SC&A S. COHEN & ASSOCIATES
AN EMPLOYEE-OWNED COMPANY

May 31, 2007

Mr. David Staudt
Center for Disease Control and Prevention
Acquisition and Assistance Field Branch
Post Office Box 18070
626 Cochrans Mill Road – B-140
Pittsburgh, PA 15236-0295

Re: Contract No. 200-2004-03805, Task Order 1: Transmittal of Draft SCA-TR-TASK1-0017, *K-25 Gaseous Diffusion Plant Site Profile Review*

Dear Mr. Staudt:

SC&A, Inc. is please to submit its draft report titled *K-25 Gaseous Diffusion Plant Site Profile Review*, SCA-TR-TASK1-0017. This report was submitted for Privacy Act (PA) review on March 9, 2007, and has been revised to accommodate that review. This report is considered pre-decisional and is being submitted to the Advisory Board for review.

Should you have any questions, please contact me at 732-530-0104.

Sincerely,

John Mauro, PhD, CHP
Project Manager

cc: P. Ziemer, PhD, Board Chairperson
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Draft

ADVISORY BOARD ON

RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

K-25 Gaseous Diffusion Plant Site Profile Review

Contract No. 200-2004-03805
Task Order No. 1
SCA-TR-TASK1-0017

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Disclaimer

This document is made available in accordance with the unanimous desire of the Advisory Board on Radiation and Worker Health (ABRWH) to maintain all possible openness in its deliberations. However, the ABRWH and its contractor, SC&A, caution the reader that at the time of its release, this report is pre-decisional and has not been reviewed by the Board for factual accuracy or applicability within the requirements of 42 CFR 82. This implies that once reviewed by the ABRWH, the Board's position may differ from the report's conclusions. Thus, the reader should be cautioned that this report is for information only and that premature interpretations regarding its conclusions are unwarranted.

S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-TASK1-0017 Effective Date: Draft — May 31, 2007 Revision No. 0 – DRAFT
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Task Manager: __________________________ Date: ____________ Joseph Fitzgerald	Supersedes: N/A
Project Manager: __________________________ Date: ____________ John Mauro	

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ACRONYMS AND ABBREVIATIONS

Advisory Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
ALARA	As Low as Reasonably Achievable
ANALIS	Old Environmental Management Laboratory Information System Database
AMAD	Activity Median Aerodynamic Diameter
ANSI	American National Standards Institute
ASA	Accelerated Safety Analysis
ASER	Annual Site Environmental Report
AVLIS	Atomic Vapor Laser Isotope Separation
BJC	Bechtel Jacobs Company, LLC
BNFL	British Nuclear Fuels Limited
Bq	Becquerel
BWXT	BWX Technologies Company
CBD	Chronic Beryllium Disease
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	Curie
CIP	Cascade Improvement System
C&S	An Oak Ridge, Tennessee Laundry Company
CUP	Cascade Upgrade Program
DAC	Derived Air Concentration
DCF	Dose Conversion Factor
DCG	Decontamination Guidelines
D&D	Decontamination and Decommissioning
DOD	Department of Defense
DOE	Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
DOL	Department of Labor
dpm	Disintegrations per Minute
DR	Dose Reconstruction
DRs	Dose Reconstructors

DRS	Dose Reconstruction System
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ECG	Electrocardiogram
EMWMF	DOE Environmental Management Waste Management Facility
EOC	Emergency Operations Center
EPA	United States Environmental Protection Agency
ESE	Entrance Skin Exposure
ETTP	East Tennessee Technology Park (Formerly the K-25 Site)
FSR	Facility Safety Representative
GSD	Geometric Standard Deviation
HEU	Highly Enriched Uranium
HHE	Health Hazards Evaluation
HP	Health Physics Group
HPSO	Health Physics and Safety Organization
HVL	Half Value Layer
ICATS	Information Corrective Actions Tracking System
ICRP	International Commission on Radiological Protection
IH	Industrial Hygiene Group
IMBA	Integrated Modules for Bioassay Analysis
INEEL	Idaho National Engineering and Environmental Laboratory
keV	Kilo electron Volt
KOH	Potassium Hydroxide
LANL	Los Alamos National Laboratory
LAT	Lateral Chest X-ray
LLD	Lower Limit of Detection
LPT	Lymphocyte Proliferation Testing
μCi	Microcurie
MCW	Mallinckrodt Chemical Works
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detectable Level
MeV	Million-electron Volt

MMC	Oak Ridge Methodist Medical Center
MPC	Maximum Permissible Concentration
mR	Milliroentgen
mrem	Millirem
NCRP	National Council on Radiation Protection and Measurements
NESHAP	National Emission Standards for Hazardous Air Pollutants
NDA	Non-Destructive Testing
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NTA	Eastman Kodak Nuclear Track Film Type A
NTS	Nevada Test Site
OCAS	Office of Compensation Analysis and Support
ORNL	Oak Ridge National Laboratory
ORAU	Oak Ridge Associated Universities
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORR	Oak Ridge Reservation
OTIB	ORAU Technical Information Bulletin
PA	Posterior-Anterior Chest X-ray
PACE	PACE Local 5-288 and International Union
PCB	Polychlorinated Biphenyls
PCM	Personnel Contamination Monitor
PEMS	Paducah Project Environment Management System
PDD	Paducah Daily Distributed Newsletter
PFG	Photofluorography
PGDP	Paducah Gaseous Diffusion Plant
PHS	Preliminary Hazards Screening
PIC	Pocket Ionization Chamber
PNAD	Personal Neutron Accident Dosimeter
POC	Probability of Causation
PPE	Personal Protective Equipment
ppm	Parts Per Million

PSS	Plant Shift Supervisor
QA	Quality Assurance Group
R&D	Research and Development
RCP	Radiological Control Permit
RCT	Radiological Control Technician
RCW	Radioactively Contaminated Waste
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
RPP	Radiation Protection Permit
RU	Recycled Uranium
RWP	Radiation Work Permit
SC&A	S. Cohen and Associates
SEC	Special Exposure Cohort
SP	Security Policeman
SRS	Savannah River Site
SWP	Special Work Permit
TBD	Technical Basis Document
TCE	Trichloroethylene
TDEC	Tennessee Department of Environment and Conservation
TIB	NIOSH Technical Information Bulletin
TLD	Thermoluminescent Dosimeter
TOXCO	Tennessee Reindustrialization Tennant Company
TRU	Transuranics
TSCA	Toxic Substances Control Act
TSR	Technical Safety Review
UCC	Union Carbide Corporation
UMTRA	Uranium Mill Tailings Remedial Action Program
USEC	USEC, Inc., A Global Energy Company
UT-B	ORNL University of Tennessee – Battelle Company
Y-12	Y-12 National Security Complex

1.0 EXECUTIVE SUMMARY

This report provides the results of an independent audit conducted by S. Cohen and Associates (SC&A, Inc.) of the Technical Basis Documents (TBDs) that make up the site profile developed by the National Institute for Occupational Safety and Health (NIOSH) for the Oak Ridge K-25 Gaseous Diffusion Plant Site. This audit was conducted during the period of October 3, 2006–February 22, 2007, in support of the Advisory Board on Radiation and Worker Health (Advisory Board) in the latter's statutory responsibility under the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA) to conduct such reviews and advise the Secretary of Health and Human Services on the "completeness and adequacy" of the EEOICPA program.

The Oak Ridge K-25 Gaseous Diffusion Plant Site (K-25 Site) is owned by the U. S. Department of Energy (DOE) and played an important role in the U.S. nuclear weapons program. It is currently known as the East Tennessee Technology Park (ETTP). The K-25 Site processes included uranium enrichment (U-235), radiochemical processing, uranium recycling, and waste management. The dates of operation of the K-25 facilities and activities are summarized in the K-25 Site Description TBD, ORAUT-TKBS-0009-2 (Szalinski 2006b), and as the TBD explains, are based on information from *Recycled Uranium Mass Balance Project, Oak Ridge Gaseous Diffusion Plant (Currently Known as East Tennessee Technology Park) Site Report* (BJC and Haselwood Enterprises 2000).

The Site Description TBD (Szalinski 2006b) provides the following summary of the scope of the nuclear activities conducted at the K-25 Site:

> *The K-25 Site, now known as the East Tennessee Technology Park (ETTP), processed thousands of tons of uranium through diffusion cascades for more than 40 years. The vast majority of the uranium was extracted and purified from ore, but some was recycled material obtained from spent reactor fuel.*
>
> *The primary K-25 areas that enriched ^{235}U using the gaseous diffusion process include Cascade Buildings K-25, K-27, K-29, K-31, K-33, K-413, and K-631. Uranium was initially processed in series operation in Buildings K-25, K-27, and K-29. Buildings K-31 and K-33 were later placed in series operations with the existing cascade. When the enrichment process was active, the uranium in these areas was almost exclusively in the form of uranium hexafluoride (UF_6).*
>
> *The uranium processed in these areas originated both from natural ores and recycled uranium products. The uranium feed materials, whether natural or recycled uranium, were purified before reaching K-25 and were chemically identical. Various natural sources were used but the uranium feed material was not source-dependent. The recycled uranium contained trace amounts of activation and fission products that were not completely removed by the recovery and purification processes. The recycled feed material could have varied somewhat depending upon both time in the reactor and process of recovery.*

Processing of recycled uranium from spent reactor fuel was intermittent, with campaigns conducted in 1952 to 1964, 1969 to 1974, and 1976 and 1977. Virtually all of the recycled uranium came from plutonium production reactors at the Hanford and Savannah River Sites, with little from power or demonstration reactors.

The material recycled from reprocessed reactor fuels contained trace quantities of fission products and transuranic (TRU) elements formed during irradiation of the fuels. Most of these impurities were removed during chemical processing of the fuels. Because fluorinated compounds of the elements in question have limited volatility, much of the impurity activity initially present remained in the feed cylinders or was deposited in the cascade equipment very close to the feed point. However, trace quantities passed through the chemical and physical separations to contaminate the diffusion cascades. Process operations primarily resulted in ^{234}U, ^{235}U, and ^{238}U contamination. Characterization of the recycled uranium included in the Recycled Uranium Mass Balance Project Oak Ridge Gaseous Diffusion Plant Site Report indicate the primary contaminants incident to the recycled uranium are technetium-99 (^{99}Tc), neptunium-237 (^{237}Np), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and $^{239/240}Pu$ (Szalinski 2006b, pp. 6–7).

SC&A's review focused on the six TBDs that make up the K-25 Site Profile. These address Introduction, Site Description, Internal Dose, External Dose, Occupational Medical Dose, and Occupational Environmental Dose, as they pertain to historic occupational radiation exposure to K-25 workers. As "living" documents, TBDs are constantly being revised as new information, experience, or issues arise. For the K-25 Site Profile, in particular, interviews with NIOSH and ORAU staff underscored their ongoing and extensive efforts to upgrade the existing TBDs. In that context, SC&A discussed with NIOSH (and ORAU) the latter's dose estimation guidance for K-25 that may figure in their next TBD revision and would supersede earlier site profile direction. That discussion is reflected in several of the SC&A findings in order to add an updated perspective of how NIOSH plans to address these issues (notwithstanding that the SC&A review remains based on the current TBD editions).

SC&A's review process included a review of the TBDs, one onsite visit to conduct interviews with site experts and identify documents for data retrieval, reviews of retrieved K-25 and other historic records, and an exchange of questions and answers, in addition to TBD-specific conference calls, between SC&A and its NIOSH and ORAU counterparts. The TBDs were evaluated for their completeness, technical accuracy, adequacy of data, compliance with stated objectives, and consistency with other site profiles, as stipulated in the *SC&A Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). A complete list of the K-25 TBDs, as well as supporting documents, that were reviewed by SC&A is provided in Attachment 1.

The Site Description TBD states that, along with uranium enrichment, recycling, and waste management, there was radiochemical processing; however, there is little information provided covering this or any special research or programs that may have used sources other than the traditional uranium source terms it describes. Comments have been made at a project meeting with former employees that K-25 had other programs that involved radionuclide sources that were different than the uranium fuel mixtures (NIOSH 2005). There is also some inconsistency in the TBDs regarding the time periods of processing recycled uranium (RU) (the site description states in one section that 1977 and in another section that 1984 was the end of processing RU; the internal dosimetry description states that it was 1976).

The site profile does not address occupational radiation sources beyond the more established and well-documented ones. This is potentially problematic, given the radiological significance of many of these "other" radionuclides, the steadily evolving nature of radiological controls, dosimetry practices, and recordkeeping at the site through the late 1940s, 1950s, 1960s, and into the 1970s, and the lack of individual specific radiological monitoring and dose data that may have contributed to information gaps critical to dose estimation.

The Site Description and Internal Dose TBDs do not consistently identify all potentially important radionuclides in the source terms (Pu-241 and U-236 are not identified in the Site Description TBD; Th-230, Am-241, Cm-242, and Cm-244 are not identified in the source terms listed for specific buildings in the internal dosimetry TBD). There is no discussion on the contamination levels (air and surface contamination) that could have been involved with exposures at the site. Radiological controls, such as source containment, air-monitoring data, respiratory protection usage, and surface contamination monitoring and the changes in these practices as the site progressed were not covered in the TBDs.

Issues presented in this report are sorted into the following categories, in accordance with SC&A's review procedures:

(1) Completeness of data sources
(2) Technical accuracy
(3) Adequacy of data
(4) Consistency among site profiles
(5) Regulatory compliance

Following the introduction and a description of the criteria and methods employed to perform the review, the report discusses the strengths of the TBD, followed by a description of the major issues identified during our review. The issues were carefully reviewed with respect to the five review criteria. Several of the issues were designated as primary findings, because they represent key deficiencies in the TBDs that need to be corrected, and which have the potential to substantially impact at least some dose reconstructions. Others have been designated "secondary findings" to both connote their importance for the technical adequacy and completeness of the site profile, and to indicate that they have been judged by SC&A to have relatively less influence on dose reconstruction or the ultimate significance of worker doses estimated.

1.1 SUMMARY OF STRENGTHS

The K-25 Occupational Environmental TBD, ORAUT-TKBS-0009-4 (East 2006), describes the potential exposures from ambient sources to unmonitored workers while outside the facilities. The document presents data for estimating annual intakes from radionuclides in air and external dose from ambient radiation, as well as from cylinder storage yards. The TBD provides references to numerous environmental reports for the site.

The K-25 Occupational Internal Dose TBD, ORAUT-TKBS-0009-5 (Thomas 2006), identifies that interpretation of bioassay data can be difficult, due to uncertainty regarding enrichment, solubility, and the contribution of environmental uranium. It also identifies intakes that could involve soluble and insoluble fractions, which could complicate interpretation. This TBD also states that samples were collected at work, so cross-contamination could contribute to uncertainty. The K-25 Site Description TBD, ORAUT-TKBS-0009-2 (Szalinski 2006b) provides numerous examples of the varying uranium to transuranic radionuclide (U:TRU) and uranium to technetium-99 (U:Tc) ratios that could have occurred at the site, which can help internal dose assessment.

1.2 SUMMARY OF FINDINGS

1.2.1 Primary Findings

Finding 1: More guidance is needed on appropriate enrichment assumptions when interpreting uranium bioassay mass concentration data. The K-25 Occupational Internal Dose TBD (Thomas 2006) needs to provide more guidance on the appropriate enrichment to assume when interpreting uranium bioassay mass concentration data, and the enrichment assumed for the default isotopic distribution may not be appropriate or claimant favorable.

Finding 2: No default absorption (solubility) classes for any of the intakes are identified. Absorption classes for two important forms of uranium (UO_3 and U_3O_8) listed are incorrect. There is no discussion on high-fired uranium oxides or Special Class Y (S) material that would have different biokinetics than traditional Class S uranium compounds

Finding 3: The default isotopic distribution does not appear to be claimant favorable. It does not contain Pu-238, Pu-240, Pu-241, and Pu-242; Cm-242 and Cm-244; assumes only low enriched (2%) uranium; and the Tc-99 ratio is questionably low. The Site Description, as well as the Internal Dose TBD, describe the use of higher enrichments and identify 3% as the predominant enrichment at the site, as discussed in the finding above, along with the fact that higher enrichment would lead to higher activity intakes and doses when interpreting uranium urine mass concentrations. There needs to be a strong justification for the assumptions regarding enrichment, as adopted by NIOSH, because they do not appear to be claimant favorable or correct.

Finding 4: The TBD is inconsistent or lacks complete information on radionuclides for K-25 facilities. There is a general inconsistency or lack of complete radionuclide guidance and information for facilities shown in the tables of the TBD. Several major radionuclides are not shown in source terms at various buildings in Table 5-4 (Thomas 2006), Source Term Summary by Location. Table 5-2, principal radionuclides found at uranium facilities and gaseous diffusion plants, list Th-230, Am-241, Cm-242, and Cm-244, and the default isotopic distribution in Table 5-6 lists Th-230 and Am-241, yet these radionuclides are not shown as part of the source term in any buildings listed in Table 5-4.

Finding 5: Lack of information regarding incidents may be a problem for accurate and claimant-favorable internal dose reconstructions. The lack of information on incidents that could have caused significant intakes of radionuclides could hinder accurate interpretation of bioassay results and identification of intakes by unmonitored or inadequately monitored workers. There are no incidents identified in this TBD. There were likely several incidents which have incident investigation information that would help dose reconstructors perform accurate and claimant favorable intake and dose assessments. Interpretation of bioassay data can be assisted by the use of incident records information and, if no bioassay data are available for an unmonitored or inadequately monitored claimant that may have been involved in an incident, then other types of data from the investigation may be used for dose assessment.

Finding 6: Coworker data use and approach for unmonitored employees may not be appropriate or claimant favorable. NIOSH's use of the median bioassay data values from 1948 to 1988 for uranium intake rates and 1978 to 1988 data for Tc-99 intake rates may not be reasonable or claimant favorable for several reasons. Because there was undoubtedly some variation of intake rates around the median values, it does not appear to be claimant favorable to assume that a claimant's intake was a median intake, as opposed to a higher value such as the 84^{th} percentile value. NIOSH needs to determine if the work processes (such as production level/throughput), exposure conditions, and radiological controls (engineering, administrative, personal protective equipment (PPE)) for the 1945–1947 period were similar to the periods that followed it.

Finding 7: Uranium cylinder storage yard dose may be underestimated. Section 6.7.3 of the Occupational External Dose TBD (Miles 2006) states that the neutron dosimeters in use "were generally insensitive to the low neutron dose rates at K-25…" In addition, as discussed elsewhere in this review, the dosimeters were insensitive to **any** dose rate due to neutrons below the NTA cutoff (somewhere between 0.5 and 1.0 MeV.) In spite of this, DRs are instructed to add missed neutron dose only for workers in the cylinder yards. There will have been pervasive, low-level neutron fields in other areas of the plant due to the alpha-N reaction, spontaneous fission, the presence of trace levels of transuranics in some feed stocks, and possible incidents or "slow cooker" events. Given these facts, SC&A recommends that all areas of the plant be evaluated to determine an appropriate missed dose component for neutron exposure. NIOSH should evaluate the advisability of using the PGDP recommended 200 mrem/2,000 hr as the basis for a more claimant favorable dose estimate for K-25 workers.

Finding 8: Until 1980, some dosimeters were only processed upon request, resulting in ambiguity regarding the construction of doses in the early years. Until 1980, the TBD (Miles 2006) states that dosimeters were only processed upon request. Another TBD statement points out that ORNL provided K-25 dosimeter and processing technical support starting in 1945. It is unclear from these two statements whether dosimeters were routinely processed for workers or only done in some random frequency. If the latter is true, many workers may have missed dose due to lack of processing or recording. SC&A recommends that this issue be investigated and appropriate data be collected to address this missed dose if NIOSH finds that it did occur.

The Occupational External Dose TBD (Miles 2006, pg. 10) states that "From 1945 to 1979, ORNL processed dosimeters only on request," yet there is no discussion as to the meaning of this statement. For example, who was able to make such a request, and on what basis? Were any random dosimeters selected to check for unanticipated exposures? What was entered in the record if a dosimeter was processed that revealed a worker had been receiving an exposure over an extended period? SC&A recommends that this issue be investigated and data collected in situations such as the percentage of issued badges that were processed, the procedures for selecting which badges to process, the procedures for handling positive results, and the implementation of a QA program if any, etc.

Finding 9: Chronic neutron exposure opportunities may have been overlooked for the early years. For health physics and safety coverage during the early years, it seems that little attention was paid to the possibility of neutron exposures. While it is possible that this was because there were no significant neutron fields, it is also possible that limited staff, inexperience, inadequate instrumentation, and a generally more relaxed attitude to chronic exposure levels may have resulted in safety staff overlooking or ignoring neutron exposure potential. SC&A suggests that this issue should be revisited and a determination made as to whether some categories of workers could have been exposed to chronic low-level neutron fields.

Finding 10: Potential exposures to Tc-99 betas were not recorded by dosimeters and are not addressed elsewhere in the TBD. It is also likely that the film badges used in the 1945 to 1979 period did not detect Tc-99. (Details on wrapping and cover materials in mg/cm^2 would be helpful.) It is asserted that only skin contamination could have given rise to significant beta exposure due to Tc-99, yet this claim is unsupported by any discussion of typical quantities of Tc-99 that might be present or any measurements or calculations of dose rates. The potential for exposure to beta fields needs to be more fully evaluated, with a parallel consideration of the dosimetry in use at the time and the potential for unreported or under-reported dose.

Finding 11: Reliance on a single neutron-to-photon ratio for the entire plant is questionable. Reliance on a single neutron-to-photon ratio for the entire plant geography and history and a ratio that additionally is based on a measurement at another facility is questionable. The K-25 plant had a number of potential sources of neutron exposure that will have varied over time as processes, facilities, procedures, impurities, and enrichments changed. Additional research and analysis is recommended to evaluate the neutron-to-photon ratio(s) that should be used to estimate missed neutron doses over the K-25 plant history. SC&A recommends that careful consideration be given to situations where the photon component of the field may have been effectively shielded by process equipment and pipe work, leaving a neutron component of exposure that is not accompanied by a significant photon component. This would undermine the application of the ratio method for these situations.

Finding 12: All beta dosimetry was based on a uranium slab calibration. Given that it is likely that at least some workers were routinely exposed to Tc-99, and given that the dosimeters will have partly or completely missed this lower energy beta, SC&A recommends that an evaluation be performed to determine the degree to which Tc-99 dose was under-reported or missed entirely. The use of only a uranium slab calibration may well have missed these lower energy betas.

1.2.2 Secondary Findings

Finding 13: There is a lack of guidance on bioassay interpretation. There is a lack of guidance on bioassay interpretation regarding appropriate assumptions for intake assessments. The TBD needs to either provide more specific guidance to the dose reconstructor on several parameters that must be chosen or adjusted for intake and dose assessment, or reference the documents that will provide this guidance.

Finding 14: There is no comparison between measured and predicted ambient radiation dose data. The PGDP Occupational Environmental TBD, ORAUT-TKBS-0019-4 (East 2004) states that since 1962, "At PGDP all personnel wore film badges…" The ORNL Occupational Environmental TBD, ORAUT-TKBS-0012-4 (Burns 2004) states, "ORNL went to a take home badge (i.e., security badge and dosimeter combined) in the early 1950s…" It is reasonable to postulate that given similar activities to a sister site (PGDP) and being a part of the Oak Ridge Reservation (ORR), K-25 employed a similar personnel dosimetry arrangement for workers. A comparison between personnel dosimetry data (measured) with estimates based on ambient environmental exposures (predicted) would prove useful to validate the methods for reconstructing external environmental doses.

Finding 15: The TBD does not provide a consistent time period for the processing of RU at K-25. The potential radionuclide contaminants in RU (Tc-99, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Cm-242, and Cm-244) can give a significant increase in the dose from intakes of RU process material compared to natural uranium ore sources that do not contain these radionuclide contaminants. The Occupational Internal Dose TBD (Thomas 2006) does identify a default isotopic distribution that contains some of these contaminants to assume for intakes in Table 5-6; however, it does not make it clear for which years to assume this default. The TBD should identify specific time periods that RU and its default isotopic distribution are to be assumed in intake assessment for possible claimant-favorable exposures.

