The majority of the cases, especially for the SRS review, were best estimate type cases since it was evident that the individual professional judgements would be most relevant for these cases.

The assessment also included:

- Attendance at multiple ABRWH meetings (both in person and telephonically) to gain a current understanding of the issues of concern to the Board.
- Review of transcripts from several dose reconstruction subcommittee meetings and methods workgroup meetings
- Review of comments made in relation to the 10 year review (in NIOSH Docket)
- Discussions with ORAU and NIOSH staff (related to site specific comments as well as broader issues)
- Source documents form the site research database
- External reports, including the NRC review of the NDRP program
- More than 100 CATI reports – mostly related to SRS site.

Additionally, after discussions with NIOSH about the notion of program assumptions the scope was expanded to include consideration of some of these issues which NIOSH has in the past identified as global issues (e.g., determining doses from residual contamination), consideration of findings from the 10 year review project and consideration of the enhanced QA/QC system (enhanced around 2012).

Consideration of the DR guidance documents within this review was also critical since these documents often provide prescriptive instructions for issues that can be characterized as program assumptions.

Although these are professional judgements, they are not judgements made by each individual dose reconstructor and therefore the guidance assures consistency between different dose reconstructors. It is worth noting that in reviewing the SRS site it was determined that there were 16 different versions of DR guidance from 2009 through 2016 (it is unclear if guidance documents existed prior to 2009).

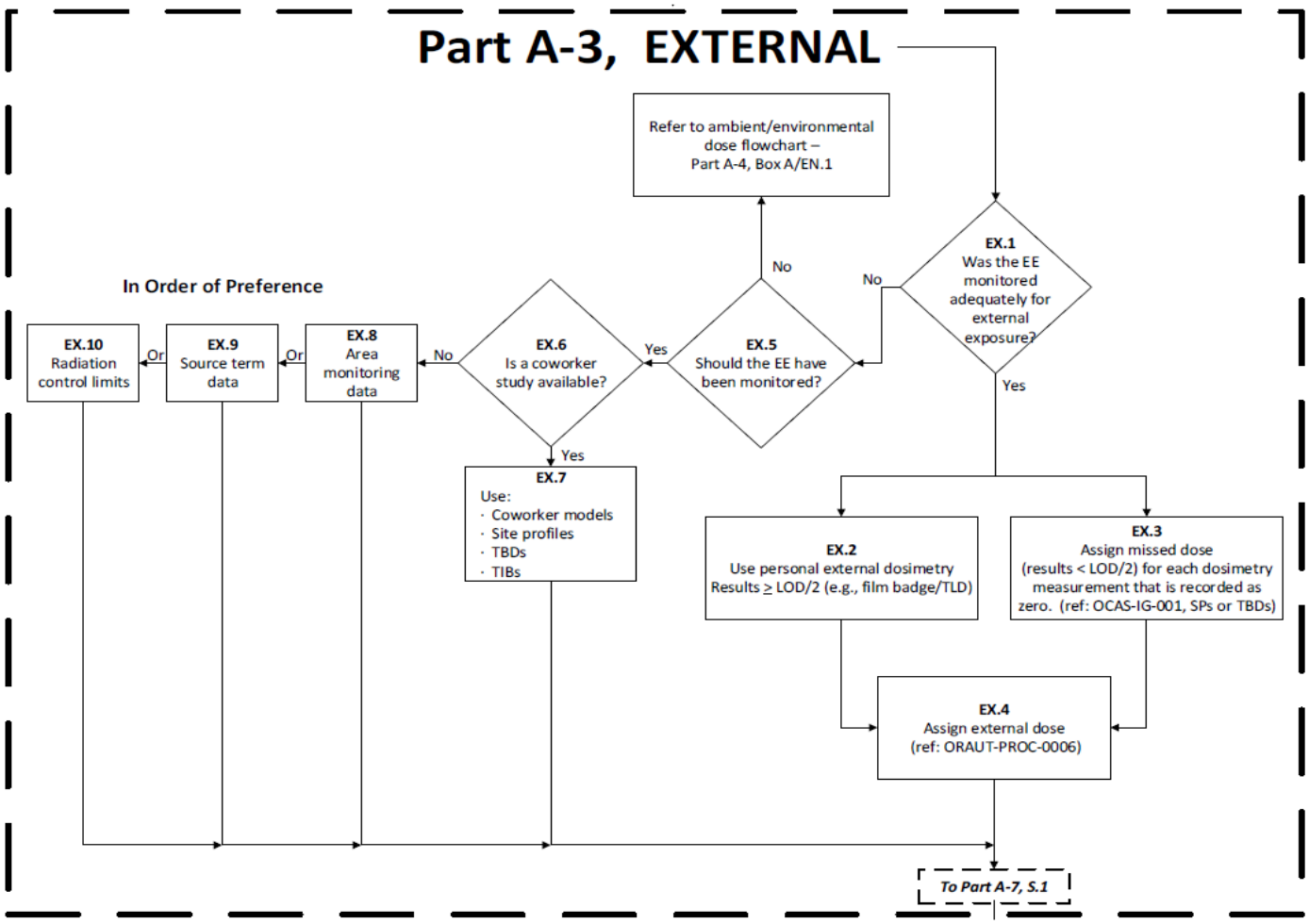
Overview of the DR Process

The dose reconstruction process starts when NIOSH receives a claim from the Department of Labor. The next step is to request and review individual data from the Department of Energy and as applicable begin data review and data entry (review DOE data and inputing this data into excel spreadsheet). The next step is to conduct an interview with the claimant or survivor. Then the actual dose reconstruction is performed. ORAU-PROC-0016, Roadmap to reconstructing dose (Attachment 4), details the protocol for claims processing, including:

- Decision making regarding the appropriate dose reconstruction approach - an 'underestimating approach', an 'overestimating approach' or a 'best estimate' approach,
- Reconstructing doses from accidents / incidents,
- Reconstruction of external and internal doses,
- Reconstruction of medical doses, and
- Required quality reviews

The procedure includes a comprehensive flow diagram detailing all of the above elements of the dose reconstruction and the decisions in each step. One portion of the flow diagram, showing the decision making process for external dose estimation, is shown below.

ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



It is interesting to note, within the diagram above, where professional judgements are required. Just looking at the first few steps: 1) was the EE monitored adequately, 2) if no, should the EE have been monitored?

Site specific guidance (Technical Basis documents and/or DR guidance) are designed to reduce the amount of judgement that has to be made by each individual dose reconstructor. Further, the improved automation of the dose reconstruction tools (workbooks with pre-loaded information – dose reconversion factors, energy distributions, etc.) reduces inconsistencies in judgement and also reduces data entry errors. Another important aspect of the way in which ORAU completes the dose reconstructions is the team approach. There is a team of individuals that work on SRS cases and there are frequent team meetings. This allows for discussions and resolution of issues, including differing interpretations of the technical basis documents, related to SRS cases and would seem to improve consistency of the DR approach. Additionally, ORAU conducts objective management meetings intended to discuss and resolve 'cross

cutting' issues in dose reconstruction[11]. Finally, issues of differing judgements may come up during the quality assurance review (ORAU reviewers and / or NIOSH review). These issues are tracked, discussed and resolved in a manner similar to that described above.

Professional judgements

Personal dose reconstruction judgements vs. Program judgements

The observations and recommendations in this report are based on the review of two sample sites –the Savanah River Site (SRS) and the Linde Ceramics site. These sites were selected to attempt to gain insights into professional judgements that may be associated with DOE sites (SRS) and AWE sites (Linde Ceramics). These types of sites tend to be very different in the nature of the dose reconstruction. The larger DOE sites often have an extensive amount of data including individual claimant monitoring data while the AWE sites often have very little if any personal monitoring data and the dose reconstructions often rely on other types of information to supplement or substitute for individual monitoring data (e.g., co-worker data, survey data, source term data, etc.).[12] [13]

In the course of this assessment several professional judgements were identified, some were judgements which would have to be made by the staff person doing the individual dose reconstruction while other judgments are what I am referring to as program judgements. The program judgements are professional judgements but they are dealt with directly in procedures, technical basis documents or DR guidelines. In the Linde Ceramics site, for example, a matrix is established which defines the dose to be assigned for a given time period – the program assumptions are associated with the assumptions involved in the development of the matrix. For SRS, the decision to use coworker data to estimate dose for periods of time when no records are available is a personal judgement while the construction of the coworker model and the assumption that it is appropriate for use for all site workers is a program judgement.

This assessment attempted to identify areas of personal and program judgements associated with dose reconstructions for the two specific sites (SRS and Linde Ceramics). While the assessment was focused on these two sites it is quite apparent that many of the personal as well as program judgements will be broadly applicable across the other sites covered under the EEOICPA program.

---

[11] ABRWH, Dose Reconstruction Review Methods Workgroup, November 05, 2015, page 79-81.

[12] 42 CFR 82.17 describes the types of information that could be used to supplement or substitute for individual monitoring data. Three types of information could be used:

(a) Monitoring data from co-workers, if NIOSH determines they had a common relationship to the radiation environment; or,
(b) A quantitative characterization of the radiation environment in which the covered employee worked, based on an analysis of historical workplace monitoring information such as area dosimeter readings, general area radiation and radioactive contamination survey results, air sampling data; or,
(c) A quantitative characterization of the radiation environment in which the employee worked, based on analysis of data describing processes involving radioactive materials, the source materials, occupational tasks and locations, and radiation safety practices.

[13] The ABRWH developed criteria for use of surrogate data for dose reconstruction. "CRITERIA FOR THE USE OF SURROGATE DATA", Prepared by the ABRWH Work Group on Use of Surrogate Data May 14, 2010

Observations / Recommendations

This section includes summary observations along with recommendations. The focus of the assessment was to consider, based on two pilot sites, areas where professional judgements occur in the dose reconstruction process and to postulate possible means for assessing the consistency of identified areas of judgement and, as necessary, means for improving consistency.

It should be stressed that the personal dose reconstruction judgements would seem to be most relevant for best estimate cases which constitute less than 5 percent of all claims NIOSH processes. Nonetheless, these are the cases where small variances in the approach to dose reconstruction can be the difference between compensation and no compensation and therefore these judgements can be very important.

Personal dose reconstructor judgements

Observation 1

Several areas were identified where personal dose reconstructor judgements could potentially result in inconsistent assessment of a portion of an individual's dose. Details of the individual professional judgements identified in the review of the SRS and Linde Ceramics sites are included in the attached SRS and Linde Ceramics reports and include:

- Judgements regarding worker location for purposes of internal dose estimates and external dose estimates (photon, neutron, electron, and assumptions regarding sources of internal exposure) and assumed energy distribution,
- Judgements regarding job title and the associated potential for exposure (e.g., whether a job, not listed in ORAU-OTIB-0052 – "Parameters for Processing Claims for Construction Workers" - should be treated as a construction trade worker job for purposes of estimating external dose, job title can affect the decision to assign ambient dose, coworker dose based on the 50^{th} percentile of the distribution or coworker dose based on the 95^{th} percentile of the distribution, etc.),
- Judgements in the calculation of missed external and internal dose (using limit of detection (LOD)/2, coworker data, use of 'nearby' data to fill gaps in dosimetry data, determination and use of minimum detectable activity (MDA) for assessing missed internal doses),
- consistency in reconciling discrepancies in available dosimetry data (e.g., annual external summary data versus cycle data),
- Judgements in calculating internal dose based on in-vivo and/or in-vitro measurements for best estimate cases (fitting models, approach using measured data and values less than the Minimal Detectable Activity (MDA), estimate of doses for long periods without monitoring data, cases where both in-vivo and in-vitro data are available), and
- Judgements regarding calculating dose associated with incidents / events noted in the claimant interview or DOE records.

Recommendation 1

Assessments should be performed in the areas identified where personal professional judgements were made by individual dose reconstruction staff to determine consistency of judgements or assumptions. There are several means of assessment which may be useful in achieving the goal of determining whether there are inconsistencies in the areas of professional judgement including:

1. ORAU blind reviews – one case done by two different dose reconstructors (for SRS two different staff that work on SRS cases).
2. ORAU focused reviews – select areas of one case (or multiple cases) compared to determine if judgements were consistent. These type of reviews could lead to the identification of areas where procedures or guidance is ambiguous.
3. NIOSH blind reviews – similar blind review as described in item 1 conducted by NIOSH staff rather than ORAU.
4. NIOSH focused reviews – similar reviews as described in item 2 above.
5. ABRWH blind reviews – Board review (with Board contractor). Could be particularly useful for AWE sites that do not have a technical basis document.
6. ABRWH focused reviews – Board review (with Board contractor). The external Board review may be difficult if the cases do not include detailed documentation and basis for the professional judgement.
7. Refine current peer review conducted by NIOSH to assure a greater percentage of best estimate cases undergo a comprehensive review. The current procedure provides for 5% random sample of all completed cases undergo extensive peer review by NIOSH. NIOSH should consider biasing the sampling to select a greater percentage of best estimate cases for the comprehensive review.

The focused assessments described above involve the following challenges: 1) need to identify a sufficient number of cases involving 'similar' types of judgements and 2) need to be able to interpret what judgements were made (cases with more documentation and even timelines make this process most efficient). The author's opinion is that this type of focused review would not necessarily require cases that involved workers in same areas, same jobs, same years, etc. since the focus of such a review should be to determine what basis is used to support the judgement and, in cases of greater uncertainty, assurance that guidance available for the DR staff results in consistency in their approach. The focus should be on assuring that the decision making logic is adequate and is implemented consistently. The purpose of such a review should not be to evaluate or judge individual performance but rather to determine if there are significant discrepancies and if so to determine what system (e.g., procedure, guidance, Quality Assurance review) can be modified to improve consistency.

The focus should be on trying to understand why there was a difference in judgement and whether possible improvements / clarifications are necessary in policy or procedures to reduce the inconsistency in the approach. In conducting the review the ABRWH should consider a blend of the approach used in conducting the review of individual cases and the approach used in reviewing the dose reconstruction procedures[14]. The process currently in place for dose reconstruction reviews is focused on the outcome, which is certainly of utmost importance, however more attention to the process – what lead to the discrepancies or mistakes – should be useful in assuring consistency. Of course, training and lessons

[14] Note that SC&As review protocol, "A Protocol for the Review of Procedures and Methods Employed by NIOSH for Dose Reconstruction" (SCA-PR-Task3, Rev. 1, Final, April 29, 2004)," includes two metrics related to consistency and fairness. Specifically, item 4 "Assess procedure for providing a consistent approach to dose reconstruction regardless of claimants' exposures by time and employment locations," and item 5 "Evaluate procedure with regard to fairness and giving the benefit of the doubt to the claimant."

learned are important elements of an effective program however, if recurrent 'mistakes' are identified it is more likely that the system (e.g., procedures, guidance) needs to be improved.

Program Judgements

Observation 2

Professional judgements are necessarily a part of the development of technical basis documents and procedures. These decisions are made at a program level and undergo extensive internal and external review including review by the ABRWH through the Subcommittee on Procedures Review, the site profile reviews and in some instances the reviews associated with special exposure cohort evaluation reports. Some of these judgements are site specific while some are judgements made regarding cross-cutting or what have sometimes been characterized as 'global' issues. Some of these issues include:

- The method for developing and using coworker models and the assumption that the approach is bounding for all workers has been reviewed and debated extensively by the ABRWH – in general terms and regarding site specific use. A summary of the general approach may be useful.
- The logic used in determining whether potential exposure from an incident (short term acute exposure) is or is not bounded by assessment of dose from routine measurements over a long period of time (assuming a chronic exposure).
- The method used for estimating uncertainty associated with external and internal doses. While it is clear this issue has been discussed extensively over the life of the program, it may be useful to summarize the approach to uncertainty and the reviews conducted.
- For some sites (specific time period at a site) there is an underlying, general, assumption that if individuals should have been monitored they were monitored (assumption of a 'robust' radiation safety program). In the SRS DR guidance document[15] it is stated that "For 1989 and later it is generally assumed all employees that needed monitoring were monitored." The basis for the assumption is included[16] within the guidance nonetheless it is a program assumption which could influence the approach for estimation of doses during the time period in question. For SRS it is also assumed, due to the inexpensive nature of tritium sampling, the all worker's requiring monitoring were monitored. These assumptions were extensively reviewed (internal and ABRWH review) and it may be useful to summarize the basis for the assumptions and the ABRWH review.

Observation 3

The external dose matrix for the Linde Ceramics site operational period (ORAUT-TKBS-0025, Table 4-24) is based on a variety of data and is rather difficult to recreate from underlying data. However, the approach used in deriving the values in this table (which are the basis for the calculations of individual external doses) have been extensively reviewed by SC&A and the ABRWH with all issues being 'closed' during the resolution process. Since site matrices for several other AWE sites are based on similar types of underlying data a review and comparison for consistency may be useful.

[15] DR Guidance – SRS 08 02 2016.

[16] SRDB Ref ID10931; *A History of Personnel Radiation Dosimetry at the Savannah River Site* [WSRC-RP-95-234 (Taylor et al. 1995)]

Recommendation 2

A summary document should be developed for several of the program assumptions, including but not limited to what NIOSH has defined as global issues. A document similar to that produced by NIOSH regarding the treatment of residual contamination seems appropriate[17].

Recommendation 3

Since site matrices for several AWE sites, in addition to Linde Ceramics are based on similar types of underlying data a review and comparison for consistency in methods may be useful.

Additional Observations / Recommendations

Detailing approach used in Dose Reconstruction

Observation 4

ORAU has made great improvements in including all work in case files. Most notably, due to a recommendation from the ABRWH, the inclusion of DR guidance[18] within each case file became standard procedure. Additionally, ORAU includes multiple IMBA dose calculations runs to demonstrate that the most claimant favorable approach regarding internal dose estimation was adopted for the final dose reconstruction report. It appears, however, that the level of specificity for the DR Notes or DR guidance varies from site to site. This may be due to the nature of the specific issues with each site however it may be something that should be discussed by DR teams and, where appropriate, standardized.

Observation 5

The DR guidelines are not controlled documents and yet it seems they are very important 'procedures' regarding site specific dose reconstruction 'rules'. It is unclear what triggers a change in DR guidelines, whether the change in DR guidelines results in other changes (e.g., workbook modification), and whether cases that could be affected by such a change should be re-calculated based on new guidelines. It seems that cases are reviewed, when warranted, after a significant change(s) are made to a controlled document (technical basis document) but not necessarily when DR guidance is changed. This is a difficult issue to resolve since on the one hand the TBD review by the Board can take quite some time but on the other hand doing multiple reworks of cases is not efficient and also could bring into question the credibility of the program. It is of note that the SRS Technical Basis document has not been revised since 2005 and a few important TIBs have also not been updated since 2003. The latest SRS DR guidance was developed in 2016 and there have been 16 revisions since 2009. To look at this more closely, a comparison of an early version of the DR guidance (04/27/2011) was compared with a recent version of the DR guidance (08/02/2016) (Attachment 3a) and a comparison was made between DR guidance (09/02/2015) and the more recent version (08/02/2106) (Attachment 3b). It is clear that there are significant differences, even when comparing the 2015 version with the 2016 version. One example of a change made after 2015 was the addition of a table including Minimum Detectable Activity values (MDAs) to be used when assessing post 1990 Lung count data. Again, the question is whether re-assessment of any cases should be done

[17] Advisory Board Review of Residual Period (002), NIOSH, Dr. James Neton, November 15, 2016.

[18] DR Guidance are site specifics guides developed by ORAU to assist the dose reconstructor. These are not controlled documents.

after 'significant' changes are made to DR guidance (prior to updates of the TBD which would trigger such a review).

Observation 6

The inclusion of what has been called a DR timeline within the case file seems like something that would be valuable especially for best estimate cases. This would allow for a more straightforward review process and would allow a better understanding of assumptions (where applicable – e.g., assumed work location). ORAU mentioned that this was done for some SRS dose reconstructions but was not required. Some Hanford cases do include an excel spreadsheet titled 'dose reconstruction timeline'[19]. In the notes on timeline preparation sheet the first note states "The supplied time line or others may be applied. However, a timeline should be used for most all but the simplest of Dose Reconstructions, since they help the DR assure consistent and systematic dose reconstruction, assure all information is considered, and provide for a final check of completion. They help the PR understand the DR's approach, thus expediting the review process." It seems this approach should be standardized and included in files for at least all best estimate cases.

Observation 7

While great strides have been made over the life of this program regarding the inclusion of documentation within the DR case file, better documentation in the individual case files, for best estimate cases, would be very helpful in determining if the appropriate process was followed. It seems to me this is very important for areas where professional judgement comes into play. Rather than trying to 'read the mind' of why a DR staff person made the assumption they did it should be documented so as to avoid any confusion. While there is certainly a limit to how detailed of a roadmap is needed, these kind of questions have come up over the years in the ABRWH dose reconstruction review committee. It slows the resolution process when those involved in the review are left to speculate what they believe the dose reconstructor did and how they got the result they did.

Recommendation 4

NIOSH / ORAU should review DR Notes or Guidance to consider whether some degree of standardization is warranted or useful. NIOSH / ORAU should consider using a more standardized form for the DR guidelines for sites where they are necessary and consider requiring the inclusion of a case narrative document which specifies the judgements made and the basis for the judgement. Such details are included within some case files (sometimes within comment fields within DR workbooks) but it does not appear to be done on a consistent basis. This may be useful for best estimate cases; probably not as important for over and under estimating approaches.

Recommendation 5

NIOSH / ORAU should consider whether re-assessment of any cases should be done after 'significant' changes are made to DR guidance (prior to updates of the TBD which would trigger such a review).

Recommendation 6

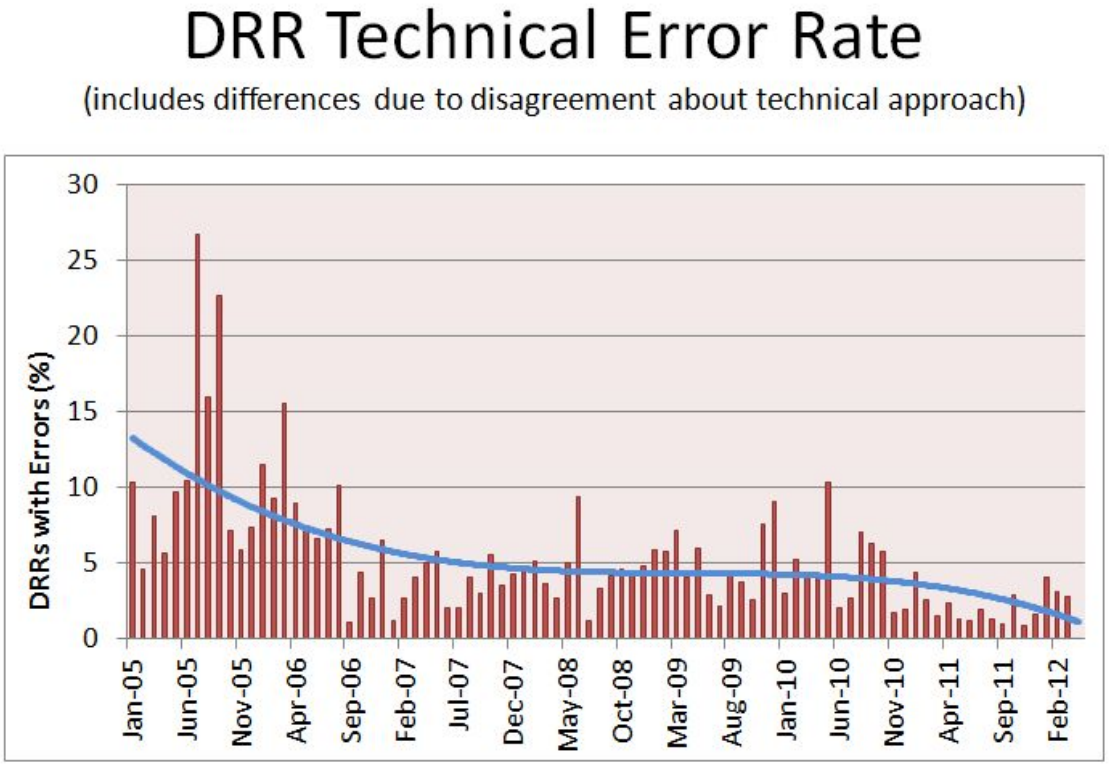
NIOSH / ORAU should consider including a 'timeline' for, at a minimum, best estimate cases.

[19] Case Reference O and P.

Quality Assurance and Quality Control

Observation 8

The QA/QC program has been greatly enhanced since about 2005 and even more so after about 2011. This can be seen by the reduction in 'errors' shown in the following table.



[20]

It is assumed that this table was generated from DCAS review findings (PROC-0077). It is interesting to note, on the graph above, that these recorded technical errors include 'differences due to disagreement about technical approach'. A very important aspect of the continuous improvement of the program is to understand how these differences were resolved.

Over the last four years (9/2012-9/2016), there were 18 SRS cases with technical comments (a total of 35 technical comments – several cases had multiple comments). ORAU did not categorize any of the comments as professional judgement comments (my independent categorization resulted in 4 of the 35 having a professional judgement component)[21]. Earlier data from NIOSH (from November 2003 through April 2004) included a total of 304 technical findings and 108 SRS findings. 39 of the SRS findings included a professional judgement component (based on my assessment – not categorized by NIOSH)[22].

[20] QMS Summary Dose Reconstruction Draft, 2012, NIOSH.

[21] ORAU provided a copy of the database which includes the technical comments based on DCAS reviews (see Attachment 1 – QA/QC program for description of the various DR reviews.

[22] NIOSH early version of comment tracking database from November 2003 – April 2004.

Quality Assurance and Quality Control Tracking are a very important components of the program and it seems clear that these elements have been improved (especially since 2012 – a much improved system for tracking and categorizing comments).

It is clear that since 2012 the DCAS review comments (ORAUT-PROC-0077) are being tracked in a database. The case specific comments (Form 35 comments – DR Comments) are also included in the individual case file. It is less clear, however, how these findings / comments are considered in aggregate and whether they result in changes in the DR process.

It appears that since about 2005 a formal internal review process was in place (ORAUT-PROC-0059). The case specific comments (Form 41 comments) do not appear to be included within the case file – these are internal ORAU documents. It is clear that these comments are considered in aggregate and improvements in the tracking system and feedback process have been made. It seems that the database tracking this information is internal to ORAU. It is clear, based on a presentation to the ABRWH DR subcommittee [23], that this information is considered and used to make improvements in the dose reconstruction program.

Recommendation 7

It is recommended that a tracking mechanism should be developed, to the extent possible, to consider findings / comments from all reviews (Peer review, NIOSH review, ABRWH review, other?), in an aggregate fashion, for purposes of improving dose reconstruction methods and particularly, as it relates to this report, for improvements in assuring consistency in areas of professional judgement.

Recommendation 8

For cases where a 'significant' amount of professional judgements were necessary, it may be useful to have additional level of review prior to finalizing the case. ORAU has indicated that since 2012 they have required a second peer review for all cases with POC between 40% and 52%. Based on PROC-0077 NIOSH conducts an extensive review on 5% of all cases (randomly selected from NOCTS). NIOSH may want to consider a biased sampling approach to select a greater percentage of the best estimate type cases.

Use of CATI information

Observation 9

The current approach requires the dose reconstructor to consider all incidents or accidents mentioned by the claimant in completing the dose reconstruction. In the course of this review ORAU commented that "the presence of enough technical information to address an incident in detail is unusual" and that "the ORAU Team uses the best information available from the claim files and the interviews, but most mentions of incidents are usually generic in nature and cannot be specifically assessed without further technical information." While this is understandable, it is worth noting that in the course of this assessment a dose reconstruction was identified in which an individual described a period of neutron exposure and although the claimant had no recorded neutron dose for that time period the initial DR report included an estimate of missed neutron dose from this activity that was much greater than the missed dose that would have been assigned. It may be useful to know whether others were involved in this job during

[23] ORAU presentation to the ABRWH DR subcommittee, Nov 2012 PR Process Evolution and Stats_final (003) (Powerpoint presentation)

this specific time period. I believe this information, while often lacking the desired detail, may be useful if it is possible to extract such information without too great of a burden and consider it in aggregate. Further, in querying specific job types, I identified a great deal of CATI reports with detailed accounts of events / incidents (often with specific buildings and time periods). This likely is not the case for many of the CATI reports but consideration of this information in aggregate may provide valuable and useful information.

Recommendation 9

NIOSH and ORAU may want to consider the use of CATI interview information and outreach information (information obtained from outreach meetings and employee / expert interviews conducted by SC&A and NIOSH) in aggregate form. Perhaps a pilot test (perhaps based on looking at data provided by a certain sub-group of claimants from a site)[24] can be done on one site to consider feasibility of extracting such data and is utility in the overall dose reconstruction program.

Savannah River Site Dose Reconstruction professional judgement areas

Overall Approach for Assessment

The focus of this site review was to review the DR process from the initial claimant interview through internal review to final reworks if needed. This review required review of all relevant Technical Basis Documents, Technical Information Bulletins and procedures (both site specific as well as many of the overarching documents (e.g., OCAS-IG-001 – External Dose reconstruction, OCAS-IG-002 – Internal Dose reconstruction, ORAUT-OTIB-0060 – Internal Dose Reconstruction)) and review of SC&A review documents for the site specific procedures and technical basis documents and SC&A case reviews done in support of the Advisory Board on Radiation and Worker Health (ABRWH). Additionally, the review involved a detailed examination of the internal guidance documents associated with the example sites ("DR guidelines" for SRS site).

In the course of this assessment dozens of cases were reviewed first to review calculations associated with the fairly complex dose reconstruction process and then to focus on areas where professional judgements are necessary and the measures which are being taken and can be improved on with regard to assuring consistency in these areas. The cases were selected from a query of primarily best estimate cases from the NOCTS database, from the ORAU QA database (which identified cases with technical errors – 2012 – 2016), from findings from earlier reviews (2002-2003) and from cases reviewed by the ABRWH. The majority of the cases, especially for the SRS review, were best estimate type cases (several 'full internal and full external' cases were reviewed and found not to be best estimate cases – defined as cases falling between 45-52 percent POC) since it was evident that the individual professional judgements would be most relevant for these cases.

The assessment also included:

- Attendance at multiple ABRWH meetings (both in person and telephonically) to gain a current understanding of the issues of concern to the Board.

