Review of ORAUT-OTIB-0081, Revision 04, “Internal Coworker Dosimetry Data for the Savannah River Site ”

Bob Barton, Ron Buchanan,
Harry Chmelynski, Rose Gogliotti,
Joyce Lipzstein
SC&A, Inc.

Savannah River Site/SEC Issues Work Groups Meeting
December 5–6, 2019

ORAUT-OTIB-0081 Purpose

- “Some employees at DOE sites were not monitored for potential intakes of radioactive material, or the records of such monitoring are incomplete or unavailable. In such cases, data from monitored coworkers can be used to assign an internal dose to address potential intakes of radioactive material.”
- “The purpose of this TIB [OTIB-0081] is to provide monitored coworker information for calculating and assigning occupational internal doses to employees at SRS for whom no or insufficient monitoring records exist.”

OTIB-0081 Conclusions

- “The bioassay analytical techniques discussed above [in OTIB-0081] and review of the results provide evidence that the techniques were valid, reliable, and can be interpreted.”
- “The bioassay sample schedules indicate that SRS had a process in place to identify and collect samples from potentially exposed workers with a graded approach commensurate with the exposure potential and that unmonitored workers could be adequately represented by monitored workers.”
- “The stratified statistical analyses established two populations of workers (CTWs and nonCTWs), evaluated the bioassay data from each, and determined intake rates or doses applicable to each for the evaluated range of years. The intake rates or doses in Section 5.0 [OTIB-0081] may be assigned to unmonitored workers to evaluate potential unmonitored internal dose.”

SC&A's Review Focus

Adherence to the principles and guidance in the 2015 NIOSH document: "Draft Criteria for the Evaluation and Use of Coworker Datasets"

- **Data Adequacy:** Do the available data and monitoring methods accurately reflect the exposure intended to be reconstructed?
- **Data Completeness:** Do the coworker data effectively represent the various exposure potentials experienced by workers at the site and are such data available for analysis?
- **Evaluation of the Monitoring Program:** Did the procedures in place at the time and the actual execution of the internal monitoring program sufficiently cover the exposed worker population?
- **Stratification:** Is there a subpopulation of workers who had a distinctly different exposure potential and are data available to develop separate exposure profiles for that subpopulation?

SC&A's Evaluation Focus

- Coworker Data Adequacy:
  - Instrumentation and measurement technique
  - Treatment of censored data using imputation methods
  - Use of data less than the minimum detectable activity (MDA)
- Coworker Data Completeness:
  - Completeness of NOCTS data (plutonium, uranium, fission products, and tritium)
  - Completeness of laboratory logbook data (Am/Cm/Cf, thorium, and neptunium).
- Evaluation of the Monitoring Program:
  - Addressed via SC&A's review of RPRT-0092 on job-specific monitoring

SC&A's Evaluation Focus (cont.)

- Coworker stratification:
  - OTIB-0081 coworker model stratified into construction trade workers (CTWs) and all other monitored workers
  - Evaluation of the identification of workers with the appropriate strata
- In addition to the "Draft Criteria for the Evaluation of Coworker Datasets," OTIB-0081 performed an extensive quality assurance (QA) assessment:
  - Completeness of SRS claims tracking system data
  - Completeness of SRS logbook data
  - SRS construction worker classification QA summaries
  - Construction worker determination QA summaries

Coworker Data Adequacy – Bioassay Variability

- SC&A has expressed concern about observed variability in transuranic (Am/Cm/Cf) measurements of the same bioassay sample in previous SRS reviews and work group discussions.
- **Key Question:** Is the measurement technique sufficiently accurate to reflect the exposure potential it is intended to quantify?
- **OTIB-0081 Concluded:**
  - Small percentage of the identified samples that are unaffected by chelation showed high variability (4 of 52)
  - “aliquot variability has an insignificant effect on the overall results”