Finding 16: The TBD fails to adequately define frequency and assess all types of x-rays in occupational medical exposure. Initial guidance on medical exposure and dose guidelines, as presented in Revision 2 of ORAUT-OTIB-0006 (Kathren 2003), provides basic guidelines that the dose reconstructor can use to ensure that all occupational medical exposures are reasonably included in determining the overall dose estimations for claimants. Unfortunately, the interpretation, to date, by the contractor (ORAU) has not been applied conservatively to be claimant favorable. The Occupational Medical Dose TBD (Turner 2006) assumes an interpretation that has been considered and applied at other sites, such as the Mound Plant, Los Alamos National Laboratory (LANL), Paducah, and Pinellas. It is assumed that occupationally related medical exposures are included in dose reconstruction for pre-employment, annual, health monitoring examinations, and post-employment chest x-rays. Although NIOSH has stated that they rely on the K-25 Site to provide all medical records information (Attachment 4), an interview with a K-25 medical x-ray technologist, there since 1957 (Attachment 2, Medical X-ray Procedures section), indicated that the data provided may not contain information retired to microfiche. In the early period, workers with potential for exposure to uranium dust inhalation were reported in the TBD (Turner 2006, Table 3-1) to have often received monthly chest x-rays. NIOSH needs to review the microfiche to verify the frequency of chest x-rays in the early years, and what the appropriate number of chest x-rays for inclusion in dose reconstruction is, for workers exposed to uranium dust. This would need to be developed for those workers whose individual medical records do not document the frequency of chest x-rays.

Finding 17: Techniques and protocols increase uncertainty of dose conversion factors (DCFs) listed in the TBD. The Occupational Medical Dose TBD (Turner 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from ICRP Publication 34 (ICRP 1982). The TBD states that a posterior-anterior (PA) chest x-ray was typically the only view taken until the early 1950s. It is an undocumented assumption in the TBD that exams required only a PA view. SC&A has inquired whether a definitive protocol existed to validate that chest exams possibly included PA views and lateral (LAT) views on a limited basis. NIOSH has acknowledged in other TBD reviews that the lack of verifiable protocols is a generic problem at many sites, has planned to search all available records, and will include pertinent records and references in any future revision of this section of the TBD. The Occupational Medical Dose TBD is also deficient in that little documentation exists to validate x-ray protocols, equipment maintenance, and upkeep records.

1.3 OPPORTUNITIES FOR IMPROVEMENT

(1) There is ambiguity in the Internal Dosimetry TBD (Thomas 2006) about ending of RU processing.

The Site Description TBD (Szalinski 2006b) states in one section that RU was processed through 1977, and through 1984 in another section; however, the Internal Dose TBD identifies that 1976 was the last year of using RU for feed material. These TBDs need to be in agreement. The lack of considering that RU was also used in later periods could lead to an incorrect intake assessment and unfavorable determination for the claimant. NIOSH, in its response to SC&A's Internal Dose section question 9, which is included in Attachment 3 of this report, states that the reference that they used to identify the period that RU was received at K-25 states that it was 1952 through 1988 (BJC 2000), and that they will revise the appropriate section of the TBD for clarity. In the conference call (Attachment 4, Internal Dosimetry, question 9), NIOSH stated that all intakes of uranium will assume that RU was involved from 1952 through the present, and will use the default isotopic distribution in the Internal Dose TBD (Table 5-6) for assessed intakes.

(2) Use of ICRP 23 (ICRP 1974) Reference Man anatomical and physiological data may be questionable, because this document has been updated with ICRP 89 data (ICRP 2002).

A determination should be made on the applicability of using the larger daily urine excretion volume from ICRP 89 for the conversion of urine bioassay concentration data (µg U/liter) to 24-hour excretion activity that is used to calculate intakes. The ICRP 89 volume (1.6 liters for men and 1.2 liters for women) is larger than the volume recommended in ICRP 23 (1.4 liters for men and 1.0 liters for women). Using the larger volumes will increase the intakes and doses determined from concentration (e.g., mass or activity per liter) bioassay data interpretation for internal dose assessment. If NIOSH does not believe that the larger volumes are applicable, it should state this and defend the use of the smaller volumes.

(3) There is no discussion on the respiratory protection program—air sampling or other radiological control practices—that would help provide potentially valuable information for internal dose reconstruction.

This information provides a general overview and possibly specific data on the conditions that claimants were exposed to and the methods employed to minimize or limit intakes of radionuclides. This information may be useful if a dose reconstructor must make a professional judgment decision on the potential for intakes to occur. Another important piece of information that may be extracted from this is the level of knowledge of a claimant's work locations, which would help identify their specific exposure conditions. There also is no discussion of the cascade improvement/cascade upgrade programs in the 1970s, which may have involved increased exposure problems (mentioned in the site expert's interview in Attachment 2).

In addition to this basic program information, NIOSH needs to determine if the site has done any airborne radionuclide particle size and/or lung solubility analyses for the radionuclides in the source terms of buildings, and then provide any applicable information to dose reconstructors.

NIOSH, in its response to SC&A's Internal Dose section question 5 (Attachment 3), states that the primary method of evaluation for dose reconstructions is use of individual monitoring data, and, if it is necessary, area-monitoring information will be reviewed. In its response to question 3 of this attachment, NIOSH states that particle size distributions are specific to operations and conditions in the locations, and it is not reasonable to assume that a measurement in one location is universally applicable to other locations. However, it notes that dose reconstructors may use site-specific information if it is contrary to the 5-micrometer default activity median aerodynamic diameter (AMAD) assumption.

(4) Table 5-7 (Thomas 2006) identifies in-vitro MDCs, yet incorrectly labels these as being in mg/L units in its heading, and no fecal bioassay MDCs are identified.

The units do not need to be identified in the heading of Table 5-7 of the Internal Dose TBD, because each bioassay MDC unit is identified in the table next to its numerical value (some in mass and some in activity concentration units). The type of samples these MDCs apply to is not identified specifically in the table, but from reading the text, it can be assumed that these are for urine bioassay, because it is the only in-vitro bioassay discussed. No fecal bioassay is identified, which infers that fecal bioassay data is not available. During the site interview and document search, a research paper was obtained that indicated fecal sampling was performed for a period from 1964–1966 at the Uranium

Recovery Facility (Schultz 1966), and this was reported to NIOSH in the conference call (Attachment 4, Internal Dosimetry, question 2). NIOSH should discuss the availability of any fecal bioassay data.

(5) A discussion of the determination for potential radium and thorium sources is needed to identify if dose assessment for workplace-related radon exposures is warranted.

Although K-25 was primarily a uranium-processing site, it was claimed in a project meeting (NIOSH 2005) that there were some special research missions at the site. NIOSH should look for any information that could indicate the significant use of radium or thorium sources. If any sources are found, NIOSH should then discuss the internal dosimetry effort (including radon dose assessment) that may be needed to account for these. NIOSH, in its response to SC&A's Internal Dose section question 8 (Attachment 3), states that, "No information on the presence of radium sources at the site is currently available." The site expert interviews indicated that radium was a significant radionuclide in K-1024, K-1030, and K-1035 (Attachment 2); therefore, it is recommended that NIOSH investigate this possibility, and any potential radium and radon doses that could have resulted.

(6) Occupational Medical Dose TBD (Turner 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from ICRP Publication 34 (ICRP 1982).

The TBD provides a summary on the use of PA and LAT chest x-rays. NIOSH should attempt to find additional data to validate that the process described leads to the most claimant-favorable dose for occupationally related chest x-rays.

(7) Figure 4-1 of the Occupational Environmental Dose TBD (East 2006) shows major buildings and environmental monitoring stations relative to release points.

It would be valuable to include wind rose data to validate the chosen monitoring stations. Also include the discussed administrative area in relation to these locations. Table 4D-4 provides estimated average gamma radiation levels for two perimeter K-25 stations. For the years 1973–1985, asterisks need to be included denoting data derived from empirical site measurements.

(8) Photographs showing typical facilities, equipment, and processes would be helpful.

Photographs showing typical facilities, equipment, and processes would assist dose reconstructors and reviewers unfamiliar with the K-25 facilities in understanding the layout, inherent shielding, and distances commonly encountered by workers. Any photos of the dosimeters in use and associated dosimeter processing facilities and equipment would also be helpful.

(9) A discussion of major incidents is needed.

A discussion of major incidents throughout the site history and how unusual doses were added to the record over the extended time period under review would be helpful.

(10) A discussion of the range and type of non-standard operations would be helpful.

A discussion of the range and type of non-standard operations, such as plant upgrades, maintenance, research and development (R&D), etc., would be helpful. For example, while Tc-99 recovery is mentioned, it is unclear to the reader what this entails.

(11) The Site Description TBD needs a comprehensive list of buildings.

Site interviews with a number of workers make it clear that a number of buildings are not addressed in the site profile. K-25 Site Expert Interviewees (Attachment 2, Production/Operations section) identified numerous buildings including K-101, K-131, K-631, and others. SC&A recommends that NIOSH prepare a comprehensive list of all the buildings on the site and use this to identify work areas with potential for missed dose. The table in Attachment 2 should be helpful to the dose reconstructor when reviewing a claimant's work area for potential higher external or internal dose. This is important, as there could be an opportunity for exposure to internal and external hazards, even if the building is clean. There is documentation of contaminated equipment being transferred to inactive areas for repairs or modification during the life of the K-25 plant.

2.0 SCOPE AND INTRODUCTION

The review of the K-25 Site Profile was conducted from October 3, 2006– February 22, 2007, by a team of SC&A health physicists and technical personnel.

2.1 REVIEW SCOPE

Under the EEOICPA and Federal regulations defined in Title 42, Part 82, *Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program,* of the *Code of Federal Regulations* (42 CFR Part 82), the Advisory Board is mandated to conduct an independent review of the methods and procedures used by NIOSH and its contractors for dose reconstruction. As a contractor to the Advisory Board, SC&A has been charged under Task 1 to support the Advisory Board in this effort by independently evaluating a select number of site profiles that correspond to specific facilities at which energy employees worked and were exposed to ionizing radiation.

This report provides a review of the following six documents related to historical occupational exposures at the K-25 Gaseous Diffusion Plant:

- ORAUT-TKBS-0009-1, *K-25 Introduction, Rev. 01*, May 4, 2006 (Szalinski 2006a).

- ORAUT-TKBS-0009-2, *Technical Basis Document for the K-25 Site – Site Description, Rev. 01*, October 4, 2006 (Szalinski 2006b).

- ORAUT-TKBS-0009-3, *Technical Basis Document for K-25 the Site – Occupational Medical Dose, Rev. 00 PC-1, November 7, 2006* (Turner 2006).

- ORAUT-TKBS-0009-4, *Technical Basis Document for the K-25 Site – Occupational Environmental Dose*, *Rev. 00 PC-1,* September 26, 2006 (East 2006).

- ORAUT-TKBS-0009-5, *K-25 Gaseous Diffusion Plant -Occupational Internal Dose Rev. 00 PC-1,* October 4, 2006 (Thomas 2006).

- ORAUT-TKBS-0009-6, *Technical Basis Document for the K-25 Site – Occupational Internal Dose, Rev. 00 PC-1,* September 26, 2006 Miles 2006).

These documents are supplemented by technical information bulletins (TIBs), which provide additional guidance to the dose reconstructor. A complete list of these documents is available in Attachment 1.

Implementation guidance is also provided in "workbooks," which have been developed by NIOSH for selected sites to provide more definitive direction to the dose reconstructors on how to interpret and apply TBDs, as well as other available information.

SC&A, in support of the Advisory Board, has critically evaluated the K-25 Site TBDs for the following:

- Determine the completeness of the information gathered by NIOSH in behalf of the site profile, with a view to assessing its adequacy and accuracy in supporting individual dose reconstructions
- Assess the technical merit of the data/information
- Assess NIOSH's use of the data in dose reconstructions

SC&A's review of the six TBDs focuses on the quality and completeness of the data that characterized the facility and its operations, and the use of these data in dose reconstruction. The review was conducted in accordance with *SC&A Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004), which was approved by the Advisory Board.

The review is directed at "sampling" the site profile analyses and data for validation purposes. The review does not provide a rigorous quality control process, whereby actual analyses and calculations are duplicated or verified. The scope and depth of the review are focused on aspects or parameters of the site profile that would be particularly influential in deriving dose reconstructions, bridging uncertainties, or correcting technical inaccuracies. This review does not explicitly address the issue of radiation exposures to cleanup workers and decommissioning workers, as that is not addressed in the TBDs.

The six TBDs serve as site-specific guidance documents used in support of dose reconstructions. These site profiles provide the health physicists who conduct dose reconstructions on behalf of NIOSH with consistent general information and specifications to support their individual dose reconstructions. This report was prepared by SC&A to provide the Advisory Board with an evaluation of whether and how the TBDs can support dose reconstruction decisions. The criteria for evaluation include whether the TBDs provide a basis for scientifically supportable dose reconstruction in a manner that is adequate, complete, efficient, and claimant favorable. Specifically, these criteria were viewed from the lens of whether dose reconstructions based on the TBDs would provide for robust compensation decisions.

The basic principle of dose reconstruction is to characterize the radiation environments to which workers were exposed, and determine the level of exposure the worker received in that environment through time. The hierarchy of data used for developing dose reconstruction methodologies is dosimeter readings and bioassay data, coworker data and workplace monitoring data, and process description information or source term data.

2.2 REVIEW APPROACH

SC&A's review of the TBDs and supporting documentation concentrated on determining the completeness of data collected by NIOSH, the adequacy of existing K-25 personnel and environmental monitoring data, and the evaluation of key dose reconstruction assumptions.

2.3 REPORT ORGANIZATION

In accordance with directions provided by the Advisory Board, and with site profile review procedures prepared by SC&A and approved by the Advisory Board, this report is organized into the following sections:

(1) Executive Summary
(2) Scope and Introduction
(3) Assessment Criteria and Method
(4) Site Profile Strengths
(5) Vertical Issues
(6) Overall Adequacy of the Site Profile as a Basis for Dose Reconstruction

Based on the issues raised in each of these sections, SC&A prepared a list of findings, which are provided in the Executive Summary. Issues are designated as Findings if SC&A believes that they represent deficiencies in the TBD that need to be corrected, and which have the potential to have a substantial impact on at least some dose reconstructions. Issues can also be designated as Secondary Issues if they simply raise questions, which, if addressed, would further improve the TBDs and may possibly reveal deficiencies that will need to be addressed in future revisions of the TBDs.

Many of the issues that surfaced in the report correspond to more than one of the major objectives (i.e., strengths, completeness of data, technical accuracy, consistency among site profiles, and regulatory compliance). Section 6.0 provides a list of the issues in summary form, and to which objective the particular issue applies.

The TBDs, in many ways, have done a successful job in addressing a series of technical challenges. In other areas, the TBDs exhibit shortcomings that may influence some dose reconstructions in a substantial manner. Major issue areas include the following:

- Insufficient data for early worker dose reconstructions
- Appropriate uranium enrichment assumptions for internal dose assessment are not sufficiently documented
- Lack of guidance for default absorption classes to assume for internal dose assessment
- Inadequate consideration of missed dose to other radionuclides not as well characterized or monitored
- Lack of incident information for accurate and claimant-favorable internal dose reconstructions
- Underestimation of neutron dose, due to the assumption that the only major source of neutron exposure was around the cylinder yards

- Lack of data, particularly in the early days, of the type of x-ray equipment used, the beam quality, and the x-ray protocols that impact the dose conversion factors (DCFs)

SC&A believes that these important issues need to be effectively dealt with in any upcoming revisions to the K-25 Site Profile TBDs in order that more claimant-favorable dose reconstructions can be effectively conducted in areas where these data gaps exist.

3.0 ASSESSMENT CRITERIA AND METHODS

SC&A is charged with evaluating the approach set forth in the site profiles that is used in the individual dose reconstruction process. These documents are reviewed for their completeness, technical accuracy, adequacy of data, consistency with other site profiles, and compliance with the stated objectives, as defined in *SC&A Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). This review is specific to the K-25 Site Profile, supporting TIBs, and dose reconstruction worksheets; however, items identified in this report may be applied to other facilities, especially facilities with similar source terms and exposure conditions. The review identifies a number of issues and discusses the degree to which the site profile fulfills the review objectives delineated in SC&A's site profile review procedure.

3.1 OBJECTIVES

SC&A reviewed the site profile with respect to the degree to which technically sound judgments or assumptions are employed. In addition, the review identifies assumptions by NIOSH that give the benefit of the doubt to the claimant.

3.1.1 Objective 1: Completeness of Data Sources

SC&A reviewed the site profile with respect to Objective 1, which requires SC&A to identify principal sources of data and information that are applicable to the development of the site profile. The two elements examined under this objective include (1) determining if the site profile made use of available data considered relevant and significant to the dose reconstruction, and (2) investigating whether other relevant/significant sources are available, but were not used in the development of the site profile. For example, if data are available in site technical reports or other available site documents for particular processes, and if the TBDs have not taken into consideration these data where it should have, this would constitute a completeness of data issue. The Oak Ridge Associated Universities (ORAU) site profile document database, including the referenced sources in the TBDs, was evaluated to determine the relevance of the data collected by NIOSH to the development of the site profile. Additionally, SC&A evaluated records publicly available relating to the K-25 Site and records provided by site experts.

3.1.2 Objective 2: Technical Accuracy

SC&A reviewed the site profile with respect to Objective 2, which requires SC&A to perform a critical assessment of the methods used in the site profile to develop technically defensible guidance or instruction, including evaluating field characterization data, source term data, technical reports, standards and guidance documents, and literature related to processes that occurred at K-25. The goal of this objective is to first analyze the data according to sound scientific principles, and then to evaluate this information in the context of compensation. If, for example, SC&A found that the technical approach used by NIOSH was not scientifically sound or claimant favorable, this would constitute a technical accuracy issue.

3.1.3 Objective 3: Adequacy of Data

SC&A reviewed the site profile with respect to Objective 3, which requires SC&A to determine whether the data and guidance presented in the site profile are sufficiently detailed and complete to conduct dose reconstruction, and whether a defensible approach has been developed in the absence of data. In addition, this objective requires SC&A to assess the credibility of the data used for dose reconstruction. The adequacy of the data identifies gaps in the facility data that may influence the outcome of the dose reconstruction process. For example, if a site did not monitor all workers exposed to neutrons who should have been monitored, this would be considered a gap and, thus, an inadequacy in the data.

3.1.4 Objective 4: Consistency among Site Profiles

SC&A reviewed the site profile with respect to Objective 4, which requires SC&A to identify common elements within site profiles completed or reviewed to date, as appropriate. In order to accomplish this objective, the K-25 TBD was compared to several of the sites already reviewed by SC&A.

3.1.5 Objective 5: Regulatory Compliance

SC&A reviewed the site profile with respect to Objective 5, which requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in 42 CFR Part 82. In addition, SC&A evaluated the TBD for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions.
In order to place the above objectives into the proper context as they pertain to the site profile, it is important to briefly review key elements of the dose reconstruction process, as specified in 42 CFR Part 82. Federal regulations specify that a dose reconstruction can be broadly placed into one of three discrete categories. These three categories differ greatly in terms of their dependence on and the completeness of available dose data, as well as on the accuracy/uncertainty of data.

Category 1: Least challenged by any deficiencies in available dose/monitoring data are dose reconstructions for which even a partial assessment (or minimized dose(s)) corresponds to a probability of causation (POC) value in excess of 50%, and assures compensability to the claimant. Such partial/incomplete dose reconstructions with a POC greater than 50% may, in some cases, involve only a limited amount of external or internal data. In extreme cases, even a total absence of a positive measurement may suffice for an assigned organ dose that results in a POC greater than 50%. For this reason, dose reconstructions in behalf of this category may only be marginally affected by incomplete/missing data or uncertainty of the measurements. In fact, regulatory guidelines recommend the use of a partial/incomplete dose reconstruction, the minimization of dose, and the exclusion of uncertainty for reasons of process efficiency, as long as this limited effort produces a POC of greater than or equal to 50%.

Category 2: A second category of dose reconstruction is defined by Federal guidance, which recommends the use of "worst-case" assumptions. The purpose of worst-case assumptions in dose reconstruction is to derive maximal or highly improbable dose assignments. For example, a worst-case assumption may place a worker at a given work location 24 hours per day and 365 days per year. The use of such maximized (or upper-bound) values, however, is limited to those instances where the resultant maximized doses yield POC values below 50%, which are not compensated. For this second category, the dose reconstructor needs only to ensure that all potential internal and external exposure pathways have been considered.

The obvious benefit of worst-case assumptions and the use of maximized doses in dose reconstruction is efficiency. Efficiency is achieved by the fact that maximized doses avoid the need for precise data and eliminates consideration for the uncertainty of the dose. Lastly, the use of bounding values in dose reconstruction minimizes any controversy regarding the decision not to compensate a claim.

Although simplistic in design, to satisfy this type of a dose reconstruction, the TBD must, at a minimum, provide information and data that clearly identify (1) all potential radionuclides, (2) all potential modes of exposure, and (3) upper limits for each contaminant and mode of exposure. Thus, for external exposures, maximum dose rates must be identified in time and space that correspond to a worker's employment period, work locations, and job assignment. Similarly, in order to maximize internal exposures, highest air concentrations and surface contaminations must be identified.

Category 3: The most complex and challenging dose reconstructions consist of claims where the case cannot be dealt with under one of the two categories above. For instance, when a minimum dose estimate does not result in compensation, a next step is required to make a more complete estimate. Or when a worst-case dose estimate that has assumptions that may be physically implausible results in a POC greater than 50%, a more refined analysis is required. A more refined estimate may be required either to deny or to compensate. In such dose reconstructions, which may be represented as "reasonable," NIOSH has committed to resolve uncertainties in favor of the claimant. According to 42 CFR Part 82, NIOSH interprets "reasonable estimates" of radiation dose to mean the following:

> *. . . estimates calculated using a substantial basis of fact and the application of science-based, logical assumptions to supplement or interpret the factual basis.* ***Claimants will in no case be harmed by any level of uncertainty involved in their claims, since assumptions applied by NIOSH will consistently give the benefit of the doubt to claimants.*** [Emphasis added.]

In order to achieve the five objectives described above, SC&A reviewed each of the six TBDs, their supplemental attachments, and TIBs, giving due consideration to the three categories of dose reconstructions that the site profile is intended to support. The six K-25 TBDs provide well-organized and user-friendly information for the dose reconstructor when adequate data were available to do that comprehensively.

ORAUT-TKBS-0009-1, Rev. 00, *Technical Basis Document for K-25 Site – Introduction* (Szalinski 2006a), explains the purpose and the scope of the site profile. SC&A was attentive to this section, because it explains the role of each TBD in support of the dose reconstruction process. During the course of its review, SC&A was cognizant of the fact that the site profile is not required by the EEOICPA or by 42 CFR Part 82, which implements the statute. Site profiles were developed by NIOSH as a resource to the dose reconstructors for identifying site-specific practices, parameter values, and factors that are relevant to dose reconstruction. Based on information provided by NIOSH personnel, SC&A understands that site profiles are living documents, which are revised, refined, and supplemented with TIBs as required to help dose reconstructors. Site profiles are not intended to be prescriptive nor necessarily complete in terms of addressing every possible issue that may be relevant to a given dose reconstruction. Hence, the introduction helps in framing the scope of the site profile. As will be discussed later in this report, NIOSH may want to include additional qualifying information in the introduction to this and other site profiles describing the dose reconstruction issues that are not explicitly addressed by a given site profile.

ORAUT-TKBS-0009-2, Rev. 01, *Technical Basis Document for the K-25 Site – Site Description* (Szalinski 2006b), is an extremely important document because it provides a description of the facilities, processes, and historical information that serve as the underpinning for subsequent K-25 TBDs.

ORAUT-TKBS-0009-3, Rev. 00 PC-1, *Technical Basis Document for the K-25 Site – Occupational Medical Dose* (Turner 2006), provides an overview of the sources, types of exposure, and the frequency of exams that workers potentially received.

ORAUT-TKBS-0009-4, Rev. 00 PC-1, *Technical Basis Document for the K-25 Site – Occupational Environmental Dose* (East 2006), provides background information and guidance to dose reconstructors for reconstructing the doses to unmonitored workers outside of the facilities at the site who may have been exposed to routine and episodic airborne emissions from these facilities.

ORAUT-TKBS-0009-5, Rev. 00 PC-1, *K-25 Gaseous Diffusion Plant – Occupational Internal Dose* (Thomas 2006), presents background information and guidance to dose reconstructors for deriving occupational internal doses to workers.