[24] During this assessment (SRS assessment) a sub-group of claims was identified that appeared to have significant information within section 9 of the CATI reports (accident and incident information).

- Review of transcripts from several dose reconstruction subcommittee meetings and methods workgroup meetings
- Review of comments made in relation to the 10 year review (in NIOSH Docket)
- Discussions with ORAU and NIOSH staff (related to site specific comments as well as broader issues)
- Source documents form the site research database
- External reports, including the NRC review of the NDRP program
- More than 100 SRS CATI interview reports.

Reviewed dozens of cases from NOCTS query of best estimate cases, from ORAU QA database (Excel post 2012 dbase), from NIOSH comment spreadsheet from early years (2001-2003), and from cases reviewed by the ABRWH to first perform detailed reviews of all calculations associated with the detailed dose reconstruction process for best estimate cases at SRS and then to identify areas where professional judgements may affect consistency of the dose reconstructions.

SRS Dose Reconstruction Process

Preparation of Electronic Files

ORAU has two data entry teams – one for external and one for internal dose data. Data is entered into site specific templates (external and internal). After entry is complete the data entry is reviewed by another member of the data entry team. QA / QC of data entry in further described in Attachment 1.

Preparation for DR

ORAU staff person assigned to the case (DR) will review information on job descriptions, facilities, dates, and related dosimetry data. In the overview presentation[25] it was mentioned that for more complicated cases the DR may develop a timeline. ORAU later clarified that this was not required and that there wasn't a standardized format for such a timeline.

One very important part of this phase is determining work location as a function of time worked at the site. DR guidance provides instructions on making this determination. The primary data used in this determination is the HP codes on external dosimetry records, work locations on bioassay records, and locations reported during CATI interview along with other records in DOE files (incident reports, etc.). HP Codes and associated buildings / areas are listed in ORAU-OTIB-81 (rev2). This is one of the areas where judgement is required – decisions on location can have an effect on both external and internal dose assigned. It is unclear how discrepancies between HP codes and CATI information are resolved. The HP codes are associated with buildings / areas, not job, and it is not clear whether individuals may have been assigned a badge in a certain area but worked in other areas during that badge cycle. It is therefore unclear how and whether an assignment to a HP code for a certain area would have limited the individual's exposure solely to that area.

ORAU clarified the means for resolving discrepancies as follows:

> "The DR takes all information into account and applies the most claimant-favorable location when conflicts or overlap arise. Determining the work locations when the CATI indicates the EE worked

[25] Presentation by ORAU staff outlining the SRS DR process

all over the site or that the EE worked in certain areas but no date information is provided or the CATI information does not line up with the actual records, becomes more involved. The DR reviews the available sources of information; telephone interviews, DOL documents (Employment History for a Claim under the EEOICPA, EEOICPA Occupational History Interview, etc., i.e., anything that might provide more information on where the EE worked) external dosimeter records, internal bioassay records and incident report records. Once all of the available information is collected, the DR applies a claimant-favorable determination based upon information considered. For example, if the EE was a production operator and the records indicated he worked in the 221 FB-line for one year but no other information was provided for several years, the DR may look to see if the EE was routinely internally monitored for the same nuclides. This may help the DR determine the EE worked in the same location. But if the bioassay records are limited, it would be claimant favorable to assume the EE continued working in the 221 FB-line (as compared to the 200 Area) based on the knowledge of the partitioning of the dose for the photon/neutron energy ranges. If the EE had significant external dose when working in the 221 FB-line area but then the doses dropped in the subsequent years, then the DR may assume the 200 F area a more reasonable assignment for the subsequent years. The DR must use professional judgement in making the work location/facility determination and be able to support the decision based on a summary of the available (or lack of available) information.[26]"

This explanation seems to be much more specific then what is provided in the DR guidance and it may be useful to consider adding some of this information to the guidance. This also seems to make a strong argument for including a timeline within the case file to precisely document the basis of for these determinations.

The procedures do allow for follow-up with the claimant regarding work activities. It is unclear how often this is done although the sense was that it was unusual. The CATI also includes a field where the claimant can provide information on other people who may have useful information about the claimant's job, work activities or exposures. It is also unclear how often this is done but it appears this is not done very often.

External Dose Assessment

The details of executing the calculation of the external dose to an individual claimant is described in the DR guidance document (most recent document reviewed for this assessment was from 8/2/2016). The parameters essential for determining organ doses from the raw data in the individual's dose files are included in section 5 of the SRS Technical Basis Document (ORAUT-TKBS-0003, revision 3), the External Dose Implementation Guide (OCAS-IG-001), the Interpretation of External Dosimetry Records (OCAS-OTIB-006), neutron dose reconstruction (OCAS-OTIB-007) and Interpretation of dose data for assignment of shallow dose (ORAUT-OTIB-0017).

The dose reconstructor first verifies the data entry files against the data in the DOE files and other claims documents. Other data can include monitoring data found within the supplied DOL file, claimant-supplied data, and other records found in the Site Research Database (SRDB) that are linked to the employee.

[26] Comments provided by ORAU to preliminary summary draft SRS report, February, 2017.

1. Reconciling Personal dose records

At this point in the process the individual dose reconstructor has to consider all of the personal external dose records. These raw records often require adjustments before they can be used to calculate the organ dose of interest for the final dose reconstruction.

For SRS the important guidance documents for this step include:

ORAU-TKBS-0003 (SRS Technical Basis document)
OCAS-TIB-006 (Interpretation of External Dosimetry Records – 73-88)
OCAS-TIB-007 (Neutron Exposures at the Savannah River Site)
DR guidance document (internal guidance documents – specific version used is included with each case file)[27],

As is outlined in the SRS DR Guidance document the records used to determine external dose include the following:

- Handwritten records (through 2nd quarter of 1958); included photon, beta and neutron doses in separate columns;
- Computer generated reports (1958-1963); tritium and neutron doses identified by specific codes;
- Computer reports (1963-1972); whole body dose reported in cycle data includes photon, neutron and tritium doses.
- Computer reports (1973-1988); tritium and neutron doses may or may not be separated out in the cycle data (OCAS-TIB-006 gives specific guidance on interpretation of results from this time period);
- Health Protection Annual Radiation Exposure History (HPAREH) database was developed in 1980 and includes annual dose reports. In 1989 this system was transferred into the Health Protection Radiation Exposure Database (HPRED)[28].

Dose reconstructors must resolve discrepancies in the annual reported doses (HPAREH) and the cycle data (involves separating out the tritium and neutron dose from photon doses). After reconciling the summation of the cycle doses and annual doses (considering tritium and neutrons) the dose reconstructor must address any differences. The approach for resolving these discrepancies is detailed in the DR guidance. An excerpt of the DR guidance document (6/27/2016) outlines the process for making these determinations (see below). The detailed instructions (and incorporation within the workbooks) provide a level of assurance that the issues are being handled in a consistent fashion. These professional judgements, as detailed in the technical basis documents, technical information bulletins and DR guidance documents put the decisions or judgements more in the hands of the program as opposed to the individual dose reconstructor. These 'program judgements' are reviewed extensively by the ABRWH through the

[27] DR guidelines are included with case file materials (this has been the practice at least for the past several years). It should be noted that the guidelines have been modified fairly frequently (16 in the last 7 years). ORAU noted that "When the SRS TBD is updated, it will include the information from the DR Guidance Document. The SRS TBD update will initiate the PER that covers the changes in the methods that result in potential increased dose." (ORAU comments, February, 2017)

[28] A History of Personnel Radiation Dosimetry at the Savanah River Site, Taylor et al, 1995.

procedures review subcommittee, the dose reconstruction subcommittee, and site specific workgroups (which are focused on the review of site specific guidance documents and review of NIOSH reports on Special Exposure Cohort petitions).

DR Guidance States[29]:

> *"HPAREH may not always be easily reconcilable with the routine monitoring cycle data for photons, electrons, and neutrons. There are a number of reasonable explanations, including the fact that the results of dose investigations may add or remove dose from the cycle results."*
>
> *"The tritium dose was typically, but not always, included in both the deep and shallow doses recorded on the cycle data sheets." "A pattern in the inclusion of tritium dose in the records was not observed, so the Dose Reconstructor will need to determine if the tritium dose needs to be subtracted from the cycle data."*
>
> *"Neutron doses, like tritium, are sometimes included in the cycle deep and shallow dose. These must also be identified and subtracted out in a manner similar to that done with tritium. There may be a situation with a minimal photon dose and a measured neutron dose (due to shielding material that works great for photons but is essentially worthless for neutrons). However, if neutron exposure > 0.100-0.200 rem and a zero photon dose then this might indicate a situation similar to a lost or missing dosimeter (for gamma dose). In this case, it may be appropriate to assign coworker photon dose or assign photon dose based on adjacent monitoring."*
>
> *"After the sum of the cycle doses for a given year has been reconciled with the HPAREH dose for that year regarding tritium and neutron dose, the dose reconstructor should address any further differences as follows":*
>
> *<u>For non-compensable cases</u>:*
>
> *-If the sum of the cycle doses is greater than the HPAREH dose for any given year, no further action by the dose reconstructor is required as the higher cycle doses are used for calculating the external dose. This is claimant favorable. The dose reconstructor should note any differences in the comments on the cycle worksheets.*
>
> *-If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor will insert the difference in the appropriate column on the cycle data sheet and note/justify the dose entry to match HPAREH in the comments.*
>
> *<u>For compensable cases:</u>*

[29] SRS DR guidance 6/27/2016.

-If the sum of the cycle doses is greater than the HPAREH dose for any given year, the dose reconstructor may subtract the dose difference so that the sum of the cycle doses match HPAREH, and note/justify action in the comments.

-If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor may leave as is (an underestimating action). The dose reconstructor will note/justify this in the comments section of the cycle worksheet.

For best-estimate cases:

-Use professional judgment and a combination of the above to reconcile differences between HPAREH and cycle data. For non-compensable best estimates, favor the guidance for non-compensable cases; likewise for compensable best-estimates. The dose reconstructor must annotate the cycle data sufficiently to justify reconciling HPAREH and cycle data." (underlined text added for emphasis)

2. Estimating the number of 'zero' dose cycles for purposes of estimating potential missed dose

The DR guidance outlines different approaches, depending on the specific circumstances, for estimating the number of zero dose cycles.

- According to the DR guidance when only annual summary data is available the DR should *"estimate zeros as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001)."*

- For the early years, handwritten records through 1958, the DR should input the actual number of zero dosimeter results recorded.

- For computer records from 1958-1963 the DR guidance prescribes the following approach "*if the cycle is shown and the dose is blank, assume a zero dosimeter result. If no cycle shown, assume not monitored or monitoring continued on same dosimeter to next listed cycle. This is easiest to justify if all the listed cycles have a temporary or visitor badge designation/code."(emphasis added)*

- For computer records from the 2nd quarter of 1963-1972 the DR guidance prescribes the following approach, *"zero dosimeter results may be estimated in the same manner as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001), except that the prorated Site administrative control limit would be applied over each cycle in the quarter rather than the year."*

- For computer records from 1973 to 1988 the dose reconstructor is instructed to use guidance detailed in OCAS-OTIB-006, Interpretation of External Dosimetry Records at the Savanah River

Site.

- For records after 1988 the DR guidance instructs that the "*number of zero dosimeter results assigned is the actual number of zero dosimeter results in the record (with the removal of any duplicated zeros assigned for the same dosimeter exchange cycle). For 1989 and later it is generally assumed all employees that needed monitoring were monitored." (highlighting added)* The DR guidance includes an important note regarding potential gaps in monitoring records after 1989 which is important for the estimation of missed dose (discussed in section 3, below).

- For dose records after 1993 the SRS DR Guidance document indicates that "*Based on site information, (SRDB Ref ID10931; A History of Personnel Radiation Dosimetry at the Savannah River Site [WSRC-RP-95-234 (Taylor et al. 1995)]) quarterly monitoring was started in January of 1994. For this time period and later, based on the exposure potential of the worker, both monthly and quarterly monitoring may have been used. Therefore, it is not uncommon to see a mix of monthly and quarterly monitoring within a single year for a worker. If the monitoring records are complete, but there are periods where the worker was unmonitored, then assign ambient dose (prorated as appropriate). " (highlighting added)*

3. Estimation of External Dose for unmonitored periods

The primary judgements for the dose reconstructor is to determine what method is appropriate for estimating unmonitored periods in the workers dose records. Five general approaches are available:

1. Estimate missed cycle dose by using the limit of detection (LOD) for radiation type and time period (LOD/2 approach),
    - Many cases reviewed during the assessment used this approach
2. Estimate a gap in records by assessing doses prior to and after the gap (usually used for short gaps in the records),
    - 6 cases reviewed used this approach (5 with POC < 50%, 1 with POC > 50%)[30]
3. Use co-worker data to estimate the dose (involves judgement of whether to use construction trade worker (CTW) coworker data or non-construction trade worker data,
    - 9 cases reviewed used coworker data for a portion of the Dose Construction (both non-construction trade worker and construction trade worker)[31]
4. Use ambient data (used for individuals judged not to have required monitoring) and,
    - Method was observed; number of cases was not tracked.
5. Use of neutron / photon ratios[32] to estimate neutron doses.

[30] Case references – B, D, E, L, and M and H.

[31] Coworker doses based on OTIB-0032. All cases used 50th percentile. Case references – A,B,C,D,E,F,G, I and K. One case originally used coworker as an overestimating approach; rework did not use coworker dose – case was >50%. One case used coworker data for final DR and case had a POC > 50%. All others had POC < 50%.

[32] SRS Technical Basis Document, ORAU-TKBS-0003, revision 3, Table E-9.

- 2 cases reviewed used n/p ratio to estimate a portion of neutron dose[33]

The DR guidance includes instructions to assist the dose reconstructor in selecting the most appropriate approach and in how the approach is to be implemented. The specific information regarding the limits of detection (LODs), the applicable annual ambient dose and the annual coworker doses at the SRS site are included in the technical basis documents (ORAUT-TKBS-003, revision 3) and technical bulletins (OTIB-0032 – coworker model) and also are included in look-up tables within the dose reconstruction workbooks.

Some of the specific methods for certain time periods include:

1. For the period between1963-1972 the method for estimating missed dose based on the number of zero dosimeter values is rather complicated since only the quarterly dose is known – not the dose for each dosimeter cycle. The estimation, in accordance with OCAS-IG-001, is therefore based on the recorded dose, the number of dosimeter cycles per summary period (quarterly in the case of SRS), the administrative quarterly limit, and the limit of detection for the dosimeter. OCAS-IG-001, section 2.1.2.3, describes the approach as follows:

   > *"When the number of zero measurements cannot be determined, the missed dose becomes more complicated. When only the annual dose is known, the number of zero doses should be estimated based on the dose level and the monthly, quarterly, or annual limits for that year, and the number of possible zero monitoring intervals. This would be the situation, for example, if an individual received a cumulative dose of 2140 mrem in a given year, at a facility that had a monthly monitoring frequency and the maximum permissible exposure limit was 1000 mrem per month. The minimum number of months in which this dose could have been received is 3. Therefore, the maximum number of missed dose months would be 9, and the minimum would be 0 since the dose could have been received evenly throughout the year. The central estimated number of months would be the median or 5, however the upper bound would be 9."*

   All of this information is available within a table in the dose calculation workbook therefore assuring consistency. There is one selection that the individual DR staff person has to make and that is whether to choose a 'reasonable' estimate of the dose associated with possible zero cycles or to choose a 'best estimate' approach. The 'best estimate' (derived based on an average of the site limits and detector limits of detection[34]) choice results in a slightly lower annual missed dose. The 'reasonable' estimate (which is derived by evaluating against the site limits[35]) results in a slight overestimate of missed doses associated with unknown cycle doses and should be used only as an overestimating technique.

2. The DR guidance notes that "for 1989 the records routinely do not include monitoring results for the first 3 monthly (1st Quarter) badge exchanges. It is a reasonable assumption the site did not routinely

[33] One case used the 95th percentile value, one case used the 50th percentile value. Both cases had a POC < 50%.
[34] ORAU Team comments, November 3, 2017.
[35] ORAU Team comments, November 3, 2017.

report zero results as described in OCAS-TIB-006 until the 4th month (2nd quarter) of 1989. Adding zeros per the short term gap guidance may be required".

a. "If short gaps (3 months or less for monthly monitoring or 1 quarter for quarterly monitoring) in the individual's dosimetry records exist and is bounded on both ends by dosimetry data, then the individual's adjacent monitoring data should be used to fill in the gaps in their dosimetry data. The gap dose can be interpolated by a simple average between the two monitoring periods. There may instances where the averaging of the two adjacent cycles may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc."

b. "If large gaps (greater than 3 months for monthly monitoring or greater than 1 quarter for quarterly monitoring) in the individual's dosimetry records exist or the period is not bounded by dosimetry data, then, depending upon the circumstances, external coworker dose data (through 1999), or ambient dose data should be used to fill in the gaps in their dosimetry data. There may instances where the assigning of coworker dose may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc. This approach may be used for gaps greater than 1 quarter, up to 6 months." (highlighting added)

c. "The DR should always explain the gap fill-in approach used in the DR report."

Use of Coworker data

The use of external coworker data is detailed in three technical information bulletins: ORAU-OTIB-0020, ORAU-OTIB-0032 and ORAU-OTIB-0052.

External coworker data can be used for un-monitored workers or possibly for gaps in an individual's records. The general approach is implemented in accordance with ORAU-OTIB-0020, "Use of Coworker Dose Data for External Dose Assignment,". Section 6 states "data are presented in a table in each site-specific external coworker TIB as 50th- and 95th-percentile annual penetrating and non-penetrating doses for monitored workers. These doses, together with the application of dosimeter bias factors and organ dose conversion factors as described in Section 3.0, are intended to represent reasonable estimates of doses for workers who were not monitored. Also as described in Section 3.0, the 50th-percentile doses should be applied if the worker was likely exposed intermittently, and the 95th-percentile doses should be applied if the worker was likely exposed routinely. External onsite ambient doses should be used instead of external coworker doses if the worker was unlikely to have been exposed. Doses should be prorated, as appropriate, to account for partial years of exposure."

ORAU-TIB-0032, revision PC-1, has the data available for worker and construction worker penetrating and non-penetrating coworker doses from 1952 through 1999 (not intended for use in best estimate cases – see further discussion below). ORAU-TIB-0052 gives guidance on correcting coworker dose assignments for construction trade workers. An approach for determining whether a worker should be classified as a construction trade worker for purposes of assigning external and internal coworker doses is included in ORAU-OTIB-0081, rev 3, section 3.2.2. The following excerpt is from the DR guidance:

> *If large gaps (greater than 3 months for monthly monitoring or greater than 1 quarter for quarterly monitoring) in the individual's dosimetry records exist or the period is not bounded by dosimetry data, then, depending upon the circumstances, external coworker dose data (through 1999), or ambient dose data should be used to fill in the gaps in their dosimetry data. There may instances where the assigning of coworker dose may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc. This approach may be used for gaps greater than 1 quarter, up to 6 months*

After the initial assessment ORAU clarified that although the DR guidance (version 6/26/2016) seemed to suggest that the coworker data should only be used after 1989 this was not the case. ORAU indicated they modified the DR guidance to clarify this point. ORAUs comment was as follows:

> *"Although the DR Guidance document only mentions 1989 and later, it was not meant to indicate NOT to assign coworker doses prior to that time. This was included for this time period, because of the type of records at this point and to specifically address this period. The DR Guidance Document has been updated to clarify that coworker can be applied in all years it is available when it is appropriate.[36]"*

ORAU-OTIB-0032 "External Coworker Dosimetry Data for the Savanah River Site," provides information "to allow ORAU Team dose reconstructors to assign doses to Savannah River Site (SRS) workers who have no or limited monitoring data, based on site coworker data. The data in this TIB are to be used in conjunction with ORAUT-OTIB-0020, "Use of Coworker Dosimetry Data for External Dose Assignment."[37] Section 3 notes that the external data included in ORAU-OTIB-0032, rev PC-1 is not intended to be used for best estimate cases:

> *"As described in ORAUT-OTIB-0020, the general approach to developing coworker data for cases without external monitoring data involves two phases. The first*

[36] ORAU comments on preliminary SRS summary report, February, 2017. It is also noted that several of the cases identified during this review did apply coworker doses for years prior to 1989 (see case numbers in footnote 21).
[37] ORAU-OTIB-0032 Rev PC-1, page 4.

(Phase I) permits cases to be processed when a "best and final" estimate of dose is not required for claim determination. The second (Phase II) facilitates the assignment of "best and final estimates" of dose, when necessary. This initial revision of this TIB provides coworker external dosimetry summary statistics applicable to Phase I dose reconstructions; coworker dose distributions applicable to Phase II dose reconstructions will be made available in a subsequent revision.[38]"

ORAU-OTIB-0052 provides guidance for dose reconstructions for unmonitored construction trade workers (CTWs). ORAU-OTIB-0052 states that the dose reconstructor should "use the guidance in ORAUT-OTIB-0020 (ORAUT 2011a) to assign a penetrating dose that is favorable to unmonitored CTWs. Apply an adjustment factor of 1.4 to the appropriate percentile of the measured coworker data for the site, plus the assigned coworker missed dose, to determine the total assigned penetrating dose that is favorable to unmonitored CTWs.[39]"

4. Radiation Type, Energy Distribution, and Dose Conversion Factors

ORAUT-TKBS-0003 Table E-2 specifies the photon and beta energies and fractions to be used for various areas over time at the SRS site. Table E-3 specifies neutron energies and fractions to be used for various areas over time at the SRS site and Table E-5 includes an ICRP-60[40] correction factor for associated neutron energy levels. Table E-4 includes dosimeter specific calibration correction factors for beta/photon dosimeters. Other factors necessary for calculating organ doses (organ dose conversion factor, geometry factors) are included program wide guides and site specific guidance (External Dose Implementation Guide – OCAS-IG-001, SRS DR Guidance). Guidance is also available to correct doses for workers involved in glovebox work (DCAS-TIB-0010, revision 4).

OCAS-OTIB-006, "Interpretation of External Dosimetry Records at the Savanah River Site," (section 3) and ORAUT-OTIB-0017, revision 1, "Interpretation of Dose Data for Assignment of Shallow Dose," (post 1982) gives specific guidance for interpretation and dose assignment for measured and missed shallow dose. Photon and beta energies and percentages for use in calculation of shallow dose are included in the Technical Basis document, Table E-2. OTIB-0017 also provides specific information for estimating 'zero' dose cycles when the open window (OW) measurement is zero, when the shielded (S) measurement is zero, or when both are zero. Skin doses may also be adjusted based on the location on the body (for example, a clothing attenuation factor may be applied for skin cancer sites that would likely be under work clothes) or based on specific information in an incident report (reported contamination levels in area of cancer site).

[38] ORAU Team clarified this in the following response: "At the time that OITB-0032 was written it was believed that initially only a 50% and 95% coworker dose would exist (Phase I), but later revisions would be more refined. Phase I and II were removed with the revision of OTIB-0020 and this should have been propagated into OTIB-0032. Coworker values can be used for compensable claims in accordance with Section 7.0, but this could be made clearer.", ORAU Comments, November 3, 2017.

[39] OTIB-0052, revision 2.

[40] ICRP 60, 1990 Recommendations of the International Commission on Radiological Protection.

OCAS-OTIB-007, "Neutron Exposures at the Savanah River Site," along with ORAUT-TKBS-003, "SRS Technical Basis Document," give specific guidance for estimation of neutron doses. Prior to 1971 neutron dose may be included in the individual's dose records. If unavailable prior to 1971, neutron dose may have to be estimated based on neutron photon ratios (Technical Basis Document, Table E-3 and E-5). ORAU noted that "neutron monitoring was consistent when required after 1971." This seems to suggest that a neutron / photon ratio approach would not be required after 1971 and is consistent with ORAU-TKBS-003, Section E.4.1.7 which says that "following the implementation of the TLND on January 1, 1971 recorded neutron dose has been reasonably accurate. As such, OCAS-IG-001 guidance on missed dose should be followed in accordance with the LOD values presented in Table E-10." (emphasis added)

DR is to use the TBD, OCAS-TIB-007, and work locations from individual's records to determine work locations and the neutron exposure characteristics for each work area. The dose reconstructor may also need to determine whether an individual should have been monitored for neutrons based on work location, year, and job description to determine whether to assign neutron dose. Dose reconstructor may also need to determine whether to use the recorded neutron dose or to assign a neutron dose based on estimating the dose by using a neutron / photon ratio (from TBD or possibly an n/p ratio calculated from other years within an individual's dose records).

The dose reconstuctor uses available records (badge codes, work history information, other dosimetry or incident records, CATI information) to determine the appropriate work area. Selecting the incorrect area only have a small effect on overall dose reconstruction however for best estimate cases this could be important.

It is unclear how discrepancies between records (for example badge codes and interview records) are resolved for the determination of work location – especially for best estimate type of cases. In many instances workers will report that they worked all over the site. In underestimate or overestimate cases this type of general information does not pose a problem however, for best estimate cases it is unclear how or if this information could be used by the dose reconstructor.

Additional recovered data, as recovered, is added to claimants file. Again, the higher value, new data vs. original data from claimants records or derived from n/p ratio should be assigned for purposes of dose reconstruction. This appears to be documented in the case file and the dose reconstruction report however it is unclear whether these discrepancies are tracked to determine the frequency of these types of discrepancies and to assess possible trends.

External Dose Judgements

As can be seen in this section, for External Dose Assessment the Technical Basis Document (ORAU-TKBS-003), the Technical Information Bulletins (OTIB-0020, OTIB-0032, OTIB-0081 and OTIB-0052) and the SRS DR Guidance documents provide the dose reconstructor with specific instructions for estimating external dose from available measurement data and for unmonitored periods. Some critical areas of judgement remain in the hands of the individual reconstructor including:

1. Determining how to reconcile discrepancies between annual dose data and cycle data.

2. Determining the work area and type of work over time (important for energies and fractions to use and possibly to determine if unmonitored dose (such as neutron dose) should be assigned, and to determine if a glovebox correction factor is appropriate,
3. Determining if and when to use coworker dose (data set currently not available for SRS best estimate cases),
4. Determining which coworker data set to use (50^{th} percentile, 95^{th} percentile),
5. Determining whether to use coworker data corrected for construction trade workers (CTW[41]),
6. Determining whether it is appropriate to use ambient data rather than coworker data for worker assumed to have not required monitoring,
7. Determining if it is appropriate to fill short gaps in dose records based on personal records prior to and after the gap ('nearby approach'), and

Finally, it should be noted that the specifics with regard to dose reconstruction are included in the workbook, reducing chances of mistakes in data entry or mistakes in some rather complex approaches for estimating missed external dose based on the number of estimated 'zero' data cycles. This use of the workbooks certainly is a measure that has resulted in reduced quality control types of errors however, the above judgements can still have a significant impact for best estimate cases and there is a need to assure, to the extent possible, that consistent approaches are being implemented. Additionally it should be noted that the ORAU team performs a two person peer review on all best estimate claims and consults with NIOSH to clarify technical approaches and in cases where there may be a need to contact the claimant for additional information[42].

Internal Dose Assessment

The primary guidance documents for executing the calculation of the internal dose at SRS to an individual claimant is described in Section 4 of the SRS Technical Basis Document (ORAUT-TKBS-003, revision 3), the Internal Dose Implementation Guide (OCAS-IG-002), the Internal Dose Reconstruction Technical Information Bulletin (ORAUT-OTIB-0060, revision 1), and the SRS DR guidance document (most recent document reviewed for this assessment was from 8/2/2016). The parameters essential for determining organ doses from the raw data in the individual's dose files are included in section 4 of the SRS Technical Basis Document (ORAUT-TKBS-0003, revision 3) and the SRS DR Guidance.

The dose reconstructor first verifies the data entry files against the data in the DOE files and other claims documents. Other data can include monitoring data found within the supplied DOL file, claimant-supplied

[41] Guidance included in ORAU-OTIB-0052, ORAU-OTIB-0081, and OCAS PER-014 to determine if certain job titles should be considered CTW jobs.

[42] ORAU commented as follows: "It is important to note that ORAUT performs a two-person peer review on all claims that fall into the 'close to compensable' category. The purpose of these reviews is to ensure the items in the 'critical areas of judgement' are discussed in the DR report and are as accurate as possible. In addition, ORAUT staff do consult with DCAS during the DR process to clarify technical approaches or determine the need to contact claimants for additional information. This process has occurred several times over the past two years with SRS claims." ORAU Team comments, November 3, 2017.

data, and other records found in the Site Research Database (SRDB) that are linked to the employee. The next step is to determine positive bioassay values and values below the minimum detectable activity (MDA) for the given type of measurement. Guidance to assist in making this determination is included in the Technical Basis Document (default MDA values or reporting levels are included in Tables D-1 (bioassay), D-2 (whole body counting) and D-3 (chest counting)) and in SRS DR Guidance document. MDA values may also be reported within the individual's personal records in which case those MDA's should be the values used (take precedence over site default values). The SRS guidance document points out that in some instances (e.g., Tritium) the site may have used a Reporting Level (RL) which is greater than the Minimal Detectable Activity (MDA). As the Guidance states:

> "In some instances, a site may apply a *reporting level* that is greater than the MDA. This is most common when the nuclide is easily detected, such as H-3, and a result at the MDA produces a very small dose. In such cases, only measurements with values exceeding the reporting level are recorded in the employee files, i.e., results between the MDA and the reporting level are recorded as "0" or "<" the reporting level, and the reporting level becomes the MDA by default. A missed dose would be based on the value of the reporting level rather than the MDA.[43]"(emphasis added)
>
> The DR Guidance documents includes some specific information on particular reporting practices for certain types of measurements over time which are essential in determining the value to be used for estimating missed dose. The SRS Guidance documents along with the Technical Basis document also include information essential for normalizing bioassay records (for instance, the units used for certain records (dpm/1.5 Liters, pCi/liter) and how to translate gross alpha measures to nuclide specific values).

Internal Dose Assessment

For each radionuclide that the worker was monitored for the dose reconstructor calculates a dose associated with positive measurements by fitting the data and deriving an estimated intake(s) and then calculating a dose using IMBA Professional software (Integrated Modules for Bioassay Analysis). The dose reconstructor uses a similar approach to estimate potential missed dose based on non-detectable values (less than MDA or RL). Finally, for best estimate cases, the doses are compared on an annual basis and the greater value is assigned for each year.