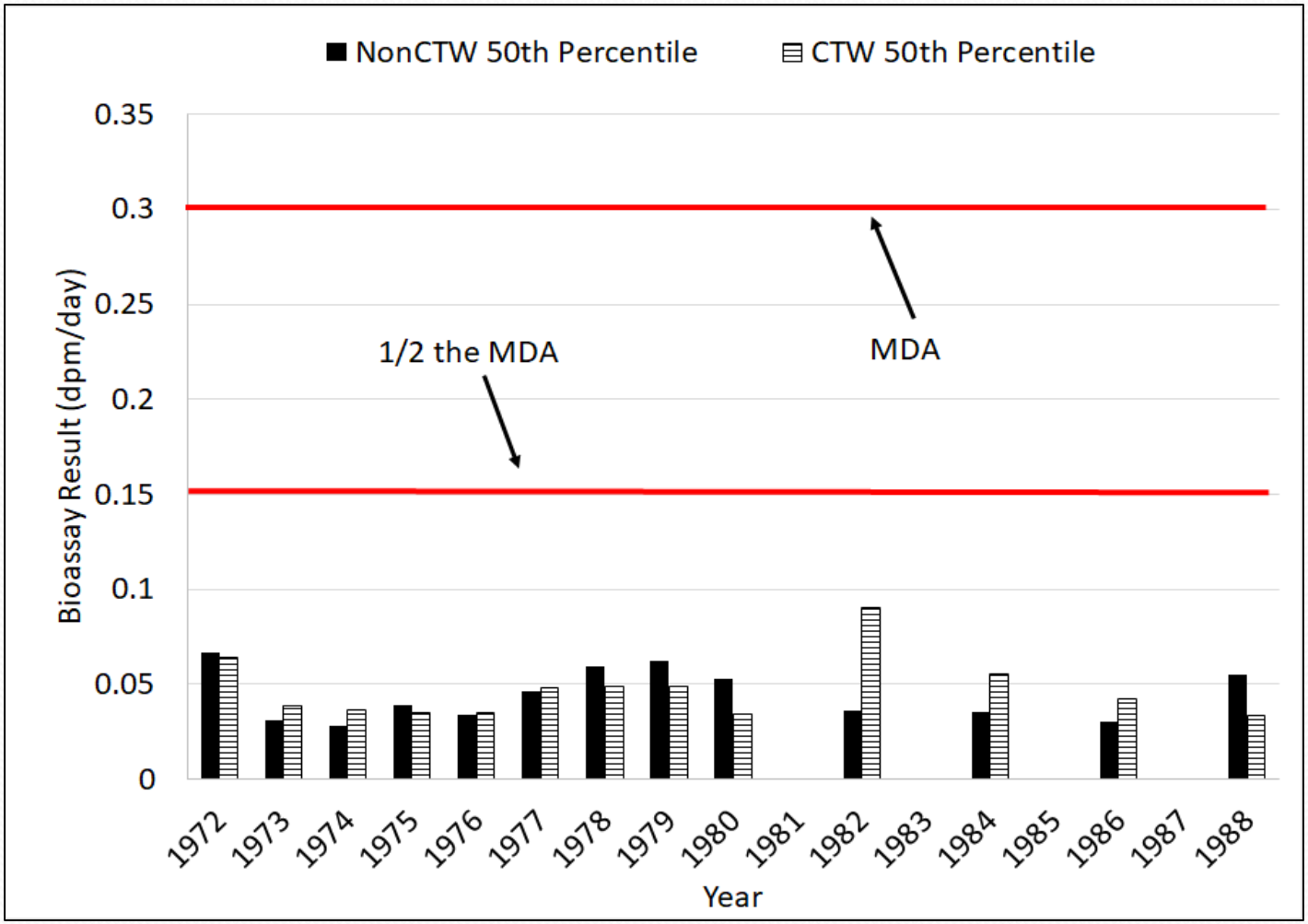
Coworker Data Adequacy – Bioassay Variability (cont.)

- **Finding 1:** Although SC&A recognizes that incident-based sampling involving chelation is not considered in final coworker modeling, the removal of DTPA-influenced samples from consideration in the analysis of the high variability observed in trivalent actinide bioassay results has not been justified sufficiently. Evidence suggests the variation among DTPA and non-DTPA samples is nearly identical. Furthermore, OTIB-0081 has not provided any reference to justify the assumption that DTPA causes heterogeneity among a single urinalysis voiding.

Coworker Data Adequacy – Less than MDA Results

- SC&A questions the SRS stated MDA for trivalent actinide bioassay results stated as far back as 1971 (0.3 dpm/day)
  - Factor of 3 less than the MDA reported by ICRP in 1989
  - Factor of 3 less than the MDA reported by Rocky Flats in 1977
  - Factor of 10 less than the MDA reported by Los Alamos National Laboratory
  - Such a low MDA is likely only achievable with alpha spectrometry
- The raw data used in the coworker model for Am/Cm/Cf results in coworker excretion rates much less than the MDA

Coworker Data Adequacy – Comparison of Coworker Am/Cm/Cf Data to MDA



Coworker Data Adequacy – Less than MDA Results (cont.)