ORAUT-TKBS-0012-6, Rev. 00, *Technical Basis Document for the K-25 Site – Occupational External Dose* (Miles 2006), presents background information and guidance to dose reconstructors for deriving occupational external doses to workers.

In accordance with SC&A's site profile review procedures, SC&A performed an initial review of the six TBDs, their supporting documentation, and the TIBs or procedures (PROCs). Interviews with Site Experts are provided in Attachment 2. SC&A then submitted questions to NIOSH with regard to assumptions and methodologies used in the site profile. Prior to the conference calls with SC&A for the K-25 Site Introduction TBD (Szalinski 2006a), the K-25 Site Description TBD (Szalinski 2006b), the K-25 Site Occupational Medical Dose TBD (Turner 2006), the K-25 Occupational Environmental Dose TBD (East 2006), the K-25 Occupational Internal Dose TBD (Thomas 2006), and the K-25 Site Occupational External Dose TBD (Miles 2006), NIOSH provided written responses to SC&A Questions (Attachment 3). The SC&A key questions and the NIOSH responses to the SC&A are provided in Attachment 3.

Two conference calls were then conducted with NIOSH, ORAU, and the SC&A team to allow NIOSH to provide clarifications and to explain the approaches employed in the site profile TBDs. A summary of the conference calls with NIOSH, ORAU, and SC&A is provided in Attachment 4.

Information provided in the conference calls with NIOSH was evaluated against the preliminary findings to finalize the vertical issues[1] addressed in the audit report. There are two levels of review for this report. First, SC&A team members review the report internally. The second level, referred to as the expanded review cycle, will consist of a review of this draft by the Advisory Board and NIOSH.

After the Advisory Board and NIOSH have an opportunity to review this draft, SC&A plans to request a meeting with Advisory Board members and NIOSH representatives to discuss the report. Following this meeting, we will revise this report and deliver the final version to the Advisory Board and to NIOSH. We anticipate that, in accordance with the procedures followed during previous site profile reviews, the report will then be published on the NIOSH Web site and discussed at the next Advisory Board meeting. This last step in the review cycle completes SC&A's role in the review process, unless the Advisory Board requests SC&A to participate in additional discussions regarding the closeout of issues, or if NIOSH issues revisions to the TBDs or additional TIBs, and the Advisory Board requests SC&A to review these documents.

Finally, it is important to note that SC&A's review of the six TBDs and their supporting TIBs is not exhaustive. These are large, complex documents, and SC&A used its judgment in selecting those issues that we believe are important with respect to dose reconstruction.

[1] The term "vertical issues" refers to specific issues identified during our review, which were identified as requiring more in-depth analysis, due to their potential to have a significant impact on dose reconstruction.

4.0 SITE PROFILE STRENGTHS

In developing a TBD, the assumptions used must be fair, consistent, and scientifically robust, and uncertainties and inadequacies in source data must be explicitly addressed. The development of the TBD must also consider efficiency in the process of analyzing individual exposure histories, so that claims can be processed in a timely manner. With this perspective in mind, we identified a number of strengths in the K-25 Site Profile TBDs. These strengths are described in the following sections.

4.1 INTERNAL DOSE TBD STRENGTHS

In the Occupational Internal Dose TBD (Thomas 2006), Table 5-5 identifies, in detail, the isotopes of plutonium and their activity per unit mass in the facility-specific radionuclide conversion factors. This TBD also identifies the urine bioassay minimum detectable concentrations (MDCs) applicable for the different in-vitro bioassays in Table 5-7 and the in-vivo minimum detectable activities (MDAs) in Table 5-9 for the site history, which are also helpful for internal dose assessment.

The K-25 Occupational Internal Dose TBD (Thomas 2006) had sections that were relatively consistent with other site profiles. Source term information for locations and bioassay analytical detection levels were covered similarly to the Paducah Gaseous Diffusion Plant Internal Dose TBD (Mantooth 2006) and the Portsmouth Gaseous Diffusion Plant Internal Dose TBD (Demopoulos 2004). The K-25 Internal Dosimetry Coworker Data TBD (Cherry 2006) uses similar approaches for estimating intakes and doses for non-monitored claimants as found in the Paducah Internal Dosimetry Coworker Data TBD (Ikenberry 2005).

Where in-vivo and in-vitro analyses are available, this information is provided for use in the determination of internal dose.

4.2 EXTERNAL DOSE TBD STRENGTHS

A good breakdown of the various site locations and activities as a function of time was provided. Dosimetry methods used for beta, photon, and neutron dose monitoring were described separately, and also as a function of time and technology changes. Bioassay methods and their associated detection limits used over the site history were provided (Thomas 2006). Ratios of U:TRU and U:Tc radionuclides were described in good detail in the Site Description TBD (Szalinski 2006b). Some prescribed health physics monitoring procedures and recordkeeping methods were described, along with the logbooks containing this information. K-25 has been fortunate to have noted scientists and R&D facilities to address radiation and health physics problems throughout its years of operations.

A well-developed approach is in place to address potentially overlooked chronic low-level skin contamination exposures (Miles 2006, Section 6.7.2).

Where routine beta/gamma and neutron dosimeters are available and adequate, this information is provided for use in determination of external exposure.

4.3 MEDICAL DOSE STRENGTHS

Within the Occupational Medical Dose TBD (Turner 2006), a very helpful table has been developed (Table 3.3, pg. 8) that assists the dose reconstructor in finding the appropriate organ dose per x-ray for the various x-ray examinations from 1944–2000.

Likewise, the Occupational Medical Dose TBD additionally provides Table 3.2 on page 7 that summarized information taken from Cardarelli et al. 2002. This table nicely summarizes each x-ray machine kVp kV) output, the assumed half-value level (HVL) of Al, the image size, and the entrance skin exposure (ESE) for both PA and LAT films. A medical x-ray technologist interviewed during the K-25 site visit did, however, describe an x-ray machine currently in use that is not included in the Occupational Medical TBD. From 1987 to the present, the K-25 Site Medical Department has been using a Bennett D-5251 Unit with a Eureka Tube (Inovision Model 4000) with an automatic collimator.

4.4 ENVIRONMENTAL DOSE TBD STRENGTHS

The TBDs' use of personnel monitoring data and environmental monitoring data to determine dose is consistent with the requirements outlined in 42 CFR Part 82, which state, "Where environmental measurements are available, these data are used as the basis for environmental dose."

The K-25 Occupational Environmental Dose TBD (East 2006) has provided a good summary of the occupational environmental dose received by unmonitored workers from onsite releases to the environment and elevated ambient radiation. The contribution from soil resuspension is accounted for in excess conservatism used to account for limitations in the source term.

5.0 VERTICAL ISSUES

SC&A has developed a list of key issues regarding the K-25 Site Profile. These issues relate to each of the five objectives defined in SC&A's review procedures (SC&A 2004). Some issues are related to a particular objective, while others cover several objectives. Many of the issues raised below are applicable to other DOE and Atomic Weapons Employer sites, and should be considered in the preparation and revision of other site profiles.

5.1 ISSUE 1: MORE GUIDANCE IS NEEDED ON APPROPRIATE ENRICHMENT WHEN INTERPRETING URANIUM BIOASSAY MASS CONCENTRATION DATA

The K-25 Occupational Internal Dose TBD (Thomas 2006) needs to provide more guidance on appropriate enrichment to assume when interpreting uranium bioassay mass concentration data, and the enrichment assumed for the default isotopic distribution may not be appropriate or claimant favorable.

Section 5.3, Scope, of the TBD (Thomas 2006) states the following:

> *The facility processed both virgin feed material and recycled or reprocessed reactor fuel to enrichments of up to 93% (by weight) of ^{235}U from 1945 to 1964. After 1964 the highest enrichment was 5%.*

Section 5.4, Source Term, of the TBD (Thomas 2006) states the following:

> *The primary mission of K-25 was to enrich uranium in the form of UF_6 (for use in domestic and foreign commercial power reactors) from roughly 0.7% ^{235}U (natural enrichment) to 93.5% ^{235}U (DOE 2000a).*

Table 5-1 provides isotopic fraction information on four uranium enrichments (2%, 4%, 93%, and natural) that were handled at K-25 along with the default (2%) to be used when information is inadequate to identify the potential enrichment to which the claimant may have been exposed. There is little discussion on which specific enrichment to use for intake and dose assessment in relation to the buildings or time frames in which the claimant may have worked. It is critical to choose a correct uranium enrichment when interpreting uranium bioassay mass concentration data (typically in μg/liter). When assessing intakes and internal doses using this data, the mass must be converted to activities of the isotopes that make up the mass to calculate radiation doses. Most of the bioassay data for K-25 is in urine mass concentration units, so the enrichment assumption will affect most internal dose assessments. As shown in Table 5-1, the activities of specific uranium isotopes change as enrichment increases. These changes result in the total alpha activity that gives the dose going up several fold with increasing enrichment (total of activities for natural = 0.0254 Bq/μg; 2% = 0.0389 Bq/μg; 4% = 0.0792 Bq/μg; 93% = 2.489 Bq/μg). The majority of the increase in activity as enrichment increases is from the U-234 isotope, which enriches at a higher rate through the diffusion process than the U-235 isotope, due to its smaller mass number.

It is obvious from the K-25 Site Description (Szalinski 2006b) that the enrichments involved with intakes could have been much higher than the default assumption of 2%. This default enrichment also is in disagreement with statements and other information in this TBD. Footnote 2 in Section 5.3 on page 6, which refers to the first statement from the text quoted above, states "The predominant enrichment level was 3.0%…" (Szalinski 2006b). Also, in Table 5-4, Source term summary by location, 3% enrichment is identified in three locations; however, 2% is not identified in any locations in the table. Use of 3 % enrichment as the default enrichment would significantly increase the alpha activity and dose assessed in intakes from interpretation of urine bioassay mass concentration data. Therefore, it is recommended that NIOSH review the appropriateness of the default uranium enrichment assumption for accuracy and claimant-favorable assessments.

NIOSH in its response to SC&A's internal dose section question 16, which is included in Attachment 3 of this report, states that:

> *…the predominant enrichment level at K-25 was 3%, except for the period of time when reprocessed fuel was used as feed. The dose reconstructors will select the input parameters on enrichment based upon the dates of exposure for each claimant*." (Attachment 3, question 16)

In its response to question 17 of Attachment 3, NIOSH states the following:

> *Because the predominant enrichment level at K-25 is described in Section 5.3 as being 3%, Table 5-1 will be revised to capture this level as the default."* (Attachment 3, question 17)

NIOSH appears to have appreciated the concern for assuming too low an enrichment for interpretation of bioassay mass concentration data, and apparently will address this by correcting the default enrichment assumption. NIOSH also stated in a conference call that most bioassay data is in activity (not mass) units and, therefore, the enrichment assumption will not be important for most intake assessments (Attachment 2, Internal Dose section, question 17). SC&A agrees with this, because no conversion from mass to activity is needed in these cases; however, for cases that have only uranium mass concentration data, the enrichment assumption still remains important.

5.2 ISSUE 2: NO DEFAULT ABSORPTION (SOLUBILITY) CLASSES FOR ANY OF THE INTAKES ARE IDENTIFIED

No default absorption (solubility) classes for any of the intakes are identified. Absorption classes for two important forms of uranium (UO_3 and U_3O_8) listed are incorrect. There is no discussion on high-fired uranium oxides or Special Class Y (S) material that would have different biokinetics than traditional Class S uranium compounds.

The Occupational Internal Dose TBD (Thomas 2006) identifies the absorption classes for the principal radionuclides in Table 5-2, and the chemical forms of uranium by location in Table 5-4. However, there is no guidance on which absorption classes to assume when assessing intakes and doses using the default isotopic distribution for intakes shown in Table 5-6. The intakes of radionuclides and doses to organs interpreted from bioassay can vary by large amounts when different absorption classes are chosen. The guidance on uranium absorption to assume is generally adequate; however, there is little discussion on the absorption to choose for plutonium, thorium, or technetium that is assumed to be in intakes assessed with the default isotopic distribution.

The TBD does not identify the potential for the UO_2 and U_3O_8 at the site to behave more like the Special Class S (Y) material that has an approximately 100-day half-life in the lung and excretion parameters more like Class M (W) material (ANSI 1995). There is no discussion on whether any high-fired forms of uranium (and/or possibly transuranic radionuclides) existed at the site, which may have been more difficult to detect by urine bioassay, and for which fecal sampling would have been more applicable. High-fired uranium dioxide is shown in the list of absorption classification for some uranium compounds in Table 5-3, but there is no statement in the text on its being or not being at the site, and this should be clarified.

In Table 5-3, the TBD (Thomas 2006) shows UO_3 as Class F absorption, yet this is identified by the ICRP as Class M, and it also shows U_3O_8 as being Class M, while the ICRP identifies this as Class S (ICRP 1994). Use of the incorrect, more quickly absorbed classes for intake assessment of these chemical forms of uranium could lead to significant underestimations of intakes and doses to organs. NIOSH needs to correct these absorption identifications before dose reconstructors use them or explain the reason for disagreement with the ICRP.

NIOSH in its response to SC&A's Internal Dose Section, question 19 (Attachment 3), states the following:

> *If a claimant has knowledge of the chemical form of the materials with which he/she worked, the dose reconstructor will use that information, along with the relevant assumptions on monitoring frequency and intake pattern, to reconstruct the dose. If information on chemical form, monitoring frequency and intake pattern are unknown, the default assumptions described elsewhere in the TBD would be applied in a manner which is favorable to claimants.*

It is doubtful that all claimants will know all of the chemical forms of the radionuclides they could have been exposed to during their work assignments. Therefore, it is important that NIOSH identify default absorption classes that must be assumed for bioassay interpretation in cases that applicable process knowledge to a claimant's case is lacking and/or bioassay data may be insufficient in number or sampling frequency for identifying likely absorption classes of intakes from modeling. NIOSH's response appears to show their knowledge of the importance of choosing an appropriate claimant-favorable absorption class. However, NIOSH's lack of elaboration or understandable discussion in the TBD on how they will handle this for K-25 claimants when there is no or insufficient process information for bioassay interpretation leaves concern regarding consistency.

5.3 ISSUE 3: THE DEFAULT ISOTOPIC DISTRIBUTION DOES NOT APPEAR TO BE CLAIMANT FAVORABLE

The default isotopic distribution does not appear to be claimant favorable. It does not contain Pu-238, Pu-240, or Pu-241. Also, the distribution for Pu-242, Cm-242, and Cm-244 is based on the assumption that only low enriched (2%) uranium was present. In addition, the Tc-99 ratio is questionably low.

The Site Description, as well as this Internal Dose TBD (Thomas 2006), describe the use of higher enrichments and identify 3% as the predominant enrichment at the site, as discussed in the finding above. Also, higher enrichment would lead to higher activity intakes and doses when interpreting uranium urine mass concentrations. There needs to be a strong justification for this, because it does not appear to be claimant favorable or correct.

Curium-242 and Cm-244 are identified in Table 5-2 (Thomas 2006) as principal radionuclides found at uranium facilities and gaseous diffusion plants; however, these are neither included in the default isotopic distribution nor discussed anywhere in the text of the TBD. Protactinium-234m is identified in Section 5.4 as one of the progeny of dosimetric interest, yet it is not discussed anywhere else in the text, nor is it addressed as part of the default isotopic distribution. Plutonium-238, Pu-240, Pu-241, and Pu-242 are isotopes of plutonium that will be in any amount of this element taken from a reactor. Since the transuranic radionuclides identified in the default isotopic mix are from reprocessed reactor fuel, then these must be part of the plutonium isotopes in the contaminants. This is reinforced by the fact that Table 5-5, Facility-Specific Radionuclide Conversion Factors, lists all of these with the other radionuclide contaminants from the reprocessed fuel. Plutonium-241 has the highest activity of the plutonium isotopes per unit mass of uranium at all of the K-25 facilities listed. NIOSH needs to discuss any rationale for not adding these radionuclides into the default isotopic distribution.

The Tc-99 activity concentration in the default isotopic distribution in Table 5-6 (Thomas 2006) is a very small fraction of the total uranium activity (very large U:Tc-99 ratio of approximately 9000:1), which appears to be an underestimate of the potential Tc-99 levels to which claimants could have been exposed. Section 5.4 (Thomas 2006) states the following:

> *The fission product Tc-99 has also been present during plant operations, particularly during the processing of reactor tails. The available documentation indicates that the tails contained from 0.041 to 7.0 ppm Tc-99 (Smith 1984, Appendix 12; DOE 2000a).*

This indicates that the Tc-99 contaminant levels varied in the source by a factor of at least 175. In addition, the Site Description TBD identifies much lower U:Tc-99 ratios, which mean that the activity levels of Tc-99 could have been much higher than shown in the default isotopic distribution. Statements from the Site Description TBD that support this are as follows:

- Section 2.2, Site Activities and Processes (Thomas 2006):

  In this area, technetium was deposited in many items of equipment. During maintenance operations, some of these materials were spilled or released from the equipment (some in the gaseous state). This resulted in significant surface contamination in Units K-310-1, K-310-2, and K-310-3 of Building K-25 and Units K-402-1, K-402-8, and K-402-9 of Building K-27…. Characterization studies to date indicate that the observed activity ratio of U:Tc has been as low as 0.002:1 in these areas. Activity ratios less than 1:1 of U:Tc are common in these areas, indicating that ^{99}Tc contamination was significant.

- Section 2.2.2, Facilities and Support Locations (Thomas 2006):

  K-1420 Decontamination Facility… The observed activity ratio of U:Tc has been as low as 0.5:1.

NIOSH needs to determine if the activity concentration of Tc-99 in the default isotopic distribution in Table 5-6 (Thomas 2006) is reasonable and claimant favorable, and why. In general, with all of the concerns about the default isotopic distribution, NIOSH should consider writing a section or attachment to discuss and defend the development of this issue.

NIOSH, in its response to SC&A's Internal Dose section question 12 (Attachment 3), states the following:

> *At this time, the only facility-specific source term information available is that shown in Tables 5-4 and 5-5. The default distribution in Table 5-6 was drawn from the same references. If additional source term information should become available, the TBD will be revised accordingly, as will the default isotopic distribution.* (Attachment 3, question 12)

As pointed out above, NIOSH identified all of the radionuclides that may need to be added into the default isotopic distribution in other tables and text in the TBD. NIOSH also provided significant information in the Site Description TBD on the varying levels of Tc-99 that could have been in source terms. Therefore, it is still not understood why these potential "missing" radionuclides and possible higher levels of Tc-99 will not be accounted for.

In the conference call, NIOSH stated that there is a TIB being developed on RU (Attachment 3, Internal Dose section, question 12). According to NIOSH, it is supposed to be released soon and addresses RU across the complex. This may answer the questions in this finding.

5.4 ISSUE 4: THERE IS GENERAL INCONSISTENCY OR LACK OF COMPLETE RADIONUCLIDE INFORMATION FOR FACILITIES IN THE TBD TABLES

There is a general inconsistency or lack of complete radionuclide guidance and information for facilities shown in the tables of the Occupational Internal Dose TBD (Thomas 2006).

Several major radionuclides are not shown in source terms at various buildings in Table 5-4, Source Term Summary by Location. Table 5-2, Principal Radionuclides Found at Uranium Facilities and Gaseous Diffusion Plants, lists Th-230, Am-241, Cm-242, and Cm-244; and the default isotopic distribution in Table 5-6 lists Th-230 and Am-241, yet these radionuclides are not shown as part of the source term in any buildings listed in Table 5-4. Several facilities (K-1410, K-1064, K-1417, K-1419, K-1037, K-1435, K-1015, K-1066, K-1004, K-1006, K-1088C) listed in Table 2-2, K-25 Radiological Hazards by Area, of the Site Description TBD (Szalinski 2006b) are not covered in Table 5-4 or Table 5-5, Facility Specific Conversion Factors. If these non-listed facilities are involved with intakes, NIOSH needs to give further guidance on the radionuclide source terms listed.

NIOSH also needs to address the possibility of intakes of other radionuclides that apparently were not bioassay monitored, but were identified during the site expert interviews (Attachment 2). Tritium (H-3) may have been in wastes from other DOE sites and were disposed of at the TSCA incinerator, which has operated since the 1990s. Radium (which produces radon) was identified as having been handled at three facilities (K-1024, K-1030, and K-1035), and U-233 was also possibly handled at the site (Attachment 2). Cesium-137 and Sr-90 (likely from other Oak Ridge facilities outside of K-25) were found to be contaminants in the drinking water, and possibly need to be investigated in the internal dose or environmental dose assessments.

NIOSH, in its response to SC&A's Internal Dose section questions 10 and 11 (Attachment 3), states that, "At this time, the only source term information available is that shown in Tables 5-4 and 5-5. If additional source term information should become available, the TBD will be revised accordingly." NIOSH appears to recognize the importance of determining accurate source terms for buildings; however, it is not understood why the Site Description TBD listing of buildings with radiological hazards (Table 2-2) includes several buildings that are not identified in the Site Description TBD (Szalinski 2006b).

5.5 ISSUE 5: LACK OF INCIDENT INFORMATION MAY BE A PROBLEM FOR ACCURACY AND CLAIMANT-FAVORABLE INTERNAL DOSE RECONSTRUCTION

The lack of information on incidents that could have caused significant intakes of radionuclides could hinder accurate interpretation of bioassay results and identification of intakes by unmonitored or inadequately monitored workers.

There are no incidents identified in this TBD. There were likely several incidents that have incident investigation information that would help dose reconstructors perform accurate and claimant-favorable intake and dose assessments. Interpretation of bioassay data can be assisted by the use of incident records information and, if no bioassay data are available for an unmonitored or inadequately monitored claimant that may have been involved, then other types of data from the investigation may be used for dose assessment. The use of medical interventions for any major intakes that would have undoubtedly been associated with incidents (e.g., chelation for plutonium intakes, bicarbonates for uranium intakes, etc.) that are not discussed in this TBD may be found in incident records, and bioassay interpretation can be assisted by this data. NIOSH needs to determine if an incident records review of greater extent needs to be performed, and to justify why it does not need to do this, if it believes it is not applicable to reconstructing doses accurately.

NIOSH, in its response to SC&A's Internal Dose section, question 4 (Attachment 3), indicates that sodium bicarbonate can be used for medical intervention in uranium intake mitigation and, if noted in the claimant file, the dose assessment would take this into account. In its response to question 6 in Attachment 3, NIOSH reaffirms their TBD statement that no incident information is available, and states the TBD revisions in the future may capture these as they are identified by claimant interviews or other information sources. This response by NIOSH indicates that they are aware that incident information can be valuable for dose reconstruction; however their effort to obtain this information appears to be reliant mainly on other parties taking the initiative to find and provide it. NIOSH stated in the conference call that if there **is** a situation where an individual claimant states in their CATI that they were involved in an incident, and the dose reconstructor does not have enough information in the records provided by the site, NIOSH can make a supplemental data request for more data to try to find more information. NIOSH stated that there does not seem to be incident documentation at K-25, but there is a system in place to pick it up. However, the site expert interviews in Attachment 2 indicate that there should have been a lot of records and probably at least one database kept on incidents.

5.6 ISSUE 6: COWORKER DATA USE AND APPROACH FOR UNMONITORED EMPLOYEES MAY NOT BE APPROPRIATE

NIOSH's use of the median bioassay data values from 1948 to 1988 for uranium intake rates and 1978 to 1988 data for ^{99}Tc intake rates may not be reasonable or claimant favorable for several reasons. Because there was undoubtedly some variation of intake rates around the median values, it does not appear to be claimant favorable to assume that a claimant's intake was a median intake as opposed to a higher value, such as 84th percentile value. NIOSH needs to determine if the work processes (such as production level/throughput), exposure conditions and radiological controls (engineering, administrative, personal protective equipment) for the 1945–1947 period were similar to the periods that followed. There more than likely were improvements to radiological controls as the site progressed over the years; therefore, it appears to be a questionable assumption that intake rates during the latter years would have been similar to intake rates during the early years. NIOSH also assumes that intakes were chronic; however, the Internal Dose TBD (Thomas 2006) states the following in Section 5.5.1, Measurement Types and Detection Levels:

> *The expected intake pattern in most cases is acute. At K-25, airborne and surface contamination was typically controlled to prevent intakes, so most would have been the result of unexpected releases.*

NIOSH needs to assess whether acute or multiple acute intakes would provide more claimant-favorable assessments. The urine bioassay data was normalized to 1,400 ml, which is from ICRP 23 (ICRP 1974), currently an outdated reference updated with ICRP 89 (ICRP 2002) that uses 1,600 ml for a 24-hour excretion volume. Using the current volume would increase the bioassay values by more than 10%. The TBD states that only gross alpha results were used to determine the intake rates, but does not discuss any background adjustment for the gross alpha results. If background adjustments were made, this needs to be discussed; if not, it should be so stated.