The overall process for performing internal dose reconstructions is detailed in the Internal Dose Reconstruction Technical Information Bulletin (ORAUT-OTIB-0060, revision 1). This bulletin provides the reconstructor with general guidance including guidance on analysis of types of bioassay, fitting of bioassay data and parameter selection (particle size, solubility, etc.).

OTIB-0060 provides detailed guidelines for calculating missed doses including how to perform this calculation when the threshold (MDA or RL) changes over the time period during which the worker was monitored (lower MDA as measurement techniques improved or fluctuations in MDAs in personal bioassay records).

The TIB also gives guidance on when to include missed dose, as follows:

[43] SRS DR Guidance 8/2/2016, page 8.

"By itself, lack of sampling for extended periods is an insufficient reason for assuming a change in exposure potential. If the three listed items[44] do not change during an individual's employment history but there is information that indicates a potential for intake at some point (e.g., bioassay data or job title), a potential for intake must be assumed for the entire employment period. In some cases, the assignment of environmental intakes only is appropriate." (emphasis added)

Radionuclide Specific Guidance

For best estimate cases tritium dose is assigned based on the claimant's tritium bioassay data (using OTIB-0060, OTIB-0011, ORAU-TKBS-003, revision 3 and SRS DR guidance). It is assumed, because of the inexpensive nature of tritium urine sampling, that all SRS workers were monitored when required[45]. Therefore, unmonitored periods are assessed using environmental levels (defined in ORAU-TKBS-0003, Attachment C) or missed dose levels[46] (cases where individual was monitored for external exposure and has no tritium records). Coworker data is also available, as an option for dose reconstructor and is included in ORAU-OTIB-0081, "Internal Coworker data for the Savanah River Site" (latest revision is revision 3)[47]. ORAU-OTIB-0081 is still being discussed in the SRS Work Group and has not been fully implemented pending the Board's resolution[48].

Assessment of Fission Product doses is detailed in the Technical Basis Document (ORAUT-TKBS-0032, revision 3) section 4.4.1 and 4.4.2. If personal data is available the results are assessed in accordance with the technical basis document section 4.4.1 (pages 69-70) and ORAU-OTIB-0060. To estimate missed doses the dose reconstructor must first determine whether the individual was a 'reactor' worker or a 'non-reactor' worker. For non-reactor workers with fission product urine sample results (and no whole body count results) technical basis document Table 4.4.2-6 or Table 4.4.2-7 can be used as an upper bound approach. For reactor workers with fission product urine samples (and no whole body count results) the guidance indicates assignment of fission product annual dose equal to tritium doses since tritium doses were assumed to dominate internal doses in the reactor areas[49]. When whole body count data is available

[44] OTIB-0060 notes that "the presence of bioassay samples is often an indicator of potential for exposure, but if there are only baseline and termination samples (i.e., no other bioassay), they do not necessarily indicate a potential. Indicators of potential for internal radiation exposure include the following: Job title, Work location, and External dose. These are the three items mentions in this excerpt.

[45] ORAU powerpoint presentation, April 6, 2016. This was also mentioned in the April 28, 2016 ABRWH Dose Reconstruction Subcommittee meeting, as follows: "… the current guidance that we use in dose reconstruction is that Savannah River monitored people generously for tritium. And if there's a year that's missed, that's because that person was probably reassigned that year and not in a tritium area. And that is a question that Work Group for Savannah River is considering during their debate." (pages 56-57 of transcript)

[46] SRS DR guidance includes dose information to be used when default MDAs (not individual specific) can be assumed.

[47] ORAU-OTIB-0081, revision 3, Table 5.2 includes coworker doses (50^{th} and 95^{th} percentile) to be assigned for construction workers and non-construction workers.

[48] ORAU noted that OTIB-0081 (revision 2) had been used for short periods (less than one year) where available bioassay data resulted in implausible intakes. ORAU powerpoint presentation, April, 2016.

[49] SRS DR Guidance (8/2/2016).

it is used (takes precedence over urine sample data) for the estimation of fission product dose. The SRS DR Guidance document specifies:

> "Negative results (missed dose): use SRS Att D Radionuclide Chooser 1.10.xls Tool to identify representative fission/activation product and Absorption Type. Do NOT assign intakes of short-lived fission products after 12/31/1989 since the last reactors (K and P) quit operations about a year before that. These include: Mn-54, Zn-65, Zr-95, Nb-95, Ru-106, Ba-140, La-140,* Ce-144, Cr-51, Fe-59, Ag-110m, and Na-24. For periods after 1988, RadChooser will have to be run separately using only the MDAs for Co-60, Cs-137, and Eu-154."

For dose assessment of Plutonium, Uranium and Americium for periods when an individual was monitored the dose reconstructor uses guidance in the Technical Basis Document, ORAU-TKBS-003, revision 3, Section 4.1. Table 4.1.1-4 includes information on MDAs for Uranium, Tables 4.1.1-1 and 4.1.1-2 include information on MDAs for plutonium in-vivo and in-vitro analysis and Table 4.1.1-3 details the activity composition for reference 6% and 12% Pu-240 mixtures[50]. The Americium 241 builds up from near zero after initial irradiation of the uranium (known as 'Fresh' mixture) however, it is removed during the production of plutonium products and then begins to build up again from the decay of remaining Pu-241. In some cases the dose reconstructor will have individual data that can be used for estimating the isotopic ratios. If unknown, the default ratios in Table 4.1.1-3 should be applied. The TBD notes that the most claimant favorable mix is the 10 year old 12% plutonium mixture. Dose assessment for these radionuclides is performed in accordance with ORAUT-OTIB-0060, revision 1 (as discussed above in this section). Guidance for determining missed dose is included in ORAUT-TKBS-0003, revision 3, Section 4.4.2.

Coworker Models

As discussed earlier in this section ORAUT-OTIB-0081 (revision 3), "Internal Coworker dosimetry data for SRS" has been developed but is not, for the most part, currently being used for dose reconstructions. The approach for unmonitored workers currently in place is described in the Technical Basis Document, Section 4.4.3. For workers who were externally monitored but have no internal dose records the dose reconstructor should assign missed tritium dose, a fission product dose equal to missed tritium dose, and environmental intakes for Plutonium, Uranium and Iodine. For workers with no monitoring records (no external or internal) only environmental doses are assigned.

Internal dose assignment based on co-worker data is described in ORAUT-OTIB-081(revision 3), "Internal Coworker dosimetry data for SRS." This model was developed in accordance with ORAU-OTIB-0019, revision 1, "Analysis of Coworker Bioassay Data for Internal Dose Assignment," ORAUT-PROC-0095, "Generating Summary Statistics for Coworker Bioassay Data," and ORAUT-OTIB-0075, revision 1, "Use of Claimant Datasets for Coworker Modeling." OTIB-0081 includes coworker models

[50] ORAU-TKBS-003, revision 3, page 66, indicates: "Plutonium existed in mixtures of Pu-238, Pu-239, Pu-240 and Pu-241. The activity of Pu-242 was always insignificant dosimetrically. The relative activities of these isotopes depended on the nature of the irradiation of the uranium fuel (referred to as burn-up) and the time between the end of irradiation and the intake. Processes at SRS did not perturb the relative activities of the isotopes. Generally, SRS created plutonium mixtures ranging from about 3% per weight Pu-240 to about 12% by weight Pu-240. Generally, the plutonium mixtures were blended to produce a final product with about 6% by weight Pu-240, which is referred to as a weapons-grade mixture."

(estimated annual intake rates or doses for the case of tritium) for Americium, Tritium, Plutonium, Uranium, Cobalt-60, Cesium-137, Neptunium, and Thorium[51].

Section 5.0 of ORAU-OTIB-0081 (revision 3) provides general guidance for dose reconstructors on assignment of intakes and doses when monitoring is not available. The document indicates that "Coworker intakes should be assigned for radionuclides that could have been present at the worker's location and for which the worker was not monitored. Table 5-1 lists the radionuclides potentially present at various SRS facilities or to which a worker who was assigned to a particular facility might have been exposed." The table also includes dosimeter codes associated with the particular buildings or facilities as another means of determining if a worker was present in a certain area.

Section 5.0 indicates that "for input into the Interactive RadioEpidemiological Program (IREP), the **50th percentile of the calculated intake rates should be assigned** as a lognormal distribution with the associated GSDs in the tables in this section to the majority of workers for whom coworker intakes are assigned as the default assumption. **For cases in which there is justification that the individual could have had intakes larger than the 50th percentile, dose reconstructors should use the 95th-percentile** intake rates input into IREP as a constant. The intake rates or dose for the last year listed may be extended to subsequent years as a measure favorable to claimants." (emphasis added)

There are some critical judgments for the dose reconstructor including ability to determine if a person worked in an area, during a certain time period when they had the potential for unmonitored internal exposures and, if assignment is justified, should the 50^{th} or 95^{th} percentile be assigned.

ORAU-OTIB-0081 (Revision 3) includes guidelines to assist in these judgements as follows:

"The dosimeter codes applicable to various periods are included to assist with determining a worker's work location. The dosimeter codes may be used to help identify an individual's work location. However, the dosimeter codes are guidance only and claimant-specific information (telephone interview statements, incident reports, U.S. Department of Labor claim file information, etc.) supersedes the guidance provided by these dosimeters codes." (emphasis added)

> "If the work location is unknown, then the radionuclides listed for "not identifiable or unknown" (the last line in Table 5-1) should be assigned. This might especially apply to maintenance workers sent from the Central Shops area to a variety of work locations and any other workers who worked in multiple facilities."

The highlighted text in the above excerpt was added to this latest revision (revision 3) and highlights the importance of considering other information including 'telephone interview statements'.

Internal Dose Judgements

The dose reconstructor has several places where judgement may be required in estimating the internal dose.

1. The interpretation of the data (positive results or less than the minimal detectable activity (MDA),

[51] Note: OTIB-0081- Revision 3 only provides worker data for Americium, Tritium, and Thorium-232, the other nuclides are reserved for Revision 04. ORAU Team Comments, November 3, 2017.

2. Determining the solubility of the material (most often this involves assessment of all plausible options and use of most claimant favorable solubility for final dose determination). ORAU commented that in addition to detailed instructions in the DR guidance document "ORAUT-OTIB-0060 removes decisions on solubility in that it requires the DR to assess all different solubility types and use the model that results in greatest dose to the organ of concern unless it conflicts with other measurements or there is enough information in the case file to make a determination of the actual material, such as an incident report with specific information such as a solubility study.[52]"
3. Fitting of data for determination of dose from positive results and potential missed dose (based on MDA values),
4. Determination of location of worker over time – impacts interpretation of positive bioassay measurements and missed dose (e.g. determination of appropriate plutonium mixture, assessment of dose from fission products),
5. Determination of dose for un-monitored periods (e.g., long periods between bioassay samples, long period after last bioassay and before last day of work, individual worked in area where internal exposures were indicated as a potential (ORAU-OTIB-0081, revision 3, Table 5.1), and
6. Consideration of incidents within the employee's records or reported in CATI interview.

Consideration of Incidents in personnel files or from CATI

During this assessment several cases were identified that included information on incidents or special information related to work performed during their time at the site. In cases where incidents (intakes, contamination events, etc.) were mentioned in the CATI the dose reconstructor evaluated each case to determine the possible effect on the case. In most cases the incidents were resolved without the need to modify the dose. In several cases involving skin cancer cases incidents mentioned in the CATI report resulted in a separate calculation (based on specific incident report identified in DOE file). In most cases the information in the CATI lacks sufficient specificity (time, contamination level) to allow for a specific dose calculation however, there is usually sufficient information available (e.g., general time frame and radionuclide) to come to resolution (e.g., individual had full bioassay monitoring records during the time period which was sufficient for estimating dose).

In one specific case, considered during this review, the individual noted (with a reasonable amount of detail) exposure to a Californium source. In this case[53] a neutron dose estimate for this activity was made and included in the initial DR report[54]. The claimant's dose records had no record of neutron exposure during this several month time period. Missed dose or coworker dose would have been significantly lower than the estimated dose.

ORAU did note that "the presence of enough technical information to address an incident in detail is unusual" and that "the ORAU Team uses the best information available from the claim files and the interviews, but most mentions of incidents are usually generic in nature and cannot be specifically assessed without further technical information."

[52] ORAU comments on preliminary summary report, February, 2017.
[53] Reference case N.
[54] The estimated dose was not included in the final DR since rework resulted in POC > 50% without including this dose.

Recommendations

SC&A and Board

1. The Board (with support from SC&A) should conduct focused, targeted case reviews to look at particular 'judgement' areas outlined above. Start with looking at best estimate external cases, external dose assignment.

ORAU

1. Require case DR overview in case file outlining approach used in case. This would provide a roadmap to those reviewing the cases to understand the approach used in particular case. Would also be a way to assure overall consistency in the way like cases are handled.
2. Include 'timelines' for best estimate cases within the case file. If possible, consider a standardized format for such timelines (at least site specific, perhaps consistency across many sites).
3. Further consider actions to be taken subsequent to DR guidance modifications.

NIOSH and / or ORAU

1. Collect all DR review comments and resolutions in a database (could start with best estimate cases for SRS). Use this, along with ORAU internal QA database, to identify common areas for improvement in dose reconstruction. ORAU noted that "the ORAU Team already gathers this information since 2012 and periodically reviews it for improvement."
2. Collect all incident information from CATI interviews in database. Assess the data in aggregate form to determine if certain reported 'incidents' may warrant further investigation.
3. Develop a report summarizing the use and review of uncertainty assumptions. ORAU correctly noted that "the uncertainty assumptions used are documented in various documents (OCAS-IG-001 sections 1.6, 2.1.1.3.1, 2.1.2.2, and 2.1.2.4 for external dose and ORAUT-OTIB-0060 sections 3.3.1 and 3.5.3.1 for internal dose). The introduction of the Weibull distribution is described in a paper by Dr. Daniel Stancescu of DCAS (SRDB#165617 page 6 of the document). These distribution assumptions have been discussed extensively over the life of the EEOICPA Project and accepted.[55]" While it is clear this issue has been discussed extensively over the life of the program, it would be useful to summarize the approach to uncertainty and the reviews conducted.

Linde Ceramics DR professional judgement areas

Purpose

The purpose of this review was to identify possible areas of professional judgement associated with the dose reconstruction process that may result in inconsistencies. Linde Ceramics was selected as an example AWE site to consider the types of assumptions and judgements associated with sites where the primary basis of the dose reconstruction are exposure matrices rather than individual personal dosimetry data. This review considers judgments which have to be made by the person conducting the dose reconstruction for an individual claim as well as the professional judgements associated with the model development.

[55] ORAU comments to preliminary summary report, February, 2017.

Approach

This review considered the dose reconstruction process for Linde Ceramics (Including Tonawanda Laboratory) from the initial CATI interview through the case reworks. Particular emphasis in this review was on the program assumptions that went into the development of the technical basis document (TKBS-0025- Revision 4) and the associated workbooks used for calculating external and internal doses.

Overall this review included the review of several cases including best estimate cases and focusing on cases that were completed after the most recent addition to the SEC class for Linde (cases completed after 2013). The review involved review of the Linde Ceramics Technical Basis Document (TKBS-0025 version 4), associated technical information bulletins, the SC&A site profile review document (SC&A July 14, 2006), the SC&A comment resolution document (SC&A August 2009), and the prior versions of the Linde Technical Basis document (Rev 1, Rev 1 PC, Rev 2 and Rev 3).

The review of the previous versions of the technical basis document was essential in understanding the nature of the SC&A review comments and to understand how the comments were resolved and what changes were made from the earlier versions to the most current version of the technical basis document.

While previous versions of the technical basis document and the SC&A review were important in understanding the history of dose reconstructions and claims assessment for the Linde site the focus regarding professional judgement (program judgement and individual dose reconstructor's judgement) and consistency was based on the most current technical basis document and associated DR workbooks.

Preparation of the Technical Basis Document and DR's

The process for dose reconstructions for Linde Ceramics claims is slightly different than the DOE site claims. In the case of Linde Ceramics Oak Ridge Associated Universities (ORAU) developed the initial technical basis document and was responsible for all revisions of the document (the most current being TKBS-0025- Revision 4) but the cases are assessed by NIOSH staff. This approach is also used for some other AWE site claims. One thing this may affect is the quality assurance review of the claims however, it should be noted that these assessments tend to be less complex and involve fewer professional judgements (when it comes to claims assessment) than claims for the larger DOE sites in part because the claims are processed using an external and internal dose model since individual records are very limited.

SEC Classes for Linde Ceramics

An important factor in the assessment of the dose reconstruction claims for Linde Ceramics is that special exposure cohorts have been added for three sequential time periods from October 1, 1942 through December 31 1969. The basis of the classes was insufficient information to assess internal radiation exposures. The specifics of each class are outlined below.

SEC Petition 44 (1942-1947) – SEC Class was added; basis, as noted in the ABRWH letter to the Secretary (November 8, 2005) was as follows: "Monitoring for internal dosimetry was not implemented at this facility until November 1947. The other monitoring, process, and source information available for this facility is not sufficient for estimating internal radiation exposures in order to conduct individual dose reconstruction for workers at this facility during the earlier time period"

- SEC Petition 154 (1947-1953 – SEC Class added; the basis, as noted in the ABRWH letter to the Secretary (December 29, 2011) was as follows:

"The National Institute for Occupational Safety and Health (NIOSH) review of available monitoring data, as well as available process and source term information for this facility found that NIOSH lacked the sufficient information necessary to complete individual dose reconstructions with sufficient accuracy for internal radiological exposures due to uranium and uranium progeny (with the exception of radon) during the time period in question. The Board concurs with this determination."

- SEC Petition 107 (January 1, 1954 – July 31, 2006) – SEC Class added for years from 1954-1969; the basis, as noted in the ABRWH letter to the Secretary (March 18, 2011) was as follows:
- "The Board reviewed available monitoring data, as well as process and source term information for various production activities at the Linde Ceramics Plant during the time period in question, and concluded that National Institute for Occupational Safety and Health (NIOSH) lacked adequate data necessary to complete individual dose reconstructions with sufficient accuracy for internal doses during the time period in question."

Job Categories and Departments

One of the challenges in dose reconstructions for many of the sites has been to determine where individuals worked throughout their time period on a site. Without individual dosimetry records this proves to be very important in estimating individual exposures. For Linde similar or identical job titles were used for workers in quite different operations and therefore further information is necessary in aiding in the estimation of exposures. (Section 2.5 ORAUT-TKBS-0025-rev4)

Section 2.5 notes that there are two lists of workers available for Tonawanda Laboratory workers. It also indicates that it is not clear if this includes all employees. For the Ceramics Plant, it is noted that there is an employee listing from 1944 and a job description listing from 1945. "Because the same title (e.g., chemical operator) was sometimes used in different departments in which the nature of the work was very different (e.g., Step I and nickel processing), knowing the department might help identify the type of activity in which a worker was involved." Table 2-2 includes some department codes. This is likely the most significant judgement made by the individual assessing an individual claim since all of the external doses and intakes are based on job category assignment.

Exposure Estimates

The site profile notes that "the Linde information is considered in conjunction with information from facilities that did similar types of uranium processing to establish preliminary estimates of internal intakes and exposures. These estimates are considered best estimates until data can be further considered. It is believed that additional analysis of the data will lower at least some of the intakes and exposures that are estimated in this section." The use of data from the Linde site along with surrogate data from other facilities does involve several programmatic assumptions however, it should be stressed that these assumptions have been extensively reviewed by SC&A and the ABRWH and all issues were resolved. [56] Since the Linde dose reconstructions, for the most part, are done using external radiation models and internal radiation models specified in the technical basis document there is only a minimal amount of judgement required in doing the claimants dose reconstruction.

Although, as noted above, the approach used for dose reconstruction for Linde Ceramics along with the associated assumptions (detailed in the Technical Basis Document - TKBS-0025- Revision 4) has been

[56] Sanford Cohen & Associates (SC&A), *Linde Site Profile Review: SC&A Comments on Issue Resolution Matrix Items*, SC&A Working Group Draft Report (OGC Reviewed May 16, 2007), April 27, 2007

extensively reviewed some of the program assumptions will be discussed below since they likely impact other AWE site dose reconstructions.

Assessment of External Doses

SC&As review noted that the external dose estimates were complicated and included several different assumptions during different time periods and involved in different operations. The Site Matrix resolution document (SC&A, August 2009) indicates that all comments and findings were resolved.
Some of the assumptions associated with the external dose assessment process include:

1. The technical basis document uses a combination of film badge data, survey measurements, and solid sample analysis along with information related to production history to estimate the external dose for the operational, 'standby', 'rehab' and residual period. Section 4.1 of the technical basis document details the data used to estimate gamma and beta exposures and the approach for estimating individual beta and gamma doses.
2. The technical basis document assumes that the models (external and internal) are bounding and in the course of the ABRWH review NIOSH indicated that when using what are considered bounding parameters it is not necessary to include uncertainty into the estimated annual doses (for IREP model). In response to SC&A issue 12, finding 9 (see SC&A 2009 Table 2) NIOSH indicated that OCAS IG-002 discusses uncertainty but says that "It is important to remember at this point that if the preliminary overestimate or underestimate is conclusive, no uncertainty analysis is required since the estimate is already a bounding case." For Linde cases photon and beta doses include uncertainty however, the internal annual alpha dose is considered as a constant value. Both of these assumptions appear to be claimant favorable. The different approach in handling uncertainty may be an area that should be more extensively reviewed to determine whether and if consistent default approaches are used for similar types of sites.
3. Parameters used in estimated exposures are included in the technical basis document and according to NIOSH response to SC&A issue 9, finding 6 (SC&A August 2009, page 47) the parameters can be modified by dose reocnstructors (DRs), based on claim-specific details. It appears this was primarily in response to exposure times (inhalation, ingestion and external exposures). The statement suggests that individual DRs would have the option to modify parameters regarding internal (uranium and progeny) and external exposures. In the limited number of cases reviewed no such modification was identified.
4. The external dose matrix for the AWE operational period (Table 4-24 – shown below) is based on a variety of data and is rather difficult to recreate from underlying data. However, the approach used in deriving the values in this table (which are the basis for the calculations of individual external doses) have been extensively reviewed by SC&A and the ABRWH with all issues being 'closed' during the resolution process. Since site matrices for several other AWE sites are based on similar types of underlying data a review and comparison for consistency may be useful.

Table 4-24. Summary of annual external exposure from AWE operations, 1942 to 1953.

Year[a]	Work category	Beta (rem)[a]		Gamma (R)[a]	Neutron (rem)[a,b]
		Hands & forearms	Rest of body		
Ceramics Plant (Buildings 30, 31, 37, and 38)					
1942[c]	All workers	2.55E–02	2.55E–02	4.97E–03	([d])
1943[e]	High	1.51E+02[f]	5.05E+01	3.65E+00	3.41E–01[g]
		5.05E+01[h]			
	Medium	1.20E+01	3.97E+00		
	Low	2.08E+00	2.08E+00		
1944 1945	High	2.21E+02[f]	7.40E+01	5.35E+00	5.00E–01[g]
		7.40E+01[h]			
	Medium	1.76E+01	5.85E+00		
	Low	3.00E+00	3.00E+00		
1946[i]	High	1.28E+02[f]	4.32E+01	3.11E+00	3.33E–01[g]
		4.32E+01[h]			
	Medium	1.04E+01	3.59E+00		
	Low	1.93E+00	1.93E+00		
1947[j]	Medium	2.04E+00	8.91E–01	5.37E–01	1.48E–01[g]

Year[a]	Work category	Beta (rem)[a]		Gamma (R)[a]	Neutron (rem)[a,b]
		Hands & forearms	Rest of body		
	Low	6.10E–01	6.10E–01	2.03E–01	
1948	Medium	5.85E+00	1.95E+00	1.61E+00	5.00E–01[g]
	Low	1.00E+00	1.00E+00	4.80E–01	
1949	Medium/low[k]	6.85E+00	2.28E+00	1.73E+00	3.74E–01[g]
	Cleanup				[d]
	Non-cleanup[l]	6.60E–01	6.60E–01	2.94E–01	
1950 1951 1952 1953	Cleanup[m]	7.83E+00	2.61E+00	1.85E+00	[d]
	Non-cleanup[n]	3.26E–01	3.26E–01	1.11E–01	
Tonawanda Laboratory (Building 14)					
1942[c]	Research	2.80E+01	9.33E+00	1.35E+00	3.63E–02
	Office	7.56E–01	7.56E–01		
1943	Research	1.11E+02	3.70E+01	5.35E+00	1.44E–01
	Office	3.00E+00	3.00E+00		
1944 1945	Research	1.11E+02	3.70E+01	5.35E+00	1.44E–01
	Office	3.00E+00	3.00E+00		
1946	Research[o]	6.78E+01	2.26E+01	3.88E+00	8.36E–02[p]
	Office[q]	1.78E+00	1.78E+00	3.15E+00	
1947 1948 1949 1950 1951 1952 1953	All workers	3.26E–01	3.26E–01	6.80E–02	[d]

a. Total annual exposure (dose) for the designated year. Prorated based on calendar year and applicable notations below.
b. Because of the possible difficulty in determining whether a worker was working with oxide or fluoride materials, each worker was assigned the larger neutron dose due to fluorides.
c. Exposure for the period from October 1 through December 31, 1942 only.
d. Neutron dose rate was negligible.
e. Values prorated: For January 1 through April 26, 1943 (preproduction period), applicable values from Table 4-1 applied; for April 27 to December 31, 1943, applicable 1944 to 1945 values applied.
(Example calculation: 1943 high-ball mill operator = 0.315 × 1.01E-01 + 0.685 × 2.21E+02 = 1.51E+02).
f. Based on 221 rem/yr for ball mill operator, Step I and Step II process operators, and weighmaster.
g. The Building 38 neutron dose rate for Step III processing was assumed to apply from April 27, 1943, to August 31, 1946, and from September 15, 1946, to September 30, 1949. The neutron dose rate was negligible from September 1, 1946, to September 14, 1949 (standby), and after September 30, 1949 (cleanup and postcleanup). The period of neutron exposure extended beyond the end of production in 1946 and 1949 due to remaining inventory of UF_4.
h. Based on 74 rem/yr for loader per Section 4.1.2.1.3.
i. Values prorated: For January 1 to July 31, 1946, applicable 1944 to 1945 values applied; for August 1 to December 31, 1946 (standby period), applicable values from Table 4-4 (guard) applied.
j. Values prorated: For January 1 to September 14, 1947 (standby period), applicable values from Table 4-4 (guard) applied; for September 15 to December 31, 1947, applicable 1948 values applied.
k. Values prorated: For January 1 to June 30, 1949 (Step III production), applicable 1948 medium values applied; for July 1 to December 31, 1949, 1950 to 1953 cleanup values applied.
l. Values prorated: For January 1 to June 30, 1949 (Step III production), applicable 1948 low values applied; for July 1 to December 31, 1949, 1950 to 1953 non-cleanup values applied.
m. All cleanup workers and cleanup support workers as defined in Section 4.1.5 are assigned to the cleanup exposure category. Parameters are those of the cleanup worker for a 6-day week in Table 4-20.
n. All non-cleanup workers as defined in Section 4.1.5 are assigned to the non-cleanup exposure category. Parameters are those of the non-cleanup worker for a 6-day week in Table 4-20.
o. Values prorated: For January 1 to July 31, 1946, applicable 1944 to 1945 values applied; for August 1 to December 31, 1946, applicable values from Table 4-21 (cleanup-R&D scenario) applied.
p. Includes neutron exposures through July 31, 1946.
q. Values prorated: For January 1 to July 31, 1946, applicable 1944 to 1945 values applied; for August 1 to December 31, 1946, applicable values from Table 4-21 (cleanup-office scenario) applied.

5. Assumptions were made in identifying and defining exposures for job groups (high, medium and low) job exposure categories. "Job titles that were specified in the records were binned into

categories that combined jobs that were judged to have had similar exposure potential" (TKBS-0025- revision 4; page 54 – Table 4-14)

6. Table 4-24 of the technical basis document (TKBS – 0025 Revision 4) summarizes external dose estimates for 1942-1953 by job category. DR must make decision on whether worker should be in high, medium or low exposure category and whether they should be considered a 'cleanup' worker or 'non-cleanup' worker. Job titles associated with production work and the defined exposure category are included in Table 4-25. The technical basis document indicates that "if the exact job of a worker is not listed, dose reconstruction should be based on the most similar job." Clean-up worker and non-cleanup worker are defined in section 4.1.5.
7. All beta and gamma exposures listed in table 4-24 are assumed median values of a lognormal distributed with a GSD of 3.0. Neutron estimates, assumed to be bounding, are treated as a constant value for purposes of dose reconstruction.
8. In the 1942 to 1953 time period some measurements and parameters post 1953 were used to estimate external exposures during this time period. This backward extrapolation of data has also been used at other sites and should, perhaps, be reviewed to assure consistency in approach.
9. Table 4-1 shows estimates of beta and gamma doses before and after decontamination. These estimates were based in part on a correction factor derived from a few surveys (April 19 and 22 of 1949). A factor of 1.3 times higher for beta measurements and a factor of 4 times higher for gamma measurements. The values for the time period prior to vacuum cleaning and flushing were determined by multiplying the median beta gamma survey measurements by a factor of 3. It should also be noted that the post vacuuming and flushing survey results (beta plus gamma) were corrected to determine the fraction of gamma and beta; this correction factor was based on 1978 survey results and resulted in 6% of the beta plus gamma result being considered as the gamma portion. This was discussed at length during the ABRWH review. One question was why a factor of 3 rather than using a factor of 4 for gamma and a factor of 1.3 for the beta. In the resolution tracking matrix NIOSH "contends that any underestimate for gamma is overwhelmed by the overestimate for the dominant dose.[57]"

Internal Dose Assessment

1. The Technical basis document (TKBS-0025 revision 4) notes that "by the end of 1949, exposure levels were significantly reduced at these larger plants even though production levels increased." (Mason 1959 cited in ORAU TKBS-0025 revision 4, page 32) This is an assumption that has been applied to other AWE sites and is based on the documented improvements in industrial controls during that time period. While this assumption is not a factor for the Linde dose assessments, since production ended prior to 1949, this is an important assumption in other AEC site models
2. The inhalation and ingestion rates for the residual time period (starting in 1970) are shown in Table 6-2 and 6-3. These values are considered bounding values and so the doses associated with uranium and progeny intakes during this time period are considered constant values for input into IREP. An "exponential interpolation was made between the uranium concentrations that were assumed for the remediation period (161 dpm/m^3) and the levels that were measured in the 1976 survey (4.22 x 10^{-2} dpm/m^3)." The 1976 level (4.22 x 10^{-2} dpm/m^3) is used to derive the daily intake rate from 1976-2009 (4.22 x 10^{-2} dpm/m^3 x 1.2 m^3/day x 2000 days equals 0.277 dpm/day).