- Significant proportions of the available monitoring data are reported simply as below the MDA (e.g., <0.1 dpm/day for plutonium).
- OTIB-0081 adopts a method to infer numerical results below the MDA referred to as multiple imputation.
- **Observation 1:** While the multiple imputation method is mathematically correct, it has the potential to result in biasing the simulated bioassay results unnecessarily low. Alternate approaches, such as the maximum possible mean method, which replaces censored data with the actual censoring limit (or alternately one-half the censoring limit), would solve the issues associated with datasets containing a large number of censored values in a claimant-favorable manner.

Coworker Data Adequacy – Less than MDA Results (cont.)

- **Finding 2:** Use of imputed values that are less than one-half of the MDA raises a fundamental fairness issue in that monitored workers who have bioassay results that are less than the MDA are assigned a missed dose in accordance with ORAUT-OTIB-0060, "Internal Dose Reconstruction."
  - Per that guidance, bioassay values that are censored are assumed to be equal to one-half of the MDA rather than the use of an alternate imputed value. In order to further address this issue, SC&A performed scoping calculations using imputed values, numerical values reported less than MDA, and missed dose approaches.
  - Scoping calculations are illustrative and not all encompassing.

.

Coworker Data Adequacy – Less than MDA Results (cont.)

- In general, missed dose analysis resulted in higher intakes and doses; however, the effect on POC was mostly negligible.
- Sr-90: Missed dose was 2.5 times higher than coworker dose; however, POCs were only a factor of 1 to 1.2 times higher (all POCs were much less than 1%).
- Co-60: Missed dose was 5.1 times higher than coworker dose, and the maximum difference in POC was a factor of 2.3; however, POCs were much less than 1%.
- Np-237: Missed dose was a factor of 1.4 higher than coworker dose; however, coworker POCs were all slightly higher than missed dose approach.
- Pu-239: Missed dose was a factor of ~1.5 to 1.9 higher than coworker dose; however, coworker POCs were all slightly higher than missed dose approach.

Coworker Data Adequacy – Less than MDA Results (cont.)

- **Observation 2:** A scoping assessment of the use of coworker bioassay data that are significantly less than the MDA versus an alternate missed dose approach concluded that, while intakes and doses are significantly higher using a missed dose approach in most of the sample calculations, the overall effect on resulting POC values was relatively minor, and, in most cases, the coworker-derived POC bounded the missed dose evaluation. This appears to be because of the use of a triangular distribution for missed dose evaluation versus a lognormal distribution for coworker data.
  - The observation included analysis of intakes of strontium, cobalt, neptunium, and plutonium to several major organs.
  - However, SC&A found that uranium did not follow the pattern described in Observation 2.

Coworker Data Adequacy – Less than MDA Results (cont.)

- **Finding 3:** The sample comparison of coworker intakes to a missed dose method for uranium showed that the coworker model derived intakes were a factor of 4 or more higher than the missed dose approach. This illustrates the potential for inequity between the treatment of unmonitored workers assigned coworker intakes and monitored workers with results less than the detection limit in some situations.