Also, the guidance for dose reconstructors is vague when it comes to use of coworker data. Section 6.9 of the Occupational External Dose TBD (Miles 2006) contains specific guidance for dose reconstructors. The third bullet suggests, "In general, assign the maximum **reasonable** coworker dose as a favorable to claimant estimate" (Emphasis added). Guidance is needed to avoid individual dose reconstructors selecting their own definition of "reasonable" for this aspect of the dose determination.

NIOSH, in its response to SC&A's Internal Dose Coworker Data section of Attachment 3, question 4, indicates that an individual who was never monitored is assumed to not have the potential to have received larger intakes than the majority of those who were monitored, and that they assume that the coworker distribution is representative of their intakes. The median dose is, therefore, assigned as a lognormal distribution, and the associated GSD is assigned to account for possible larger intakes and uncertainty associated with the distribution. This approach is reasonable, as long as these assumptions have validity, and the intake scenarios (radiological conditions and controls) were not significantly worse in the earlier years.

NIOSH, in its response to SC&A's Internal Dose Coworker Data section, questions 1 and 2 (Attachment 3), indicates that information was not available for determining if air concentrations and surface contamination, as well as levels of general radiological control, were different before bioassay data are available (pre-1948). NIOSH is using intakes modeled from 1948–1988 to estimate the intakes of workers prior to 1948, and states that if the workers "had larger intakes in the earlier years their bioassay results would have reflected this in the years that samples were collected." However, NIOSH must be aware that relatively large acute intakes of uranium in chemical forms that have fast (Class F) absorption rates (such as UF_6, which was the most prevalent form at the site) may not be detectable several months or years after initial intakes and, therefore, may not be reflected in samples taken this length of time after the intake. If any workers had relatively large intakes of Class F chemical forms of uranium in the early years (e.g., 1945 or 1946), it is very possible that bioassay in 1948 did not detect or reflect the intake(s). In an instance like this, only air samples or surface contamination data would be relatively useful for identifying the intake.

NIOSH, in its response to SC&A's Internal Dose Coworker Data section, question 3 (Attachment 3), states that it is not possible to model all intake scenarios, and that the default assumption applied across the complex has been to assume chronic intakes. It also points out that a chronic intake assumption can be used to approximate small acute intakes. There is no doubt that chronic, acute, or a series of either types or combinations of these types of intakes could have occurred at this site. The important issue is that NIOSH should have a strong basis for using any intake assumption that is not as claimant favorable as any realistic potential intake scenario that could be assumed.

NIOSH stated in the conference call that they do not know if anything has been found on radiological controls (Attachment 3, Internal Dosimetry Coworker Data, question 2). Their approach is to take people who started in the days before monitoring, and look at their bioassay results later on. NIOSH assumes that with the slow excretion of uranium, you can take samples several years later and still get a relatively reasonable picture of what their exposure has been. From this approach, they assumed the same intake rate for each period (before and after bioassay started). NIOSH did note that the urine results were pretty steady, and varied up or down by a factor of 3 or 4. This still leaves two concerns; (1) the possibility of quicker excretions from more soluble form intakes in the early years that could go undetected, and (2) since there is some variation observed, choosing the median value projections may not be a reasonable claimant-favorable approach.

5.7 ISSUE 7: URANIUM CYLINDER STORAGE YARD DOSE MAY BE UNDERESTIMATED AND NEUTRON DOSE MAY HAVE BEEN MISSED

The K-25 Occupational Environmental Dose TBD (East 2006) states that, "Uranium cylinder storage yards remain the only significant source of external exposure at K-25. Surveys in cylinder yards at the sister plants show dose rates up to 200 mrem/2000h." It also states that, "The ORR Annual Environmental Report for 2003 (DOE 2004) reports a dose from the K-25 cylinder yards to a nearby parking area at 4.75 mrem/125h (75 mrem/2000h)." The PGDP Occupational Environmental Dose TBD (East 2004) states the following:

> *Unmonitored workers in the early years did not have significant inventories of depleted uranium to contribute to external dose. Later, unmonitored workers would not spend their entire work year at the depleted cylinder yards and, therefore, would not reach the maximum dose recorded by fence line monitoring. No other significant sources of external exposure are associated with the PGDP operations. An assumed deep dose equivalent rate of 200 mrem/yr for all years would be reasonable, and deficiencies in earlier measurement techniques thereby become immaterial.*

The recommended 200 mrem/2,000 hr for the PGDP is quoted in the K-25 TBD, yet 75 mrem/2,000 hr is used as the K-25 recommended external dose from the uranium cylinder yards. It is also reasonable to assume that doses in a nearby parking area would be less than doses nearer to the cylinder storage yards. NIOSH should evaluate the advisability of using the PGDP-recommended 200 mrem/2,000 hr as the basis for a more claimant-favorable dose estimate for K-25 workers.

In addition, Bechtel Jacobs published a report in May 2000 entitled, *Evaluation of Potential Radiation Doses to Members of the Public and ETTP Unmonitored Site Workers, East Tennessee Technology Park, Oak Ridge, Tennessee, BJC/OR-585/R1* (BJC 2000), to evaluate exposures from the K-25 cylinder yards. The report concluded that an unmonitored site worker who may spend 250 hours in a year (1 hour per work day) close enough to several cylinder yards could receive 125 mrem. These individuals are able to access the radiological posted areas present inside the fencing to get close enough to areas with potential exposure rates exceeding 0.4 mrem/hr. This exposure rate includes exposure to both gamma and neutrons using a conservative 4:1 gamma-to-neutron dose ratio.

Section 6.7.3 of the TBD states that the neutron dosimeters in use "were generally insensitive to the low neutron dose rates at K-25…" In addition, the dosimeters were insensitive to **any** dose rate due to neutrons below the NTA cutoff (somewhere between 1.0 and 0.5 MeV). In spite of this, dose reconstructors are instructed to add missed neutron dose only for workers in the cylinder yards. There will have been pervasive, low-level neutron fields in other areas of the plant, due to the alpha-N reaction, spontaneous fission, the presence of trace levels of transuranics in some feed stocks and incidents or "slow cooker" (Cardarelli undated–circa 1966) events. Given these facts, SC&A recommends that all areas of the plant be evaluated to determine an appropriate missed dose component for neutron exposure.

5.8 ISSUE 8: UNTIL 1980, SOME DOSIMETERS WERE ONLY PROCESSED UPON REQUEST RESULTING IN AMBIGUITY REGARDING THE CONSTRUCTION OF DOSES IN THE EARLY YEARS

The Occupational External Dose TBD (Miles 2006, pg. 9) stated the following:

> *K-25 began operations in 1945 using dosimeter and processing technical support provided by the Oak Ridge National Laboratory (ORNL). ORNL, then the Clinton Laboratory, had implemented its dosimetry methods based on the personnel beta/photon dosimeter design developed at the Metallurgical Laboratory at the University of Chicago (Pardue, Goldstein, and Wollan 1944). ORNL provided K-25 with beta/photon film dosimeters and neutron nuclear track, type A (NTA) emulsion.*

The TBD (Miles 2006, pg. 10) also made the following declaration:

> *From 1945 to 1979, ORNL processed dosimeters only on request.*

There is, however, no discussion as to the meaning of this statement. It is unclear from these two statements whether dosimeters were routinely processed for workers or only done in some random frequency. If the latter is true, many workers may have missed dose, due to lack of processing or recording. A key question is whether the practical determination to process a badge was based on an expected reading above the lower limit of detection (LLD) or above the weekly allowable dose, or some other action level. This information is vital in order to assess the validity of the coworker database.

SC&A recommends that this issue be investigated and data collected in situations such as the percentage of issued badges that were processed, the procedures for selecting which badges to process, the procedures for handling positive results, the implementation of a QA program (if any), etc.

5.9 ISSUE 9: CHRONIC NEUTRON EXPOSURE OPPORTUNITIES MAY HAVE BEEN OVERLOOKED

The TBD contains the statement that there was minimal potential for significant neutron doses. In the same paragraph, it states that doses ranged up to "less than 0.05mSv/hr." These seemingly low fields could give rise to a 10 rem/yr dose to a worker who spent a full work year in this field, not even accounting for x, beta, and gamma (2,000 hours × 0.05 mSv/hr = 100mSv). It appears that the authors may have assumed that certain areas, processes, operations, or equipment did not pose a hazard, when perhaps they did. SC&A suggests that this issue be revisited, and a determination made as to whether some categories of workers could have been exposed to chronic low-level neutron fields. (In addition, did workers routinely work more than 40 hrs/week? If so, then chronic dose rates have an even greater impact.)

For health physics and safety coverage during the early years, it seems that little attention was paid to the possibility of neutron exposures. While it is possible that this was because there were no significant neutron fields, there is another more likely scenario—limited staff, inexperience, inadequate instrumentation, and a generally more relaxed attitude to chronic exposure levels—may have resulted in safety staff overlooking or ignoring neutron exposure potential. In a contemporaneous health physics and safety review in the 1950s (HPSO 1954), there is no mention of potential neutron exposures, yet alpha, beta, and gamma hazards are discussed. Given what we now know regarding neutron exposure, due to slow cooker events and in the cylinder yard, and that the NTA dosimeters worn at the time would have missed most or all of the neutron exposures, potential neutron dose cannot be simply disregarded.

SC&A suggests that this issue should be revisited and a determination made as to whether some categories of workers could have been exposed to chronic low-level neutron fields.

5.10 ISSUE 10: POTENTIAL EXPOSURE TO TC-99 BETA WERE NOT RECORDED BY DOSIMETERS AND ARE NOT ADDRESSED IN THE TBD

Section 6.5.4 of the Occupational External Dose TBD (Miles 2006) discusses potential beta exposure from Tc-99 (294 keV endpoint). It is recognized that TLD dosimeters that were used for part of the site history would not detect these betas. It is also likely that the film badges used in the 1945 to 1979 period did not detect Tc-99. (Details on wrapping and cover materials in mg/cm^2 would be helpful.) It is asserted that only skin contamination could have given rise to significant beta exposure due to Tc-99, yet this claim is unsupported by any discussion of typical quantities of Tc-99 that might be present, or any measurements or calculations of dose rates. Note that, although the wrapping on the dosimeter would completely adsorb the technetium betas, they are still more than capable of penetrating $7mg/cm^2$ to deliver skin dose.

There is evidence from other gaseous diffusion sites that problems can arise where substantial external exposure is possible. For example, in 1968 at Paducah (a sister facility), an incident was reported where workers were exposed to a significant unsuspected beta field from Tc-99 (BJC 1968a, BJC 1968b). Resultant skin doses of up to 36 rem were recorded.

The potential for exposure to beta fields needs to be more fully evaluated, with a parallel consideration of the dosimetry in use at the time and the potential for unreported or under-reported dose.

5.11 ISSUE 11: RELIANCE ON A SINGLE NEUTRON-TO-PHOTON RATIO FOR THE ENTIRE PLANT IS QUESTIONABLE

Reliance on a single neutron-to-photon ratio for the entire plant geography and history that additionally is based on a measurement at another facility is questionable. The K-25 plant had a number of potential sources of neutron exposure that will have varied over time as processes, facilities, procedures, impurities, and enrichments changed. Section 6.5.4 of the Occupational External Dose TBD (Miles 2006) describes the process by which the ratio was derived. Measurements at Paducah during a cylinder-painting project are construed to be applicable to the entire depth and breadth of K-25 operations. This seems to be unlikely, given that K-25 went through several upgrades, utilized virgin and recycled feed, and was an experimental facility to some extent.

The choice of this neutron-to-photon ratio is significant, since the entire dosimetry record (based on NTA film) will be completely disregarded, due to the NTA low-energy cut-off in the energy region likely to be of concern at K-25 (Miles 2006, Section 6.7.3).

Additional research and analysis is recommended to evaluate the neutron-to-photon ratio(s) that should be used to estimate missed neutron doses over the K-25 plant history. SC&A recommends that careful consideration be given to situations where the photon component of the field may have been effectively shielded by process equipment and pipe work, leaving a neutron component of exposure that is not accompanied by a significant photon component. This would undermine the application of the ratio method for these situations.

5.12 ISSUE 12: ALL BETA DOSIMETRY WAS BASED ON A URANIUM SLAB CALIBRATION

The Occupational External Dose TBD (Miles 2006, pg. 16) states the following:

> *…beta calibrations were routinely performed using a slab of uranium, the primary source of shallow dose at K-25. No adjustment to recorded dose from the dosimeter is recommended.*

While energetic uranium betas may well have been the predominant source of beta exposure at the site, it is recognized that Tc-99 was also present, concentrated, and collected as part of the process. The TBD does not give any insight into this process, however. Given that it is likely that at least some workers were routinely exposed to Tc-99, and given that the dosimeters will have partly or completely missed this lower-energy beta, SC&A recommends that an evaluation be performed to determine the degree to which Tc-99 dose was under-reported or missed entirely.

5.13 SECONDARY ISSUES

5.13.1 Secondary Issue 1: There is a Lack of Guidance on Bioassay Interpretation

There is a lack of guidance on bioassay interpretation. The TBD needs to either provide more specific guidance to the dose reconstructor on several parameters that must be chosen or adjusted for intake and dose assessment, or reference the documents that will provide this guidance.

In Section 5.5.3, Instructions for Addressing Possible Interferences and Uncertainties (Thomas 2006), the following is stated:

> *The practice of offsite collection of samples that takes place approximately 24 to 48 hours after leaving the plant not only minimizes the possibility of sample cross-contamination, but it ensures that samples are collected after the transfer of the rapid clearance component. Some K-25 employees were asked to collect samples after 1 or 2 days off from work; if so, that collection instruction was sometimes noted in the analytical record.*

The next paragraph states the following:

> *Urine samples were typically collected in the workplace at K-25. Therefore, contamination of samples from worker's hands or clothing cannot be ruled out as a contributor to any given result. If a second analysis was performed and if that result was negative, sample cross-contamination could have occurred during first collection.*

This information is apparently conflicting and confusing. If the author is discussing two separate eras of sampling, then it should be noted. Another issue is ruling out an intake with a second analysis (presumably from a second bioassay sample, i.e., follow-up or special bioassay). The TBD (Thomas 2006) does not identify that a calculation (modeling) should be performed to determine if an intake could have occurred that would not have been detectable by a second bioassay. Such a bioassay could easily take several days after the first sample, which would be a more claimant-favorable approach. Another issue that appears unresolved regarding the sampling methods was the use of spot urine samples. Spot urine samples have a greater variability than 24-hour samples, and a determination for any needed adjustment to these results should be made (Medley et al. 1994).

NIOSH, in its response to SC&A's Internal Dose section, question 13 (Attachment 3), states the following:

> *As described in Section 5.5 of the TBD, urine samples were collected as both "spot" samples and as 24-hour collections, with the latter the standard procedure after 1950. If the measurement results are given in units of concentration, the dose reconstructors will convert them to 24-hour-equivalent excretion rates by using the Reference Man volume in ICRP Publication 23. If results are given in*

> *units of activity only, a 24-hour collection may be presumed if the date of the analysis is after 1950* (Attachment 3, question 13).

NIOSH should elaborate on any needed adjustments for the greater variability of spot urine sample concentrations when interpreting spot urine data, per the reference cited above. It also should consider using the replacement to ICRP Publication 23 (ICRP 1974), which is ICRP Publication 89 (ICRP 2002), which identifies larger 24-hour excretion volumes. This would increase 24-hour-equivalent uranium excretion rates proportionally and likely increase doses for urine bioassay concentration data.

In Section 5.6.3, Instructions for Addressing Possible Interferences and Uncertainties (Thomas 2006), there is a statement regarding in-vivo bioassay interpretation:

> *For in-vivo measurements, contamination could have occurred as external to the body or, in the case of chest counting, as external to the lung. If a follow-up in-vivo count (the same day or within a few days) showed a dramatic decrease in activity or no detectable activity, then external contamination should be assumed.*

This should be qualified with a statement that a determination of a possible intake of a form of the radionuclide with short lung retention must be made to be claimant favorable, particularly when urine bioassay is available.

There is little guidance on addressing the potential situation of a claimant having multiple intakes of different absorption classes, which could increase the complexity of the bioassay data interpretation. Also, if lung absorption/solubility analysis was performed on any of the materials at the site, this information needs to be made available to the dose reconstructors if the data warrants adjustment to the modeling input parameters or applicable biokinetic models. There is very little discussion on background subtraction for gross alpha counting or alpha spectrometry for isotopic uranium in urine. If there is going to be any adjustment for background radionuclides in urine, this should be discussed and defended in detail, because it will have a significant affect on interpreting these results. According to Attachment A of the *K-25 Urinalysis Codes (Definitions) 1948–1988*, Attachment A (Wallace 2005), describing the bioassay database, sampling frequency varied from monthly to semi-annually. There should be some discussion on the default assumed intake dates with these wide-ranging sampling frequencies when there is not enough bioassay data to determine most likely intake dates from modeling.

NIOSH, in its response to SC&A's Internal Dose section question 2 (Attachment 3), states the following:

> *When assessing intakes based on uranium urinalyses, our standard procedure has been to assume that the entire result is due to occupational exposure… No background subtraction is performed.*

This is a reasonable claimant-favorable approach and NIOSH should ensure that it is consistently followed, in light of its statement within the TBD that interpretation of results can be difficult because of the contribution of environmental uranium. In its response to SC&A's Internal Dose section question 15 (Attachment 3), NIOSH states the following:

> *The frequency of sampling as a programmatic issue is not a useful piece of information; the worker sample results are in the DOE files so the required frequency is irrelevant after the fact. Because uranium is long-lived and long retained, a dose reconstruction can be performed with very few results.*

Uranium is not retained for long periods if it is in chemical forms that have fast (Class F) absorption rates, such as UF_6, which was the most prevalent form at the site. Relatively large intakes could have gone undetected for acute intakes that may have occurred many weeks before a urine sample was taken if the claimant did not provide a timely urine sample. This is most significant with the bioassays that were analyzed for uranium mass concentration by fluorimetry (pre-1989), which had a much higher MDC than more recent analytical methods. The intake date assumption can be critical when modeling acute intakes and the TBD (Thomas 2006) should be clear on directions for intake date assumption, or refer to other ORAU procedural documents that clearly provide the necessary guidance.

5.13.2 Secondary Issue 2: There is No Comparison between Measured and Predicted Environmental Dose

The PGDP Occupational Environmental TBD, ORAUT-TKBS-0019-4 (East 2004), states that since 1962, "At PGDP all personnel wore film badges…" The ORNL Occupational Environmental TBD, ORAUT-TKBS-0012-4 (Burns 2004), states that, "ORNL went to a take-home badge (i.e., security badge and dosimeter combined) in the early 1950s…" It is reasonable to postulate that given similar activities to a sister site (PGDP) and being a part of the Oak Ridge Reservation (ORR), K-25 employed a similar personnel dosimetry arrangement for workers, as well. A comparison between personnel dosimetry data (measured), with estimates based on ambient environmental exposures (predicted), would prove useful to validate the methods for reconstructing external environmental doses.

5.13.3 Secondary Issue 3: The TBDs do not provide a Consistent Time Period for the Processing of RU at K-25.

The Site Description TBD (Szalinski 2006, Section 2.2, Site Activities and Processes) states the following:

> *Processing of recycled uranium from spent reactor fuel was intermittent, with campaigns conducted in 1952 to 1964, 1969 to 1974, and 1976 and 1977.*

The Site Description TBD then states the following (Section 2.2.1, K-25 Processing History):

1964 to 1985

> *In 1964, Buildings K-25 and K-27 were shut down, with the exception of K-25 purge cascade and its pigtail operation. In 1968, part of Building K-29 was shut*

> *down. The bottom of the cascade was now in Building K-31. ORGDP processed reactor returns through 1984, and continued to receive product from PGDP for use as feed.*

The Occupational Internal Dose TBD (Thomas 2006, Section 5.3, Scope, pg. 6, footnote 2) states the following:

> *The predominant enrichment level was 3.0%. Reprocessed fuel was used as feed from 1952 until 1976. At that time, the cascade facilities were upgraded and most of the TRU and fission product materials were removed. Campaigns involving reprocessed fuel elements ended in the 1980s.*

Then the Occupational Internal Dose TBD (Section 5.4, Source Term) states the following:

> *Certain TRU isotopes have been present at K-25 including ^{237}Np, and ^{239}Pu. These resulted from the processing of reactor tails. Reactor tails were fed to the cascade from 1953 to 1964, and again from 1969 to 1976, with the exception of 1971 when none of the feed was of reactor origin* (Smith 1984, pg. 9).

These statements in the two TBDs make it somewhat difficult to determine an appropriate ending date for the potential of exposure to the radionuclide contaminants in RU during processing work. It appears that 1976, 1977, 1984, and "the 1980s" are identified as ending dates. The potential radionuclide contaminants in the RU (Tc-99, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Cm-242, and Cm-244) can give a significant increase in the dose from intakes of RU process material compared to natural uranium ore sources that do not contain these radionuclide contaminants. The Occupational Internal Dose TBD (Thomas 2006) does identify a default isotopic distribution that contains some of these contaminants. The default isotopic distribution is assumed for intakes in Table 5-6. However, the TBD text does not clarify the years to assume for this default. The TBD should identify specific time periods that RU and its default isotopic distribution are to be assumed in intake assessment. This is not consistent with current guidance, and may not be claimant favorable.

In the conference call (Attachment 4, Internal Dosimetry, question 9), NIOSH stated that all intakes of uranium will assume that RU was involved from 1952 through the present, and will use the default isotopic distribution in the Internal Dose TBD for assessed intakes (Thomas 2006, Table 5-6).

5.13.4 Secondary Issue 4: The TBD Does Not Adequately Define Frequency and Assess All Types of X-rays in Occupational Medical Exposure.

Initial guidance on medical exposure and dose guidelines, as presented in Revision 2 of ORAUT-OTIB-0006 (Kathren 2003), provides basic guidelines that the dose reconstructor can use to ensure that all occupational medical exposures are reasonably included in determining the overall dose estimations for claimants. Although the conference call with NIOSH (Attachment 4) indicated that dose reconstructors were using these guidelines, the latest Occupational Medical Dose TBD (Turner 2006) does not provide information that the updated

Revision 3 of ORAUT-OTIB-0006 (Kathren and Shockley 2005) is being used. The Occupational Medical Dose TBD (Turner 2006) assumes an interpretation that has been also considered and applied at other sites, such as the Mound Plant, the Los Alamos National Laboratory (LANL), Paducah, and Pinellas. It is assumed that occupationally related medical exposures are included in dose reconstruction for pre-employment, annual, health monitoring examinations, and post-employment chest x-rays. There is no indication in the TBD that a review of individual medical records (particularly in the early years, where medical data is on microfiche) has been conducted to verify the frequency of chest x-rays in the early years, and what the appropriate number of chest x-rays for inclusion in dose reconstruction is for workers exposed to uranium dust. This would need to be developed for those workers whose individual medical records do not document the frequency of chest x-rays. Table 3.1 (Turner 2006, pg. 7) points out in the footnotes to that table that during 1944–1945, some workers with the potential for exposure to uranium dust received monthly chest x-rays, while uranium dust workers between 1946 and 1959 received chest x-rays every few months. Although NIOSH has stated that they rely on the K-25 Site to provide all medical record information (Attachment 4), an interview with a K-25 medical x-ray technologist working there since 1975 (Attachment 2, Medical X-ray Procedures section), indicated that the data provided may not contain information retired to microfiche. In the early period, workers with potential for exposure to uranium dust inhalation were reported in the TBD (Turner 2006, Table 3-1) to have often received monthly chest x-rays. NIOSH needs to review the microfiche to verify the frequency of chest x-rays in the early years for claimants, and what the appropriate number of chest x-rays for inclusion in dose reconstruction is for workers exposed to uranium dust. This would need to be developed for those workers whose individual medical records do not document the frequency of chest x-rays.