[57]Sanford Cohen & Associates (SC&A) and Saliant, Inc., Assessment of the Disposition of SC&A's Linde Site Profile Review Issues in Response to SEC Petitioner Concerns, August, 2009, page 32.

This exponential interpolation is described in ORAU OTIB-070, "Dose Reconstruction during Residual Radioactivity Periods at Atomic Weapons Employer Facilities" and is an approach applied to several AWE sites. A review to determine if this approach is used consistently may be useful.

3. During the residual contamination period (post 1953) , to account for uranium progeny potentially present from past activities data from post operational period was reviewed to estimate bounding activity ratios. The ratios (presented in Table 6-1 and shown in comparison table below) are based on the "highest observed values from the indoor and storm sewer sampling locations." (TKBS - 0025 Revision 4, page 68). Since this certainly is a factor that must be considered in other AWE sites it may be beneficial to assure a consistent approach is used for all sites. This may also be useful since earlier versions of the technical basis document base the derivation of the activity ratios on measured monthly outdoor airborne concentrations (TKBS-0025 revision 1, table 6-1).

Table: Comparison of Activity Ratios from version 1 technical basis document and version 4

Progeny/ U	Ratio (version 4)	Ratio (version 1)
Th-230/U	0.26	0.84
Ra-226/U	0.21	1.7
Po-210/U	0.21	
Ac-227/U	0.29	
Pa-231/U	0.01	

References

1. NIOSH, (2007) *External Dose Reconstruction Implementation Guideline, Rev 3*, OCASIG-001, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio, SRDB Reference ID 38864.
2. NIOSH, (2002) *Internal Dose Reconstruction Implementation Guideline, Rev 0*, OCASIG-002, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio, SRDB Reference
3. ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0003, *Technical Basis Document for the Savannah River Site, Rev 03*, April 5, 2005, SRDB Reference ID 20176.
4. *A History of Personnel Radiation Dosimetry at the Savannah River Site(U)* (Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina, WSRC-RP-95-234, May 1995), SRDB Reference ID 12098.
5. OCAS-TIB-006, *Technical Information Bulletin: Interpretation of External Dosimetry Records at the Savannah River Site (SRS), Rev 2*, October 4, 2007, SRDB Reference ID 35409.
6. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0017, *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose, Rev 01*, October 11, 2005, SRDB Reference ID 19434.
7. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0032, Technical Information Bulletin: External Coworker Dose Data for SRS, Rev 00 PC-1, November 7, 2006.
8. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PROC-0060, *Occupational On-Site Ambient Dose Reconstruction for DOE Sites, Rev 01*, June 28, 2006, SRDB Reference ID 29986.

9. Office of Compensation Analysis and Support, OCAS-TIB-007, *Technical Information Bulletin: Neutron Exposures at the Savannah River Site, Rev 1*, October 15, 2007, SRDB Reference ID 35675.
10. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0011, *Technical Information Bulletin: Tritium Calculated and Missed Dose Estimates, Rev 00*, June 29, 2004, SRDB Reference ID 19430.
11. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0019 Revision 1, Analysis of Coworker Bioassay Data for Internal Dose Assignment, October 17, 2005.
12. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0020 Revision 3, Use of Coworker Data for External Dose Assignment, November 14, 2011.
13. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0052 Revision 2, Parameters to Consider When Processing Claims for Construction Trade Workers, July 24, 2014.
14. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0081 Revision 3, Internal Coworker Dosimetry Data for the Savanah River Site, November 22, 2016.
15. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PROC-0020 Revision 0, Claims Processing: Receiving, Scanning, Quality Reviewing, Uploading, and Filing of DOE Exposure Data, January 9, 2006.
16. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FLOW-0001 Revision 0, Claim Processing, December 22, 2004.
17. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FLOW-0013 Review 0, Verification and Validation Process for the Tools Development Group, January 5, 2006.
18. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FORM-0035 Revision 1, Dose Reconstruction Review, May 3, 2006.
19. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FORM-0041 Revision 1, Peer Review Checklist, August 25, 2005.
20. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FORM-0059 Revision 1, Initial Quality Control Checklist for Dose Reconstruction Reports, January 11, 2011.
21. ORAUT (Oak Ridge Associated Universities Team), ORAUT-FORM-0061 Revision 1, Final Quality Control Checklist for Dose Reconstruction Reports, January 1, 2011.
22. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PROC-0059 Revision 0, Peer Review of Dose Reconstructions, September 6, 2005.
23. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PROC-0096 Revision 1, Initial Quality Control, Technical Editing and final Quality Control of Dose Reconstruction Reports, February 28, 2011.
24. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PROC-0106 Revision 0, Roadmap to Reconstructing Dose, November 4, 2016.
25. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PLAN-0028 Revision 1, Quality Assurance Program Plan, May 28, 2014.
26. ORAUT (Oak Ridge Associated Universities Team), ORAUT-PLAN-0029 Revision 1, Project Management Plan, May 12, 2014.
27. ORAUT (Oak Ridge Associated Universities Team), ORAUT-SRVL-0003 Revision 0 PC-1, Consideration of Claimant-provided information and Public Meeting Comments in Dose Reconstruction, January 12, 2006.

28. ORAUT (Oak Ridge Associated Universities Team), ORAUT-OTIB-0070 Revision 1, Dose Reconstruction during Residual Radioactivity Periods at Atomic Weapons Employer Facilities, March 5, 2012.
29. ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0025 Revision 4, An Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory), May 28, 2015.
30. ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0025 Revision 1, An Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory).
31. ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0025 Revision 2, An Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory).
32. ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0025 Revision 3, An Exposure Matrix for Linde Ceramics Plant (Including Tonawanda Laboratory).
33. Sanford Cohen & Associates (SC&A) and Saliant, Inc., Review of the NIOSH Site Profile for the Linde Ceramics Plant and Tonawanda Laboratory, SCA-TR-TASK1-0014, July 14, 2006.
34. Sanford Cohen & Associates (SC&A) and Saliant, Inc., Assessment of the Disposition of SC&A's Linde Site Profile Review Issues in Response to SEC Petitioner Concerns, August, 2009.
35. Sanford Cohen & Associates (SC&A), *Linde Site Profile Review: SC&A Comments on Issue Resolution Matrix Items*, SC&A Working Group Draft Report (OGC Reviewed May 16, 2007), April 27, 2007

Attachment 1 – QA/QC Program

Quality Assurance / Quality Control and professional judgement

Quality assurance and quality control measures have been in place since the beginning of the dose reconstruction program. The most recent version of the ORAU Quality Management System (QMS) is modeled based on the International Organization for Standardization (ISO) document ISO 9001 Quality Management Systems requirements. The Management system includes two overarching plans: the Quality Assurance Plan Program (QAPP) and the Project Management Plan (PMP). It is apparent that the QA/QC program has improved over time and it is evident in the results – the reduction in the number of technical errors over time.

ORAUT-PLAN-0028 QAPP (replaced ORAUT-Plan 001)

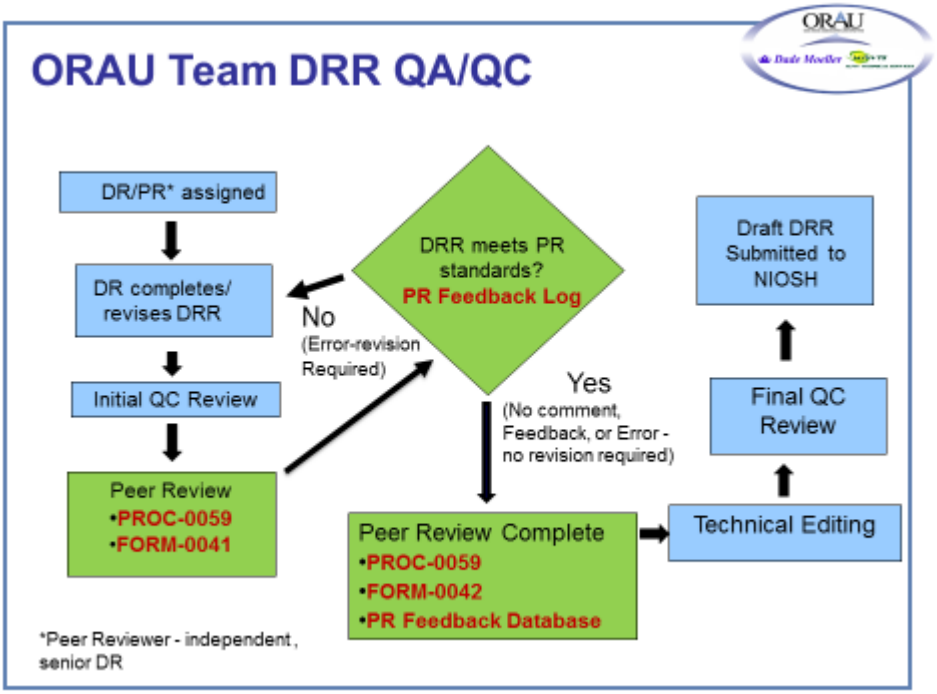
The purpose of the Quality Assurance Program Plan (QAPP) as described in the plan is "to document the Quality Management
System (QMS) for the Oak Ridge Associated Universities (ORAU) Team Dose Reconstruction Project for the National Institute for Occupational Safety and Health (NIOSH)." The QAPP and the PMP along with all referenced procedures make up the Quality Manual.

ORAUT-Plan 029 Project Management Plan (PMP) (replaced plan 9)

As described in ORAUT-PLAN-029, the plan defines the work processes, the schedule for completion and the budget. The performance baselines are based on regulatory and contractual requirements.
While the overall program is very important to continuous improvement two components which are very important with regard to identifying errors in dose reconstruction processes and final product (completed dose reconstructions) are the internal review process (described in ORAUT-PROC-0059 – Peer Review Process) and the NIOSH review process (described in ORAUT-PROC-0077).

ORAU-PROC-0059

As stated in ORAU-PROC-0059, this procedure "provides the process for peer review of dose reconstructions for the Oak Ridge Associated Universities (ORAU) Team Dose Reconstruction Project for the National Institute for Occupational Safety and Health (NIOSH)." This process applies to all Dose Reconstruction Reports and defines the level of peer review required (both technical and editorial (Peer review checklist – ORAU-FORM-0041). See diagram below.



From Nov 2012 ORAU PPT presentation to ABRWH DR Subcommittee

(The dose reconstruction peer review process outlined in the flow diagram above and detailed in ORAUT-PROC-0059 (Peer Review of Dose Reconstructions) applies to all DR reports. Implementation of this procedure along with ORAUT-PROC-0077 (DR Error Tracking and Reporting) constitutes the quality review process outlined in the Quality Assurance Program (ORAUT-PLAN-0026).

ORAU-PROC-0077

As stated in ORAU-PROC-0077, this procedure "provides the process for review, disposition, correction, tracking, and trending of Dose Reconstruction Report errors and comments received by the Oak Ridge Associated Universities (ORAU) Team Dose Reconstruction Project for the National Institute for Occupational Safety and Health (NIOSH)." This process applies to all Dose Reconstruction Reports and describes "the procedure and process for managing and responding to NIOSH and DOL comments regarding Dose Reconstruction Reports that are returned to the ORAU Team because the Reviewer(s) have determined that there are errors, omissions, questions, and/or other problems with a Report." The issues are documented on ORAUT-FORM-0035. The document also includes guidance on tracking, trending, and reporting of the review comments and errors. Both ORAU-PROC-0059 and ORAU-PROC-0077 discuss a mechanism for considering the findings in aggregate. "Based on analysis of the trends identified by the Comment Utility Tracking Database, appropriate findings of substantive, systemic

process errors can be prepared. The development of appropriate corrective actions for the findings can then be developed pursuant to ORAUT-PROC-0065, Internal Finding and Corrective Action to Prevent Recurrence. Independent verification and validation of closure of corrective actions shall be accomplished through the implementation of ORAUT-PROC-0074, Commitment Control." It is unclear to the author whether the database includes both internal findings (ORAU Peer Review – PROC-0059) and external findings (NIOSH comments – PROC-0077). The excel database provided for this review included only NIOSH comments (Attachment 5).

OCAS-PR-007

OCAS-PR-07, "Dose Reconstruction Review", Revision 2, outlines the process for the conduct, documentation, and performance of dose reconstruction (DR) reviews performed by the Office of Compensation Analysis and Support (OCAS).

In section 5.1.2 "Detailed Review and Approval" it is noted that "the minimum frequency of such reviews is programmed into NOCTS." During the ABRWH procedures subcommittee review of this procedure it was noted that "every DR is reviewed according to the requirements of section 5.1.1, Basic Review and Approval. 5% of all DRs reviewed are selected at random, automatically by NOCTS.[58]"

Other important components of the QA/QC Program

Other important components of the QA/QC program specifically as it pertains to the dose reconstruction program include the following:

Control of Documents

Project documents are developed, reviewed and approved, and used in the implementation of dose reconstructions. Controlled documents include technical information bulletins (OTIBs), site profiles, technical basis documents (TBDs), procedures (PROCs), and Forms. These include technical guidance (general and site specific) as well as QA/QC procedures (Peer Review).

It should be noted that some rather important documents are not controlled documents. These include DR guidance documents, DR Notes and DR time-lines. These documents include specific instructions / guidance for completing the dose reconstruction and / or provide a roadmap of how a specific case was reconstructed. When applicable these files are included with the specific claim files.

Previously a document control tracking application (DCTA) was in place which allowed one to see the evolution of all controlled procedures. This feature was applauded by Spitz, et al[59]. They described the database as follows: "Information on the life-cycle of some technical documents is available using a web-based database referred to as the *Document Control and Tracking Application* (DCTA). The database is used to track documents throughout all stages of development, including status on levels of review and resolution to review findings" They went on to say "the DCTA appears to be an invaluable tool and noteworthy feature of the DCAS

[58] Board Tracking System, finding number PR-007-03, November 7, 2007.

[59] Spitz, year review, Quality of Science,

document management system." The DCTA has been discontinued. Although the Board Review database remains in place and includes similar information regarding the external review of procedures it may be worth considering reinstating the use of the DCTA database.

Data Entry

"With regard to external data entry, completion of each quality control (QC) activity is recorded on a hardcopy QC checklist and completion of the QC check is denoted next to each claim's electronic folder. For internal data entry, completion of each QC check is recorded in the Dose Reconstruction Tracking System (DRTS). "[60]

Control of Dose Reconstruction Templates

"Dose Reconstructors utilize controlled dose reconstruction templates that are electronically organized by site. These templates are advantageous in providing a consistent quality product, reducing errors and enhancing efficiencies that result in greater production outputs."[61]

Dose Reconstruction Software Tools

Workbooks (Microsoft® Excel spreadsheets) have been developed to carry out many aspects of dose reconstructiion work. The use of workbooks improves efficiency and consistency in dose reconstructions. The workbooks contain site-specific data tables and dose reconstruction algorithms used with individual claimant information to complete the individual DR.

"All dose reconstruction tools are independently verified and validated per quality review requirements and in accordance with ORAUT-PLAN-0026, Software Development Methodology or ORAUT-PROC-0094, Verification and Validation Process for the Tools Development Group, respectively."[62]

"Verification and validation of the more complex tools and workbooks is performed in accordance with a documented test plan. The test plan validates the general intent and applicability of the tool or workbook and ensures independent verification of all health physics assumptions and equations by a senior Dose Reconstructor who has not been involved in the preparation of the tool or workbook. This process is described in more detail in ORAUT-PROC-0094, Verification and Validation Process for the Tools Development Group."[63]

[60] QMS summary report, NIOSH, 2012.
[61] QMS summary report, NIOSH, 2012
[62] QMS summary report, NIOSH, 2012
[63] QMS summary report, NIOSH, 2012

Attachment 2: SC&A Memo – Consistency in Dose Reconstruction

MEMO

NOTICE: This memo has been reviewed to identify and redact any information that is protected by the Privacy Act 5 U.S.C. § 552a and has been cleared for distribution.

TO: Dose Reconstruction Review Methods Work Group

FROM: Rose Gogliotti, SC&A

DATE: March 11, 2016

SUBJECT: Consistency in Dose Reconstruction

During the Dose Reconstruction Review Methods Work Group Teleconference held on November 5, 2015, the Work Group discussed ways in which the dose reconstruction (DR) review process could be modified to better assess how consistently assumptions that require judgment by the dose reconstructor are applied to DRs. SC&A was tasked with using institutional knowledge to suggest possible areas where there may be inconsistencies and to propose possible ways to investigate consistency issues through DR. This memo satisfies that request.

Historically, SC&A has performed two types of DR-related reviews: 1) DR reviews and 2) blind DR reviews. These review types target different aspects of the DR process. A DR review looks at a previously completed National Institute for Occupational Safety and Health (NIOSH) DR and compares the DR against guidance documents. DR reviews identify technical and quality assurance (QA) errors to measure how well Oak Ridge Associated Universities Team (ORAUT)/NIOSH follow their own technical guidance documents. Alternatively, in a blind DR review, SC&A independently completes a DR and then compares its review to the DR completed by NIOSH for the same claimant. Blind reviews are intended to quantify how well two independent dose reconstructors interpret the same data and guidance documents, and seek to identify key decision points that might affect a compensation decision. Blind DR reviews do not identify errors in the form of findings; instead, differences between the SC&A and NIOSH dose reconstructions are outlined in a comparison report. At the discretion of the Dose Reconstruction Subcommittee (DRSC), discrepancies from the comparison report are discussed in the DRSC forum; however, only those discrepancies that may impact the compensation decision are typically investigated further by the DRSC. Given the differences outlined above, SC&A believes that a non-blind approach is better suited for a consistency comparison.

In order for the Advisory Board to effectively use the non-blind DR approach to target consistency-related issues, the criteria for selecting cases would need to be modified to reflect the change in priorities. A non-blind DR approach is best used to verify if assumptions are consistently applied within a specific site. To do this, a set number of cases from a single site should be selected for review. To obtain a useful comparison, the selected cases should have similar employment histories. Once the reviews were

completed, a report comparing the assumptions used in each approach would be generated that highlights inconsistencies through

Memo: Consistency in Dose Reconstruction 2 SC&A – March 11, 2016 NOTICE: This memo has been reviewed to identify and redact any information that is protected by the Privacy Act 5 U.S.C. § 552a and has been cleared for distribution.

The use of findings. SC&A suggests the Advisory Board first target sites without formal, reviewed Technical Basis Documents (TBDs) that may or may not have accompanying templates. While, in general, these sites tend to have fewer employees and thus fewer claimants, the DR approach is far less prescriptive than for the larger, more complex sites. With less formal DR guidance, SC&A believes that these cases are more likely to contain inconsistencies in approach. A drawback of this type of review is that SC&A has not been tasked to review the DR templates for technical merit. Thus, while this approach would help to verify consistency, the question of technical adequacy remains.

Another possible approach to target consistency-related issues is to limit the review scope to only certain aspects of the DR review process (i.e., focused or partial reviews). Reviewers could look at a single aspect of a number of cases to identify potential inconsistencies. Although a partial or focused approach has never been applied to DR reviews, there is nonetheless precedence for this type of approach: Subtask 4 of Program Evaluation Reports (PER) Reviews involves a focused review of only the aspects of select cases impacted by a PER. This approach could be extended to the investigation of consistency in the DR process by focusing on a single aspect or select aspects of multiple DRs. This would enable reviewers to look at a large sample of similar cases to verify that a consistent approach was applied within the sample. It is important to keep in mind that partial reviews do not substantially reduce the amount of work needed to research background information on a given type of case; however, they would reduce the time spent on each individual review.

Similar to the suggested non-blind approach, for a partial review a set number of cases for a given criteria should be selected and reviewed, limiting the scope of the review to the targeted criteria. Once the partial reviews are completed, a report comparing the assumptions used in each DR would be generated that highlights inconsistencies through the use of findings. To effectively use a partial approach, the Advisory Board would need to carefully select specific criteria to target in order to identify aspects of the DR process where consistency issues are most likely to arise. Based on SC&A's institutional knowledge, some potential criteria to target are listed below; however, a more exhaustive list could be developed through a thorough analysis of past DR reviews.

1. Coworker Dose – Coworker dose is typically assigned as a 50th and 95th percentile. Selection of which percentile should be applied to a DR has a very significant impact on the dose assigned to an energy employee (EE). SC&A has long felt that the limited instructions provided to aid dose reconstructors in selecting the appropriate percentile of the dose distribution to assign may lead to an inconsistent application of assumptions. *Recommendation: Select numerous cases from a single site where coworker dose was applied and compare the percentile applied with case specifics to analyze if consistent assumptions are applied to select the percentile assigned.*

2. Location of Skin Cancers – The location of a skin cancer is very important when determining the appropriate x-ray dose. Many claimants have multiple skin cancers, and the assignment of x-ray doses can

greatly impact the total assigned dose and resulting probability of causation (POC). One example is a skin cancer listed as being on the back: a cancer located in the middle of the back would be assigned greater x-ray dose than

Those located elsewhere on the back; additionally, left or right side is important. Another example includes skin cancers located on the scalp, face, and neck: the assigned dose varies depending on the location of the cancer, which is not always specific in the U.S. Department of Labor (DOL) files. *Recommendation: Select cases that have similar back and head skin cancers.*

3. Use of In-vitro and/or In-vivo Data – It is not apparent that there is consistency in the selection of the bioassay data used to derive internal intakes and resulting doses. Sometimes both in-vitro and in-vivo data are used, sometimes only one, and sometimes comparisons are performed, with the greater intake/dose used—or discarded if it exceeds some of the other results. *Recommendation: Select some cases with EEs who would have potentially numerous bioassays, such as operators, over long employment periods.*

4. Construction Trade Worker Determination – Despite not being monitored in many instances, many Construction Trade Workers (CTWs) have been determined to have elevated risks of exposure during employment. Unmonitored workers who are classified as CTWs are assigned unmonitored dose 1.4 times greater than non-CTWs. An abbreviated list of construction careers is provided in ORAUT-OTIB-0052; however, the determination of careers that qualify as CTW is largely left up to the dose reconstructor. SC&A questions if construction careers outside the short list are consistently processed as CTW claims. *Recommendation: Select cases with unmonitored dose applied and construction careers not listed in ORAUT-OTIB-0052 (e.g., heavy equipment operators, millwrights, maintenance workers, etc.) and verify CTW coworker dose was applied consistently.*

5. Glovebox Factor – It is not apparent what criteria are used to determine if a glovebox correction factor is applied. In some cases, it appears to be the years that the EE had extremity monitoring; in other cases, it depends on if the EE worked at a glovebox; and in others it appears to be the ratio of the shallow to deep dose. *Recommendation: Select some cases where the EE may have worked with gloveboxes and/or had shallow dose exposures over long employment periods.*

6. Exposure Area Criteria – It is not always apparent in the DR reports what criteria are used to determine whether an EE's work involved exposure to environmental (non-radiation) areas, general work areas (such as laborer), or operational areas (i.e., production area) and whether that changed during the EE's employment history. If badging and bioassaying were intermittent, or if DOL files do not provide details of job assignments (with dates), this is sometimes a subjective decision without apparent support in the DR reports. *Recommendation: Select cases from a site that did not have consistent monitoring practices, workers with numerous job titles, and/or sites that performed Atomic Energy Commission/U.S. Department of Energy work intermittently*.

7. Oak Ridge Sites – For EEs who worked at multiple Oak Ridge sites (Oak Ridge National Laboratory, Y-12, and/or K-25), it is not always obvious what facility performed the dosimetry, bioassays, and x-ray exams, and the records are sometimes intertwined. Determination of the correct TBD to use is sometimes subjective and not

Memo: Consistency in Dose Reconstruction 4 SC&A – March 11, 2016 NOTICE: This memo has been reviewed to identify and redact any information that is protected by the Privacy Act 5 U.S.C. § 552a and has been cleared for distribution.

always supported in the DR report; this leads to potential inconsistency in the DR for different cases. *Recommendation: Select Oak Ridge cases where EEs worked at multiple sites.*

Selecting cases for a partial review comparison will be somewhat challenging, because, in order to be compared for consistency in approach, depending on the criteria being investigated, the cases must have similar exposure history, work locations, and employment dates. Additionally, because the program has matured over time, cases selected for comparison should have been completed within similar time periods to ensure the same procedure revisions are used.

SC&A stresses the importance of selecting numerous cases with similar employment characteristics for any consistency investigation. A minimum of two cases are needed for a consistency comparison; however, SC&A recommends a greater number of cases be selected for a more statistically sound comparison. Cases for any type of consistency review would also need to be selected with POCs near the 50% threshold to ensure best-estimate assumptions were applied. Efficiency claims (minimizing and maximizing) are not suited for a consistency review because efficiency cases do not aim to accurately calculate POC but rather seek to confirm the expected compensation decision. As a result, consistency in approach is less important.

Attachment 3a: SRS DR guidance comparison

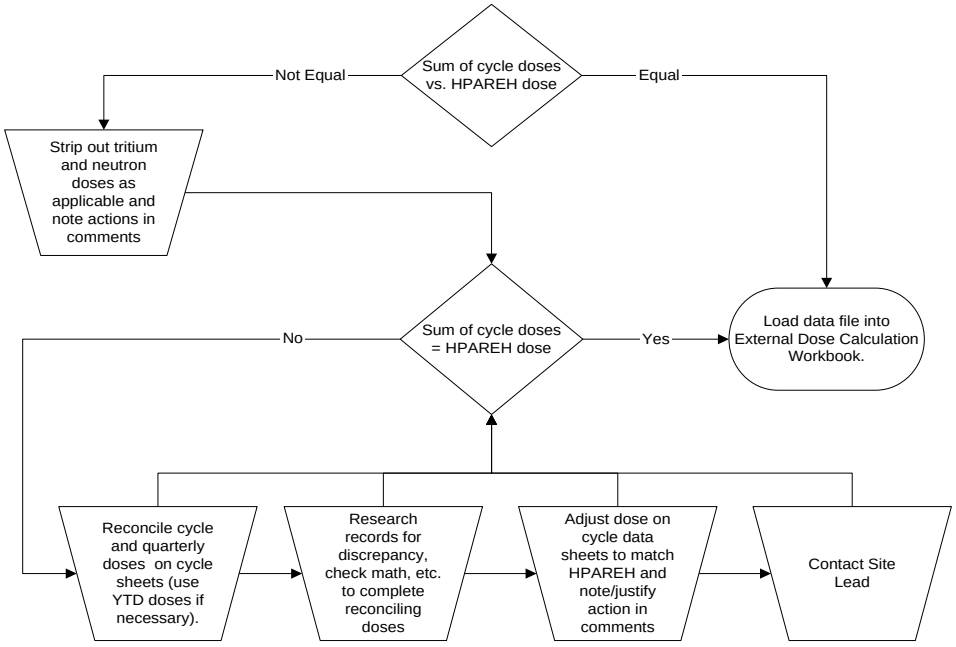
The document below is a <u>comparison</u> of DR guidance (04272011) and a more recent version (08022106). The document shows (highlighted in underlined text) the changes that are included in the 2016 version that were not in the 2011 version.

SRS Guidance Document

The Health Protection Annual Radiation Exposure History (HPAREH) database was used to generate yearly radiation exposure reports to SRS employees beginning in 1980. (ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0003, *Technical Basis Document for the Savannah River Site, Rev 03*, April 5, 2005, SRDB Reference ID 20176). It is considered the dose of record for dose reconstruction purposes. Handwritten dose records are provided through the second quarter of 1958. Neutron doses are specified in separate columns from the photon and beta doses. Computer generated reports start in 1958 and there is some overlap with the handwritten records (1st and 2nd quarters of 1958). Tritium and neutron doses are identified by codes (see Tables 1 and 2). From the second quarter of 1963 through December 31, 1972, the total whole body dose reported in the cycle data is comprised of the photon,

neutron, and tritium doses. From 1973 on, tritium and neutron doses may or may not be separated out in the cycle doses shown on HPRAD data sheets. In preparation for reconstructing the external dose, Dose Reconstructors are responsible for reconciling the reported cycle doses with the annual dose reported in HPAREH which involves separating the neutron and tritium doses from the photon dose during this period. This process is outlined in the following flowchart.

Most of the monitored workers were placed on a quarterly dosimetry cycle in January of 1994. It is also noted that the recorded doses in the quarterly cycle data reports represent the beginning of the read periods (i.e., the issue date). Readings for cycles 1, 4, 7 and 10 would represent one year of monitoring. Monthly cycle readings were also conducted during specific job circumstances.



HPAREH may not always be easily reconcilable with the routine monitoring cycle data for photons, electrons, and neutrons. There are a number of reasonable explanations, including the fact that the results of dose investigations may add or remove dose from the cycle results.

The tritium dose was typically, but not always, included in both the deep and shallow doses recorded on the cycle data sheets. As such, the tritium dose reported on HPAREH must be subtracted from the cycle data. A pattern in the inclusion of tritium dose in the records was not observed, so the Dose Reconstructor will need to determine if the tritium dose needs to be subtracted from the cycle data.

Neutron doses, like tritium, are sometimes included in the cycle deep and shallow dose. These must also be identified and subtracted out in a manner similar to that done with tritium. There may be a situation with a minimal photon dose and a measured neutron dose (due to shielding material that works great for photons but is essentially worthless for neutrons). However, if neutron exposure > 0.100-0.200 rem and a zero photon dose then this might indicate a situation similar to a lost or missing dosimeter (for gamma dose). In this case, it may be appropriate to assign coworker photon dose or assign photon dose based on adjacent monitoring.