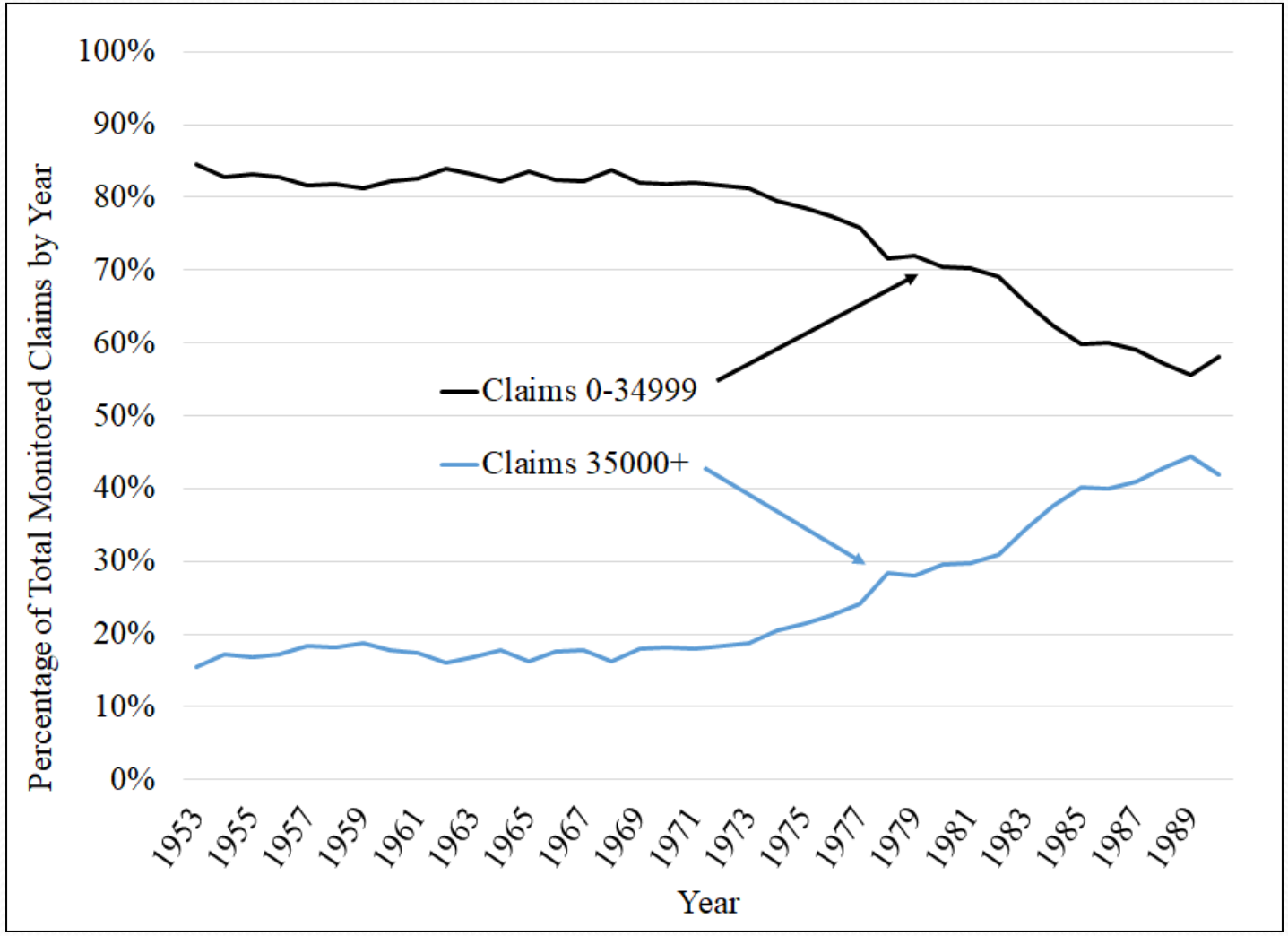
Coworker Data Adequacy – Less than MDA Results (cont.)

- Important caveat: Individual claim conditions have a large impact on the dose and POC assigned in a case. The above exposure estimates comparing missed dose to worker dose do not encompass the range of conditions seen in the dose reconstruction process and are intended only to quantify the impact for example exposures.
- Coworker model intakes/doses are frequently based on a majority of less than detectable results.
- Monitored worker doses are reconstructed assuming missed dose based on MDA data.
- Monitored workers are treated differently than unmonitored workers.
- Care should be taken when evaluating data that are presented as less than the MDA to assure favorable treatment of monitored and unmonitored workers.
- One option would be to use bioassay data for monitored workers and coworker data for unmonitored workers that were derived using values no less than 1/2MDA.

Coworker Data Completeness – Additional Data

Finding 4: The coworker analysis uses the internal monitoring for claimants for which data were available to NIOSH in approximately August 2011 (~4,000 claims). Since that time, approximately 2,000 additional claims have been submitted that could be used to augment the coworker dataset. Inclusion of these data would be especially important for the two contaminants that required a combination of multiple years for analysis due to lack of a sufficient number of data points (uranium and cesium).