The TBD (Turner 2006) does indicate that the reconstruction of occupational dose should include all occupational x-rays according to the frequency listed in Table 3.1, unless the individual-specific frequency is known and is more frequent than that in Table 3.1 (Turner 2006, pg. 7).

If the dose reconstructor, as a general rule, assumes only one annual chest x-ray, this would substantially underestimate some workers' medical exposure. In the more recent documentation in Revision 3 of ORAUT-OTIB-0006 (Kathren and Shockley 2005), it is concluded that other examinations should be included, such as special screening exams (e.g., respiratory protection, beryllium workers, asbestos workers, food handlers, etc., and termination examinations). The TBD does not address assigned dose for these special chest x-rays.

The Occupational Medical Dose TBD (Turner 2006) does not refer the dose reconstructor to either the earlier version (Revision 2) of ORAUT-OTIB-0006 (Kathren 2003) or to the updated Revision 3 (Kathren and Shockley 2005). Revision 2 assumes that special chest radiography for respirator certification, beryllium workers, asbestos workers, and food handlers are accomplished as part of the routine physicals. This is not documented in the Occupational Medical Dose TBD. Another factor not discussed in the TBD is the potential and impact of x-ray procedures utilized by medical authorities to do special screenings that are performed outside the frequency suggested in the TBD or at alternate locations. The ORR had numerous sites, and contracted with numerous radiology services and hospitals that provided these services upon request.

It is also known that Oak Ridge did upper GI fluoroscopy and lumbar spines up through 1953; however, no specific recommendation is given to dose reconstructors on how to incorporate these types of x-rays into the dose reconstruction process. It is suggested that the policy during 1960 to 1979 was to assume that radiation workers were given one annual chest x-ray. From 1980 to 2002, that frequency was reduced to one chest x-ray every 5th year for radiation workers. But nothing is documented regarding a policy covering the frequency of these exams. To the contrary, there is ample evidence that chest x-rays were often provided on a voluntary basis to nearly all workers, usually on an annual basis from 1944 to 1959 (Turner 2006, Table 3.1, pg. 7). The majority of workers had chest x-rays annually as a routine at DOE sites until the mid-1980s, when Federal guidelines warning against routine screening were first being enforced.

NIOSH made the decision to limit occupational medical exposure to those chest exams and frequencies described above, except for some lumbar spine exams in 1950 to 1953, and to include all other exposure as part of worker non-occupational medical dose. SC&A believes such an interpretation is not claimant favorable to those most at risk. Our concern is that specified "high-risk" workers, those most likely exposed to radiation and beryllium, would be at risk of having an incomplete dose assessment if not all radiation associated to medical screening for job-related activities were included. Since all radiation provides some risk, and arguably, is cumulative, workers warrant consideration of all forms of work-related x-ray exposure to be claimant favorable. SC&A believes NIOSH should review its interpretation of included medical exposure, and should reasonably adopt a broader interpretation in the K-25 Occupational Medical TBD of occupational medical dose, as provided in the most recent version of ORAUT-OTIB-0006 (Kathren and Shockley 2005).

5.13.5 Secondary Issue 5: Techniques and Protocols Increase Uncertainty of Dose Conversion Factors Listed in the TBD

The Occupational Medical Dose TBD (Turner 2006) fails to describe adequately all the information upon which to establish beam quality for x-ray units in use from 1943. The TBD relies on Publication 34 (ICRP 1982) to provide that data:

> *ICRP (1982) provides tables of average absorbed dose (mGy) in selected organs for selected X-ray projections at 1 Gy entrance kerma (i.e., air kerma without backscatter) for selected views and selected beam qualities [i.e., various half-value layers (HVLs)]. These tables list the basic dose conversion factors for converting air kerma to organ dose. Air kerma was obtained from Table 3.2-1 for machine, view, and period by assuming R = cGy (kerma). This assumption is conservative* (Turner 2006, pg. 5).

The TBD goes on to point out additional information organ dose and assumed collimation prior to 1979. Table 3.3 (Turner 2006, pg. 8) lists organ doses based on Publication 34 (ICRP 1982) equations. The TBD points out that the results of Table 3.3 assume poor collimation prior to 1970, which means that some organs are included in the primary beam that would not normally be included had the beam been properly collimated.

The TBD describes the type of x-ray machines used at K-25:

> *Two X-ray machines were used at K-25 during the 1940s and 1950s: (1) a General Electric (GE) Model KX-10 Photoroentgen X-ray machine, used primarily for photofluorography of the chest, and (2) a Westinghouse 200-mA X-ray machine, used with an adjustable table and fluoroscopic attachment to examine extremities, spine, hips, skull, shoulder, and other nonthoracic locations. The Westinghouse machine, which produced the now-conventional 14-in. x 17-in. chest X-ray, was primarily a backup to the GE machine (Cardarelli 2000)* (Turner 2006, pg. 5).
>
> *…The K-25 site used only the conventional PA chest X-ray technique for routine examinations after the early 1950s, which substantially reduced radiation doses per examination. In 1962, a Westinghouse 300-mA machine replaced the 200-mA machine. Additional X-ray exposure was introduced in the early 1970s when the health monitoring program added a lateral (LAT) chest view to the routine chest X-ray examination procedure (Cardarelli 2000). In 1987, a Westinghouse 500-mA X-ray unit replaced the 300-mA machine. Routine PA and LAT chest views were performed through 2000* (Turner 2006, pg. 6).

The TBD (Turner 2006, pg. 7) has provided a very helpful table (Table 3.2) that lists each type of x-ray equipment and also includes the following data:

- kVp (kV)
- Assumed HVL (mm Al eq)
- Image size in inches
- Entrance Skin Exposure PA (cGy)
- Entrance Skin Exposure LAT (cGy)

It is pointed out in the TBD that the values in Table 3.2 are used for obtaining air kerma, and that the entrance skin exposures (ESEs) are all from actual measurements made and documented in the literature (Turner 2006, pg. 6).

The TBD acknowledges that occupational medical dose is the largest part of worker dose:

> *….workers might have received their largest occupational doses from the required medical X-ray examinations. The amount of dose received depends on the type of equipment, the technique factors, and the number of examinations typical in the early years (Cardarelli 2002). K-25 medical records include notations in individual worker files regarding the date and the purpose of the of X-ray examinations* (Turner 2006, pg. 6).

In the absence of definitive tube output measurements, the TBD directs the use of default values and dose conversion factors (DCFs) derived from ICRP Publication No. 34 (ICRP 1982). These values are then applied to determine organ doses using Tables A.2 through A.8 of ICRP Report

No. 34 (ICRP 1982). An issue of concern is that the DCFs are derived using a default half-value layer of 2.5 mm Al for Type 1 units in use from 1946–1980.

The Occupational Medical Dose TBD (Turner 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from ICRP Publication 34 (ICRP 1982). The TBD provides the following summary on the use of PA and LAT chest x-rays:

> *The K-25 site used only the conventional PA chest X-ray technique for routine examinations after the early 1950s, which substantially reduced radiation doses per examination… Additional X-ray exposure was introduced in the early 1970s when the health monitoring program added a lateral (LAT) chest view to the routine chest X-ray examination procedure (Cardarelli 2000)* (Turner 2006, pg. 6).

It is an undocumented assumption in the TBD that exams required only a PA view. SC&A has inquired whether definitive protocol existed to validate that chest exams possibly included PA views and LAT views on a limited basis. NIOSH has acknowledged in other TBD reviews that the lack of verifiable protocols is a generic problem at many sites, has planned to search all available records, and will include pertinent records and references in any future revision of this section of the TBD. The Occupational Medical Dose TBD is also deficient in that little documentation exists to validate x-ray protocols, equipment maintenance, and upkeep records.

5.14 REVIEW OF TECHNICAL SUPPORT DOCUMENTS

5.14.1 Review of Internal Coworker Data for K-25, ORAUT-OTIB-0035

For K-25 workers that may have had occupational internal dose from intakes of radionuclides, but were not monitored for the intakes or were inadequately monitored, NIOSH has calculated estimated intake rates for uranium and Tc-99 based upon analysis of coworker bioassay data, as described in ORAUT-OTIB-0035 (Cherry 2006). NIOSH followed the processes for this analysis described in ORAUT-OTIB-0019, *Analysis of Coworker Bioassay Data for Internal Dose Assignment* (Brackett 2004) and ORAUT-PLAN-0014, *Coworker Data Exposure Profile Development* (ORAUT 2004). Although their approach is generally consistent for unmonitored or inadequately monitored worker assessments, there are potential weaknesses, inaccuracies, and assumptions made that could result in dose calculations that are not claimant favorable.

NIOSH is using intakes modeled from 1948–1988 to estimate the intakes of workers prior to 1948, and states that if the workers "…had larger intakes in the earlier years, their bioassay results would have reflected this in the years that samples were collected" (Attachment 3, questions 1 and 2). However, NIOSH must be aware that relatively large acute intakes of uranium in chemical forms that have fast (Class F) absorption rates (such as UF_6, which was the most prevalent form at the site) may not be detectable several months or years after initial intakes. Therefore, these acute intakes of uranium may not be reflected with any sensitivity in samples taken several years after the intake. If any workers had relatively large intakes of Class F chemical forms of uranium in the early years (e.g., 1945 or 1946), it is very possible that bioassay in 1948 did not detect or reflect the intake(s). In an instance like this, only air-sample or surface-contamination data would be relatively useful for identifying the intake**.**

NIOSH, in its response to SC&A's Internal Dose Coworker Data section, question 4 (Attachment 3), indicates that an individual who was never monitored is assumed to not have the potential to have received larger intakes than the majority of those who were monitored. NIOSH assumes that the coworker distribution is representative of their intakes; the median dose is, therefore, assigned as a lognormal distribution, and the associated geometric standard deviation (GSD) is assigned to account for possible larger intakes and uncertainty associated with the distribution. The use of the median bioassay data values from 1948 to 1988 for uranium intake rates, and 1978 to 1988 data for Tc-99 intake rates, may not be reasonable or claimant favorable. Because there was undoubtedly some variation of intake rates around the median values, it does not appear to be claimant favorable to assume that a claimant's intake was a median intake, as opposed to a higher value, such as the 84th percentile value (+1 standard deviation).

NIOSH, in its response to SC&A's Internal Dose Coworker Data section, question 3 (Attachment 3), states that it is not possible to model all intake scenarios, and that the default assumption applied across the complex has been to assume chronic intakes. It also points out that a chronic intake assumption can be used to approximate small acute intakes. There is no doubt that chronic, acute, or a series of either types or combinations of these types of intakes could have occurred at this site. The important issue is that NIOSH should have a strong basis for using any intake assumption that is not as claimant favorable as any realistic potential intake scenario that could be assumed, and defend the use of such intake assumptions.

NIOSH stated in the conference call that they do not know if anything has been found on radiological controls (Attachment 4, Internal Dosimetry Coworker Data, question 2). Their approach is to take people who started in the days before monitoring and look at their bioassay results in later years. NIOSH assumes that with the slow excretion of uranium, you can take samples several years later and still get a relatively reasonable picture of what their exposure has been. From this approach, they assumed the same intake rate for each period (before and after bioassay started). NIOSH did note that the urine results were pretty steady, with variations of only a factor of 3 or 4. Besides the fact that reviewing any available radiological control information (such as air sampling and surface contamination data) could be helpful in determining potential intakes of unmonitored workers, this bioassay interpretation approach still leaves two concerns; (1) the possibility of quicker excretions from more soluble form intakes in the early years that could go undetected, and (2) since there is some variation observed, choosing the median value projections may not be a reasonable claimant-favorable approach.

During the conference call, it was determined that NIOSH had not found any fecal sample data for the site (Attachment 4, Internal Dose, question 2). They were informed that a report was found during the site visit that identified a fecal-sampling program used from 1964 to 1966 at the Uranium Recovery Facility (Schultz 1966). This report was sent to NIOSH for review to determine if it has any information that could be useful for a future revision of the coworker data document.

There were also a few strengths seen in the internal dosimetry coworker document. The assumption of U-234 contributing 100% of the uranium isotope activity in the intake was claimant favorable, due to having a higher dose factor for this isotope than for U-235 and U-238. Directing dose reconstructors to add the other radionuclides (plutonium, neptunium, etc.) in the default isotopic distribution identified in the Internal Dose TBD (Thomas 2006) to all uranium intakes after start of processing RU is important. The guidance to run dose calculations with each uranium absorption rate (F, M, S) to determine which gives the largest dose to the organ and POC is appropriate. The document was also consistent with other site coworker internal dosimetry approaches.

5.14.2 Review of External Dosimetry Coworker Data for K-25, ORAUT-OTIB-0026

Until approximately 1980, few of the dosimeters issued at the K-25 Site were processed. Thus, the coworker data that is developed in ORAUT-OTIB-0026 (Merwin 2006) is significant and will play a role in the dose determination for many workers.

The doses that are assigned in the database are based on a composite of limited measurements and an assignment of the LOD/2 entered in place of missing or null results, as required in ORAUT-OTIB-0020 (Merwin 2005). As discussed in the external dosimetry section (Finding 5.8), it is not entirely clear when and how dosimeters were pulled for processing. Therefore, the entire database for coworkers is based to a great extent on an unknown group of (presumably) higher exposure individuals, coupled with a large component attributable to the LOD/2.

A concern arises in the guidance provided to dose reconstructors in Section 7, item 5, of ORAUT-OTIB-0026 (pg. 8). The dose reconstructor is required to determine whether a worker was in one of the following three categories:

> …*unlikely to have been exposed…*, or
> …*Exposed to intermittent low levels of radiation…*, or
> …*routinely exposed…*

Based on the dose reconstructor's judgment, a choice is made to use the onsite ambient dose, the 50th percentile, or the 95th percentile as a best estimate of the worker's dose. This is counter to the requirement for dose calculations to follow a prescriptive approach. This concern is discussed in detail in the SC&A report, *The Review of NIOSH/ORAU Procedures and Methods Used for Dose Reconstruction, Supplement 1* (Behling 2006). NIOSH should develop a prescriptive approach to this issue that enables the dose reconstructor to categorize the worker without the routine need for personal judgment.

There is a concern with the development of the shallow dose table (Merwin 2006, Table 2). The process of deriving the data for the table resulted in zero values for the non-penetrating component of dose for 19 of the 41 years the table addresses. The TIB describes the issue on page 10:

> *…With the methodology described above, null values for non-penetrating dose can occur because of the subtraction of the reported penetrating doses from the reported shallow doses and the favorable to claimant method described above to establish coworker doses based on the addition of potential missed doses. However, a "zero" value in Table 2 for non-penetrating dose will not result in a dose of zero being assigned to an organ such as the skin. For example, the 50th percentile dose to the skin in 1948 would be assigned entirely as 0.780 rem of photons. This approach does not result in an underestimation of probability of causation (which is determined by the Department of Labor) because assigning beta dose as gamma dose in IREP has no negative effect, since the radiation effectiveness factors are the same for >15 keV electrons and >250 keV photons, and are higher for 30–250 keV photons* (Merwin 2006, pg. 10).

This issue is dismissed as unimportant, as it is stated that IREP will automatically assign the penetrating dose to the non-penetrating input. This may well be technically appropriate at the present time; however, this assumption would collapse were NIOSH to modify IREP in the future and change this particular programming rule. NIOSH should correct the table to ensure that a modification of IREP does not inadvertently cause the system to fail with regard to non-penetrating dose calculations. In this reviewer's opinion, the reliance on the current design of a software program as a method of ensuring the accuracy of input data from a very different component of the overall dose reconstruction system is a weak quality link.

There are two areas where the TIB will provide a significantly claimant-favorable approach. First, as discussed in the final paragraph of Section 7.0 of the TIB, the annual doses show a marked decline once actual dosimetry results are used in place of estimates. Although doses might be expected to decline slightly when dosimeter processing is first ramped up due to increased worker and management awareness, the reduction by factors ranging by 5 to 10 signify that the estimates were crafted conservatively.

The second area where a conservative approach has been taken is in the use of the system-wide modifying factor for construction workers, as laid out in ORAUT-OTIB-0052 (Chew et al. 2007), and incorporated in the November 2006 version of ORAUT-OTIB-0026 (Merwin 2006). This TIB reviewed a number of sites and a system-wide adjustment factor of 1.4 was adopted for construction workers. This is claimant favorable for K-25, which was a selected site for the review. The data shows that the construction worker doses were bounded by the total worker dose for every year of K-25 operation except one. Therefore, for all other years, the coworker dose assigned for construction trades will automatically be increased by a factor of 1.4, despite the fact that the data shows that this is not required for K-25.

6.0 OVERALL ADEQUACY OF THE SITE PROFILE AS A BASIS FOR DOSE RECONSTRUCTION

The SC&A procedures call for both a "vertical" assessment of a site profile for purposes of evaluation-specific issues of adequacy and completeness, as well as a "horizontal" assessment pertaining to how the profile satisfies its intended purpose and scope. This section addresses the latter objective in a summary manner by evaluation of (1) how, and to what extent, the site profile satisfies the five objectives defined by the Advisory Board for ascertaining adequacy; (2) the usability of the site profile for its intended purpose, i.e., to provide a generalized technical resource for the dose reconstructor when individual dose records are unavailable; and (3) generic technical or policy issues that transcend any single site profile that need to be addressed by the Advisory Board and NIOSH.

6.1 SATISFYING THE FIVE OBJECTIVES

The SC&A review procedures, as approved by the Advisory Board, require that each site profile be evaluated against five measures of adequacy—completeness of data sources, technical accuracy, adequacy of data, site profile consistency, and regulatory compliance. The SC&A review found that the NIOSH site profile (and its constituent TBDs) for K-25 represents an adequate accounting of the primary internal issues related to plutonium, uranium, polonium, and tritium exposures, as well as main external hazards from the reactor and accelerator facilities. The K-25 Site Profile falls short in fully characterizing a number of key underlying issues that are fundamental to guiding dose reconstruction. In some cases, these issues may impact other site profiles. Many of the issues involve lack of sufficient conservatism in key assumptions or estimation approaches, or incomplete site data or incomplete analyses of the data. Section 6.0 summarizes the key issues. Detailed evaluation of these issues is provided elsewhere in the report.

6.1.1 Objective 1: Completeness of Data Sources

The breadth of data sources used as a basis for the K-25 Site Profile is evident in the 420 documents for the K-25 Site in the Site Profile Research Database. One hundred and three reports (103) were cited in the site profile references, while others served to provide confirmatory information. The NIOSH/ORAU team consulted health physics personnel with long histories at K-25 who have extensive knowledge of key dosimetry historical processes and personnel monitoring data.

The SC&A review of the K-25 dosimetry records cited in the site profile from the standpoint of their adequacy and completeness, as well as their inclusion of known sources of K-25 worker radiation dose information, indicates a lack of verification on the part of NIOSH to ensure records provided by the site are complete. Interviews with K-25 workers have uncovered some additional sources of personal radiation exposure that may not routinely be provided by the K-25 Site to NIOSH for individual claimants (Attachment 2). K-25 has limited the information provided to NIOSH from the individual medical records to x-ray reports and, in some cases, incident information. All this data is directly relevant and should be reflected in dose reconstruction. Finally, while accidents and incidents are listed in the site profile, the site profile does not fully address the significance of such incidents, how they may have contributed to worker dose, and how they would be addressed by dose reconstruction.

The hierarchy of data used in the dose reconstruction process begins with the use of individual monitoring data as a priority. This is fundamental to the performance of dose reconstruction. The K-25 Site typically contains hardcopy internal and external monitoring results, personal contamination records, secondary dosimetry results, whole-body count reports, etc., but lacks mention of incident reports. The individual monitoring data provided to NIOSH, as cited by the site profile and applied in dose reconstruction, are pulled from these records at K-25.

6.1.2 Objective 2: Technical Accuracy

The site profile does not adequately address data insufficiency for impact and implications to early worker dose reconstruction. Information available for dose reconstruction in the early years is limited, inadequate, or in some cases, not available. The Occupational Internal Dose TBD (Thomas 2006, pg. 6) states that, "Data are available from 1952 to the present for both in vivo and in vitro analysis records and associated interpretations." It appears, therefore, that the approach is to use data from 1952 or later to assign dose for the pre-1952 period. This needs to be better clarified in the Internal Dose TBD. This may entail the use of a hypothetical chronic intake for uranium and any other radionuclides where bioassay data are unavailable. The bioassay monitoring appears to be limited to workers directly handling radionuclides, or had not been developed. The Occupational Internal Dose TBD points out the following:

> *The primary method for monitoring employees for intakes of radionuclides at K-25 was urine bioassay. Bioassay monitoring was instituted at the start of enrichment operations and has continued to the present. However, the focus of the monitoring program in the very early years was the detection of excreted soluble uranium. When monitoring for less soluble isotopes of uranium and TRU elements was necessary, in vivo methodologies were implemented, primarily whole-body counting and chest (lung) counting* (Thomas 2006, pg. 6).

The TBD (Thomas 2006) lacks guidance on bioassay interpretation. The current TBD does not consistently address potential internal dose from radionuclides such as Pu-238, Pu-241, Pu-242, Cm-242, and Cm-244, and possibly other radionuclides that were brought up in the site expert interviews, if these existed at K-25 as the interviewees reported (Attachment 2). As pointed out earlier, there is a general inconsistency or lack of complete radionuclide guidance and information for facilities, as shown in the tables of the TBD. In an effort to address both internal and external coworker dose for unmonitored workers, NIOSH/ORAU has provided two technical information bulletins for use by the dose reconstructor; ORAUT-OTIB-0026 (Merwin 2006) provides guidance for external coworker dosimetry data for the K-25 Site, and ORAUT-OTIB-0035 (Cherry 2006) similarly provides guidance for internal coworker dosimetry data for K-25.

A number of deficiencies were identified with the Internal Dose TBD (Thomas 2006) related to inadequate consideration of exposure and missed dose, where SC&A questions the premise of the approach. This was borne out by information provided by K-25 Site Expert interviewees (Attachment 2, Missed Dose section). Exposure to a number of these radionuclides was not given adequate, or in some cases, any consideration in the Internal Dose TBD, although some are listed as facility-specific radionuclides handled in particular technical areas. The completeness of results for uranium and plutonium is uncertain. No default absorption (solubility) classes for any of the intakes are identified in the TBD. The TBD (Thomas 2006, Table 5.2, pg. 8) does point out that the primary radionuclides found at uranium facilities and gaseous diffusion plants are Th-230, U-234, U-235, U-236, U-238, Pu-238, Pu-239/240, Np-237, Cm-242, Cm-244, Am-241, and Tc-99. Further research into the potential exposures from these radionuclides is needed to determine which workers may have been exposed, the quantities they were exposed to, and the potential internal doses from intakes.

The Occupational Internal Dose TBD (Thomas 2006) lacks a clear means to assign dose to unmonitored workers. Radionuclides used at K-25 are not well characterized, and this can make it difficult to find the data needed for claimant-favorable dose reconstruction.

The current methodology outlined in the Occupational External Dose TBD (Miles 2006) may result in an underestimate of neutron dose. Neutron dose is determined from NTA film results and is modified with a correction factor. The TBD fails to address the neutron detection cutoff for the NTA film that occurs below 1 MeV. The TBD makes the following general assumption:

> *Workers at the K-25 site, especially those employed during peak production in the 1950s, 1960s, and 1970s, were exposed to radiation types and energies associated with natural and recycled uranium enrichment processes* (Miles 2006, pg. 8).

In regard to energy ranges the TBD mentions the following:

> *In most areas at K-25, the majority of the photon dose is attributable to photons in the 0.06- to 0.25-MeV range, energies at which dosimeters will overestimate exposure, reported in units of roentgen* (Miles 2006, pg. 8).
>
> *In many areas at K-25, the primary cause of photon doses during normal operations was gamma rays from ^{235}U, with primary photon energies ranging from 144 to 205 keV. This is particularly true in areas where enriched uranium was present (with a higher than natural abundance of ^{235}U). The photon dose rate from uranium is proportional to the level of enrichment* (Miles 2006, pg. 11).

The energies of major radiation emissions at K-25 are provided in Table 6-3, page 12 of the TBD. From the above information, it appears that the entire spectrum is essentially below the practical 1-MeV detection limits of NTA film used in the workers' badges. The TBD is confusing, however, in regards to the upper energy levels at K-24, in that it also states the following:

> *The neutron energies at K-25 are between 0.1 and 2.0 MeV, for which the ICRP Publication 60 radiation-weighting factor is 20 (ICRP 1990). The associated dose correction factor is 1.91, which is rounded to 2. Dose reconstructors should*

> *apply this factor to both measured neutron dose equivalent and missed neutron dose equivalent* (Miles 2006, pg. 13).