After the sum of the cycle doses for a given year has been reconciled with the HPAREH dose for that year regarding tritium and neutron dose, the dose reconstructor should address any further differences as follows:

For non-compensable cases:

- If the sum of the cycle doses is greater than the HPAREH dose for any given year, no further action by the dose reconstructor is required as the higher cycle doses are used for calculating the external dose. This is claimant favorable. The dose reconstructor should note any differences in the comments on the cycle worksheets.

- If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor will insert the difference in the appropriate column on the cycle data sheet and note/justify the dose entry to match HPAREH in the comments.

For compensable cases:

- If the sum of the cycle doses is greater than the HPAREH dose for any given year, the dose reconstructor may subtract the dose difference so that the sum of the cycle doses match HPAREH, and note/justify action in the comments.

- If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor may leave as is (an underestimating action). The dose reconstructor will note/justify this in the comments section of the cycle worksheet.

For best-estimate cases:

- Use professional judgment and a combination of the above to reconcile differences between HPAREH and cycle data. For non-compensable best estimates, favor the guidance for non-compensable cases; likewise for compensable best-estimates. The dose reconstructor must annotate the cycle data sufficiently to justify reconciling HPAREH and cycle data.

Estimating Zeros

If only annual summary dose data (i.e., HPAREH) is provided, estimate zeros as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001). Otherwise, a suggested approach is:

Input the actual number of zero dosimeter results recorded on the handwritten records (through 1958).

Computer-generated records from 1958 through the second quarter of 1963: if the cycle is shown and the dose is blank, assume a zero dosimeter result. If no cycle shown, assume not monitored or monitoring continued on same dosimeter to next listed cycle. This is easiest to justify if all the listed cycles have a temporary or visitor badge designation/code.

From the second quarter of 1963 through the end of 1972 when only quarterly reports are provided, after reconciling doses as described above, zero dosimeter results may be estimated in the same manner as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001), except that the prorated Site administrative control limit would be applied over each cycle in the quarter rather than the year. The following table was generated based on information in *A History of Personnel Radiation Dosimetry at the Savannah River Site.* (Westinghouse Savannah River Company (WSRC), May 1995, *A History of Personnel Radiation Dosimetry at the Savannah River Site*(U), WSRC-RP-95-234, Aiken, South Carolina, SRDB Reference ID 12098). Document/justify inclusion/exclusion of a zero in the comments section of the cycle.

		Calculated cycle ACL			Based on info in SRDB # 12098	Assume cycle ACL		
	max cycles	pen	non-pen	neutron		pen	Non-pen	neutron
1951	52	300.00		30	Pen (x-ray or gamma): 0.5 R/week or 0.3 R/week in air. Neutron: 1/10 pen	300		30
1952	52	300.00		30		300		30
1953	52	300.00		30		300		30
1954	52	300.00		30		300		30
1955	52	300.00		30		300		30
1956	52	96.15	192.31		5 rem/yr max (WB). 10 rem skin	100	200	
1957	52	96.15	192.31			100	200	

1958	26	115.38	230.77		60% of 1956 ACL	115	230	
1959	26	115.38	230.77			115	230	
1960	26	115.38			3 rem/year (including tritium	115		
1961	26	115.38				115		
1962	26	115.38				115		
1963	26	115.38				115		
1964	26	115.38				115		
1965	13	230.77				230		
1966	12	250				250		

1991	12	250.00				250		
1992	12	166.67			2 rem/year ACL	170		
1993	12	125.00			1.5 rem/year ACL	125		
1994	12	66.67			0.8 rem/year ACL	70		
1995	12	62.50			0.75 rem/year ACL	65		

The number of zero dosimeter results from 1973 through 1988 are prescribed by OCAS-TIB-006.

Duplicate Zeros (1989 and later)

After 1988, the number of zero dosimeter results assigned is the actual number of zero dosimeter results in the record (with the removal of any duplicated zeros assigned for the same dosimeter exchange cycle).

For 1989 and later it is generally assumed all employees that needed monitoring were monitored. Based on site information, (SRDB Ref ID10931; *A History of Personnel Radiation Dosimetry at the Savannah River Site* [WSRC-RP-95-234 (Taylor et al. 1995)]) quarterly monitoring was started in January of 1994. For this time period and later, based on the exposure potential of the worker, both monthly and quarterly monitoring may have been used. Therefore, it is not uncommon to see a mix of monthly and quarterly monitoring within a single year for a worker. If the monitoring records are complete, but there are periods where the worker was unmonitored, then assign ambient dose (prorated as appropriate). See the example below.

Year	HP Area	Cycle #	Code	OW	S	Comment
1994		1				Add ambient for 1st quarter
		2				
		3				
		4				
		5				
	K01	6		0	0	Assume routine quarterly exchanges
	K01	7		0	0	Assume extra badge-no indication of monthly monitoring
		8				
		9				
	D01	10		0	0	
		11				
		12				
1995	K01	1		0	0	
		2				
		3				
	N01	4		0	0	
		5				
		6				
	N01	7		0	0	
		8				
		9				
	S01	10		0	0	
		11				
		12				

If the exception occurs where it is determined that that the monitoring records are not complete, and a short (≤3 months) or a long (>3 months) term gap exists for a worker, the following guidance should be used to assign dose.

Guidance for Dosimetry Gaps at SRS (1989 and later)

Typically the external dosimetry records were complete during this time period. However, there are exceptions when the records may not be complete. To address gaps in dosimetry data for 1989 and later, first determine if the badge exchange frequency is monthly or quarterly.

NOTE: For 1989 the records routinely do not include monitoring results for the first 3 monthly (1st Quarter) badge exchanges. It is a reasonable assumption the site did not routinely report zero results as described in OCAS-TIB-006 until the 4th month (2nd quarter) of 1989. Adding zeros per the short term gap guidance may be required.

1989							
HP Area	**Cycle #**	**Code**	**OW**	**S**	**OW**	**S**	**Comment**
3M	1		0	0			Added 0's based on short term dosimetry gap guidance
3M	2		0	0			"
3M	3		0	0			"
3M	4		0	0			
3M	5		10	0			
3M	6		0	0	10	0	
M03/3M	7		20	0			
M03/3M	8		0	0			
M03/3M	9		0	0	20	0	
M03/3M	10		0	0			
M03/3M	11		0	0			
M03/3M	12		0	0	0	0	

a. If short gaps (3 months or less for monthly monitoring or 1 quarter for quarterly monitoring) in the individual's dosimetry records exist and is bounded on both ends by dosimetry data, then the individual's adjacent monitoring data should be used to fill in the gaps in their dosimetry data. The gap dose can be interpolated by a simple average between the two monitoring periods. There may instances where the averaging of the two adjacent cycles may be less than

the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc.

b. If large gaps (greater than 3 months for monthly monitoring or greater than 1 quarter for quarterly monitoring) in the individual's dosimetry records exist or the period is not bounded by dosimetry data, then, depending upon the circumstances, external coworker dose data (through 1999), or ambient dose data should be used to fill in the gaps in their dosimetry data. There may instances where the assigning of coworker dose may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc. This approach may be used for gaps greater than 1 quarter, up to 6 months.
c. The DR should always explain the gap fill-in approach used in the DR report.

Exposure Geometry for RBM, Lung, Esophagus and Bone (surface)

NOTE: Geometry should be considered when the external organ or the surrogate organ is RBM, Lung, Esophagus and Bone (surface).

Based on information in the External Dose Reconstruction Implementation Guideline (OCAS-IG-001), consideration must be given for specific job functions in certain type of facilities for Rotational (ROT) and Isotropic (ISO) geometries in addition to Anterior-Posterior (AP) because the AP values are not the most claimant-favorable for bone (surface), bone (red marrow), esophagus and lung when a dosimeter is worn on the chest. In accordance with Table 4.1a correction factors are applied for ROT and ISO dose conversion factors (DCFs).

If an overestimate can not be used, a comparison of each geometry scenario (AP and ROT, it has been determined based on the DCF values ISO will be less than ROT so there is no need to evaluate it) using best estimate techniques must be performed and the geometry resulting in the highest POC (probability of causation) should be used.

*External Dosimetry Codes**

Below are tables listing codes used in the dosimeter records. These tables may be useful in interpreting information provided in the external dosimetry records.

Table 1: Common Acronyms Used by the Personnel Meters Group From 1951-1960.

Code Value	Description
OW	Open Window
S	Shield
B	Beta
G	Gamma
MD	Meter Service Date
NF	Fast Neutron Film
NS	Slow Neutron Pencils
FL	Film Badge Lost
FR	Film Badge Re-Issued
FF	Film Badge Found
MS	Badge Out of Service (pulled)
D	Irregularities (general)
D-1	Evidence of Fog
D-2	Evidence of Contamination
D-3	Damaged in Processing
D-4	Lost in Processing
D-5	Evidence of X-ray
D-6	Evidence of Exposure to Light
D-7	Damaged Film (manufacturer defect)
D-8	Weathered Film
D-9	Film Missing From Badge
P	Pocket Meter
TSR	Total Significant Reading
OS	Off Scale
DM	Damage Pencil Meter
PL	Lost Pencil Meter
SD	Insignificant Double
A	Not in use
R	Ring
M	Master File
V	Visitor Badge or Permanent and Visitor Badge
SP	Special Pull
TB	Temporary Badge
LP	Late Pickup
RF	Refer to Folder
NPO	No Possible Exposure (investigation result)
NBI	New Badge Issued

Table 2: External Dosimetry Codes Used in the Logbooks from 1961 through 1978.

Code Value	Description
OW	Open Window
S	Shield
1	Badge not in rack
2	Film contaminated and destroyed
3	Evidence of Fog
4	Lost by personnel meters
5	X-ray exposure
6	Film exposure to light
7	Defective film (Manufacturer defect)
8	Damaged by moisture
9	Film lost from badge
10	Complete badge lost
11	Sent through laundry
12	Film contaminated
30	Special pull badge
31	Late pickup
32	Neutron film (NTA)
33	Neutron pencil
34	Bioassay (Tritium)
35*	Off-plant exposure
51	Badge worn by two people
60*	Investigation
61	Badge canceled
62	Badge reissued
63	Name change
64	Change in payroll number or roll
65	Employee terminated
66	New Badge
67	Location change
68	Badge in process of being made
69	Out sick (badge home with employee)

* Refer to the personnel radiation exposure file for details.

Dosimeter Codes and Building/Facility Locations

The dosimeter codes found in the external dosimeter records may be listed in Table 5-1 in ORAU Technical Information Bulletin_Internal Coworker Dosimetry Data for the SRS (OTIB-0081). These codes may be used to aid in the identification of buildings/facilities for the energy employee work locations.

Occupational Medical Dose

Information provided in Technical Basis Document for the Savannah River Site – Occupational Medical Dose, (Rev 04, effective date November 20, 2009) indicates the occupational medical dose should be

assigned with an uncertainty of 35%. However, the Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures, (Rev 04 effective date June 20, 2011) indicates an uncertainty of 30% should be used. Therefore, for occupational medical dose assignment at SRS, an uncertainty of 30% should be assigned in accordance with the latest guidance provided in Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures, (Rev 04).

Internal Dose

Bioassay Results

MDAs contained in the site profile are intended as defaults when there is no better information available, i.e., sample specific MDAs. When the bioassay results in the employee's personal records include an MDA (or a clear value that the site considers the value below – such as "<0.05"), that value takes precedence over the site default value and is to be used in the dose assessment. This applies regardless of whether the sample's less than value is larger or smaller than the value in the site profile.

Internal Data Results: Reporting Level/MDA/Detection Level

In some instances, a site may apply a *reporting level* that is greater than the MDA. This is most common when the nuclide is easily detected, such as H-3, and a result at the MDA produces a very small dose. In such cases, only measurements with values exceeding the reporting level are recorded in the employee files, i.e., results between the MDA and the reporting level are recorded as "0" or "<" the reporting level, and the reporting level becomes the MDA by default. A missed dose would be based on the value of the reporting level rather than the MDA.

In the early years at SRS (handwritten records), results were reported as an actual value or as a "less than" value. Any handwritten results that do not have a "<" sign in front of the reported result would be treated as a positive value. Values reported with a "<" sign are treated as less than MDA, with the MDA equal to the reported value. For the following example data, many of the uranium results in 1955-1956 are reported as actual values rather than "<" some value. These results should be assessed using fitted dose methods.

	DATE	ELEMENT	RESULT	LOCATION
1	3-29-55	U	3.0 µg/l	200F
2	3-28-55	FP	<30 dpm/750ml	210F
3	5-22-55	Pu	<.05 dpm/1.5l	200H
4				

	DATE	ELEMENT	RESULT	LOCATION
1	12-15-55	Pu	<.05 dpm/1.5l	200H
2	2-24-56	F P	<30 dpm/750ml	200F
3	2-24-56	U	0.7 µg/l	205F
4	6-19-56	F.P.	<30 dpm/750 ml.	200F
5	6-19-56	U	0.8 µg/l	200H
6	8/17/56	Pu.	<.05 dpm/1.5l	200H
7	11/16/56	U.	1.0 µg/l	200H
8	11/16/56	F.P.	<30 dpm/750 ml.	200H
9				

	DATE	ELEMENT	RESULT	LOCATION
1	2-13-61	Pu	<.06 dpm/1.5l	F
2	4-19-61	Pu	<.05 dpm/1.5l	F
3	4-5-61	S.B.	<.05 dpm/1.5l	F
4	8-22-61	U	<1 µg/liter	F
5	8-22-61	Pu	<.05 dpm/1.5l	F
6	8-22-61	S.B.	<.05 dpm/1.5l	F
7	9-12-61	FP	<1 dpm/liter	F
8	11-21-61	U	<1 µg/liter	F
9				

<u>Information for the Interpretation of Uranium Results (1980's to early 1990's)</u>

Logbooks indicate bioassay samples for "U" were analyzed by both fluorophotometric analysis and delayed neutron counting (DNC) in 1982-1984. Logbooks also indicate bioassay samples for "EU" were analyzed by both gross alpha analysis and DNC in 1982-1985. These are not definitive dates for the overlap in methods but are based on review of available Uranium Record Books.*

Results of uranium bioassay by delayed neutron counting (DNC) in 1982-1985 are for both "U" and "EU". Results for "EU" were reported in units of dpm/1.5 L, while results for "U" were sometimes reported in units of dpm/1.5 L and sometimes in units of ug/1.5 L. Handwritten Kardex bioassay records typically do not include units of the results in this era, so a Kardex result for "U" during this era could be in units of either dpm/1.5 L or ug/1.5 L. The reporting level for "U" varied between 1 and 5 ug/1.5 L and the reporting level for "EU" was typically 1 dpm/1.5 L, although an EU reporting level as high as <4 was seen for some batches and a few reporting levels of EU were reported to two significant figures.

EU Lab Record Books for gross alpha counting indicate the typical reporting level was 1 dpm/1.5 L through mid 1988. Starting in mid 1988 a <2 dpm/1.5 L reporting level was typically used for EU. SRDB Reference ID 49644 indicates that SRS labs started reporting negative EU bioassay results as less than the critical level (CL) in the latter half of 1990. [Critical level is a statistical value that is equal to about half of the MDA.] Some of the handwritten Kardex records in NOCTS reflect the change from a <2 reporting level to a <CL value. When a value is reported with a less than symbol and is lower than a reporting level of 2, then it should be considered as a CL. The CL should be multiplied by 2 to obtain the value to be used for the MDA. For example, a Kardex result of "<0.88" in 1990 should be interpreted to be the critical level. For dose reconstruction purposes, the MDA for that sample is assumed to 1.76 dpm/1.5 L (2 * 0.88).

*Ref ID 49826, EU Record 7/21/1981 to 12/3/1985

Ref ID 49827, DNC Record 3/15/1983 to 9/16/1983

Ref ID 49829, Delayed Neutron Counting Record 6/20/1984 thru 3/11/1985

Ref ID 49830, Delayed Neutron Counting 3/12/1985 thru 6/11/1985

Ref ID 49646, DNC Record 6/21/1982 to 4/3/1982

Ref ID 49637, Uranium record Book 3/15/1979 through 6/7/1984

Ref ID 49644, EU Record Book, 6-1990 thru I-1991

The dose reconstructor should use case specific information as found in the bioassay records for reporting levels. The table below should be used as the default when bioassay records are incomplete. The reporting levels listed in the table below may be used as the MDA default value.

Nuclide	Method	Reporting Method	Time Period (Approximate)	Reporting Level	Units
U	Fluorophotometric	Kardex	Start-up to 1956	1*	ug/1.0 L

U	Fluorophotometric	Kardex	1956-1961	1	ug/1.0 L
U	Fluorophotometric	Kardex	1961-1962	1	ug/1.5 L
U	Fluorophotometric	Kardex	1962-1982	5	ug/1.5 L
U	DNC	Kardex	1982-1985	1	dpm/1.5 L or ug/1.5 L
U	KPA	Kardex	1986-1990	5**	ug/1.5 L
U or NT/D U	KPA	Computer	Early 1991	5**	ug/1.0 L
U or NT/D U	KPA	Computer	1991 and later	3.33**	ug/1 L
EU***	Gross Alpha	Kardex	Start-up to 1982	1****	dpm/1.5 L
EU	DNC	Kardex	1982-1985	1-4*	dpm/1.5 L
EU	Gross Alpha	Kardex	1985-mid 1988	1	dpm/1.5 L
EU	Gross Alpha	Kardex	mid 1988-mid 1990	2	dpm/1.5 L
EU	Gross Alpha	Kardex	Later part of 1990	CL*****	dpm/1.5 L
EU	Gross Alpha	Computer	Start 1991	CL	dpm/1.0 L

* Presumed reporting level

* *Some records may have different reporting levels.

***In early bioassay records sometimes labeled “En. Uranium” or “LMF”.

****In the 1950s some positive EU results are recorded at levels below 1.

*****Negative results were reported as less than the critical level (CL).

Ref ID57175, RefID57041, RefID57177, RefID53261

NOTE: For results for all nuclides except tritium, units are typically provided in handwritten records from start-up to 1969. Units usually not provided in handwritten records after 1969. Computer records have units.

When the units for “U” are not provided in the claimant’s records from (approximately) 1982 through 1985 , the dose reconstructor should default to the more claimant favorable units. Using a depleted

uranium specific activity of 0.372 pCi/ug (0.826 dpm/ug), a result without units should be assumed to be in units of dpm because it provides a higher radioactivity concentration.

Post 1990 Bioassay Reports

For later years (starting in 1991), some of the internal dosimetry data reports do not include a minimum detectable amount or a "<" result but can include information for "Result," "Activity," and "Detect Level" (as shown below). In the early 1990s the reports generally only include data in the Result column. If a negative value (i.e., less than 0) is reported, this indicates that SRS considered no activity to be detected and the reported value is the negative of the Detect Level. This can be seen in reports at some point in 1994, when data for Result, Activity, Detect Level and Error are usually included. When a value is reported without the '-' sign (as a positive number) and with no associated Detect Level assume the result is positive and assess as fitted dose. An example report is shown below. These later reports show the Detect Level to be the absolute value of the 'negative' Result. Beginning in 1991, when a negative Result is reported it should be assumed to be the critical level. The MDA can be assumed to be twice the critical level/detect level. In the example below for Pu-239 on May 6, 1992, the Result is reported as -0.020 dpm/L. With the assumption that the absolute value of this result is the critical level, the MDA is determined to be twice the critical level, in this case 0.040 dpm/L and corrected for daily excretion by multiplying by 1.4. In the example below for Pu-239 on May 25, 1994, the Result is reported as -0.024 dpm/L. The Detection Level is 0.024 dpm/L, therefore the MDA would be 0.067 dpm/day.

Sample ID	Sample Void Date	Sample Receive Date	Facil	Isotope	LLD Ind	Result	Result Units	Re-Run Result	Activity	Detect Level	Error	Sample Type
	09/28/1991	10/03/1991	TEC	Sr-90		-0.010	nCi/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Pu-238		-0.020	dpm/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Pu-239		-0.020	dpm/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Sr-90		-0.010	nCi/L					ROUTINE
	09/30/1992	10/08/1992	" TEC	EU		-0.850	dpm/L					ROUTINE
	09/30/1992	10/08/1992	" TEC	Sr-90		-0.010	nCi/L					ROUTINE
	12/01/1992	12/04/1992	" TEC	Pu-238		-0.030	dpm/L					ROUTINE
	12/01/1992	12/04/1992	" TEC	Pu-239		-0.010	dpm/L					ROUTINE
20393	03/31/1994	05/04/1994	"	AmCmCf		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Pu-238		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Pu-239		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Sr-90		0.000	IA					ROUTINE
23116	05/25/1994	05/31/1994		AmCmCf		-0.121	dpm/L					IAF
23116	05/25/1994	05/31/1994		Pu-238		-0.036	dpm/L		0.020	0.036	0.028	IAF
23116	05/25/1994	05/31/1994		Pu-239		-0.024	dpm/L		0.000	0.024	0.000	IAF
23116	05/25/1994	05/31/1994		Sr-90		-1.843	pCi/L					IAF
39528	04/17/1995	04/19/1995		Am-241		-0.025	dpm/L		0.013	0.025	0.023	ROUTINE

The value reported in the Activity column would be compared to the MDA (2* the Detect Level and * daily excretion) to determine if the result would be considered a 'positive' bioassay result. In the example above, the May 25, 1994 Pu-238 Activity value of 0.020 dpm/L would not be considered a positive result because it (0.020 * 1.4 = 0.028 dpm/day) is below the MDA (0.036 * 2 * 1.4 = 0.10 dpm/day). Some reporting formats do not have a 'Result' value and only report a value for 'Activity'. However, just as in the example above, the value in the Activity column is compared to the MDA (2 times

the Detect Level and corrected for daily excretion) to determine if the activity would be considered a 'positive' bioassay result.

Another report format was also used by the site for data beginning in 1991 and is shown below with the same bioassay data as discussed above. In this example, the Result column shows "<" with a value in the Result column. This value is the critical level. For example, the Pu-239 result reported for May 6, 1992 is '< 0.020' dpm/L. The MDA would be twice this critical level 0.040 dpm/L and corrected for daily excretion by multiplying by 1.4 (0.056 dpm/day).

Bottle Date	Rec Date	Type	Batch ID	Isotope		Result		Vol
09/28/1991	10/03/1991	Routine	12-91-002	Sr 90	<	0.010	nCi/L	798
05/06/1992	05/26/1992	Routine	07-92-001	Sr 90	<	0.010	nCi/L	952
05/06/1992	05/26/1992	Routine	07-92-001	Pu 238	<	0.020	dpm/L	952
05/06/1992	05/26/1992	Routine	07-92-001	Pu 239	<	0.020	dpm/L	952
09/30/1992	10/08/1992	Routine	10-92-167	EU	<	0.850	dpm/L	878
09/30/1992	10/08/1992	Routine	10-92-168	Sr 90	<	0.010	nCi/L	878
12/01/1992	12/04/1992	Routine	12-92-029	Pu 238	<	0.030	dpm/L	922
12/01/1992	12/04/1992	Routine	12-92-029	Pu 239	<	0.010	dpm/L	922
03/31/1994	05/04/1994	Routine		Sr 90	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		AmCmCf	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		Pu 238	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		Pu 239	+	0.000	IA	299
05/25/1994	05/31/1994	IA Foll	06-94-093	Sr 90	<	1.843	pCi/L	883
05/25/1994	05/31/1994	IA Foll	06-94-095	AmCmCf	<	0.121	dpm/L	883
05/25/1994	05/31/1994	IA Foll	06-94-094	Pu 238	<	0.036	dpm/L	883
05/25/1994	05/31/1994	IA Foll	06-94-094	Pu 239	<	0.024	dpm/L	883
04/17/1995	04/19/1995	Routine	04-95-148	Sr 90	<	1.988	pCi/L	921
04/17/1995	04/19/1995	Routine	04-95-147	Pu 238	<	0.043	dpm/L	921
04/17/1995	04/19/1995	Routine	04-95-147	Pu 239	<	0.020	dpm/L	921
04/17/1995	04/19/1995	Routine	04-95-151	Am 241	<	0.025	dpm/L	921

When 'IA' is recorded with a '+ 0.000' in the Result column or '0.000' in the Result column with an 'IA' in the Result Units column, as shown in the examples above for March 31, 1994 for AmCmCf, Pu-238, Pu-239 and Sr-90, this indicates "Inconclusive Analysis", meaning the analysis didn't meet Quality Control criteria and no result was reported.

When a report is not in the formats described above and a MDA cannot be determined, the Savannah River Site TBD, (Rev 3) Table D-1 should be used to determine the MDA. If the MDA is not listed in Table D-1, then refer to the 'Reporting Level' column. The reported 'Activity' should be used to compare to the 'MDA/Reporting Level' indicated in Table D-1. If the reported 'activity' is greater than or equal to the 'MDA/Reporting Level', the sample result is "positive" and an intake needs to be assessed (based on OTIB-0060 and the fact that SRS seems to have reported all results at this time – not censoring). If the reported 'activity' is less than the 'MDA/Reporting Level', then missed dose would be assigned based on half of the "MDA/Reporting Level."

Plutonium Mix – Fresh (6% and 12%)

A ratio of Am-241 ingrowth for 2 weeks following separation is used based on Table 5.5 of the Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities (SRBD Ref ID 15919). This ratio should be used for fresh (2-week aged) material of americium rather than the information provided in the current Technical Basis Document for the Savannah River Site. (ORAU-TKBS-0003, 04/05/2005).

Uranium Enrichment Assumptions

When the work area is not known, the following assumptions should be made for uranium exposure. (SRDB Ref ID16499; Historical Generation and Flow of Recycled Uranium at the Savannah River Site [ESH-PEQ-2000-00059, Louis E. McCarty, Manager Performance Evaluation and Quality Programs]):

1953 through 1967 – Natural uranium (0.683 pCi/ug)

1968 and later – Depleted uranium (0.372 pCi/ug)

Assignment of Tritium Doses: Maximizing Method

Based on tritium data collected for a coworker study at the site, it was found that an MDA of 1 µCi/L was used from the startup of the site through 1980, 0.5 µCi/L for 1981 through 1985, 0.1 µCi/L for 1986 to the present. Based on this information, the following doses can be assigned as maximizing approach when all results are below MDA. Results above the MDA are to be assessed per OTIB-0011. These doses

are calculated using the methodology in ORAUT-OTIB-0001,Rev 0; 1.946E-4 rem/day per µCi/L multiplied by the MDA (µCi/L) multiplied by 365 days per year.

Note: The OTIB-0001 maximizing method can only be used when the actual MDA's do not conflict with the MDA's stated above. If they conflict, the MDA in the bioassay data must be used. When tritium bioassay data reports an actual MDA (or '<'number), use this value for comparison to a positive result. This MDA should also be used for determining missed dose.

Years	Annual Dose (rem)
1953 - 1980	0.071
1981 - 1985	0.0355
1986 – to present*	0.0071

*SRDB Ref ID10931; *A History of Personnel Radiation Dosimetry at the Savannah River Site* [WSRC-RP-95-234 (Taylor et al. 1995)], SRBD Ref ID 11266; SRS Internal Dosimetry Technical Basis Manual (1990)

For the purpose of calculating probability of causation, doses from tritium are assumed to be chronic, and are assumed to be from electrons with energy E<15 keV. The doses are treated as a point estimate (constant).

Information for WBC MDAs

Whole body counting began in approximately 1960, using a 4" high by 8" thick diameter NaI detector. (Detection energy range was 100 keV to 2000 keV.) The monitored individual sat in a reclining chair positioned in an arc around the detector; this was referred to as the "40-cm arc geometry" in bioassay monitoring reports. Bioassay via this method was not used for plutonium and americium due to their low energy emissions. Reported MDAs for various radionuclides are shown in Tables 4.2.1-1 and 4.2.1-2 . MDAs and reporting levels were the same. It is reported the 40-cm arc detector was in service until September 1995. However, in approximately 1975 it was mostly replaced by a bed detector using an array of NaI detectors under the bed (WSRC-IM-90-139 [WSRC 1990] indicates five 4" × 4" detectors were used, while Taylor et al. 1995 says that four 4 " × 5" detectors were used.) Additionally, in the mid-1980s, whole body counting using stand-up geometry and large (4" × 4" × 16" or 5" × 3" × 16") NaI detectors was implemented. MDAs for these counting systems were generated individually for counts by processing software. Many forms for reporting the results of whole body counts were used throughout the years. The form used from about 1979 through 1986 listed the MDA for each radionuclide for each count (i.e., count-specific MDAs). Earlier forms did not list MDAs. If MDAs are not

shown, use the ones in Table 4.2.1-1. A 10-nCi follow-up level for Cs-137 was implemented sometime prior to 1975, which might show up as an MDA. However, this was based on counts on nonoccupationally exposed persons and was not reflective of the minimum sensitivity of the detector system (Fleming 1973, p. 96).*

NOTE to DR: To maximize the missed dose assignment, in the chooser tool use the maximum values for MDAs from all time periods. If a better estimate is needed, use MDAs for the applicable time periods.

Table 4.2.1-1. Whole body counting [Taylor et al. 1995, Table 11**, Fleming 1973-79, p. 162*].

Period	Nuclide	MDA, nCi	MDA method
~1960[a] – October 1974	Ce-144	29	~3X standard deviation of expected count rate in energy region.
	U[b]	62	
	I-131	1.4	
	Ru-106	6.1	
	Cs-137	1.0	
	Zr/Nb-95	2.2	
	Zn-65	5.1	
	Ba/La-140	9.3	
October 31, 1974 – December 31, 1979	Ce-144	13	99.75% confidence level, approximately 3X standard deviation of background.
	I-131	5	
	Ru-106	12	
	Cs-137	10[c]	
	Zr/Nb-95	3	
	Zn-65	9	
	Co-60	3	

a. The whole body counter was built starting in April 1959 and completed in 1960. The exact date of completion is not known. Assume January 1, 1960.

b. Listed as U, but based on measurement of U-235. A result greater than the MDA would certainly be a false positive unless it was associated with a major intake. Other counts and urinalyses would be expected.

c. Burden used to discriminate between natural background and possible occupational intake. Did not account for consumption of wild game.