Coworker Data Completeness – Percentage of Additional Claimant Data Available

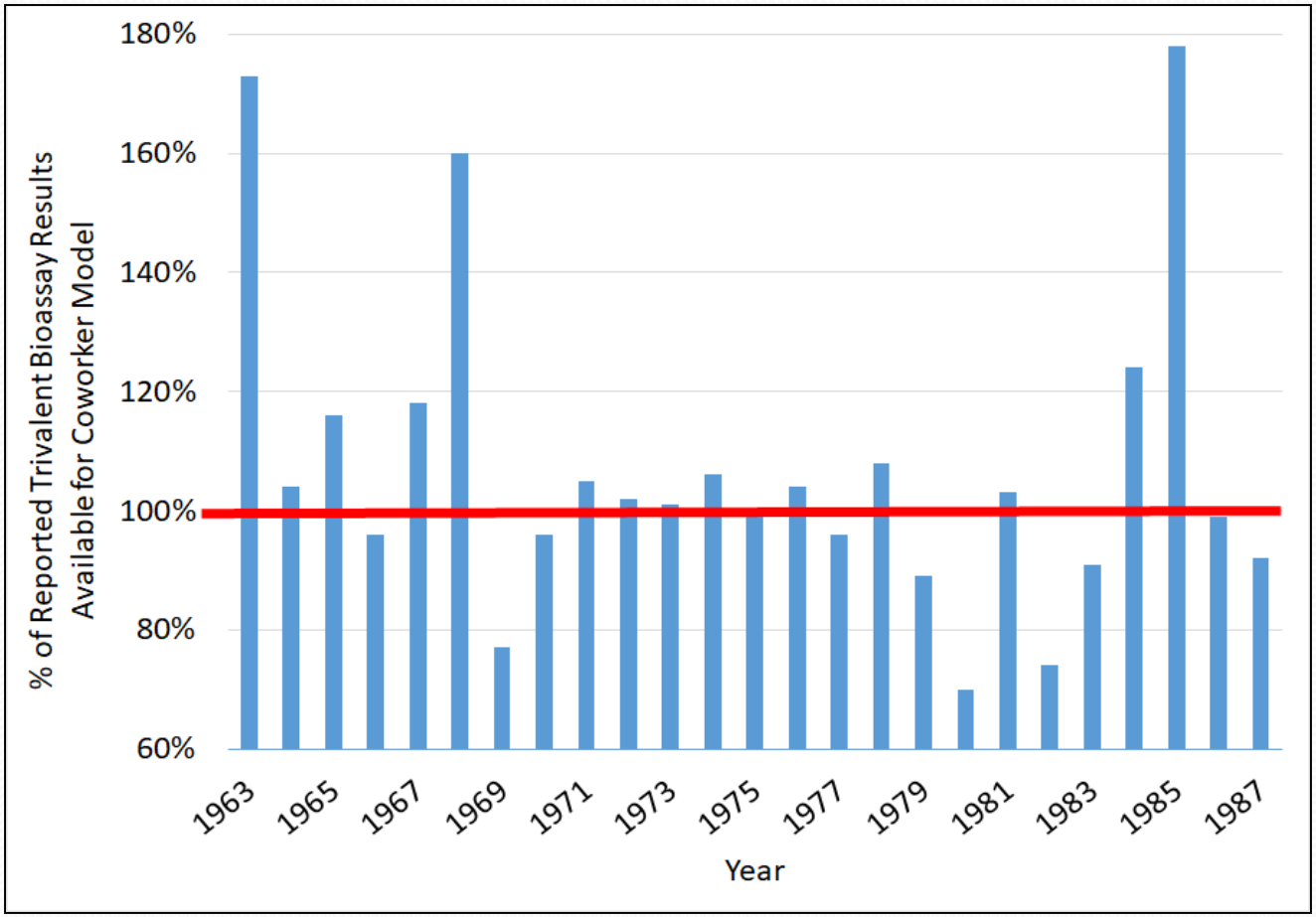


Coworker Data Completeness – Trivalent Actinides

Observation 3: Available trivalent logbook data show notable differences with the number of reported samples taken in 1980 and 1982. These years, and any changes in operations, are not discussed specifically in OTIB-0081. However, it is noted that a future NIOSH report on americium exposure potential at SRS is pending that may address the apparent gaps in the data.

- **UPDATE:** NIOSH has since released ORAUT-RPRT-0091, "Evaluation of Savannah River Site Americium-241 Source Terms Between 1971 and 1999 Using Bioassay Frequency Tables." However, the report does not specifically address the issue of missing Am/Cm/Cf bioassay results during the years identified.

Coworker Data Completeness – Comparison of Reported Bioassay Totals to Bioassay Available for Analysis



Coworker Stratification

Observation 4: OTIB-0081 does not provide a statistical comparison of the two stratified groups as prescribed in the coworker implementation guide. The various coworker models were stratified based on the a priori assumption that exposure potential between CTWs and nonCTWs was different.

- This is in contradiction to "Draft Criteria for the Evaluation and Use of Coworker Datasets," which states, "Once a dataset has been stratified based on job category, a statistical analysis should be conducted to determine if the two datasets should be modeled separately."