The Occupational Medical Dose TBD (Turner 2006) provides little documentation to support that the assumed techniques and protocols applied to calculate the dose, which are mainly derived from Cardarelli et al. 2002, are accurate. NIOSH believes that when no information is readily available about the energy spectrum, it is reasonable to use the assumptions for DCFs that are presented in the Implementation Guide (OCAS 2002).

The Occupational Medical Dose TBD (Turner 2006) does consider the potential contribution to dose that may have resulted in less than optimal use of collimation by stating the following:

> *The results of Table 3-3 assume poor collimation prior to 1970, which means that some organs are included in the primary beam that would not normally be had the beam been properly collimated* (Turner 2006, pg. 7).

For K-25, NIOISH refers the dose reconstructors to the estimated organ doses for PA and LAT chest X-rays, "...based on the dose conversion factors in ICRP (1982)" (Turner 2006, pg. 6). The TBD goes on to state the following:

> *These tables list the basic dose conversion factors for converting air kerma to organ dose. Air kerma was obtained from Table 3-2 for machine, view, and period by assuming R = cGy (kerma). This assumption is conservative* (Turner 2006, pp. 6–7).

Unresolved is the concern that the DCFs are derived from ICRP (1982) and, therefore, are not comparable in terms of beam quality, which varies from unit to unit. These factors can contribute greatly to the dose to the chest and other organs for units in operation prior to 1985, where little documentation exists.

As written, the Occupational Environmental Dose TBD (East 2006) fails to test the adequacy of evaluating the cumulative (additive) effect of numerous source terms at differing locations. Interviews of retired K-25 personnel (see Attachment 2) suggest that essential data, as far back as 1958, does exist. SC&A believes that the lack of air monitoring stations, within a particular building at the K-25 Site of known higher releases of a specified isotope, does not readily enable one to accurately estimate environmental dose, using air monitoring data, from an adjacent building air monitoring station. It will be difficult for the dose reconstructor to accurately estimate environmental dose without accurate air monitoring data derived from a station proximal to the release point.

6.1.3 Objective 3: Adequacy of Data

Questions regarding data adequacy have largely focused on the adequacy of early occupational monitoring data. The potential for unmonitored intakes was significant from 1945–1948 for site workers. In the absence of early bioassay data prior to 1948, the Occupational Internal Dose TBD (Thomas 2006) provides the dose reconstructor with little guidance. There is a large amount of uncertainty in calculation of early internal doses resulting from inadequate or incomplete monitoring data, including air concentration data, which casts doubt on the feasibility to reconstruct internal dose prior to the establishment of routine, reliable bioassay methods.

The Occupational External Dose TBD (Miles 2006) states the following:

> *During the early years, only workers entering controlled areas and likely to receive measurable dose received dosimeters. Beginning in 1951, dosimeters were issued to the entire work force as part of the security badge, although only those likely to have received measurable dose were processed. Beginning in 1980, all dosimeters were processed….Various radiation dose concepts and quantities have been in use to measure and record occupational dose since the initiation of the MED in the early 1940s. The basis of comparison for reconstruction of dose is the Personal Dose Equivalent, Hp(d), where d identifies the depth (in millimeters) and represents the point of reference for dose in tissue* (Miles 2006, pg. 5).

The TBD does provide discussion on handling of missed dose by stating the following:

> *Watson et al. (1994) examined methods analysts can consider when there is no recorded dose for a period during a working career. The missed dose for dosimeter results less than the MDL is particularly important for earlier years when MDLs were higher and dosimeter exchange was more frequent. NIOSH (2002) describes options to calculate missed dose for this situation. The preferred option estimates a claimant-favorable maximum potential missed dose as (MDL)/2 multiplied by the number of zero-dose results* (Miles 2006, pg. 13).

SC&A has concerns related to the measurement of early exposures and the consistency in which they were documented.

6.1.4 Objective 4: Consistency among Site Profiles

An extensive comparison was performed by SC&A to compare and contrast the methodologies used in the K-25 Site Profile and other site profiles reviewed to date. These comparisons focus on the methodologies and assumptions associated with dose assessments and the derivation of values used to obtain a POC for individual claimants.

The site description provides a comprehensive evaluation of activities that occurred at the different technical areas, and some of the potential hazards associated with these operations. This valuable data is not carried through to the other TBDs, such as the Environmental Dose and Internal Dose TBDs.

SC&A notes that the K-25 Site Profile TBDs do not address the significant exposure potential that existed for individuals that worked around the cascades when they were open. The Paducah Site Description TBD (Turpin 2006) brings this out as a significant source of worker exposure. It is most likely that the K-25 Cascades presented a similar potential for high external dose and may have represented a potential for significant internal dose, particularly for workers exposed to the cascade dust.

> *There were two cascade improvement/upgrade programs at PGDP – the Cascade Improvement Program (CIP) and the Cascade Upgrade Program (CUP). The first ran from 1958 to 1962 and the second from 1973 to 1981. These programs were significant because of possible worker exposure to transuranic (TRU) elements while the cascade systems were open.*

The Paducah Site Description (Turpin 2006, pp. 17 and 20–21) went on to note the following:

> ***Operations Performed in the Cascade Buildings and Maximum Radionuclide Concentrations Expected (Bechtel Jacobs 2001):***
>
> *Cascade operations – 1953–1964, 1969–1970, and 1972–1976*
> *450 ppb Np-237*
> *0.09 ppb Pu-239*
> *23,000 ppb Tc-99*
> *Moderate external radiation exposure potential*
>
> *Cascade maintenance (cascade dust) – 1954–1961 and 1973–1981 (CIP/CUP)*
> *2,740 ppb 239Pu-239*
> *3,220,000 ppb 237Np-237*
> *Specific concentrations of Tc-99 not available for this operation*
> *High external radiation exposure potential*
>
> ***Operations Performed in Building C-409 and Maximum Radionuclide Concentrations Expected (Bechtel Jacobs 2001):***
>
> *Cascade maintenance – 1954–1961 and 1973–1981 (CIP/CUP)*
> *450 ppb Np-237*
> *0.09 ppb Pu-239*
> *Specific concentrations Tc-99 not available for this operation*
> *High external radiation exposure potential.*

SC&A recommends that any updates to the K-25 TBDs provide a section that addresses this significant potential for exposure from work around the K-25 Site open cascades, and that dose reconstructors ensure that dose received during work around the cascades is included in the claimant's dose reconstruction.

The basic default values assigned for determining medical exposure are relatively consistent among site profiles. The site profiles do not always apply the same revision of ORAUT-OTIB-0006, as is the case with the K-25 Site Profile, which was not corrected in the most recent November 7, 2006 revision of the TBD (Turner 2006). Other deviations from the standard assumptions are based on site-specific information.

The Y-12 (Murray 2006), SRS (Scalsky 2005), and Hanford (Shockley and Kathren 2005) Occupational Medical Dose TBDs base their default exposure geometry on the compensability or non-compensability of the claim. The Mallinckrodt Chemical Worker (MCW) (Westbrook 2005) and Rocky Flats Plant (RFP) (Furman and Lopez 2004) Occupational Medical Dose TBDs based default exposure geometries on job titles. The ORNL (Fleming 2004), LANL (Johnson 2004), and the Idaho National Engineering and Environmental Laboratory (INEEL) (Rohrig 2004) Occupational Medical Dose TBDs choose to default to 100% Anterior-Posterior (AP) exposure. The K-25 Occupational Medical Dose TBD (Turner 2006) is silent on the use of the default of 100% Anterior-Posterior (AP) exposure by the dose reconstructor. Further evaluation of exposure geometry for photon and neutron exposure should be evaluated for K-25 workers to determine if 100% AP geometry is appropriate for all K-25 workers. NIOSH should consider development of a consistent default assumption for exposure geometry in all site profiles.

Review of site profiles to date indicates that the NIOSH/ORAU team has not come to a consensus on what components should be considered in the environmental dose. The analysis considered internal dose from onsite atmospheric radionuclide concentrations, limited evaluation of internal dose from resuspended soil, and ambient external exposure.

The K-25 Occupational Internal Dose TBD (Thomas 2006) does not present radionuclide components of the uranium source term in a similar manner as identified in the Paducah Occupational Internal Dose TBD (Mantooth 2006), Table 5-2. The Paducah TBD has identified Pu-241 and Pu-242 as contributors to this source term (from RU), whereas the K-25 TBD has missed these two contributors in its default isotopic distribution. The in-vitro measurement methods section of the Paducah TBD (Mantooth and Barton 2007) provides a table of bioassay frequencies used at the site throughout its history. A similar table in the K-25 TBD would also be helpful for internal dose assessment. The Paducah TBD also identifies several incidents with internal dose potential, which apparently was not accomplished in the K-25 development effort.

The recommended 200 mrem/2,000 hr for the PGDP is quoted in the K-25 TBD, yet 75 mrem/2,000 hr is used as the K-25 recommended external dose from the uranium cylinder yards for K-25.

The SRS TBD (Scalsky 2005) distinguishes neutron energies and neutron-to-photon ratios for reactors, fuel fabrication, plutonium production, and radionuclide production and calibration. The INEEL External Dose TBD (Rohrig and Bump 2006) considers the reactors, the processing plant, waste-handling operations, calibration sources, and uranium handling. Neutron energy spectra and neutron-to-photon ratios for Pu-238 and P-239 operations are segregated at SRS (Scalsky 2005). The categories used in the K-25 TBD lack the detailed analyses seen in other TBDs.

The K-25 Occupational External Dose TBD (Miles 2006) does not spend much time discussing the potential impact of differing exposure geometries on worker dose, and only offers the following:

> *Examinations of the beta, photon (X-ray and gamma ray), and neutron radiation type, energy, and geometry of exposure in the workplace, and the characteristics*

> *of the K-25 dosimeter responses are crucial to the assessment of bias and uncertainty of the original recorded dose in relation to the radiation quantity Hp(d). Dose reconstructors can compare earlier dosimetry systems to current systems to evaluate their performance, based on the premise that current systems have more stringent criteria, as indicated in the DOELAP and NVLAP programs* (Miles 2006, pg. 6).

The K-25 operation was large and complex, the building being the world's largest for a time. There is a dearth of information relating to the operations and how they evolved over several decades. There are almost no maps, diagrams, or flow charts provided. The Pinellas Site Profile is a study in contrasts. Detailed drawings, photographs, and maps are provided, with lists of equipment incorporated and site incidents tabulated. The K-25 Site Profile should be improved to provide as much detail as possible, as was done for Pinellas (Orr and Demopoulos 2006).

6.1.5 Objective 5: Regulatory Compliance

SC&A reviewed the site profile with respect to Objective 5, which requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in 42 CFR Part 82. In addition, SC&A evaluated the TBDs for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions. NIOSH has complied with the hierarchy of data required under 42 CFR Part 82 and its implementation guides. As mentioned above, quality assurance with respect to claimant-specific information is lacking, and further consideration should be given to evaluating records provided by sites, and how the requests for these records are communicated to the sites. In essence, if something is not explicitly requested, it will not be provided.

6.2 USABILITY OF SITE PROFILE FOR INTENDED PURPOSES

SC&A has identified seven criteria that reflect the intent of the EEOICPA and the regulatory requirements of 42 CFR Part 82 for dose reconstruction. Because the purpose of a site profile is to support the dose reconstruction process, it is critical that the site profile assumptions, analytic approaches, and procedural directions be clear, accurate, complete, and auditable (i.e., sufficiently documented). SC&A used the following seven objectives to guide its review of the K-25 Site Profile TBDs to determine whether it meets these criteria:

Objective 1 – Determine the degree to which procedures support a process that is expeditious and timely for dose reconstruction.

Objective 2 – Determine whether procedures provide adequate guidance to be efficient in select instances where a more detailed approach to dose reconstruction would not affect the outcome.

Objective 3 – Assess the extent to which procedures account for all potential exposures, and ensure that resultant doses are complete and are based on adequate data.

Objective 4 – Assess procedures for providing a consistent approach to dose reconstruction, regardless of claimants' exposures by time and employment locations.

Objective 5 – Evaluate procedures with regard to fairness and the extent to which the claimant is given the benefit of the doubt when there are unknowns and uncertainties concerning radiation exposures.

Objective 6 – Evaluate procedures for their approach to quantifying the uncertainty distribution of annual dose estimates that is consistent with and supports a Department of Labor (DOL) POC estimate at the upper 99% confidence level.

Objective 7 – Assess the scientific and technical quality of methods and guidance contained in procedures to ensure that they reflect the proper balance between current/consensus scientific methods and dose reconstruction efficiency.

6.2.1 Ambiguous Dose Reconstruction Direction

Direction provided in the site profile as a stand-alone document can be confusing, and in some cases, directions are inconsistent throughout a particular TBD. With the supplemental TIBs in the case of internal coworker dosimetry data (Cherry 2006), external coworker dosimetry data (Merwin 2006), and internal dose estimates for facilities with air sampling programs (Brackett and Bihl 2005), the approach is somewhat more clearly defined.

The conditions for application of environmental dose to K-25 employees are not clearly defined in the introduction of the Environmental Dose TBD, as is usually the case with other TBDs. There are recommendations for usage throughout the TBD, but concrete direction for which workers receive environmental dose is lacking.

Radon was specifically addressed in the MCW (Westbrook 2004) and the Fernald Internal Dose TBD (Rich 2004), where K-65 residues with high concentrations of Ra-226 were handled, yet the K-25 Occupational Internal Dose TBD indicates on page 5 that NIOSH does not consider naturally occurring radon present in conventional structures to be an exposure to be occupationally derived. The K-25 Internal Dose TBD (Thomas 2006) does not address potential radon exposure in the workplace as a contributor to dose.

6.2.2 Inconsistencies and Editorial Errors in the Site Profiles

There is an inconsistency between the Site Description TBD (Szalinski 2006b) and Occupational Internal Dose TBD (Thomas 2006) regarding the time when RU processing ended (1976, 1977, or 1984).

6.3 UNRESOLVED POLICY OR GENERIC TECHNICAL ISSUES

A number of issues were identified that are common in the K-25 and other site profiles reviewed to date and, in some cases, represent potential generic policy issues that transcend any individual site profile. These issues may involve the interpretation of existing standards (e.g., oro-nasal breathing), how certain critical worker populations should be profiled for historic radiation exposure (e.g., construction workers and early workers), and how exposure itself should be analyzed (e.g., treatment of incidents and statistical treatment of dose distributions). NIOSH indicates that it may develop separate TIBs in order to address these more generic issues. The following represents those issues identified in the K-25 and previous site profile reviews that, in SC&A's view, represent transcendent issues that need to be considered by NIOSH as unresolved policy or generic technical issues.

(1) Direction on the applicability of the TBD and/or TIBs to individual dose reconstructions is absent.

(2) Mobility of the work force between different areas of the site should be addressed. Site expert testimony that many workers moved from one plant to the next is a complicating factor. Establishment of an accurate worker history is crucial in such cases. This will be especially difficult for family member claimants.

(3) Statistical techniques used in the application of the data to individual workers should be further considered and substantiated.

(4) Dose from impurities and/or daughter products in radioactive material received and processed at sites should be assessed as a contributory exposure source.

(5) The significance of various exposure pathways and the assumptions made that influence dose contributions need to be considered (most notably) for solubility, oro-nasal breathing, and ingestion.

(6) Analysis needs to be performed regarding how "frequent or routine incidents" should be addressed, given the possibility that such "spike" exposures often may be missed by routine monitoring as a function of how often and in what manner it was conducted.

(7) Availability of monitoring records for "transient or outside workers," e.g., subcontractors, construction workers, and visitors, who may have potential exposure while working on or visiting a facility should be ascertained.

(8) Dose to decontamination and decommissioning workers should be assessed. Many facilities have large-scale decontamination and decommissioning (D&D) operations, which extend back many years. Decontamination and decommissioning (D&D) operations often require working in unknown situations, which may provide unique exposure situations.

(9) Dose reconstruction for occupational medical exposures remains incomplete. NIOSH needs to reconsider the definition to include all forms of radiation medical exposure, to ensure its considerations are claimant favorable.

(10) Dose reconstruction for workers involved in nuclear weapons testing who were employed by a site other than the test site.

(11) Quality Assurance on records provided by the site to the NIOSH/ORAU team is necessary to ascertain whether complete information is being provided.

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ATTACHMENT 1: NIOSH TECHNICAL DOCUMENTS CONSIDERED DURING THE REVIEW PROCESS

TECHNICAL BASIS DOCUMENTS

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TECHNICAL SUPPORT DOCUMENTS

ORAUT-OTIB-0002, Rev. 02, (2007), Technical Information Bulletin, Maximum Internal Dose Estimates for Certain DOE Complex Claims, Oak Ridge Associated Universities, Oak Ridge, Tennessee, February 7, 2007, (Rollins and Brackett 2007).

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ATTACHMENT 2: SITE EXPERT INTERVIEW SUMMARY

The purpose of the Site Expert Interviews was to receive first-hand accounts of past radiological control and personnel monitoring practices at the Oak Ridge K-25 Gaseous Diffusion Plant, and a better understanding of how operations were conducted. A total of 41 current or retired workers were interviewed. An attempt was made with the retirees to interview previous workers who had been employed at this facility for at least 20 years. Approximately three-quarters of the interviewees are currently employed at K-25, with the remaining one-quarter being retirees. Harry Pettengill, Abe Zeitoun, Kathy Robertson-DeMers, and R. Thomas Bell, who are all employees of SC&A, conducted the interviews. These interviews were held from December 11–15, 2006, and were conducted at the East Tennessee Technology Park (ETTP), Local UVW Union Hall, or at the DOE Federal Building in Oak Ridge, Tennessee.

These interviews were held in addition to open discussions with K-25 workers conducted by NIOSH and Oak Ridge Associated Universities (ORAU) on April 5, 2005, with the Security Police and Fire Professionals of America and the International Guards of America; and on April 6, 2005, with the Pace Local 5-288 and International Union. A more in-depth interview process with the K-25 Site workers is considered by SC&A to be helpful in better understanding the working environment and radiological conditions that occurred at the K-25 Site over its many years of operation.

Interviewees were selected so as to represent a reasonable cross-section of the various job disciplines that were characteristic of those who are currently working or who had worked at the K-25 Site. Time was also spent reviewing unclassified health physics records and reports, conversing with records staff, and reviewing documents at the DOE Reading Room, Oak Ridge, Tennessee, and the Bechtel Jacobs Library at Building K-1007.

Workers were briefed on the purpose of the interviews, and background on the EEOICPA dose reconstruction program and site profiles, and asked to provide their names, in case there were follow-up questions. Participants were advised that participation was strictly voluntary. Each participant was given the opportunity to review this interview summary for accuracy and completeness. This is an important safeguard against missing key issues or misinterpreting some vital piece of information.

When these K-25 Site Expert interviewees were asked about their review of the Oak Ridge Associated Universities (ORAU) Site Profile TBDs, they indicated that they felt that the ORAU K-25 TBDs seem accurate and complete, and that they effectively incorporated the concerns of the K-25 workers. Most all facilities seemed to be covered. The interviewees were not aware of any additional sources of information relating to historical and potential exposure situations. A few of the interviewees had not looked at Table 2-2, and were unaware of any additional buildings at K-25 that were not covered in the K-25 Site Description TBD. Another interviewee indicated that he had been interviewed by NIOSH/ORAU. Others in the group had attended one of the NIOSH /ORAU outreach meetings.

The Dosimetry staff was interviewed by NIOSH/ORAU during the preparation of the site profile. They were not given the chance to comment on the site profile once it was drafted. There have been some difficulties with employment verification.

One interviewee indicated that he was not involved in the development of the K-25 TBDs, that the SC&A interviews were the first such interviews for him, and that NIOSH/ORAU had not interviewed him. He was not involved in the NIOSH/ORAU worker outreach meetings. The interviewee did participate in the worker medical program and answered the questionnaire the Medical Department asked him to fill out.

It was one RCTs opinion that for claims in the 1940s, 1950s, and 1960s, NIOSH does not really know where workers worked. The K-25 RadCon staff is concerned about the exclusion of former K-25 workers from the development of the site profile. The conflict of interest policy does not make sense. Two interviewees indicated that they were not interviewed as a part of the site profile development. Two interviewees stated that some information provided during worker outreach meetings was considered by NIOSH/ORAU in development of their K-25 TBDs. One interviewee indicated that the coworker doses established in the NIOSH/ORAU site profiles look about right. It was pointed out that 5 to 50 projects at K-25 have been granted Special Exposure Cohort (SEC) status. Most of these involved the thermal diffusion process. One of the interviewees did not see this in operation.

All interviews have been documented and summarized below. The information provided is not a verbatim discussion, but a summary of information from multiple interviews with multiple individuals. Individuals have provided this information based on their personal experience. It is recognized that these current and former workers' recollections and statements may need to be further substantiated before adoption into the six Oak Ridge K-25 Gaseous Diffusion Plant TBDs; however, they stand as critical operational feedback. These interview notes are provided in that context; former worker input is similarly reflected in our discussion and, with the preceding qualifications in mind, has contributed to our findings and secondary issues.

The interviewees represented a wide array of job categories and responsibilities. In addition, this cross-section of personnel worked in many of the facilities/areas represented in the Site Description TBD. It should be noted that many of the interviewees stated that many facilities/area were not listed in Table 2-2 of the Site Description TBD. The following is a list of job categories represented during the interviews, and a table listing the facilities/areas listed in the TBD, along with additional facilities/areas that these interviewees identified as missing from this document. A comment section has also been added to this table that shows which buildings were missing in Table 2-2 of the Site Description TBD, and interviewee information provided about the buildings during their interviews.

The job categories represented by the interviewees included the following:

Administrative Assistant
Analytical Chemistry
Analytical Chemistry
Building Demolition
Cable Spicer/Lineman
Chemist
Commander
Community Advocacy
Coordinator
Craft Supervisor
D&D worker
Dosimetry Manager
Electrician
Engineer
Engineering Manager
Engineering Specialist
Environmental and Waste Management
Environmental Engineer
ES&H Administrator
ES&H Representative
Facility Manager
Field Services
Fire Protection
Health Physicist
Industrial Hygienist
Internal Dosimetrist
K-25 Gaseous Diffusion Plant Worker
Machinist
Maintenance
Maintenance Engineer
Maintenance Mechanic
Medical X-ray Technologist
Operator
Painter
Physician
Pollution Prevention Project Manager
Project Engineer
Quality Assurance Specialist
RadCon Field Operations Manager
RadCon Subcontractor Project Manager
Radiation Control Technician (RCT)
Radiological Engineer
RCT Supervisor
Records Manager
Security
Security Inspector
Security Police Officer
Shift Superintendent
Shift Supervisor
Site Dosimetry Coordinator
Store Clerk
Supervisor
Supervisor I
Supervisor II
System Engineer
Union Safety and Health Representative
Utilities Worker
Waste Characterization

Table of Building Information

Building No.	Comments About the Building
G-Pit	Missing in Table 2-2, K-25 Site Description TBD.
K-25	Primarily UF_6, but pervasive secondary radioisotopes were throughout (Tc-99, Am-241, Pu-240, Np-239, and thorium). There was no robust Radiological Control Program until about 1989. A ChemRisk Report of March 2000 concluded that airborne uranium releases were 50% higher than values reported by DOE. Tc-99 was present. Beryllium was stored in K-25 in the early days. There was HEU in this building and it had to be constantly cleaned up. Fires occurred in K-25.
K-27	Tc-99 was present.
K-31	Tc-99 was present. There was a fire in the K-31 ventilation ducts in the 1972–1973 timeframe. The oil in these ducts was PCB-contaminated.
K-33	Seals were often blown when they were trying to see how much pressure the seals could hold.
K-101	Missing in Table 2-2, K-25 Site Description TBD. Some incineration was done in the building in the early days.