Table 4.2.1-2 Current MDAs for whole body counting

Radionuclide	MDA (nCi)	Radionuclide	MDA (nCi)	Radionuclide	MDA (nCi)
Mn-54	3.4	Sb-125	14	Eu-152	18
Co-60	2.9	Cs-134	3.8	Eu-154	8.4
Zn-65	6.1	Cs-137	4.1	U-235	14
Ru-106	36	Ce-144	69	Np-237	14

*Fleming R.R. 1973-1979 Logbook February 1973 to October 1979 DPSTN-2011 Westinghouse Savannah River Company, Aiken South Carolina, (SRDB ID: 61649)

**Taylor (SRDB ID 10931)

Whole Body Count – Missed Dose

Negative results (missed dose): use SRS Att D Radionuclide Chooser 1.10.xls Tool to identify representative fission/activation product and Absorption Type. Do NOT assign intakes of short-lived fission products after 12/31/1989 since the last reactors (K and P) quit operations about a year before that. These include: Mn-54, Zn-65, Zr-95, Nb-95, Ru-106, Ba-140, La-140,* Ce-144, Cr-51, Fe-59, Ag-110m, and Na-24. For periods after 1988, RadChooser will have to be run separately using only the MDAs for Co-60, Cs-137, and Eu-154 .

*If La-140 assumed, assign equal intake of Ba-140

Europium-152 (Positive WBC Counts)

When a positive whole body count records a europium-152 result above a given MDA or TBD MDA, consider the following before assessing it for dose:

- is not a nuclide of concern at SRS
- Eu-152 emits a wide range of gammas
- it a good calibration source, but gives more opportunity for it to be mistakenly identified
- if the count is stamped with ”K-40” only, it is safe to assume there is nothing there.
- If several peaks for Eu-152 are identified in the spectrum, further review of the result is warranted

Special consideration for fission/activation product analysis (including CLLs)

Table 4.4.2-6 Parameters for simplified upper bound dose for fission/activation products.

For these organs/tissues:	Assume 4,400 dpm/day intake of:
Adrenals, breast, heart wall, thymus, extrathoracic, extrathoracic2, lymph nodes (extrathoracic), lymph nodes (thoracic), esophagus	Co-60 S
Urinary bladder, brain, gall bladder, kidneys, muscle, ovaries, pancreas, testes, thyroid, stomach, small intestine, upper large intestine, skin, spleen, uterus, gonads	Ru-106 F
Colon	Ru-106 M
Lower large intestine, lung	Ru-106 S
Liver, extrathoracic1	Ce-144 M
Bone surface, red bone marrow , CLL*	Sr-90 F

* all options were run for the CLL, the option with the highest dose to the CLL was selected

Table 4.4.2-7. Parameters for reconstruction upper bound dose from fission/activation products.

For these organs/tissues:	Intake assumptions (in dpm/day)			
	2200	880	660	660
Adrenals, brain, breast, gall bladder, heart wall, kidneys, muscle, muscle, ovaries, pancreas, thyroid, stomach, small intestine skin, spleen, thymus, uterus, esophagus, gonads	Ru-106 F	Cs-137 F	Ce-144 M	Co-60 S
Lymph nodes (extrathoracic)	Ru-106 S	Cs-137 F	Ce-144 M	Co-60 S
Urinary bladder, testes,	Ru-106 F	Cs-137 F	Ce-144 M	Sr-90 F
Upper large intestine	Ru-106 F	Ce-144 M	Cs-137 F	Co-60 S
Extrathoracic, extrathoracic2, lung, lymph nodes (thoracic)	Ru-106 S	Ce-144 M	Cs-137 F	Co-60 S
Colon, lower large intestine, CLL*	Ru-106 S	Ce-144 M	Cs-137 F	Sr-90 F
Liver	Ce-144 M	Ru-106 F	Cs-137 F	Co-60 S
Extrathoracic1	Ce-144 M	Sr-90 F	Cs-137 F	Ru-106 F
Red bone marrow	Sr-90 F	Ru-106 F	Cs-137 F	Ce-144 M
Bone surface	Sr-90 F	Ce-144 M	Ru-106 F	Cs-137 F

* all options were run for the CLL, the option with the highest dose to the CLL was selected

Personal Air Sample (PAS) Data

In the later years, dose assigned from PAS data may be present in the annual dose summary report. Dose assigned based on PAS data is not directly applicable to the organ of interest when performing a dose reconstruction. If a committed Effective Dose (CED) is recorded and no bioassay data was provided for the dose assignment, a request for additional data should be made from the site. If the site provides information that the dose was based on PAS data (no bioassay data is available for the assignment of dose), a direct assignment of the dose to the organ of interest can be made for an overestimate of dose for a non-metabolic organ. If a metabolic organ or if a best estimate of dose is needed, contact the PID for guidance.

Fission Product Dose Assignment (Reactor Worker versus non Reactor Worker)

The following methods are to be used for fission product dose assignment when dosimetry records indicate fission product urinalysis prior to whole body counting. When whole body counts are available, the SRS Radionuclide Chooser tool is used and neither method described below should be used.

When a worker is assigned to reactor areas assign annual dose(s) equal to the assigned tritium dose(s) and enter it into the IREP spreadsheet as "electrons >15 keV" to account for missed fission/activation product doses. The basis for this is that tritium dominated the SRS internal radiation doses in the reactor areas. Do not use this approach for periods of time when FP intakes are based on Table 4.4.2-6 or Table 4.4.2-7.

Use method in Table 4.4.2-6 (simplified) and Table 4.4.2.7 (more realistic) to assign an upper bound of fission product dose *when a worker was potentially exposed, but was not necessarily a reactor worker.*

Plutonium/Uranium Lung Counts (starting 1990)

This guidance is provided to address the possibility of uranium exposure using the plutonium/uranium lung counter results. These counts could also be used to limit other nuclides but uranium will most frequently be encountered.

Starting in December of 1989, the site began using a six detector solid state planar germanium array in a reclining chair geometry for the lung counter. In 1995, the six detector array was replaced by two larger detectors and at the same time a move was made to a new in vivo counting facility.

An example of a report commonly seen for the 'Plutonium/Uranium Lung Counter' is as follows. It has the plutonium/uranium counter location identified as the counter location on reports. Note that there was only a single lung counter in use at a time, so in this time frame uranium is implied even if it's not explicitly stated in the counter location.

counted: 26-APR-90 11:04:27 height: 68 (in) weight: 208 (lb)

printed: 26-APR-90 11:42:25 age: 32 (yrs.) sex: M CWT: 31.8 (am.)

counter location: PLUTONIUM/URANIUM LUNG COUNTER showered before count: Y

operator: F J WAKEFIELD directory: [300,001] wore special clothing for count: Y

comments: PLUTONIUM

No MDAs or nuclides are typically reported on these lung count reports. Information from the following table can be used for the appropriate MDAs. In general, if urine bioassay is present in the bioassay record for a certain nuclide, the lung count data/MDAs may be used to limit the intake(s) based on the urine data. If no urine bioassay is present in the records, there is no need to assume the worker was exposed to the nuclides listed in the lung counting table.

For this period of time (1990 to present) the assumption is made that the site was dealing with depleted uranium. (SRBD Ref ID 16499) Therefore, when uranium urinalysis are present the bioassay record and a lung count is available, it can be used to limit the data. The MDA used for uranium in the lung count is for DU, 1.2 nCi as shown in the table below. This DU MDA should be used for uranium starting in 1990 through the present time.

Table of Ge Lung Counter MDAs (nCi)			
Nuclide	**1990-2000**	**2001-2007**	**2008 to present**
Cf-252	30	32	32
Cm-242	27	28	28
Cm-244	29	37	37
Am-241	0.13	0.10	0.10
Am-243	NR	0.12	0.12
Pu-238	43	58	58

Pu-239	110	130	130
Pu-240	46	47	47
3%Pu	NR	110	110
6%Pu	NR	96	96
12%Pu	NR	70	70
Np-237	0.35	0.31	0.31
U-234	43	30	30
U-235	0.10	0.10	0.10
U-236	91	89	89
U-238	1.10	1.10	1.10
DU	NR	1.2	1.2
RU	NR	8.3	8.3
HEU	NR	5.2	5.2
Th-228	3.4	3.2	3.2
Th-232	28	31	31
Eu-152	0.13	0.056	0.056
Ce-144	0.43	0.31	0.31

NR = Not Reported

Table References: For 1990 – SRDB Ref ID 11266, For 2001 – SRDB Ref ID 722, For 2008 – SRDB Ref ID 157076

Note: A lung count cannot be used for Uranium Absorption Type F material

Reminder: Am/Pu exposure is assumed based on the presence of a lung count report in the dosimetry records.

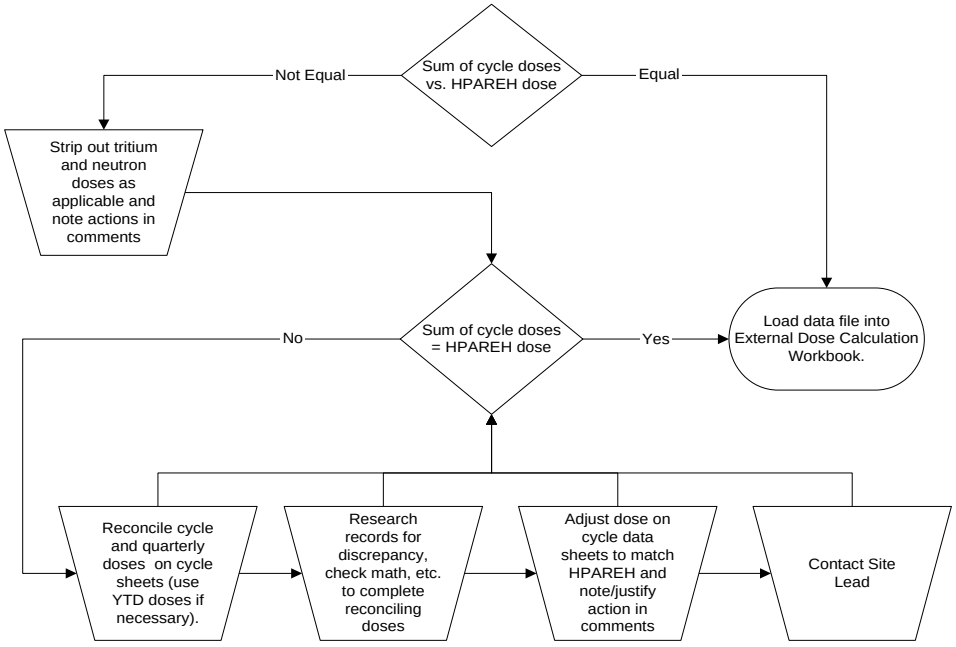
Attachment 3b: Comparison of SRS DR Guidance Documents

The document below was generated by comparing two versions of the DR guidance (0902015 and 08022016). The highlighted sections (underlined text) in this document show the additions in the 2016 version that were not in the 2015 version.

SRS Guidance Document

The Health Protection Annual Radiation Exposure History (HPAREH) database was used to generate yearly radiation exposure reports to SRS employees beginning in 1980. (ORAUT (Oak Ridge Associated Universities Team), ORAUT-TKBS-0003, *Technical Basis Document for the Savannah River Site, Rev 03*, April 5, 2005, SRDB Reference ID 20176). It is considered the dose of record for dose reconstruction purposes. Handwritten dose records are provided through the second quarter of 1958. Neutron doses are specified in separate columns from the photon and beta doses. Computer generated reports start in 1958 and there is some overlap with the handwritten records (1st and 2nd quarters of 1958). Tritium and neutron doses are identified by codes (see Tables 1 and 2). From the second quarter of 1963 through December 31, 1972, the total whole body dose reported in the cycle data is comprised of the photon, neutron, and tritium doses. From 1973 on, tritium and neutron doses may or may not be separated out in the cycle doses shown on HPRAD data sheets. In preparation for reconstructing the external dose, Dose Reconstructors are responsible for reconciling the reported cycle doses with the annual dose reported in HPAREH which involves separating the neutron and tritium doses from the photon dose during this period. This process is outlined in the following flowchart.

Most of the monitored workers were placed on a quarterly dosimetry cycle in January of 1994. It is also noted that the recorded doses in the quarterly cycle data reports represent the beginning of the read periods (i.e., the issue date). Readings for cycles 1, 4, 7 and 10 would represent one year of monitoring. Monthly cycle readings were also conducted during specific job circumstances.



HPAREH may not always be easily reconcilable with the routine monitoring cycle data for photons, electrons, and neutrons. There are a number of reasonable explanations, including the fact that the results of dose investigations may add or remove dose from the cycle results.

The tritium dose was typically, but not always, included in both the deep and shallow doses recorded on the cycle data sheets. As such, the tritium dose reported on HPAREH must be subtracted from the cycle data. A pattern in the inclusion of tritium dose in the records was not observed, so the Dose Reconstructor will need to determine if the tritium dose needs to be subtracted from the cycle data.

Neutron doses, like tritium, are sometimes included in the cycle deep and shallow dose. These must also be identified and subtracted out in a manner similar to that done with tritium. There may be a situation with a minimal photon dose and a measured neutron dose (due to shielding material that works great for photons but is essentially worthless for neutrons). However, if neutron exposure > 0.100-0.200 rem and a zero photon dose then this might indicate a situation similar to a lost or missing dosimeter (for gamma dose). In this case, it may be appropriate to assign coworker photon dose or assign photon dose based on adjacent monitoring.

After the sum of the cycle doses for a given year has been reconciled with the HPAREH dose for that year regarding tritium and neutron dose, the dose reconstructor should address any further differences as follows:

For non-compensable cases:

- If the sum of the cycle doses is greater than the HPAREH dose for any given year, no further action by the dose reconstructor is required as the higher cycle doses are used for calculating the external dose. This is claimant favorable. The dose reconstructor should note any differences in the comments on the cycle worksheets.
- If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor will insert the difference in the appropriate column on the cycle data sheet and note/justify the dose entry to match HPAREH in the comments.

For compensable cases:

- If the sum of the cycle doses is greater than the HPAREH dose for any given year, the dose reconstructor may subtract the dose difference so that the sum of the cycle doses match HPAREH, and note/justify action in the comments.
- If the sum of the cycle doses is less than the HPAREH dose for any given year, the dose reconstructor may leave as is (an underestimating action). The dose reconstructor will note/justify this in the comments section of the cycle worksheet.

For best-estimate cases:

- Use professional judgment and a combination of the above to reconcile differences between HPAREH and cycle data. For non-compensable best estimates, favor the guidance for non-compensable cases; likewise for compensable best-estimates. The dose reconstructor must annotate the cycle data sufficiently to justify reconciling HPAREH and cycle data.

Estimating Zeros

If only annual summary dose data (i.e., HPAREH) is provided, estimate zeros as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001). Otherwise, a suggested approach is:

Input the actual number of zero dosimeter results recorded on the handwritten records (through 1958).

Computer-generated records from 1958 through the second quarter of 1963: if the cycle is shown and the dose is blank, assume a zero dosimeter result. If no cycle shown, assume not monitored or monitoring continued on same dosimeter to next listed cycle. This is easiest to justify if all the listed cycles have a temporary or visitor badge designation/code.

From the second quarter of 1963 through the end of 1972 when only quarterly reports are provided, after reconciling doses as described above, zero dosimeter results may be estimated in the same manner as described in Section 2.1.2.3 of the External Dose Reconstruction Implementation Guideline (OCAS-IG-001), except that the prorated Site administrative control limit would be applied over each cycle in the quarter rather than the year. The following table was generated based on information in *A History of Personnel Radiation Dosimetry at the Savannah River Site.* (Westinghouse Savannah River Company (WSRC), May 1995, *A History of Personnel Radiation Dosimetry at the Savannah River Site*(U), WSRC-RP-95-234, Aiken, South Carolina, SRDB Reference ID 12098). Document/justify inclusion/exclusion of a zero in the comments section of the cycle.

		Calculated cycle ACL			Based on info in SRDB # 12098	Assume cycle ACL		
	max cycles	pen	non-pen	neutron		pen	Non-pen	neutron
1951	52	300.00		30	Pen (x-ray or gamma): 0.5 R/week or 0.3 R/week in air. Neutron: 1/10 pen	300		30
1952	52	300.00		30		300		30
1953	52	300.00		30		300		30
1954	52	300.00		30		300		30
1955	52	300.00		30		300		30
1956	52	96.15	192.31		5 rem/yr max (WB). 10 rem skin	100	200	
1957	52	96.15	192.31			100	200	
1958	26	115.38	230.77		60% of 1956 ACL	115	230	
1959	26	115.38	230.77			115	230	
1960	26	115.38			3 rem/year (including tritium	115		
1961	26	115.38				115		
1962	26	115.38				115		

1963	26	115.38				115		
1964	26	115.38				115		
1965	13	230.77				230		
1966	12	250				250		

1991	12	250.00				250		
1992	12	166.67			2 rem/year ACL	170		
1993	12	125.00			1.5 rem/year ACL	125		
1994	12	66.67			0.8 rem/year ACL	70		
1995	12	62.50			0.75 rem/year ACL	65		

The number of zero dosimeter results from 1973 through 1988 are prescribed by OCAS-TIB-006.

Duplicate Zeros (1989 and later)

After 1988, the number of zero dosimeter results assigned is the actual number of zero dosimeter results in the record (with the removal of any duplicated zeros assigned for the same dosimeter exchange cycle).

For 1989 and later it is generally assumed all employees that needed monitoring were monitored. Based on site information, (SRDB Ref ID10931; *A History of Personnel Radiation Dosimetry at the Savannah River Site* [WSRC-RP-95-234 (Taylor et al. 1995)]) quarterly monitoring was started in January of 1994. For this time period and later, based on the exposure potential of the worker, both monthly and quarterly monitoring may have been used. Therefore, it is not uncommon to see a mix of monthly and quarterly monitoring within a single year for a worker. If the monitoring records are complete, but there are periods where the worker was unmonitored, then assign ambient dose (prorated as appropriate). See the example below.

Year	HP Area	Cycle #	Code	OW	S	Comment
1994		1				Add ambient for 1st quarter
		2				
		3				
		4				
		5				
	K01	6		0	0	Assume routine quarterly exchanges

	K01	7		0	0	Assume extra badge-no indication of monthly monitoring
		8				
		9				
	D01	10		0	0	
		11				
		12				
1995	K01	1		0	0	
		2				
		3				
	N01	4		0	0	
		5				
		6				
	N01	7		0	0	
		8				
		9				
	S01	10		0	0	
		11				
		12				

If the exception occurs where it is determined that that the monitoring records are not complete, and a short (≤3 months) or a long (>3 months) term gap exists for a worker, the following guidance should be used to assign dose.

Guidance for Dosimetry Gaps at SRS (1989 and later)

Typically the external dosimetry records were complete during this time period. However, there are exceptions when the records may not be complete. To address gaps in dosimetry data for 1989 and later, first determine if the badge exchange frequency is monthly or quarterly.

NOTE: For 1989 the records routinely do not include monitoring results for the first 3 monthly (1st Quarter) badge exchanges. It is a reasonable assumption the site did not routinely report zero results as described in OCAS-TIB-006 until the 4th month (2nd quarter) of 1989. Adding zeros per the short term gap guidance may be required.

1989							
HP Area	**Cycle #**	**Code**	**OW**	**S**	**OW**	**S**	**Comment**
3M	1		0	0			Added 0's based on short term dosimetry gap guidance
3M	2		0	0			"
3M	3		0	0			"
3M	4		0	0			
3M	5		10	0			
3M	6		0	0	10	0	
M03/3M	7		20	0			
M03/3M	8		0	0			
M03/3M	9		0	0	20	0	
M03/3M	10		0	0			
M03/3M	11		0	0			
M03/3M	12		0	0	0	0	

d. If short gaps (3 months or less for monthly monitoring or 1 quarter for quarterly monitoring) in the individual's dosimetry records exist and is bounded on both ends by dosimetry data, then the individual's adjacent monitoring data should be used to fill in the gaps in their dosimetry data. The gap dose can be interpolated by a simple average between the two monitoring periods. There may instances where the averaging of the two adjacent cycles may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc.
e. If large gaps (greater than 3 months for monthly monitoring or greater than 1 quarter for quarterly monitoring) in the individual's dosimetry records exist or the period is not bounded by dosimetry data, then, depending upon the circumstances, external coworker dose data (through 1999), or ambient dose data should be used to fill in the gaps in their dosimetry data. There may instances where the assigning of coworker dose may be less than the individual's average dose for the other reported monitoring periods bracketing the gap. The DR may use discretion in assigning a higher gap fill-in dose in this instance, given the quality of the reported monitoring data, no change in job, work location, documented absence from work, administrative action, etc. This approach may be used for gaps greater than 1 quarter, up to 6 months.
f. The DR should always explain the gap fill-in approach used in the DR report.

Exposure Geometry for RBM, Lung, Esophagus and Bone (surface)

NOTE: Geometry should be considered when the external organ or the surrogate organ is RBM, Lung, Esophagus and Bone (surface).

Based on information in the External Dose Reconstruction Implementation Guideline (OCAS-IG-001), consideration must be given for specific job functions in certain type of facilities for Rotational (ROT) and Isotropic (ISO) geometries in addition to Anterior-Posterior (AP) because the AP values are not the most claimant-favorable for bone (surface), bone (red marrow), esophagus and lung when a dosimeter is worn on the chest. In accordance with Table 4.1a correction factors are applied for ROT and ISO dose conversion factors (DCFs).

If an overestimate can not be used, a comparison of each geometry scenario (AP and ROT, it has been determined based on the DCF values ISO will be less than ROT so there is no need to evaluate it) using best estimate techniques must be performed and the geometry resulting in the highest POC (probability of causation) should be used.

*External Dosimetry Codes**

Below are tables listing codes used in the dosimeter records. These tables may be useful in interpreting information provided in the external dosimetry records.

Table 1: Common Acronyms Used by the Personnel Meters Group From 1951-1960.

Code Value	Description
OW	Open Window
S	Shield
B	Beta
G	Gamma
MD	Meter Service Date
NF	Fast Neutron Film
NS	Slow Neutron Pencils
FL	Film Badge Lost
FR	Film Badge Re-Issued
FF	Film Badge Found
MS	Badge Out of Service (pulled)
D	Irregularities (general)
D-1	Evidence of Fog
D-2	Evidence of Contamination
D-3	Damaged in Processing
D-4	Lost in Processing
D-5	Evidence of X-ray
D-6	Evidence of Exposure to Light

D-7	Damaged Film (manufacturer defect)
D-8	Weathered Film
D-9	Film Missing From Badge
P	Pocket Meter
TSR	Total Significant Reading
OS	Off Scale
DM	Damage Pencil Meter
PL	Lost Pencil Meter
SD	Insignificant Double
A	Not in use
R	Ring
M	Master File
V	Visitor Badge or Permanent and Visitor Badge
SP	Special Pull
TB	Temporary Badge
LP	Late Pickup
RF	Refer to Folder
NPO	No Possible Exposure (investigation result)
NBI	New Badge Issued

Table 2: External Dosimetry Codes Used in the Logbooks from 1961 through 1978.

Code Value	Description
OW	Open Window
S	Shield
1	Badge not in rack
2	Film contaminated and destroyed
3	Evidence of Fog
4	Lost by personnel meters
5	X-ray exposure
6	Film exposure to light
7	Defective film (Manufacturer defect)
8	Damaged by moisture
9	Film lost from badge
10	Complete badge lost
11	Sent through laundry
12	Film contaminated
30	Special pull badge
31	Late pickup
32	Neutron film (NTA)
33	Neutron pencil
34	Bioassay (Tritium)
35*	Off-plant exposure
51	Badge worn by two people
60*	Investigation
61	Badge canceled
62	Badge reissued
63	Name change
64	Change in payroll number or roll
65	Employee terminated

66	New Badge
67	Location change
68	Badge in process of being made
69	Out sick (badge home with employee)

* Refer to the personnel radiation exposure file for details.

Dosimeter Codes and Building/Facility Locations

The dosimeter codes found in the external dosimeter records may be listed in Table 5-1 in ORAU Technical Information Bulletin Internal Coworker Dosimetry Data for the SRS (OTIB-0081). These codes may be used to aid in the identification of buildings/facilities for the energy employee work locations.

Occupational Medical Dose

Information provided in Technical Basis Document for the Savannah River Site – Occupational Medical Dose, (Rev 04, effective date November 20, 2009) indicates the occupational medical dose should be assigned with an uncertainty of 35%. However, the Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures, (Rev 04 effective date June 20, 2011) indicates an uncertainty of 30% should be used. Therefore, for occupational medical dose assignment at SRS, an uncertainty of 30% should be assigned in accordance with the latest guidance provided in Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures, (Rev 04).

Internal Dose

Bioassay Results

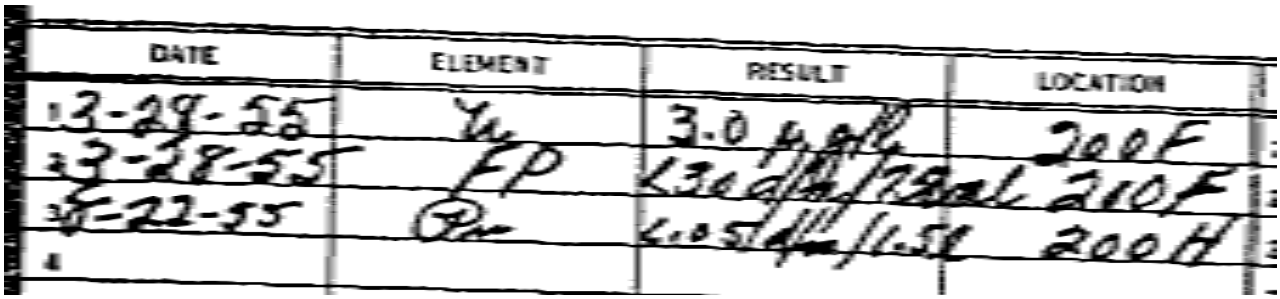
MDAs contained in the site profile are intended as defaults when there is no better information available, i.e., sample specific MDAs. When the bioassay results in the employee's personal records include an MDA (or a clear value that the site considers the value below – such as "<0.05"), that value takes precedence over the site default value and is to be used in the dose assessment. This applies regardless of whether the sample's less than value is larger or smaller than the value in the site profile.

Internal Data Results: Reporting Level/MDA/Detection Level

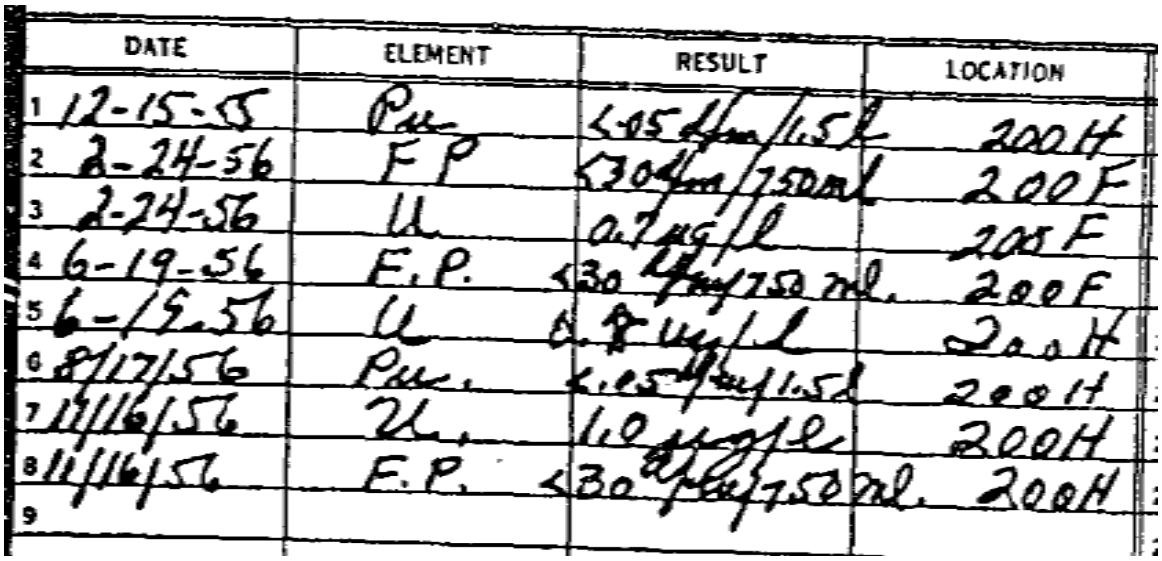
In some instances, a site may apply a *reporting level* that is greater than the MDA. This is most common when the nuclide is easily detected, such as H-3, and a result at the MDA produces a very small dose. In such cases, only measurements with values exceeding the reporting level are recorded in the employee

files, i.e., results between the MDA and the reporting level are recorded as "0" or "<" the reporting level, and the reporting level becomes the MDA by default. A missed dose would be based on the value of the reporting level rather than the MDA.

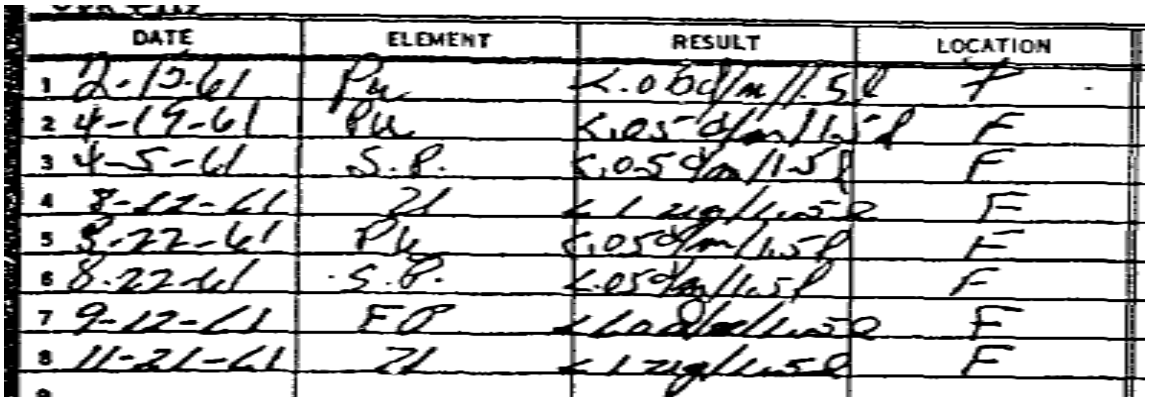
In the early years at SRS (handwritten records), results were reported as an actual value or as a "less than" value. Any handwritten results that do not have a "<" sign in front of the reported result would be treated as a positive value. Values reported with a "<" sign are treated as less than MDA, with the MDA equal to the reported value. For the following example data, many of the uranium results in 1955-1956 are reported as actual values rather than "<" some value. These results should be assessed using fitted dose methods.