Coworker Stratification (cont.)

Observation 5: SC&A believes a quantitative assessment of available job plans, rather than a qualitative basis, is appropriate to determine that prime contractor and subcontractor CTWs are part of the same exposure strata. Such an assessment has been performed by NIOSH, and a report of their findings has recently been issued.

- This issue is discussed in depth in ORAUT-RPRT-0092 and the NIOSH white paper, "Savannah River Site Plutonium Construction Trade Worker Stratification Refinement."
- SC&A has subsequently reviewed both documents.

Coworker Stratification (cont.)

Finding 5: Classification of a "Machinist" as a nonCTW in OTIB-0081 is inconsistent with its classification in OCAS-PER-014, "Construction Trades Workers."

Finding 6: A targeted sampling comparing the OTIB-0081 strata designation (CTW or nonCTW) against two alternate sources for identifying worker job classification indicated that just over 9 percent of the entries appear to be in conflict when comparing the NIOSH and SC&A analyses.

- Problematic job title examples:
  - Supervisor, Line Manager, Foreman
  - Assistant, Helper
  - Operator (in particular, General Service Operator)

Coworker Stratification (cont.)

Observation 6: SC&A acknowledges that there are inherent difficulties in correctly associating individual workers with the correct CTW/nonCTW strata. This is particularly true for job titles that could potentially be included in either stratum…. SC&A suggests a scoping analysis in which such borderline job titles are removed to ascertain the effect on the resulting distributions. Such an analysis would help determine whether current strata designations are sufficient or a more rigorous approach to individual job classification is warranted.

SC&A Quality Assurance Assessment

- QA performed on OTIB-0081 data based on RPRT-0078 guidelines:
  - 1% allowable error rate on analytical data (critical fields)
  - 5% overall allowable error rate (noncritical fields)
- The study authors noted that most classification errors observed were due to individuals changing occupations from CTW to nonCTW, or vice versa, during their career.

Observation 7: The results shown in Attachment A of OTIB-0081 demonstrate a high degree of confidence that the acceptable error rates are within the goals established for each test. However, this conclusion is dependent on the assumption that payroll ID issues identified would not affect the resulting coworker distributions.

SC&A Conclusions – Data Adequacy

- Data for trivalent actinides (Am/Cm/Cf) were reported at values much less than the MDA, which resulted in coworker excretion rates below the MDA.
- Stated MDA for SRS is significantly lower than other state-of-the-art techniques, including the ICRP and other national laboratories.
- Trivalent actinide data still show statistically significant variance between measurements of the same sample. Is the method for analyzing Am/Cm/Cf sufficiently accurate for EEOICPA?

SC&A Conclusions – Data Adequacy (cont.)

- Issues with the treatment and manipulation of censored data and/or data reported less than the MDA.
- Imputation methodology can result in modeled coworker excretion rates that are significantly lower than one-half the MDA.
- Are “imputed” bioassay results forming the basis for the coworker model sufficiently accurate?

SC&A Conclusions – Data Adequacy (cont.)

- Effects on Dose Reconstruction
  - Monitored workers with results less than the MDA are treated with a "missed dose" methodology that may underestimate the POC when compared to the coworker model based on the same "less than MDA" results because of the use of different distribution functions.
  - Potential Solution? Use bioassay data for monitored workers and coworker data for unmonitored workers that were derived using values no less than 1/2MDA.

SC&A Conclusions – Completeness

- Determinations regarding the representativeness and completeness of the available dataset, specifically for workers on job-specific bioassay, is an ongoing issue that is currently being addressed by RPRT-0092.
- A substantial portion of the claimant population was not included in the original coworker analysis due to the timing of the analysis (i.e., claims were not yet filed).
  - Inclusion of additional data would improve the completeness and accuracy of the coworker estimates.
  - May obviate the need to combine data for multiple years due to an insufficient number of bioassay results.
- Observed data gaps in trivalent actinide data have not been addressed for 1980 and 1982.

SC&A Conclusions – Stratification

- SC&A's review of the monitoring protocol and stratification aspects of the coworker model details the difficulties in correctly designating construction trade workers (CTWs) from non-construction trade workers (nonCTWs).
- Supplementary analysis excluding "borderline" job titles may indicate whether a more rigorous job title analysis is required.
- OTIB-0081 does not address the issues associated with workers who were intended to be primarily monitored via the job-specific bioassay program versus those on a routine monitoring schedule.

Questions?