Table of Building Information

Building No.	Comments About the Building
K-131	Maintenance. This building was a process auxiliary. Contamination problems were common. Some incineration was done in the building in the early days. Missing in Table 2-2, K-25 Site Description TBD.
K-200	
K-310-3	Purge Cascades. Tc-99 was not significant.
K-311-1	Purge Cascades. Tc-99 was not significant.
K-315	Fires occurred in this building. One worker cut the wrong pipe and the resulting fire created a glowing chuck of metal.
K-402-8	Purge Cascades. Tc-99 was not significant.
K-402-9	Purge Cascades. Tc-99 was not significant.
K-413	Missing in Table 2-2, K-25 Site Description TBD.
K-601	Tailings withdrawal. Some incineration was done in the building in the early days. Missing in Table 2-2, K-25 Site Description TBD.
K-622	
K-631	Missing in Table 2-2, K-25 Site Description TBD.
K-632	Missing in Table 2-2, K-25 Site Description TBD.
K-633	Test Loops. Contamination problems were common. This building was also a process auxiliary. Missing in Table 2-2, K-25 Site Description TBD. External doses as high as 1.5 R/hr were seen in this building.
K-701	This building had a beryllium problem. A beryllium prevention program was started in 1995–1996.
K-770	Scrap Yard with Converter Heads and Casks that were radioactively contaminated. Missing in Table 2-2, K-25 Site Description TBD.
K-1001	
K-1004-A	Analytical Laboratory
K-1004-B	Analytical Laboratory
K-1004-C	Analytical Laboratory
K-1004-D	Analytical Laboratory
K-1004J	
K-1004L	
K-1006	
K-1007	Administrative, Medical, and Active Records Vault
K-1008C	
K-1008D	Decontamination Facility.
K-1010	Cylinders were present in this building.
K-1015	Laundry Facility.
K-1024	Radium was common. This facility had radioactive maintenance activities. Radioactive contamination was common.
K-1030	Radium was common. This facility had radioactive maintenance activities. Radioactive contamination was common.
K-1034A	Inactive records vault. Field radiological control records were stored here until older records were shipped to the Federal Records Center in Atlanta.

Table of Building Information

Building No.	Comments About the Building
K-1035	Radium was common. This facility had radioactive maintenance activities. Radioactive contamination was common.
K-1037	Atomic Vapor Laser Isotope Separation (AVLIS) Building. There was a dumpster fire in this building. Uranium oxidized and caught fire in the dumpster. Also known as the Barrier Plant and had blend towers.
K-1037C	Smelting was done in this building.
K-1041	Laboratory where testing of instrument systems that were used in the cascades was done. Contaminated equipment was often brought in for cleaning or repairs, which lead to the contamination of building surfaces and equipment. Groundwater contamination was detected under the basement. This was an R&D area in the north end of the building that was off limits to most personnel. Contamination was common.
K-1064	The Peninsula.
K-1065	Waste Storage Facility. Missing in Table 2-2, K-25 Site Description TBD.
K-1066	Cylinder Storage Yards.
K-1070	Commonly used to describe a series of six burial grounds for contaminated waste. These burial grounds potentially contain thorium, uranium, and technetium. Missing in Table 2-2, K-25 Site Description TBD.
K-1074	Cascades were operating in this building, and there was a lot of hydrogen fluoride and uranium.
K-1121	A lot of contamination was found when this building was torn down.
K-1131	Feed Building. The operations in the building involved the conversion of Ug_4 to UF_6 through an ash-oxide fluorination system. Venting loss of 58,854 grams of uranium and 407 grams of U-235. Work from K-1421 was completed here. One interviewee read that workers manually shoveled ash into hoppers in the early 1950s. This building had a blend tower, screw conveyors, and a horizontal reactor. A lot of contamination was found when this building was torn down.
K-1133	Missing in Table 2-2, K-25 Site Description TBD.
K-1200	Hot runs were done here that resulted in some hot stream releases.
K-1210	Hot runs were done here that resulted in some hot stream releases. Many cylinders were lying there.
K-1210A	
K-1203	Radioactive sewage sludge was done in this building.
K-1220	Hot runs were done here that resulted in some hot stream releases.
K-1225	
K-1231	Waste was put into a tanker and shipped to K-25 for waste treatment. Missing in Table 2-2, K-25 Site Description TBD.
K-1233	Missing in Table 2-2, K-25 Site Description TBD.
K-1300	A complex of buildings. K-1300 had stacks. Missing in Table 2-2, K-25 Site Description TBD. Some of these buildings were involved in uranium recovery.
K-1301	Fluoride Production Facility and also the Nitrogen Plant. There was a large area painted with magenta paint and signs are posted that read "Do Not Disturb." Missing in Table 2-2, K-25 Site Description TBD. Involved in uranium recovery.
K-1302	On May 26, 2006, 20.5 pounds of scaling containing 34.8% uranium were removed from the walls and bottom of the K-1302 vent stack.
K-1310B	Offices.
K-1310LM	

Table of Building Information

Building No.	Comments About the Building
K-1401	Machine Shop. Materials went from this building to the decontamination labs in K-1401 or K-1420. Oxidants were used to remove the plugs from the barriers and the oxidants became contaminated. Contamination problems were present. The ventilation ductwork was contaminated in this building. Gaseous diffusion done in this building. Process compressors alloyed with beryllium, during tipping operations on the compressor blades, spread machining dust containing beryllium throughout the building. Missing in Table 2-2, K-25 Site Description TBD.
K-1405	Missing in Table 2-2, K-25 Site Description TBD.
K-1407	Laboratory. This building was a Pit radioactive acids neutralization area. Missing in Table 2-2, K-25 Site Description TBD.
K-1413	Radium was common. This building was used for experiments in the early phases of the uranium gaseous diffusion process development. One interviewee described the building as a "bad lab." Missing in Table 2-2, K-25 Site Description TBD. In K-1413, they did radioactive material experiments, and the building served as one of the development labs.
K-1417	Raffinate Ponds.
K-1420	Decontamination Facility. This building was the most contaminated place on the K-25 Site. This building housed the pickling operations, acid baths, and a decontamination facility, and was the building where operations of various types were carried out. Attempts were made in this building to recover uranium. K-1420 had showers that were regularly used. Hand contamination was common, and most workers didn't even know they were contaminated. There was no monitoring in the early days. The floor was painted a lot to fix contamination spread. The break room was found to be contaminated at one time. They used blowguns to blow off the paint used to cover contaminated floors, and the chunks went all over the place. This was around the 1975 timeframe. K-1420 sludge ponds had to be cleaned out by dredging dirt and sludge out of them. K-1420 had a flame tower.
K-1421	Incinerator Building. This building had the original furnaces, which were like brick oven fireplaces with stacks. Smelting was done in this building. This building had few RadCon controls in the early years and anything that could burn was incinerated there. In the northwest corner of this building, they burned contaminated clothing in the incinerator. This area often had a lot of radiological hot spots. The incinerator in K-1421 had few controls in the early days and anything that could burn was incinerated there.
K-1423	A release of yellow cake leaked on the floor in this building.
K-1435	TSCA Incinerator.
K-1580	Offices.
K-1600	Series of Buildings, all bearing 1600 numbers. Missing in Table 2-2, K-25 Site Description TBD.
K-2527	
K-3133	
K-Shop	
L-Lab	This was a hot area around 1984 according to one interviewee painter.
Chin Building	
Commerce Park	
ETTP Site	East Tennessee Technology Park. Recent name for the old K-25 Site.

This Site Expert Interview Summary has been divided into the following sections:

- Production/Operations
- Work for Others
- Transfer between Facilities
- Radiological Control (RadCon) and Health Physics Aspects
- Radiation Monitoring
- Internal Dosimetry
- External Dosimetry
- Potential Missed Dose
- Contamination
- Decontamination and Decommissioning
- Waste Disposal
- Incidents/Unusual Occurrences
- Audits
- Environmental Dose and Monitoring
- Industrial Hygiene/Chemical Exposures
- Maintenance/Crafts/Utilities
- Dosimetry Records
- Medical Examinations
- Medical X-ray Procedures
- Union and Safety Concerns
- Security
- Safety Hazards
- References Provided or Cited by Interviewees

PRODUCTION/OPERATIONS

Worker health and safety at K-25 was overshadowed by production. The culture that was maintained at the site was to impede information about risks and hazards from reaching the employees under the umbrella of protecting technical secrets. This statement was similar to a quotation in the DOE's Office of Oversight 2000 report, *Independent Investigation of the East Tennessee Technology Park, Volume 1: Past Environment, Safety, and Health Practices,* which the interviewees provided.

Workers were exposed to a variety of radionuclides, but mainly uranium compounds, uranium decay products, transuranics, and fission products, including technetium. Supervisors at the plant were aware that workers were receiving internal doses from their work environment. Workers left the complex with uranium dust on their clothes and shoes. Protective equipment provided to workers was inadequate. Frequent airborne contamination problems were common while doing cell change-outs and maintenance. Assigning respirator use for workers evolved from multi-user, to single user, to single use. In the early years, workers would reuse their respirators and carry them around their necks. Some maintenance workers stored their respirators in the bottom of their toolboxes, where many rotted from lack of use and exposure to heat. Respirators were stored in cabinets, and there was intermittent cleaning of respirators between uses. Respirators were in use when one interviewee reported to K-25 in 1975.

Types of radioactive material at K-25 included primarily UF_6, but also large amounts of UF_4 in the early days. UO_2F_2 was the primary waste form. There are pervasive secondary radionuclides throughout (Tc-99, Am-241, Pu-240, Np-237, and thorium) as minor constituents to the U. The labs worked with much more, which included fission products of many types. The physical form is gas (primarily), solid (in cylinders), or liquid (in autoclaves). Other forms were mainly solids (in fluoride or oxide forms). In 1976, working on seals was a radiological hazard, since it was known that Tc-99 was a contaminant of these operations. HP knew how much radiation was coming off the above radionuclides, as well as some of the fission products. HP moved toward experiments to learn more about what was present. In the early days, it was hard to detect some of these radionuclides with the survey instruments they had.

There were small-scale operations conducted by ORNL in the Powerhouse area. K-25 provided support services to these operations.

In regards to operations with uranium that required heating to high temperatures, one interviewee responded by saying that he didn't know for sure. There were oxide conversion facilities in K-1420 and maybe K-101, K-601, and K-131.

During this time, the functions of HP and protection and medical programs were ancillary and poorly funded. Health and Safety oversight was a function of line management, who lacked training and the incentive to be effective. The emphasis was always on production.

In the early days, major leaks were done by qualified welders, but these workers had poor training. General Wesley Groves, the project manager, wanted the building built in 69 days, and it was hard to ensure that the welds were done properly. As a result, there were many leaks—some huge leaks. There were thousands of pounds of U-235 brought in. The operational time for the three early plants was short. The push to increase production contributed to the building of Y-12.

It was reported that the Army Corps of Engineers captured draftees out of the Universities and brought them to Oak Ridge to help build the K-25 gaseous diffusion plants.

K-1401 was the Maintenance Shop. Materials went from there to the decontamination labs in K-1401 or K-1420. The basement of K-1420 had a different purpose and had conditioning stands. The purpose of the basement area was to convert plugs (using primary separation devices). Oxidants were introduced to remove the plugs from the barriers. During the process, the oxidants became contaminated with uranium. These oxidized contaminants were evacuated through stacks to the atmosphere outside the plant. In K-1420, attempts were made to recover as much of the uranium as was possible. In the early days, little was done in the way of radioactive waste management. There were only one or two health physicists (HPs) in those early days.

In 1959, they shut down the old electrical plant. In the 1960s, they sold the generators, stripped them out, and hauled them out by rail. Another power plant was built to replace the old electrical plant. The power plant provided the steam to create the electricity needed. It was most difficult to tear down. In the 1990s, they demolished the power plant. There are now five power sources into the site. The coal dust from these power generation stations is a good source of radium that sometimes is carried by the wind to the K-25 Site.

In 1972, production was emphasized over safety. Meeting production schedules was paramount. In those days, K-25 management was immune to audits, and there appeared to be no radiological concerns. For instance, they were allowed to eat and drink in the production area of the labs, and then this was no longer allowed; regulations tightened up in the late 1980s. Also in the late 1980s, Union Carbide began setting up separate lunchrooms away from the production areas. Health Physics coverage and overview improved throughout the 1980s.

The responsibilities of the Field Services Department were mainly uranium recovery, which was recycled from solutions generated in K-1420. Monitoring for exposure to radionuclides and external exposure was very scant in the 1970s and early 1980s. In 1983, the Resource Conservation and Recovery Act (RCRA) began to have an impact on how K-25 handled their radiological waste. They did not do waste processing for other facilities at Oak Ridge or outside. Rad Safety's major problems had to do with decontamination until the late 1980s. It was not until the late 1980s that the Toxic Substances Control Act (TSCA), the National Emission Standards for Hazardous Pollutants (NESHAPs), and Department of Energy (DOE) regulation changes purged a lot of the old timers and brought in an increased staff of health physics personnel that ushered in more stringent radiological control programs. This also coincided with the shutdown of production.

Uranium was more valuable than gold, thus the workers at the K-25 Site attempted to recover as much of the uranium from the enrichment waste products as they could. Materials were taken out of the process building, decontaminated, and extracted principally by a wet process. Liquid was discharged in low concentrations for recovery. A liquid-liquid extraction process was used to convert uranium to UO_2. As a part of this, the material was heated in a calciner at temperatures as high as 1,300^{o}F to 1,500^{o}F. The uranium fluoride was oxidized to make UF_6. It was a U_3O_8 conversion that was done in Building K-1420. They took uranium out of trapping systems, oils, paper, plastic, and woods by a leaching out process. Building 1421 had the original furnaces, which were like brick oven fireplaces with stacks. By simple gas combustion, impurities were burned off. This facility was shut down in the late 1980s, because the TSCA incinerator was being put into operation.

Operations with uranium at K-25 that required heating of oxides to high temperatures involved work in the calciner where U_3O_8 was produced, and later where UF_4 was converted to UF_6. This latter process involved the highest temperatures.

The principal radioactive materials found at K-25 are uranium, plutonium, neptunium, and Tc-99. There was no field characterization at K-25. K-25's principal role was to handle, process, and store both enriched and depleted uranium.

Some smelting was done in both K-1420 and K-1037C. The process was used to recover aluminum and nickel. Personnel manually removed ash from the smelter. Personnel protective clothing was worn during this job. Most of the material that needed smelting went to Paducah.

Building K-1131 was involved in the conversion of UF_4 to UF_6 through an ash-oxide fluorination system. Ash was put into hoppers. Respiratory protection was worn at the drumming station.

In 1975, the staff at K-25 totaled about 4,000–5,000. By 1978, the staff peaked at 6,000–6,500. Production in the gaseous diffusion plant was stopped in 1985. They worked hard to meet the growing need for enriched uranium, and conducted uranium recoveries to assist in adding to the uranium on hand. The production phase of uranium enrichment at the original K-25 gaseous diffusion occurred from 1953–1965. Production at the other facilities (i.e., K-31/K-33) continued until 1984. The whole plant site is sometimes referred as K-25, similar to ORNL being called X-10. One interviewee indicated that overtime was not common at K-25.

There was little HP coverage until mid-to-late 1980s. It was about that time that they started using friskers in K-25 and K-27, and set up better radiation control procedures. The number of safety employees gradually increased until 1989, when the HP staff was greatly increased. For this interviewee, little transfer occurred between facilities and he did not have much communication with Y-12 or X-10.

In 1980, the HP and IH groups were in Technical Services. Earlier on, they were under the Medical Department. IH did surveys but they were not radiological in nature. The two groups did not work much with each other.

The Chemical Operations Group evolved into the TSCA Incinerator Group. All waste that could be burned went to the incinerators. The second generation TSCA Incinerator had a sophisticated offgas process. So as not to jeopardize the permitting process, all other incinerators on the K-25 Site were shut down. The average assay at the facility at the time was 1.5% of the authorized limits.

The TSCA Incinerator management, testing, and permitting had been conducted by one of the interviewees up until the time of almost the last permitting process, when that function was assigned to another office. The final permitting of the new TSCA Incinerator took place around the 1989–1990 timeframe. An incident happened that brought close scrutiny on the whole permitting process. The predecessor to the first Tiger Teams also got involved. The TSCA Incinerator was designed to burn TSCA and RCRA regulated solids, liquids (organic liquids), and mixed waste. All these contaminants had some radiological constituents. The TSCA Incinerator was not for burning oils. K-25 had thousands upon thousands of gallons of PCBs (polychlorinated biphenyls). The TSCA regulations said the Incinerator had to operate below 2,200^{o}F and the RCRA regulations said it had to operate below 1,900^{o}F. So it took some time to work this out. The TSCA Incinerator has been, and still is, periodically tested and re-permitted.

Production had already been shut down when the TSCA Incinerator came up to operation. Through the 1990s, the decontamination organizations continued their decontamination processes at K-25. The TSCA incinerator had an off gas treatment system.

It was mentioned that the Portsmouth Gaseous Diffusion Plant had a larger and better HP staff, especially their airborne monitoring program. The programs at K-25, however, were similar. Paducah dealt more with fission products, but the work was about the same. K-25 seemed to have more problems than the other gaseous diffusion plants. There were a lot more facilities and a lot more contaminated facilities. K-25 had a high change-out of low activity projects.

ORNL, Y-12, and K-25 management would bid on jobs in the 1980s, and as a result of who got the funding, personnel would be laid off at one site and take a job at another site. This was during the era of Lockheed Martin and Martin Marietta. This was very common in those days. Some of the interviewees indicated that they transferred between K-25 and other Oak Ridge sites (e.g., Y-12 and X-10). One interviewee went to Y-12 frequently.

Operations personnel worked areas K-31/33, K-29 Area, Utilities, etc. Maintenance personnel worked in the same areas and K-1420 or K-1401. Many maintenance personnel worked many buildings and were reassigned several times. Some crews worked the entire plant. Building K-1041, which was constructed in the early 1940s, contained a laboratory where testing of instrumentation systems used in the cascades took place. Contaminated equipment was often brought in for cleaning or repairs, which led to the contamination of building surfaces and equipment. Groundwater contamination was detected under the basement of K-1041. A copy of a draft report BJC/OR-1384 dated 2004 (Tetra Tech Inc. 2004) was provided that detailed the extent of contamination at Building K-1041. This report, however, was not part of the K-25 Site records database.

DOE personnel rarely visited the K-25 Site facilities prior to the 1990s.

It appears that NIOSH based their listing of facilities on the 1993 Consort Technologies document (K/HS-570). It appears all they know is what they read in that document. In general, though, the Site Description TBD has done a good job of listing major facilities.

The following buildings were missing in the K-25 Site Description TBD (Szalinski 2006) and represent work areas of potential missed dose:

- K-101
- K-131
- K-413
- K-631
- K-632
- K-633 (Test Lab)
- K-1133
- K-1231
- K-1233
- K-1231
- The 1300 complex (K-1300 – stacks, K-1301 – fluoride production, K-1301)
- K-1405
- K-1407 (Laboratory)
- K-1413
- The Centrifuge Complex (i.e., K-1200, K-1210 and K-1220)
- The 1600 buildings
- The 1070 series burial grounds
- G-pit
- K-1065 (Waste Storage Facility)

- K-770 (scrap yard with converter heads and casks)
- K-601 (tailings withdrawal)

Some of these facilities were involved in uranium recovery in all these buildings. In K-1423 and K-633 (Test Loop), external dose exposure got as high as 1.5 R/hr. The burial grounds potentially contain thorium, uranium, and technetium.

K-1131 contained the blend towers, the screw conveyors, and had a horizontal reactor. In 1954, it was gutted out and all the equipment was upgraded. Reactor vessels came in during the 1970s.

K-1413 was used for experiments in the early phases of the uranium gaseous diffusion process development. Two of the workers at the time both knew about these experiments. Buildings K-1004-A, K-1004-B, K-1004-C, and K-1004-D were the analytical laboratories.

WORK FOR OTHERS

There were inter-assignments between facilities at the K-25 Site and between K-25 and Y-12 or X-10. Also, work was done for other DOE facilities, e.g., Los Alamos, Sandia National Laboratory, Portsmouth and Paducah Gaseous Diffusion Plants and others.

K-25 implemented and participated in a program referred to as “Work for Others.” Other sites or organizations sent work to K-25 because of their unique capabilities (e.g., precision machining). This program included work for other DOE complex facilities, the National Aeronautics and Space Administration (NASA), and the DOD. Y-12 provided the decontamination services in the early days.

The Work for Others program at K-25 didn’t start until about 1985. Y-12 conducted Power Operations on the K-25 Site starting in 1998. Laboratories on the K-25 Site processed radioactive material from Hanford. Uranium gas was introduced to the AVLIS system. There were office areas within the production facilities. USEC conducted research for the new centrifuge prototype in Building 1600 on the K-25 Site. It was noted that there was work for others in the 1960s, in the 1980s, and in the 1990s. Most of it was fabrication or engineering of things. It was also mentioned that K-25 did do a little bit of work for other countries.

Also, the site could bid out plant services to other entities, such as the Navy, Air Force, and other DOE complex sites. K-25 was involved in the Aircraft Nuclear Propulsion (ANP) activities conducted by DOE.

In 1982, DOE mandated that K-25 meet the requirements of RCRA. A local judge required the K-25 Site to treat approximately a million gallons of liquid radioactive waste. This waste was predominantly from the barrier production process. In addition, Y-12 was to discontinue discharging material to the S-3 Ponds. As a result, the waste was put into a tanker and shipped to K-25 for waste treatment. A lot of this work was done in Building 1231. Operators provided the liquid waste that was to go into the burners. Types of liquid waste included mop water, organic contaminants with uranium contamination, and cleaning solutions. Y-12 waste was burned. If this had not been handled effectively, the Judge’s ruling could have shut down Y-12.

The uranium recovery process involved uranyl nitrate. Contaminants were released into the air. Air monitoring was done periodically on the incinerator in 1986–1987. They developed a Work for Others program group onsite that was dedicated to stack monitoring. The first real-time test of the stack monitoring system was when they purged the cascades in the late 1980s. The TSCA regulations required that continuous sampling and analysis be done in compliance with NESHAP.

Another Work for Others project involved the National Pollutant Discharge Elimination System (NPDES) permits and work for other DOE laboratories. K-25 provided a place to store waste. It had a sophisticated machine shop. K-25 also had a nickel-plating capability that permitted the nickel-plating process to pull the nickel out of other materials and reclaim it.

K-25 had the capability to perform a series on neutralization precipitations that was used on sludge being stored for disposal. The waste processing capability did not involve the recovery of uranium.

In K-1420, K-25 supported other sites as “Work for Others.” They worked with the Savannah River Site and with Hanford National Laboratory in radiochemical development projects. Some of this work was done in the K-1004 complex where they did bench scale work.

The gaseous diffusion plants operated as if they were one site. Paducah served as the feed plant. Paducah released uranium to Oak Ridge, uranium that K-25 enriched to 1% or 1.5%. This was some of the source of the Tc-99. K-25 did reactor returns, but the main source was Paducah.

K-25 did a limited amount of work for others in foreign countries, but not a lot (e.g., Cogema reactor returns).

TRANSFER BETWEEN FACILITIES

There was a lot of interchanging between facilities, especially before the Bechtel Jacobs days. This involved transferring workers between K-25 and the other Oak Ridge sites (e.g., X-10 and Y-12). Workers went from one site to the other, but often stayed as an employee at K-25. Prior to 1989, they actually were employed at different places, depending on where there was funding to hire them.

Prior to 1989, Lockheed Martin or Martin Marietta often moved workers between K-25, Y-12, and X-10. When jobs slowed down at one site, the other sites were generally hiring and a worker could pick up a job there. It was mentioned that K-25 had some supervising responsibilities for environmental monitoring at the other Oak Ridge sites.

Workers employed at the K-25 Site were loaned out to either X-10 or Y-12, but the K-25 employee continued to work through his K-25 reporting chain and was provided with K-25 support.

Paducah fed materials to Portsmouth and K-25, and K-25 personnel were involved in the material transfer. Tc-99 came primarily from the reactor returns.

K-25 relied on Y-12 and X-10 mainly for product and feed transfers, and for some technical support.

One interviewee recalled that there was relatively little transferring until the mid-1980s when the plant shut down. Even then, there were still only a small percentage of workers who transferred between facilities.

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In regard to the relationship between K-25, Paducah, and Portsmouth, one interviewee responded that there was not too much transferring between sites in the earlier years. There were Engineers that did work at all three sites, however. One interesting example is that Engineers were assigned strike duty in Portsmouth during a strike in the early 1990s, and some of them did instrument work with contaminated instrumentation. When asked if these facilities shared parts and equipment, the interviewee responded that this was not normally done, though there was some equipment shipped during the CIP/CUP, and a lot of spare parts were left that came from Paducah and Portsmouth after shutdown. A lot of these parts were not decontaminated at K-25.