	DATE	ELEMENT	RESULT	LOCATION
1	3-29-55	U	3.0 µg/l	200F
2	3-28-55	FP	<30 dpm/750ml	210F
3	3-22-55	Pu	<.05 dpm/1.5l	200H
4				



	DATE	ELEMENT	RESULT	LOCATION
1	12-15-55	Pu	<.05 dpm/1.5l	200H
2	2-24-56	FP	<30 dpm/750ml	200F
3	2-24-56	U	0.7 µg/l	205F
4	6-19-56	F.P.	<30 dpm/750 ml.	200F
5	6-15-56	U	0.8 µg/l	200H
6	8/17/56	Pu.	<.05 dpm/1.5l	200H
7	11/16/56	U.	1.0 µg/l	200H
8	11/16/56	F.P.	<30 dpm/750 ml.	200H
9				



	DATE	ELEMENT	RESULT	LOCATION
1	2-12-61	Pu	<.06d/m/1.5 l	F
2	4-19-61	Pu	<.05 d/m/1.5 l	F
3	4-5-61	S.B.	<.05 d/m/1.5 l	F
4	8-22-61	EU	< 1 ug/1.5 l	F
5	8-22-61	Pu	<.05 d/m/1.5 l	F
6	8-22-61	S.B.	<.05 d/m/1.5 l	F
7	9-12-61	EU	< 1 ug/1.5 l	F
8	11-21-61	EU	< 1 ug/1.5 l	F
9				

Information for the Interpretation of Uranium Results (1980's to early 1990's)

Logbooks indicate bioassay samples for "U" were analyzed by both fluorophotometric analysis and delayed neutron counting (DNC) in 1982-1984. Logbooks also indicate bioassay samples for "EU" were analyzed by both gross alpha analysis and DNC in 1982-1985. These are not definitive dates for the overlap in methods but are based on review of available Uranium Record Books.*

Results of uranium bioassay by delayed neutron counting (DNC) in 1982-1985 are for both "U" and "EU". Results for "EU" were reported in units of dpm/1.5 L, while results for "U" were sometimes reported in units of dpm/1.5 L and sometimes in units of ug/1.5 L. Handwritten Kardex bioassay records typically do not include units of the results in this era, so a Kardex result for "U" during this era could be in units of either dpm/1.5 L or ug/1.5 L. The reporting level for "U" varied between 1 and 5 ug/1.5 L and the reporting level for "EU" was typically 1 dpm/1.5 L, although an EU reporting level as high as <4 was seen for some batches and a few reporting levels of EU were reported to two significant figures.

EU Lab Record Books for gross alpha counting indicate the typical reporting level was 1 dpm/1.5 L through mid 1988. Starting in mid 1988 a <2 dpm/1.5 L reporting level was typically used for EU. SRDB Reference ID 49644 indicates that SRS labs started reporting negative EU bioassay results as less than the critical level (CL) in the latter half of 1990. [Critical level is a statistical value that is equal to about half of the MDA.] Some of the handwritten Kardex records in NOCTS reflect the change from a <2 reporting level to a <CL value. When a value is reported with a less than symbol and is lower than a reporting level of 2, then it should be considered as a CL. The CL should be multiplied by 2 to obtain the value to be used for the MDA. For example, a Kardex result of "<0.88" in 1990 should be interpreted to be the critical level. For dose reconstruction purposes, the MDA for that sample is assumed to 1.76 dpm/1.5 L (2 * 0.88).

*Ref ID 49826, EU Record 7/21/1981 to 12/3/1985

Ref ID 49827, DNC Record 3/15/1983 to 9/16/1983

Ref ID 49829, Delayed Neutron Counting Record 6/20/1984 thru 3/11/1985

Ref ID 49830, Delayed Neutron Counting 3/12/1985 thru 6/11/1985

Ref ID 49646, DNC Record 6/21/1982 to 4/3/1982

Ref ID 49637, Uranium record Book 3/15/1979 through 6/7/1984

Ref ID 49644, EU Record Book, 6-1990 thru I-1991

The dose reconstructor should use case specific information as found in the bioassay records for reporting levels. The table below should be used as the default when bioassay records are incomplete. The reporting levels listed in the table below may be used as the MDA default value.

Nuclide	Method	Reporting Method	Time Period (Approximate)	Reporting Level	Units
U	Fluorophotometric	Kardex	Start-up to 1956	1*	ug/1.0 L
U	Fluorophotometric	Kardex	1956-1961	1	ug/1.0 L
U	Fluorophotometric	Kardex	1961-1962	1	ug/1.5 L
U	Fluorophotometric	Kardex	1962-1982	5	ug/1.5 L
U	DNC	Kardex	1982-1985	1	dpm/1.5 L or ug/1.5 L
U	KPA	Kardex	1986-1990	5**	ug/1.5 L
U or NT/D U	KPA	Computer	Early 1991	5**	ug/1.0 L
U or NT/D U	KPA	Computer	1991 and later	3.33**	ug/1 L
EU***	Gross Alpha	Kardex	Start-up to 1982	1****	dpm/1.5 L
EU	DNC	Kardex	1982-1985	1-4*	dpm/1.5 L
EU	Gross Alpha	Kardex	1985-mid 1988	1	dpm/1.5 L
EU	Gross Alpha	Kardex	mid 1988-mid 1990	2	dpm/1.5 L
EU	Gross Alpha	Kardex	Later part of 1990	CL*****	dpm/1.5 L

EU	Gross Alpha	Computer	Start 1991	CL	dpm/1.0 L

* Presumed reporting level

* *Some records may have different reporting levels.

***In early bioassay records sometimes labeled “En. Uranium” or “LMF”.

****In the 1950s some positive EU results are recorded at levels below 1.

*****Negative results were reported as less than the critical level (CL).

Ref ID57175, RefID57041, RefID57177, RefID53261

NOTE: For results for all nuclides except tritium, units are typically provided in handwritten records from start-up to 1969. Units usually not provided in handwritten records after 1969. Computer records have units.

When the units for “U” are not provided in the claimant’s records from (approximately) 1982 through 1985 , the dose reconstructor should default to the more claimant favorable units. Using a depleted uranium specific activity of 0.372 pCi/ug (0.826 dpm/ug), a result without units should be assumed to be in units of dpm because it provides a higher radioactivity concentration.

Post 1990 Bioassay Reports

For later years (starting in 1991), some of the internal dosimetry data reports do not include a minimum detectable amount or a “<” result but can include information for “Result,” “Activity,” and “Detect Level” (as shown below). In the early 1990s the reports generally only include data in the Result column. If a negative value (i.e., less than 0) is reported, this indicates that SRS considered no activity to be detected and the reported value is the negative of the Detect Level. This can be seen in reports at some point in 1994, when data for Result, Activity, Detect Level and Error are usually included. When a value is reported without the ‘-‘ sign (as a positive number) and with no associated Detect Level assume the result is positive and assess as fitted dose. An example report is shown below. These later reports show the Detect Level to be the absolute value of the ‘negative’ Result. Beginning in 1991, when a negative Result is reported it should be assumed to be the critical level. The MDA can be assumed to be twice the critical level/detect level. In the example below for Pu-239 on May 6, 1992, the Result is reported as -0.020 dpm/L. With the assumption that the absolute value of this result is the critical level, the MDA is determined to be twice the critical level, in this case 0.040 dpm/L and corrected for daily excretion by multiplying by 1.4. In the example below for Pu-239 on May 25, 1994, the Result is reported as -0.024 dpm/L. The Detection Level is 0.024 dpm/L, therefore the MDA would be 0.067 dpm/day.

Sample ID	Sample Void Date	Sample Receive Date	Facil	Isotope	LLD Ind	Result	Result Units	Re-Run Result	Activity	Detect Level	Error	Sample Type
	09/28/1991	10/03/1991	TEC	Sr-90		-0.010	nCi/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Pu-238		-0.020	dpm/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Pu-239		-0.020	dpm/L					ROUTINE
	05/06/1992	05/26/1992	" TEC	Sr-90		-0.010	nCi/L					ROUTINE
	09/30/1992	10/08/1992	" TEC	EU		-0.850	dpm/L					ROUTINE
	09/30/1992	10/08/1992	" TEC	Sr-90		-0.010	nCi/L					ROUTINE
	12/01/1992	12/04/1992	" TEC	Pu-238		-0.030	dpm/L					ROUTINE
	12/01/1992	12/04/1992	" TEC	Pu-239		-0.010	dpm/L					ROUTINE
20393	03/31/1994	05/04/1994	"	AmCmCf		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Pu-238		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Pu-239		0.000	IA					ROUTINE
20393	03/31/1994	05/04/1994		Sr-90		0.000	IA					ROUTINE
23116	05/25/1994	05/31/1994		AmCmCf		-0.121	dpm/L					IAF
23116	05/25/1994	05/31/1994		Pu-238		-0.036	dpm/L		0.020	0.036	0.028	IAF
23116	05/25/1994	05/31/1994		Pu-239		-0.024	dpm/L		0.000	0.024	0.000	IAF
23116	05/25/1994	05/31/1994		Sr-90		-1.843	pCi/L					IAF
39528	04/17/1995	04/19/1995		Am-241		-0.025	dpm/L		0.013	0.025	0.023	ROUTINE

The value reported in the Activity column would be compared to the MDA (2* the Detect Level and * daily excretion) to determine if the result would be considered a 'positive' bioassay result. In the example above, the May 25, 1994 Pu-238 Activity value of 0.020 dpm/L would not be considered a positive result because it (0.020 * 1.4 = 0.028 dpm/day) is below the MDA (0.036 * 2 * 1.4 = 0.10 dpm/day). Some reporting formats do not have a 'Result' value and only report a value for 'Activity'.

However, just as in the example above, the value in the Activity column is compared to the MDA (2 times the Detect Level and corrected for daily excretion) to determine if the activity would be considered a 'positive' bioassay result.

Another report format was also used by the site for data beginning in 1991 and is shown below with the same bioassay data as discussed above. In this example, the Result column shows "<" with a value in the Result column. This value is the critical level. For example, the Pu-239 result reported for May 6, 1992 is '< 0.020' dpm/L. The MDA would be twice this critical level 0.040 dpm/L and corrected for daily excretion by multiplying by 1.4 (0.056 dpm/day).

Bottle Date	Rec Date	Type	Batch ID	Isotope		Result		Vol
09/28/1991	10/03/1991	Routine	12-91-002	Sr 90	<	0.010	nCi/L	798
05/06/1992	05/26/1992	Routine	07-92-001	Sr 90	<	0.010	nCi/L	952
05/06/1992	05/26/1992	Routine	07-92-001	Pu 238	<	0.020	dpm/L	952
05/06/1992	05/26/1992	Routine	07-92-001	Pu 239	<	0.020	dpm/L	952
09/30/1992	10/08/1992	Routine	10-92-167	EU	<	0.850	dpm/L	878
09/30/1992	10/08/1992	Routine	10-92-168	Sr 90	<	0.010	nCi/L	878
12/01/1992	12/04/1992	Routine	12-92-029	Pu 238	<	0.030	dpm/L	922
12/01/1992	12/04/1992	Routine	12-92-029	Pu 239	<	0.010	dpm/L	922
03/31/1994	05/04/1994	Routine		Sr 90	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		AmCmCf	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		Pu 238	+	0.000	IA	299
03/31/1994	05/04/1994	Routine		Pu 239	+	0.000	IA	299
05/25/1994	05/31/1994	IA Foll	06-94-093	Sr 90	<	1.843	pCi/L	883
05/25/1994	05/31/1994	IA Foll	06-94-095	AmCmCf	<	0.121	dpm/L	883
05/25/1994	05/31/1994	IA Foll	06-94-094	Pu 238	<	0.036	dpm/L	883
05/25/1994	05/31/1994	IA Foll	06-94-094	Pu 239	<	0.024	dpm/L	883
04/17/1995	04/19/1995	Routine	04-95-148	Sr 90	<	1.988	pCi/L	921
04/17/1995	04/19/1995	Routine	04-95-147	Pu 238	<	0.043	dpm/L	921
04/17/1995	04/19/1995	Routine	04-95-147	Pu 239	<	0.020	dpm/L	921
04/17/1995	04/19/1995	Routine	04-95-151	Am 241	<	0.025	dpm/L	921

When 'IA' is recorded with a '+ 0.000' in the Result column or '0.000' in the Result column with an 'IA' in the Result Units column, as shown in the examples above for March 31, 1994 for AmCmCf, Pu-238, Pu-239 and Sr-90, this indicates "Inconclusive Analysis", meaning the analysis didn't meet Quality Control criteria and no result was reported.

When a report is not in the formats described above and a MDA cannot be determined, the Savannah River Site TBD, (Rev 3) Table D-1 should be used to determine the MDA. If the MDA is not listed in Table D-1, then refer to the 'Reporting Level' column. The reported 'Activity' should be used to compare to the 'MDA/Reporting Level' indicated in Table D-1. If the reported 'activity' is greater than or equal to the 'MDA/Reporting Level', the sample result is "positive" and an intake needs to be assessed (based on

OTIB-0060 and the fact that SRS seems to have reported all results at this time – not censoring). If the reported 'activity' is less than the 'MDA/Reporting Level', then missed dose would be assigned based on half of the "MDA/Reporting Level."

Plutonium Mix – Fresh (6% and 12%)

A ratio of Am-241 ingrowth for 2 weeks following separation is used based on Table 5.5 of the Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities (SRBD Ref ID 15919). This ratio should be used for fresh (2-week aged) material of americium rather than the information provided in the current Technical Basis Document for the Savannah River Site. (ORAU-TKBS-0003, 04/05/2005).

Uranium Enrichment Assumptions

When the work area is not known, the following assumptions should be made for uranium exposure. (SRDB Ref ID16499; Historical Generation and Flow of Recycled Uranium at the Savannah River Site [ESH-PEQ-2000-00059, Louis E. McCarty, Manager Performance Evaluation and Quality Programs]):

1953 through 1967 – Natural uranium (0.683 pCi/ug)

1968 and later – Depleted uranium (0.372 pCi/ug)

Assignment of Tritium Doses: Maximizing Method

Based on tritium data collected for a coworker study at the site, it was found that an MDA of 1 µCi/L was used from the startup of the site through 1980, 0.5 µCi/L for 1981 through 1985, 0.1 µCi/L for 1986 to the present. Based on this information, the following doses can be assigned as maximizing approach when all results are below MDA. Results above the MDA are to be assessed per OTIB-0011. These doses are calculated using the methodology in ORAUT-OTIB-0001,Rev 0; 1.946E-4 rem/day per µCi/L multiplied by the MDA (µCi/L) multiplied by 365 days per year.

Note: The OTIB-0001 maximizing method can only be used when the actual MDA's do not conflict with the MDA's stated above. If they conflict, the MDA in the bioassay data must be used. When tritium bioassay data reports an actual MDA (or '<'number), use this value for comparison to a positive result. This MDA should also be used for determining missed dose.

Years	Annual Dose (rem)
1953 - 1980	0.071
1981 - 1985	0.0355
1986 – to present*	0.0071

*SRDB Ref ID10931; *A History of Personnel Radiation Dosimetry at the Savannah River Site* [WSRC-RP-95-234 (Taylor et al. 1995)], SRBD Ref ID 11266; SRS Internal Dosimetry Technical Basis Manual (1990)

For the purpose of calculating probability of causation, doses from tritium are assumed to be chronic, and are assumed to be from electrons with energy E<15 keV. The doses are treated as a point estimate (constant).

Information for WBC MDAs

Whole body counting began in approximately 1960, using a 4" high by 8" thick diameter NaI detector. (Detection energy range was 100 keV to 2000 keV.) The monitored individual sat in a reclining chair positioned in an arc around the detector; this was referred to as the "40-cm arc geometry" in bioassay monitoring reports. Bioassay via this method was not used for plutonium and americium due to their low energy emissions. Reported MDAs for various radionuclides are shown in Tables 4.2.1-1 and 4.2.1-2 . MDAs and reporting levels were the same. It is reported the 40-cm arc detector was in service until September 1995. However, in approximately 1975 it was mostly replaced by a bed detector using an array of NaI detectors under the bed (WSRC-IM-90-139 [WSRC 1990] indicates five 4" × 4" detectors were used, while Taylor et al. 1995 says that four 4 " × 5" detectors were used.) Additionally, in the mid-1980s, whole body counting using stand-up geometry and large (4" × 4" × 16" or 5" × 3" × 16") NaI detectors was implemented. MDAs for these counting systems were generated individually for counts by processing software. Many forms for reporting the results of whole body counts were used throughout the years. The form used from about 1979 through 1986 listed the MDA for each radionuclide for each count (i.e., count-specific MDAs). Earlier forms did not list MDAs. If MDAs are not shown, use the ones in Table 4.2.1-1. A 10-nCi follow-up level for Cs-137 was implemented sometime prior to 1975, which might show up as an MDA. However, this was based on counts on nonoccupationally exposed persons and was not reflective of the minimum sensitivity of the detector system (Fleming 1973, p. 96).*

NOTE to DR: To maximize the missed dose assignment, in the chooser tool use the maximum values for MDAs from all time periods. If a better estimate is needed, use MDAs for the applicable time periods.

Table 4.2.1-1. Whole body counting [Taylor et al. 1995, Table 11**, Fleming 1973-79, p. 162*].

Period	Nuclide	MDA, nCi	MDA method
~1960[a] – October 1974	Ce-144	29	~3X standard deviation of expected count rate in energy region.
	U[b]	62	
	I-131	1.4	
	Ru-106	6.1	
	Cs-137	1.0	
	Zr/Nb-95	2.2	
	Zn-65	5.1	
	Ba/La-140	9.3	
October 31, 1974 – December 31, 1979	Ce-144	13	99.75% confidence level, approximately 3X standard deviation of background.
	I-131	5	
	Ru-106	12	
	Cs-137	10[c]	
	Zr/Nb-95	3	
	Zn-65	9	
	Co-60	3	

d. The whole body counter was built starting in April 1959 and completed in 1960. The exact date of completion is not known. Assume January 1, 1960.

e. Listed as U, but based on measurement of U-235. A result greater than the MDA would certainly be a false positive unless it was associated with a major intake. Other counts and urinalyses would be expected.

f. Burden used to discriminate between natural background and possible occupational intake. Did not account for consumption of wild game.

Table 4.2.1-2 Current MDAs for whole body counting

Radionuclide	MDA (nCi)
Mn-54	3.4
Co-60	2.9
Zn-65	6.1
Ru-106	36

Radionuclide	MDA (nCi)
Sb-125	14
Cs-134	3.8
Cs-137	4.1
Ce-144	69

Radionuclide	MDA (nCi)
Eu-152	18
Eu-154	8.4
U-235	14
Np-237	14

*Fleming R.R. 1973-1979 Logbook February 1973 to October 1979 DPSTN-2011 Westinghouse Savannah River Company, Aiken South Carolina, (SRDB ID: 61649)

**Taylor (SRDB ID 10931)

Whole Body Count – Missed Dose

Negative results (missed dose): use SRS Att D Radionuclide Chooser 1.10.xls Tool to identify representative fission/activation product and Absorption Type. Do NOT assign intakes of short-lived fission products after 12/31/1989 since the last reactors (K and P) quit operations about a year before that. These include: Mn-54, Zn-65, Zr-95, Nb-95, Ru-106, Ba-140, La-140,* Ce-144, Cr-51, Fe-59, Ag-110m, and Na-24. For periods after 1988, RadChooser will have to be run separately using only the MDAs for Co-60, Cs-137, and Eu-154 .

*If La-140 assumed, assign equal intake of Ba-140

Europium-152 (Positive WBC Counts)

When a positive whole body count records a europium-152 result above a given MDA or TBD MDA, consider the following before assessing it for dose:

- is not a nuclide of concern at SRS
- Eu-152 emits a wide range of gammas
- it a good calibration source, but gives more opportunity for it to be mistakenly identified
- if the count is stamped with ”K-40” only, it is safe to assume there is nothing there.
- If several peaks for Eu-152 are identified in the spectrum, further review of the result is warranted

Special consideration for fission/activation product analysis (including CLLs)

Table 4.4.2-6 Parameters for simplified upper bound dose for fission/activation products.

For these organs/tissues:	Assume 4,400 dpm/day intake of:
Adrenals, breast, heart wall, thymus, extrathoracic, extrathoracic2, lymph nodes (extrathoracic), lymph nodes (thoracic), esophagus	Co-60 S
Urinary bladder, brain, gall bladder, kidneys, muscle, ovaries, pancreas, testes, thyroid, stomach, small intestine, upper large intestine, skin, spleen, uterus, gonads	Ru-106 F

Colon	Ru-106 M
Lower large intestine, lung	Ru-106 S
Liver, extrathoracic1	Ce-144 M
Bone surface, red bone marrow , CLL*	Sr-90 F

* all options were run for the CLL, the option with the highest dose to the CLL was selected

Table 4.4.2-7. Parameters for reconstruction upper bound dose from fission/activation products.

For these organs/tissues:	Intake assumptions (in dpm/day)			
	2200	**880**	**660**	**660**
Adrenals, brain, breast, gall bladder, heart wall, kidneys, muscle, muscle, ovaries, pancreas, thyroid, stomach, small intestine skin, spleen, thymus, uterus, esophagus, gonads	Ru-106 F	Cs-137 F	Ce-144 M	Co-60 S
Lymph nodes (extrathoracic)	Ru-106 S	Cs-137 F	Ce-144 M	Co-60 S
Urinary bladder, testes,	Ru-106 F	Cs-137 F	Ce-144 M	Sr-90 F
Upper large intestine	Ru-106 F	Ce-144 M	Cs-137 F	Co-60 S
Extrathoracic, extrathoracic2, lung, lymph nodes (thoracic)	Ru-106 S	Ce-144 M	Cs-137 F	Co-60 S
Colon, lower large intestine, CLL*	Ru-106 S	Ce-144 M	Cs-137 F	Sr-90 F
Liver	Ce-144 M	Ru-106 F	Cs-137 F	Co-60 S
Extrathoracic1	Ce-144 M	Sr-90 F	Cs-137 F	Ru-106 F
Red bone marrow	Sr-90 F	Ru-106 F	Cs-137 F	Ce-144 M
Bone surface	Sr-90 F	Ce-144 M	Ru-106 F	Cs-137 F

* all options were run for the CLL, the option with the highest dose to the CLL was selected

Personal Air Sample (PAS) Data

In the later years, dose assigned from PAS data may be present in the annual dose summary report. Dose assigned based on PAS data is not directly applicable to the organ of interest when performing a dose reconstruction. If a committed Effective Dose (CED) is recorded and no bioassay data was provided for the dose assignment, a request for additional data should be made from the site. If the site provides information that the dose was based on PAS data (no bioassay data is available for the assignment of dose), a direct assignment of the dose to the organ of interest can be made for an overestimate of dose for a non-metabolic organ. If a metabolic organ or if a best estimate of dose is needed, contact the PID for guidance.

Fission Product Dose Assignment (Reactor Worker versus non Reactor Worker)

The following methods are to be used for fission product dose assignment when dosimetry records indicate fission product urinalysis prior to whole body counting. When whole body counts are available, the SRS Radionuclide Chooser tool is used and neither method described below should be used.

When a worker is assigned to reactor areas assign annual dose(s) equal to the assigned tritium dose(s) and enter it into the IREP spreadsheet as "electrons >15 keV" to account for missed fission/activation product doses. The basis for this is that tritium dominated the SRS internal radiation doses in the reactor areas. Do not use this approach for periods of time when FP intakes are based on Table 4.4.2-6 or Table 4.4.2-7.

Use method in Table 4.4.2-6 (simplified) and Table 4.4.2.7 (more realistic) to assign an upper bound of fission product dose *when a worker was potentially exposed, but was not necessarily a reactor worker.*

Plutonium/Uranium Lung Counts (starting 1990)

This guidance is provided to address the possibility of uranium exposure using the plutonium/uranium lung counter results. These counts could also be used to limit other nuclides but uranium will most frequently be encountered.

Starting in December of 1989, the site began using a six detector solid state planar germanium array in a reclining chair geometry for the lung counter. In 1995, the six detector array was replaced by two larger detectors and at the same time a move was made to a new in vivo counting facility.

An example of a report commonly seen for the 'Plutonium/Uranium Lung Counter' is as follows. It has the plutonium/uranium counter location identified as the counter location on reports. Note that there was only a single lung counter in use at a time, so in this time frame uranium is implied even if it's not explicitly stated in the counter location.

counted: 26-APR-90 11:04:27 height: 68 (in) weight: 208 (lb)

printed: 26-APR-90 11:42:25 age: 32 (yrs.) sex: M CWT: 31.8 (am.)

counter location: PLUTONIUM/URANIUM LUNG COUNTER showered before count: Y

operator: F J WAKEFIELD directory: [300,001] wore special clothing for count: Y

comments: PLUTONIUM

No MDAs or nuclides are typically reported on these lung count reports. Information from the following table can be used for the appropriate MDAs. In general, if urine bioassay is present in the bioassay record for a certain nuclide, the lung count data/MDAs may be used to limit the intake(s) based on the urine data. If no urine bioassay is present in the records, there is no need to assume the worker was exposed to the nuclides listed in the lung counting table.

For this period of time (1990 to present) the assumption is made that the site was dealing with depleted uranium. (SRBD Ref ID 16499) Therefore, when uranium urinalysis are present the bioassay record and a lung count is available, it can be used to limit the data. The MDA used for uranium in the lung count is for DU, 1.2 nCi as shown in the table below. This DU MDA should be used for uranium starting in 1990 through the present time.

Table of Ge Lung Counter MDAs (nCi)			
Nuclide	**1990-2000**	**2001-2007**	**2008 to present**
Cf-252	30	32	32
Cm-242	27	28	28
Cm-244	29	37	37
Am-241	0.13	0.10	0.10
Am-243	NR	0.12	0.12
Pu-238	43	58	58
Pu-239	110	130	130
Pu-240	46	47	47
3%Pu	NR	110	110
6%Pu	NR	96	96

12%Pu	NR	70	70
Np-237	0.35	0.31	0.31
U-234	43	30	30
U-235	0.10	0.10	0.10
U-236	91	89	89
U-238	1.10	1.10	1.10
DU	NR	1.2	1.2
RU	NR	8.3	8.3
HEU	NR	5.2	5.2
Th-228	3.4	3.2	3.2
Th-232	28	31	31
Eu-152	0.13	0.056	0.056
Ce-144	0.43	0.31	0.31

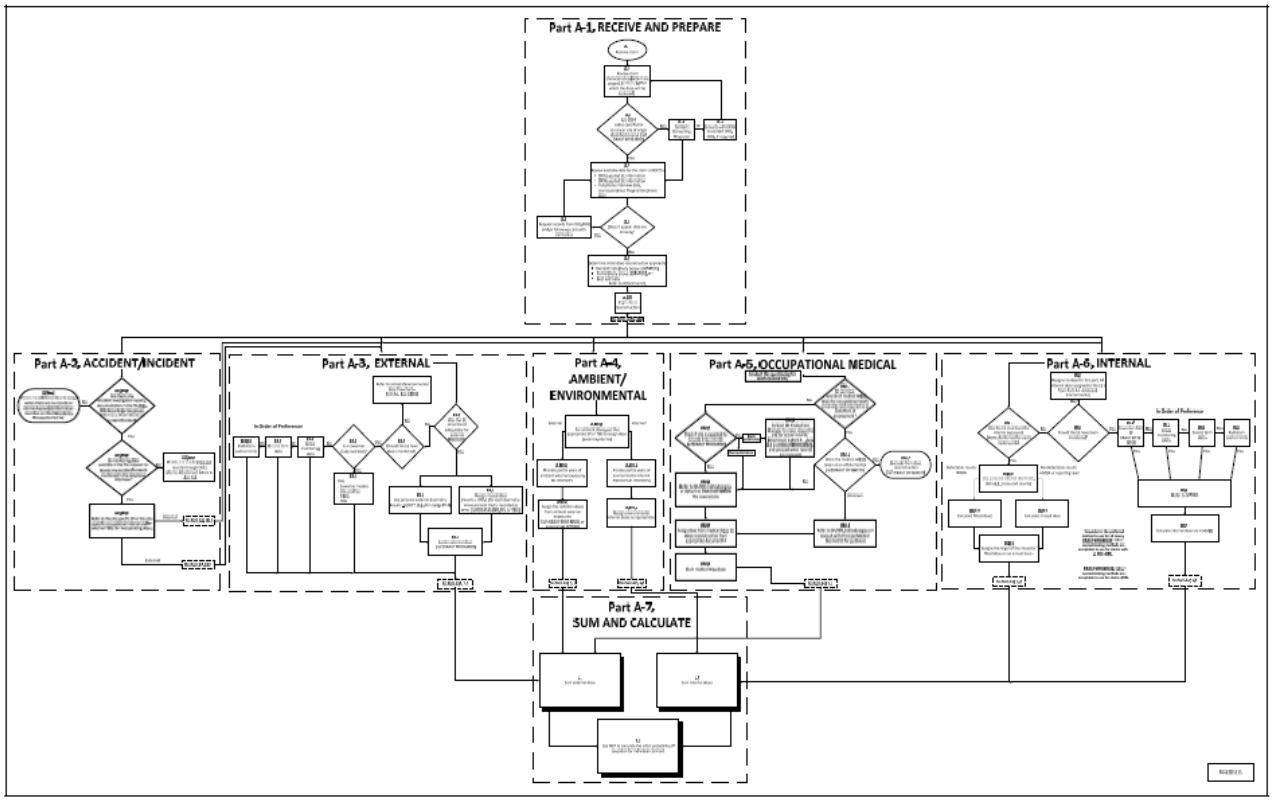
NR = Not Reported

Table References: For 1990 – SRDB Ref ID 11266, For 2001 – SRDB Ref ID 722, For 2008 – SRDB Ref ID 157076

Note: A lung count cannot be used for Uranium Absorption Type F material

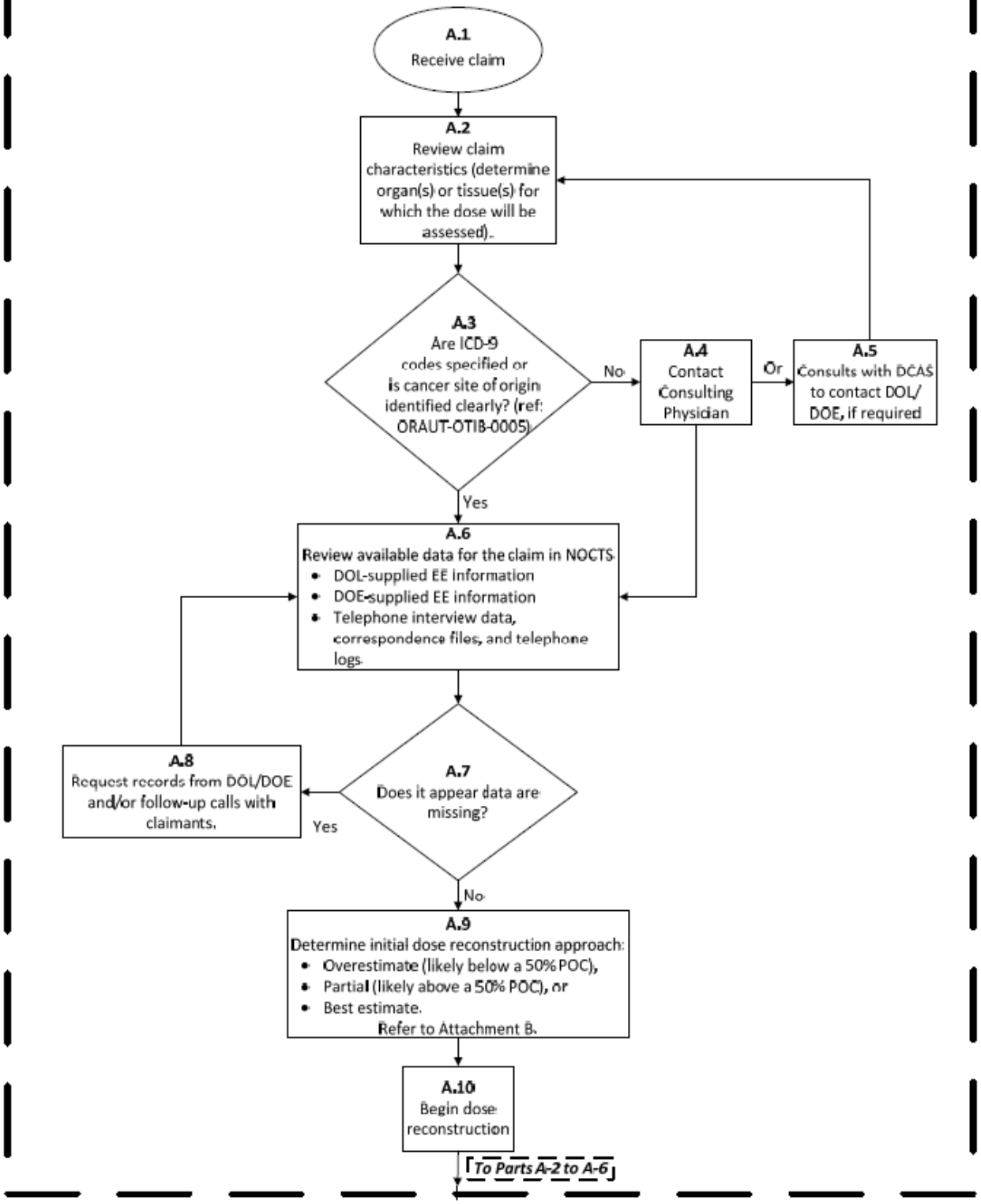
Reminder: Am/Pu exposure is assumed based on the presence of a lung count report in the dosimetry records.

Attachment 4 : ORAU-PROC-0106 Attachments – Roadmap to Reconstructing Dose

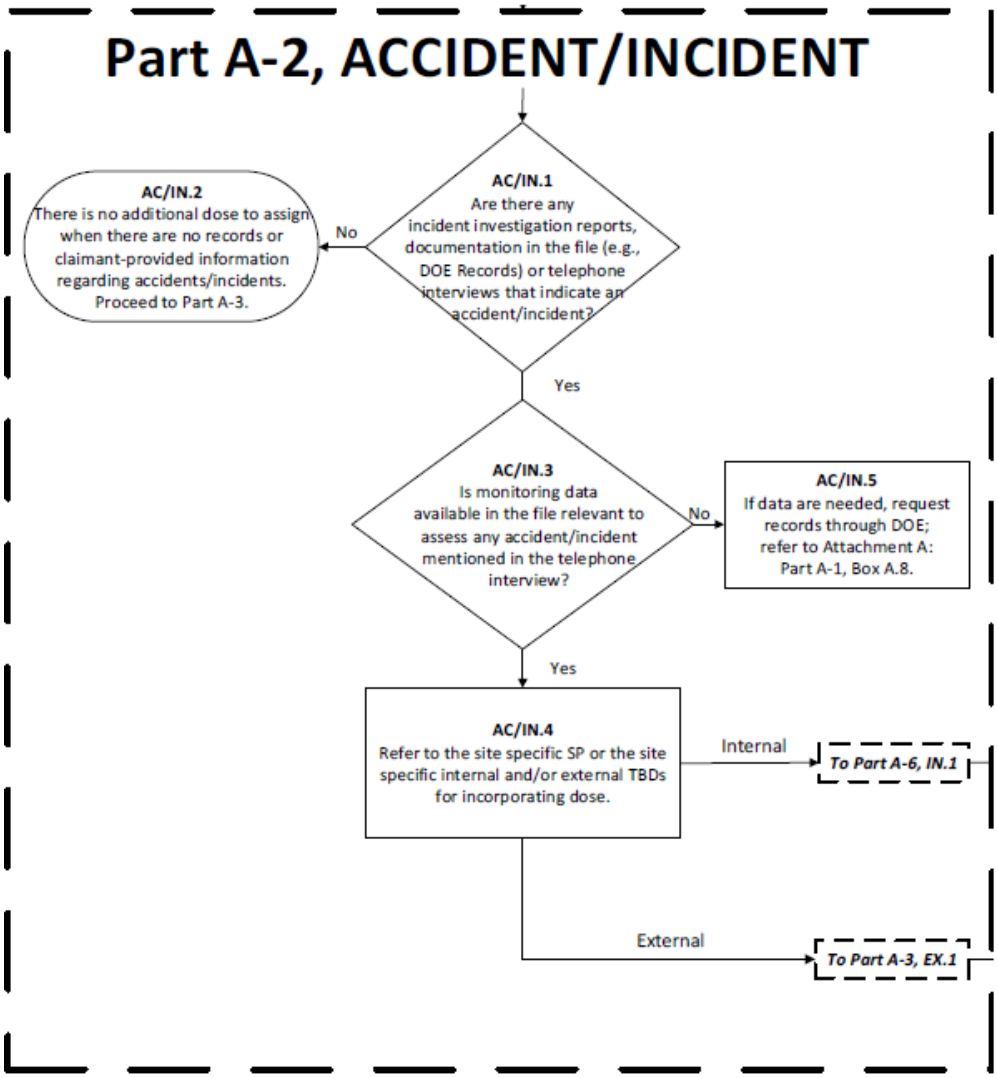


ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)

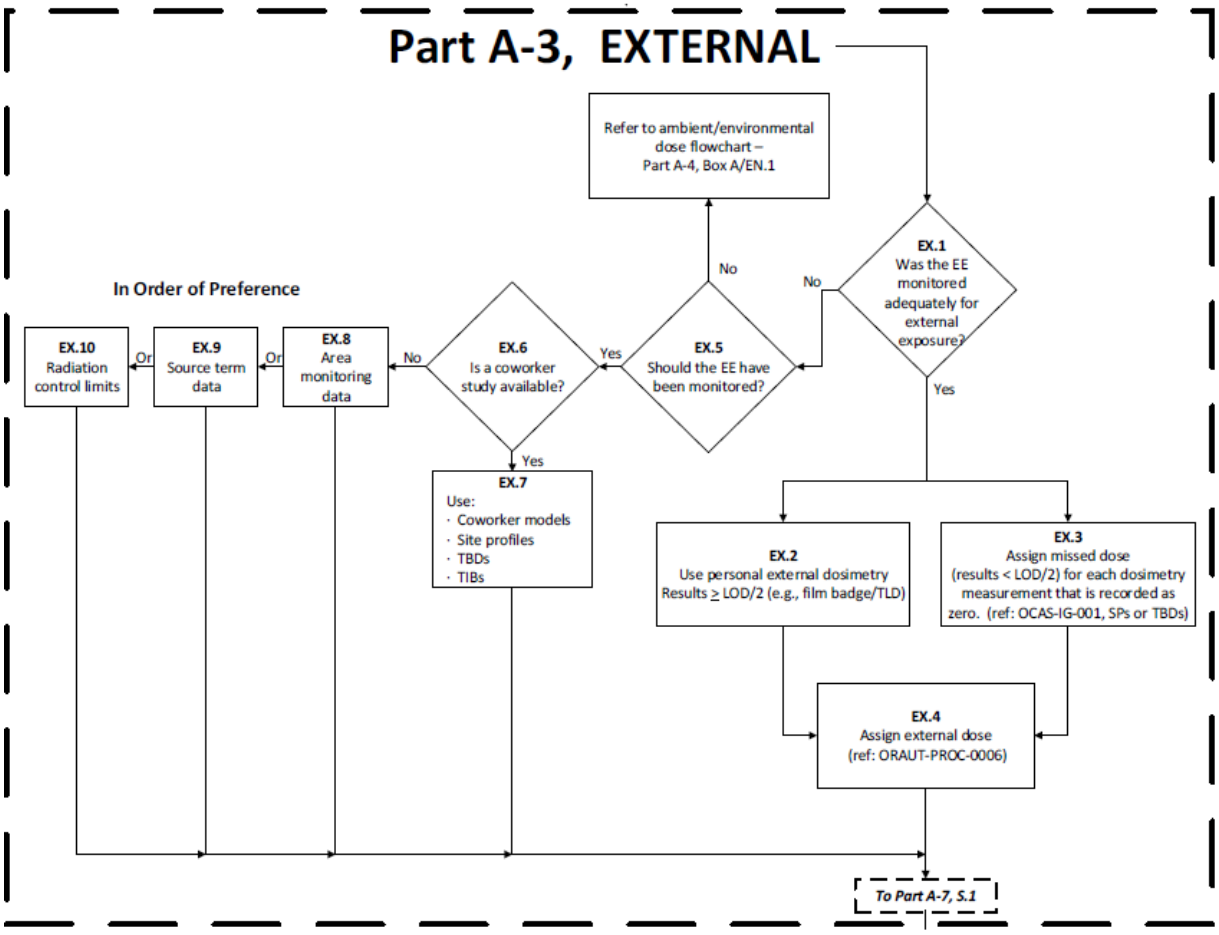
Part A-1, RECEIVE AND PREPARE



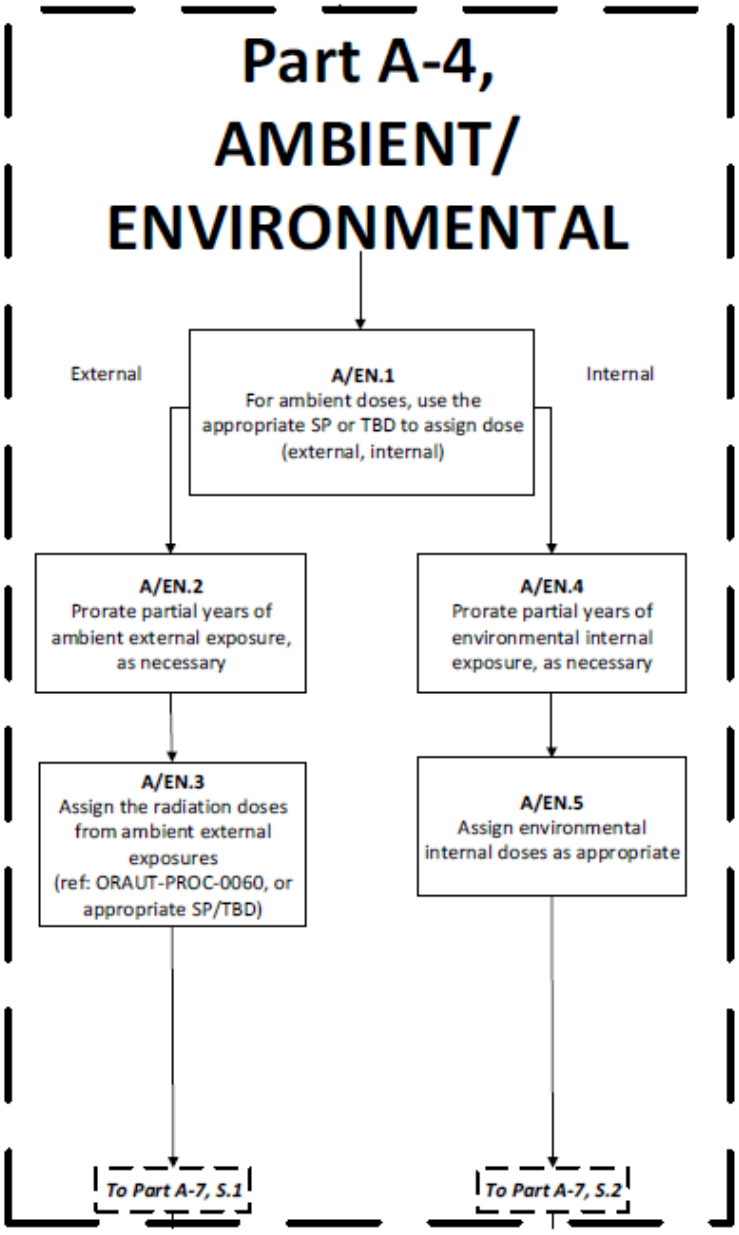
ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



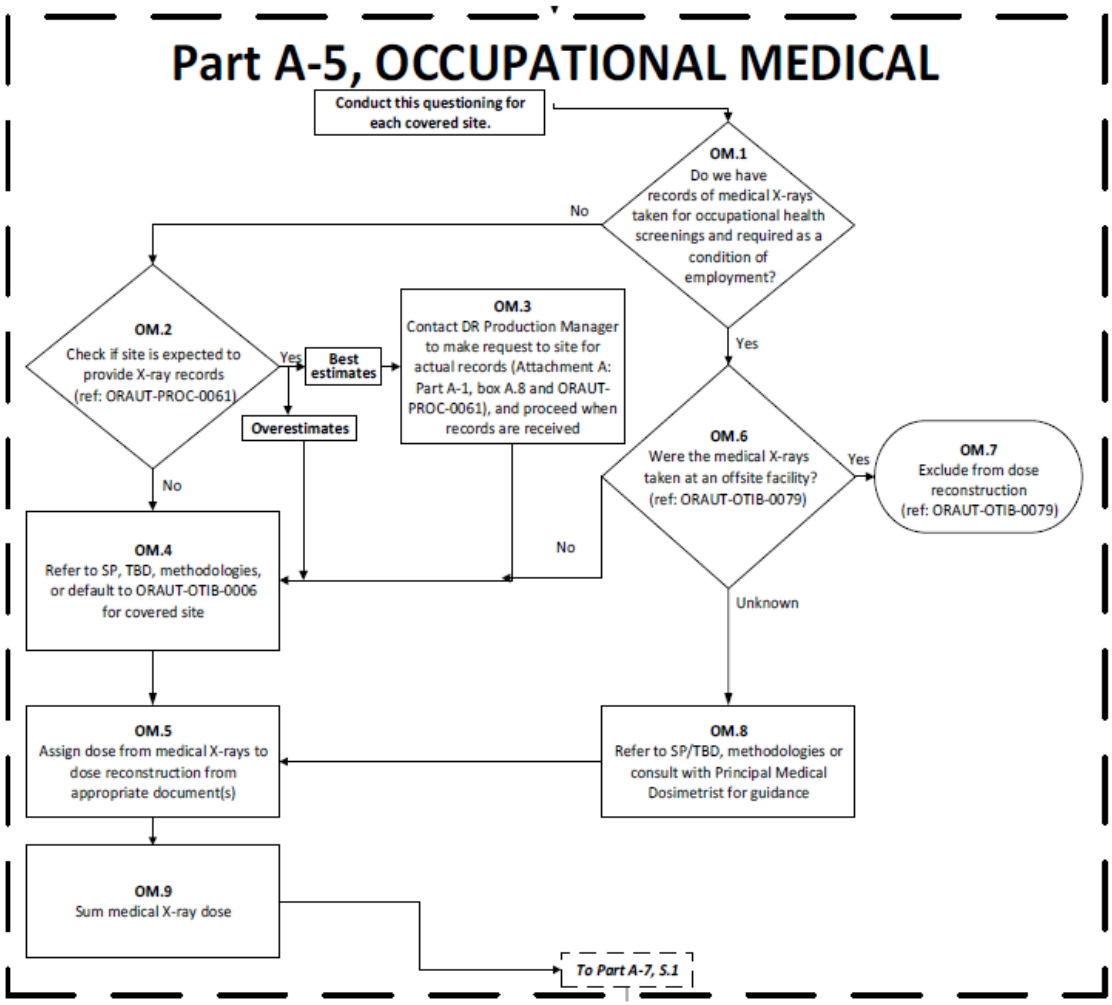
ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



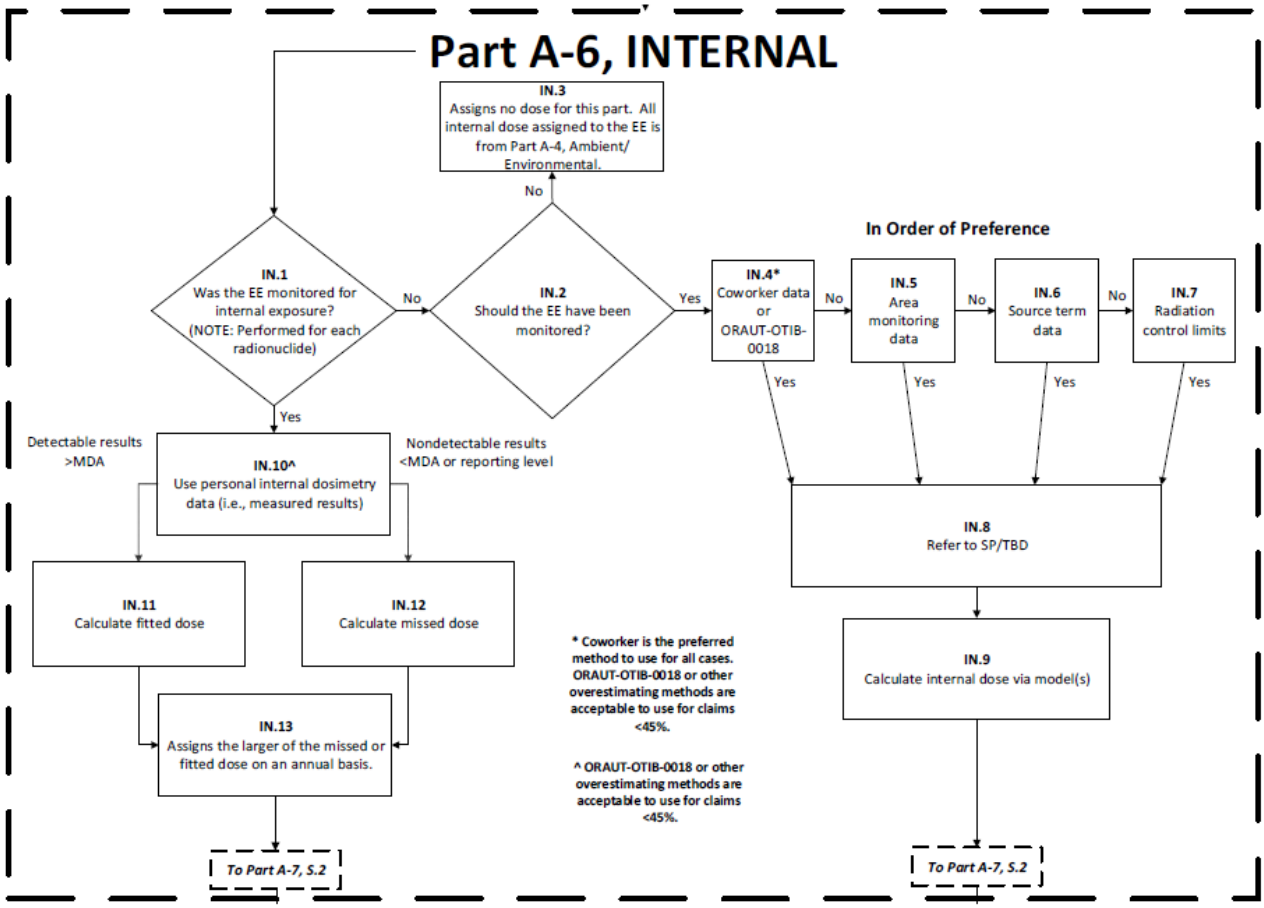
ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



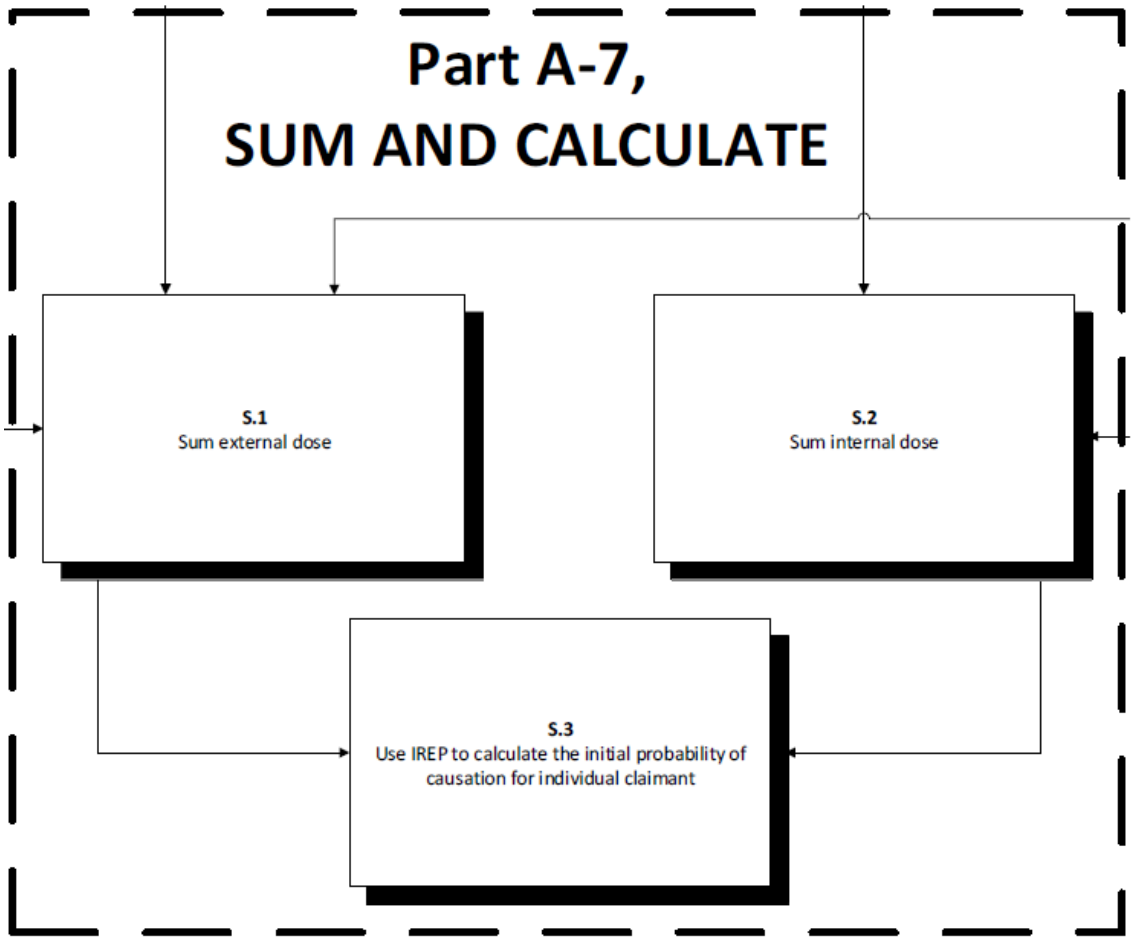
ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



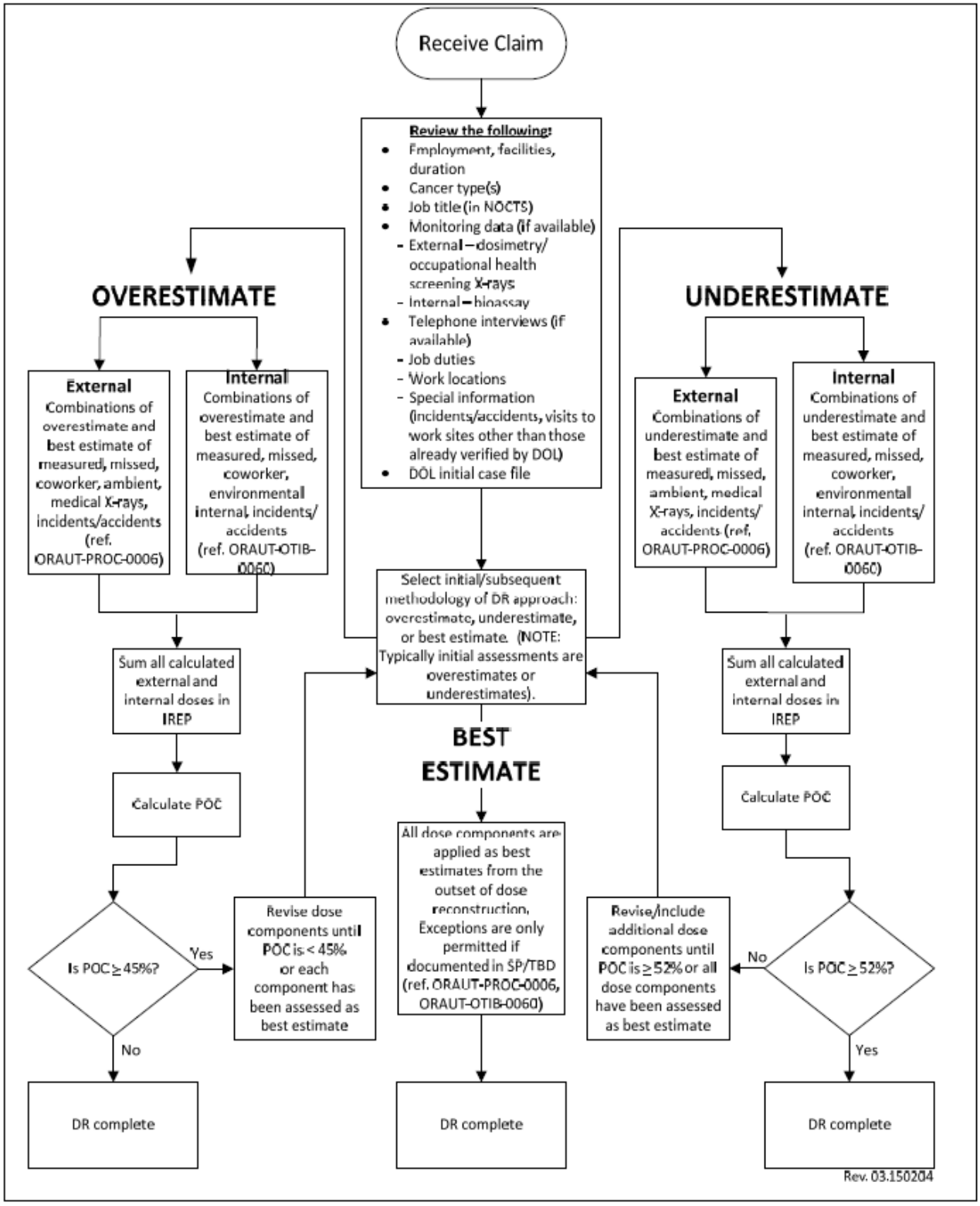
ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



ATTACHMENT A
DOSE RECONSTRUCTION ROADMAP (continued)



ATTACHMENT B
DETERMINING THE APPROACH



Attachment 5: 2012 Database Excerpt: (NIOSH review comments – PROC-0077)

Ver / Rev	Comment Received	OCAS Returned Claim	DRreturn Type	Section	Comment Category	Comments	Resolution Notes
2.3	9/18/2012	9/17/2012	NIOSH/OCAS Technical Returns	Attachment 1: IREP	J. IREP->1. IREP/DRR mismatch	Was not able to match the IREP input sheet numbers with some of the information in the DR Draft. The numbers I was not able to reconcile are as follows:: -Onsite ambient dose was said to be 1.491 rem while the IREP input sheet total was 1.737 rem. -The DR summary listed the external dose total to be 11.575 rem while the IREP input sheet totaled 13.258 rem when adding missed plus unmonitored dose. -Internal dose is listed as 7.804 rem while the IREP input sheet totals was 7.236 rem,	Discrepancies in dose between IREP and the report were corrected in the report.
2.1	10/2/2012	10/2/2012	NIOSH/OCAS Technical Returns	General	E. Data Collection Issues->3. Left out data/data linking problems/used out of date information	Please evaluate DOE supplemental data and its impact to the cancer diagnosed after 2009.	E-This claim was updated to address the DOE supplemental data for the cancer diagnosed in 2012.

0.0	10/10/2012	10/9/2012	NIOSH/OCAS Technical Returns	General	B. No Error/Misinterpretation of ORAUT Approach->3. New policy/guidance change	The use of the overestimating assumptions in OTIB-0018 is not appropriate for a claim with a POC over 50%. Additionally, this claim may be affected by the recent X-10 SEC designation, and if so, may be pulled by DOL in the near future. (The SEC ER recommended that certain internal doses could not be reconstructed during the time period which this EE was employed at X-10.) In the event that this claim is not pulled by DOL, the DR should be reworked using a methodology consistent with that described in the feasibility determination of the SEC ER.	