Another interviewee reported in the 1980s, they had an assignment at Y-12 in the 1515U complex. There was movement between facilities at the K-25 Site. One interviewee remembered taking tours and going to K-33.

In the early days, they took their dosimeters with them wherever they went.

RADIOLOGICAL CONTROL (RADCON) AND HEALTH PHYSICS ASPECTS

There was no robust Radiological Control program at K-25 until about 1989. Four technicians were responsible for radiological monitoring at the K-25 Site for the first 40 years. Initially, individuals worked by job request. With the improvement of the RadCon program, more technicians were hired. There are currently about 60 technicians provided by an outside contractor. The site is currently in a Surveillance and Maintenance mode operating 24 hours per day, 7 days per week. The site is currently in a D&D mode. Two technicians are maintained on the back shift. Only about six areas on the whole K-25 Site had any reliable internal dose coworker data before 1989. By the mid-1980s, coworker doses averaged about 60 mrem.

At K-25, uranium fell under the jurisdiction of the Radiation Control (Health Physics Department) organization, based on its properties as an alpha emitter, as a radioactive material. The Heath Physics Group did the monitoring and analysis for radiological exposure to uranium, which included urinalysis, whole-body counting, and airborne area and personal sampling. The Industrial Hygiene Department was notified if results indicated a health concern from a heavy metal perspective. Both the Industrial Hygiene and the Health Physics Departments reported directly to the Medical Department. Routine area and integrated personal sampling was performed by the Industrial Hygiene Department for non-radiological air contaminants, and results were recorded and provided to management and the individual sampled.

In the early days in K-1210, there were many cylinders and most were stored rather indiscriminately. As the interviewee was taking samples there and in the K-1205 areas, while wearing all the appropriate PPE (lab coat, cotton gloves, hard hat, safety glasses, and respirator—which the one interviewee indicated she religiously wore), others would come around and watch, but these onlookers did not have on any PPE protection. The interviewee indicated that she adhered to the dress out instruction and did as the procedure prescribed as she did this sampling. When the onlookers left the area, they were not monitored for radiation contamination before going home. This occurred in the mid- to late-1970s timeframe. The interviewee also did cylinder sampling in the K-1010 building, as well as in the K-1200 complex areas. There were a lot of workers in the K-1200 area buildings.

There was a lack of knowledge in the 1970s about what materials were radiologically contaminated or contaminated with chemicals or toxics. It was assumed that if you took a shower at the end of the day, everything was fine. Showering was required in areas where it was needed. In the late 1980s, there was less emphasis on showering, since the production processes were shut down. After production shutdown, there was still a lot of processing of liquids that went to Paducah. Bioassay sampling was done appropriately for what was known at the time. Select workers received annual whole-body counts.

Around 1976–1977, there was a dosimeter that had a detachable picture badge. The dosimeter badge was dropped off at a dosimeter rack before leaving and the picture badge was taken home. Later on, they stopped doing it this way, and workers would take home both their dosimeters and their picture badges, and bring them back in the following day.

There were no friskers until 1976. At this point in time, workers did not wear PPE unless they were going into the pots. There were no health physics (HP) technicians onsite at that time. In the late 1970s, there were only two HPs. One interviewee recalled that the HPs came around only once every 6 months. It wasn't until 1986–1987 that HP coverage started to really improve and become more efficient. The new regulations resulted in a heightened awareness and concern by the HP Group.

Bioassays were not routinely provided in the 1970s – only certain workers in certain jobs participated. The taking of urine bioassay was not started until 1980, when they first started taking baseline urine bioassay on workers who had internal exposures or were thought to have the potential for internal exposure. Whole-body counts and bioassay were done on workers involved in incidents. In the 1970s, bioassay was yet to become common at K-25. If workers were called in to have a urine bioassay, it usually reflected a concern about a higher potential for uranium uptake.

It wasn't until the early 1990s that Bechtel Jacobs started to provide each worker with radiation exposure feedback in the form of an annual personal radiation exposure summary.

In the earlier days, operators did wear rubber gloves, aprons, and galoshes. Their hands still, however, looked pink.

During the mid to late 1970s, several industrial hygiene and safety professionals were hired to address the increased demands of the cascade improvement/cascade upgrade (CIP/CUP) program, as well as to comply with the newly created Occupational Safety and Health Act of

1971. The number of industrial hygiene and safety employees remained constant until 1985, which is when all uranium enrichment at the K-25 Site ended.

In the early days, workers were pretty much alone, and not really provided with much HP supervision. It wasn't until the mid-1980s that HPs started to be increased. This was about the time of the shutdown of production in the gaseous diffusion plant. K-25 was shut down without workers wearing anti-Cs. About this time, friskers began to be used as boundary control monitors.

The interviewees said they did not submit nasal smears. They all, however, did participate in the urine bioassay program. They indicated that the need for these was driven by the time they worked under a Radiation Work Permit (RWP), which did not start up until 1990 or so. At one point in the 1970s, bioassays for them were done quarterly.

One of the interviewee said he worked in blue jeans, but did wear company shoes. They remembered that the one HP would bring a meter over once in a while in the late 1970s and check things out. K-770 was the radiologically contaminated waste yard. There was usually no check done on clothing. There was no one to even check if workers were wearing their gloves. When clothes got to the laundry, they were checked, but they did not check the individual worker. Work uniforms were laundered onsite. One interviewee did say that he showered every day.

RWP and Special Work Permit (SWP) requirements as to who needed PPE, bioassay, dosimeters, RCT coverage, and entry/exit requirements were done on a building-specific basis and was decided by the building Supervisor. Local protocols were followed. The RWP process started at K-25 in 1989 for one interviewee.

One interviewee recalled that he wore his film badge from the first day he arrived. In the 1970s, film badges were left on a rack before leaving for the day. Dosimetry processing was done at K-25. In the 1970s, the picture badge had the film inserted within it. Sometime in the 1970s, they transitioned to TLDs. Everybody was issued a TLD. In 1984, they installed a TLD reader at K-25. There were portals to control access for security. The guards, however, never checked for dosimeters.

Workers were sent for a whole-body count if they knew they had received some internal dose exposure.

One interviewee reported that he felt that Rad Safety did know what was hot and what was not hot. It was reported that Rad Safety was able to inspect most of the experimental equipment. Monitoring and "green tagging" of equipment, however, did not start until mid to late 1980s. In 1991, Rad Safety began to find items that had been green tagged but were found to be contaminated.

The first radiation-training course that those interviewed could recall was in 1988. The first Rad Worker II course at K-25 was offered in the early 1990s.

One interviewee recalled entering an area where workers were wearing respirators and was told to stay away from the area.

One interviewee was involved in monitoring the centrifuge machines. The interviewee reported wearing a dosimeter during these operations, and wearing a respirator when samples were pulled. The interviewee did not receive any radiation training for these jobs, but was Q-cleared. The interviewee learned how to sample the machines from the person who performed the task before her, and followed the procedure thereafter. The interviewee always wore PPE—cotton gloves, a respirator, a hard hat, safety glasses, and a lab coat—to take these samples. The degree of PPE protection was based on pre-surveys done by Rad Safe to identify radiation areas.

Some interviewees indicated that they did eat, drink, and smoke in the break room that was a separate room in the middle of the work area. Sometimes they even would take their food back into the work area. Eating on the job was not a concern of the worker or management.

One worker worked in K-131 and K-27, which was across the street from the Process Building. The Process Building had a cool area that would remain cool, even if it were 97^{o} outside. They would go into the Process Building to cool down and didn't think much about the contamination. The lack of concern about contamination was that way even up into the 1980s. But K-25 Site was a good place to work. The workers felt that had a good Medical Facility. They believed in what they were told.

One interviewee noted that respirators were issued on an as needed basis, and stated that he was never issued or wore a respirator himself. Banana oil was used in the early years for respirator fit testing. He was allowed to eat, drink, and smoke in the immediate vicinity of radioactive material.

Respirators should have been worn in the appropriate areas. Some workers would change out their respirators daily and dispose of them, while others did not seem to care much about it. Coveralls were issued in the 1972–1973 timeframe, but some workers preferred to wear their own blue jeans.

In the northern end of K-1401, there was a Research and Development (R&D) area. You needed to have a reason to go there.

There were radiological hazards when working within the converters. One worker had to do this often, and these areas were contaminated.

There was no green tagging of radiation waste until the mid-1980s.

Workers were allowed to take their dosimeters home with them.

Posting of radiation areas was started post-1985. Workers in the Steam Plant worked around coal dust and ashes, and wore either a half-face mask or a respirator. Yellow rope and magenta and yellow radiation area signs were not evident at K-25 until the mid-1990s.

When gaseous diffusion activities ended, there was a downsizing of the Industrial Hygiene and Health Physics Departments, with many professionals leaving to accept jobs at other Oak Ridge facilities. In 1990, based on a DOE initiative (Tiger Team Inspections), Industrial Hygiene, Safety, and Health Physics Organizations increased staffing to meet the new DOE requirements.

Posting as defined by DOE orders and 10-CFR-835 was not implemented onsite until about 1989. After 1989, every building with the potential for radiation exposure was suddenly posted. In earlier years, the areas may have been posted as Zone 1, Zone 2, and Zone 3 for contamination.

Everybody was monitored with TLDs or bioassayed, where it was needed, from the late 1980s to 1995, when the potential for exposure dropped significantly. In 1995, the local DOE representatives pushed to stop monitoring those workers who did not enter known radiation areas or areas of radiation or inhalation exposure, or who were suspected to have no potential for radiation exposure. As a result, health physics stopped badging workers who were not entering the radiation areas. Workers did get a personal neutron accident dosimeter (PNAD) if they were out in the field.

It was mentioned that RCTs were the most likely workers to move around between K-1131 and K-1420. In the early days, there were only two HPs on the whole K-25 Site, and radiological control overview was very limited. One maintenance worker was mentioned as an individual who moved around a lot. Laborers were usually steady where they worked in the early days.

Since 1989, respirators are used in areas where uranium dust or other airborne contaminants are present. This can be a full-face respirator in heavy dust areas, or half-face respirators in other areas. The RCP defines when the full-face respirators are needed. Workers often decide themselves when they think half-face respirators are needed, although the RCP may define this in some areas.

There were significant quantities of Tc-99 even outside the area where it was processed. The cascades were highly contaminated with Tc-99, which was easily tracked throughout the facilities. Based on characterization data and waste profiling, Tc-99 is not **high** outside of the Purge Cascades (K-311-1, K-310-3, K-402-9, and K-402-8). Tc-99 was not processed per se. It is a radionuclide that could not be chemically separated during the plutonium and uranium recovery by the extraction (PUREX) process, and was subsequently fed into the process system as an impurity in the recycled uranium.

Workers were often in the immediate vicinity of areas where work required PPE. For example, it was not unusual to find one worker wearing a respirator and several others working with him unprotected. It was indicated that showers and change room facilities were available to the workers, but there were no requirements concerning showering after work. Workers used to eat in lunchrooms and offices throughout the process buildings, drank from water fountains and coolers, ate candy bars and snacks, and drank soft drinks on the process floors, and smoked everywhere.

There were x-rays done for non-destructive testing of welds. These x-ray areas were roped off. Most workers were not sure where this testing area was in K-1401. The site also had a 1.25 MeV gamma Co-60 sealed source for calibration of the survey instruments.

Things were not controlled by written procedures in the early days. The Radiological Control Program often did not provide appropriate field monitoring. It was extremely rare to see radiological monitoring occurring. For example, one individual who worked in Building K-1131 for 3 years reported seeing RadCon monitoring only a few times. In about 1989–1990, there was an improvement in the overall safety programs at K-25. Field monitoring was conducted more routinely and workers received training. Although the Oak Ridge sites were run by the same contractor for many years, the safety program was not equivalent between Y-12, K-25, and X-10. X-10 had the best safety program of the three plants. Y-12 and K-25 originally had poor programs.

Facilities creating the highest potential for exposure to radiation included the five major cascade buildings; a feed manufacturing plant; disassembly, decontamination, and cleaning facilities; maintenance buildings; uranium recovery facilities; numerous laboratories, pilot plants, and test facilities; the barrier manufacturing plant; smelters; and incinerators.

Radionuclides other than uranium present at K-25 included americium, neptunium, plutonium, and technetium. These were mostly contaminates from reactor tails. There was thorium work done as a part of testing work for the Navy.

The contamination within the K-1131 area was controlled by vacuuming and washing down floors and other accessible areas. This water flowed to Poplar Creek. Individuals liked to fish in this creek. If an area could not be decontaminated, it was painted to keep the contamination from going airborne.

Building K-1131 was the Feed Manufacturing plant. The radiological conditions in this building were not good. This area handled green salt, yellowcake, or a blend of material. In some areas (e.g., on beams), green salt and yellowcake were often visible.

While working on the fluid bed in K-1131, workers were required to wear lead aprons and finger rings, and were given a time limit for work in this area. There was also a Co-60 source in this building.

Personnel were allowed to eat in the process area. In fact, cantinas were located in process buildings where personnel could order grilled or cooked food. Lunchrooms and drinking fountains were also available. The cafeteria (K-1002) was often found to be contaminated, because workers wore their coveralls and shoes from the process area into this area without changing.

Dust masks or respirators weren't always available. As a result, workers had the potential for inhaling airborne radioactive material.

Maintenance workers did not receive body counts prior to the 1970s. Individuals were selected at random for body counts prior to the 1970s.

Personnel Protective Equipment (PPE) varied by location. In Buildings like K-25, K-27, and K-1131, workers wore company-issued coveralls, shoes, underwear, and socks. In K-1037, workers wore their personal clothing. At the Steam Plant, coveralls were required for work inside the boilers. In 1954, the union negotiated with the company to provide all workers with coveralls.

Work around fluorine generators required heavy rubber gloves, safety glasses, plastic suits, and a face shield.

There were issues with contaminated vehicles at K-25.

RADIATION MONITORING

The primary external dose received at K-25 comes from exposure in the cylinder yard. A measurable dose rate is also associated with the Building 1401 machining trap. This is primarily from Tc-99.

K-25 currently has a DOELAP-accredited bioassay program; however, ORNL does the analysis on bioassay samples now. At one time, K-25 had its own analytical laboratory. ORNL is responsible for processing the Harshaw brand TLDs for K-25, and they hold the external dosimetry DOELAP accreditation. K-25 also works under ORNL's external dosimetry TBD and DOELAP Accreditation.

When Special Bioassay samples were requested, a 24-hour bioassay sample was collected.

Beta/gamma dosimetry was on a quarterly exchange cycle starting in 1989. Prior to this, there were individuals on up to a monthly exchange cycle. Neutron dosimeters (i.e., TLDs) were on a quarterly exchange cycle.

Personnel were directed to wear beta/gamma dosimeters on the chest. Neutron dosimeters were worn on a belt at the waist. Currently, personnel are allowed to take dosimeters home. ORNL conducted a study of background on dosimeters that are taken home by workers. As a result of the study, they subtract a standard background.

If the dosimeter is accidentally left at home, an individual can get a temporary dosimeter, which is linkable back to the individual.

All employees were externally monitored through the 1980s until about 1995. At that time, assignment of dosimeters to administrative support personnel was discontinued. Only personnel qualified as Radiological Workers are assigned a regular dosimeter. Others may be issued a Nuclear Accident Dosimeter, which would be processed only in the case of a nuclear criticality accident.

Neutron monitoring depended on the area to which you were assigned. Neutron dosimetry was assigned to personnel in non-destructive analysis who worked with neutron sources, those working in the cylinder yards, and those working in Building K-25. Since 1989, a correction factor of 10 has been used for the limited neutron exposure at K-25. Prior to that, there is no information on historical procedures.

TSCA (the kiln), the AVLIS, and material from the Building 1420 are considered Type S materials for internal dosimetry. Building 1401 has a furnace in the basement, which also had Type S material. Bioassay for Buildings 1401 and 1420 include uranium and technetium.

During waste-handling operations, individuals are potentially exposed to plutonium, neptunium, tritium, and uranium. Thorium may also be present in waste. There may be high levels of tritium in the TSCA waste as a result of accepting material from across the DOE complex.

A lapel air-sample monitoring program was implemented by BJC. Lapels are placed on 1 out of every 3 to 5 individuals, where necessary. With areas containing transuranics, lapels are placed on all personnel. The site uses derived air concentration (DAC) hour tracking for thorium and transuranics to compensate for technology shortfalls in the bioassay program. Respiratory protection factors are considered when tracking dose.

In cases where urine samples are compromised, dose is assigned using the lapel air monitoring results or by assigning coworker dose.

INTERNAL DOSIMETRY

Airborne uranium and other radionuclides were often present, creating a potential for inhalation. The interviewee provided a copy of a memo from contractor personnel dated June 4, 1963, which indicated that 20.5 pounds of scale containing 34.8% uranium were removed from the walls and bottom of K-1302 vent stack. The same contractor also reported two additional occasions that uranium-contaminated scales were removed from the same vent. An October 4, 1963, memo reported the removal of 8 lbs of solids containing 6.3% of U- 235. A November 5, 1963, memo reported the removal of a total of 75 lbs of solids containing 2.7% U-235. The interviewee also provided a copy of a memorandum dated September 18, 1958, that highlights the venting loss of 58,854 grams of uranium and 407 grams of U-235 from building K-1131. The interviewee commented that, “One must wonder how much went into the lungs of the workers.”

A ChemRisk Report of March 2000 to the Tennessee Department of Health concluded that airborne uranium releases from K-25 were 50% higher than the values reported by DOE. It was estimated that 10,713 kilograms of uranium were released, compared to the 1,600 kilograms reported by DOE.

Bioassays were not provided in the 1970s. Urine bioassays were not taken until 1980, when they were used on workers who had internal exposures or when the workers were thought to have the potential for internal exposure. We were provided with a copy of a letter dated October 11, 1991, from Martin Marietta’s Fred Mynatt, VP of Compliance, Evaluations, and Policy, to

Dr. D.L. Cragle, an epidemiologist with Oak Ridge Associated Universities, detailing the limitations of the use of pre-1989 worker radiation exposure data in epidemiological studies. He concluded that this data was not sufficient for dose assessment.

Tc-99 was present in some K-25 buildings, especially in the 1970s. The meters used then, however, could not detect Tc-99, so bioassay was not always done in these areas if it was not realized that TC-99 was present. A RadCon individual determined if there was Tc-99 in the K-25 building. Later, Tc-99 appeared in K-27, K-29, and K-31.

One interviewee reported that whole-body counting was done once a year at K-25 for employees who worked in areas of potentially high contamination when the whole-body counting trailer was set up at K-25. Later, workers went to ORNL for their whole-body counts. This, however, was done on a low percentage of workers at K-25.

Urinalysis bioassays were commonly done, but rarely did they do fecal samples. Nasal smears were commonly taken to detect Tc-99. Workers were also monitored for the presence of Tc-99 in their hair, where it tended to accumulate and represented a potential for inhalation or scalp exposure.

The supervisors knew that workers were receiving internal dose from their work environment. It was not uncommon for workers to have 12,000 cpm on their hands. Bioassay was done for U and Pu. Of particular concern were manual operations, such as when workers shoveled ash into hoppers. One interviewee read of this happening in K-1131 in the early 1950s.

In regards to a question about the basis for determining who was put on a bioassay program, the following was offered. Bioassay was required for workers in K-1401 who had the potential for exposure to uranium and Tc-99. Bioassay was also required in K-1420, which had the potential for exposure to neptunium, tritium, uranium, and thorium. Tritium was high in some areas, and often came into the building from other facilities and DOE sites.

Once bioassay sampling began, there were generally no gaps in covering individuals that worked in areas where internal dose potential existed. Starting in 1989, the Radiological Control Permits (RCPs) set out the requirements for who needed to be bioassayed, and only those individuals had urine bioassays done. In the early days, they did urine bioassays on everyone just to try to ensure that they captured workers who were receiving internal dose uptakes.

In regard to a question about whether 24-hour bioassay samples were considered routine, interviewees confirmed that they either took 24-hour urine collections or simulated 24-hour urine collections (void in the morning and void in the evening).

Processing of the urine bioassays was done in the earlier days by BWXT, UT Battelle, or Bechtel Jacobs. Currently they are done at X-10.

When asked about whether there is a routine fecal sampling program at K-25, it was learned that since 1989, this is done only when employees are working on classified uranium projects.

In regards to a question about U-233 processing and storage at the K-25 Site, it was mentioned that there were different chemical forms of uranium that could have included U-233. In two areas specifically, Class S solubility U was handled or processed. This involved one small area of Building K-1420 in the calciner area, where the temperature got up to 860°. Also in K-1401, Super S solubility U could have been present. Materials were burned in burners in the Toxic Substances Control Act (TSCA) area. Workers had to go inside the kiln itself to scrape and knock off the slag. This definitely would have represented exposure to Class S uranium. Workers, however, were only bioassayed for uranium, but this did not start until about 1989.

When asked about isotopic fractions of U-234, U-235, U-236, and U-238, it was explained that DAC-hour tracking has been used since 1989 when Bechtel Jacobs came in and tightened up the health physics program. DAC-hour exposure tracking has been helpful in determining these isotopic fractions, especially if there is no data to determine the maximum dose. It is used to look into what is really a reasonable dose to assign to the worker so exposed.

According to an interviewee, NIOSH uses a default value of Type S in dose reconstructions. This is the most claimant-favorable solubility for calculation of dose. One interviewee indicated that this is not necessarily so. He indicated that it depends on the site, if the absorption type is known, and what is claimant-favorable. The favorability is based on the cancer organ. Type S solubility is most favorable for the lung.

If needed, personnel were sent to Y-12 or ORNL for a whole-body count. Routine counts were conducted, first in a portable trailer on the K-25 Site, but later at ORNL.

Stack discharges and treatment discharges were routine at K-25. Specific facilities involved were all the Purges and Process Buildings, some of the Process Auxiliaries, the Sewage Plant, the K-1420 Facilities, all the discharges to K-1407-B&C Pond, and the RCW process.

RWPs required bioassay samples to be taken if the worker was expected to get a dose greater than 100 mrem. The type of bioassay is determined based on a characterization of the area. At times, it seemed that bioassay was overdone. However, urinalysis was the most effective means to identify if workers were receiving internal dose.

When an injury occurred in a radiological area, the individual was asked to submit a Special Bioassay sample. Incidents were documented in e-mails, which were placed in an individual's personal exposure file. An interviewee did not know if this is true historically; however, he did indicate that this has been true since the 1990s.

Dosimeters didn't measure inhalation dose, and there was potential for internal exposure at the K-25 Site. According to one interviewee, however, there really wasn't much potential for environmental dose. The Health Physics Department tried to get a handle on occupational environmental dose, but it was just too difficult. It was hard to handle inhalation dose from airborne contamination that was not a direct result of local workplace releases, because HP didn't know how long they were exposed and in what location.

EXTERNAL DOSIMETRY

The first film badge remembered was the Lazarus badge, which was turned in every day and picked up the next morning. The badge was read during the night and recorded. The interviewee was not aware of where the dosimeters were turned in or who processed them. Later when TLDs came in, the TLDs were changed quarterly. At that point, dosimeters could be taken home at night and brought back in the morning. Since Bechtel Jacobs took over in 1998, ORNL has been doing the TLD processing.

Workers were instructed to wear their film badge at chest level on the front of their bodies. In the 1970s, workers left their dosimeters on racks and did not take them home. They only took home their cover security badge. When they transitioned to TLDs in the 1980s, workers were allowed to take their dosimeters home with them along with the attached security badge. There was a problem with TB screening, whereby workers' badges would receive non-workplace dose on them. In regards to possible directional problems with the dosimeter not really capturing the dose from behind or above, this was usually only a problem with Dosimetry personnel who used calibration sources.

In the early days, most workers did not move around a lot. The exception to this was the security guards, the samplers, and the RCTs that did move around all over their facilities, as well as throughout all the K-25 Site facilities.

During the period when the site was actively engaged in the gaseous diffusion process, the Dosimetry group was in the analytical labs and in K-1004 (now torn down). Instrument analysis (Electron microscopy) was done in K-1006 on samples from the centrifuge machines and various components.

One RCT indicated that external dose at K-25 was very low. The LLD of the dosimeter was 14 mrem. He felt that external dose was not a problem at K-25, except in a few limited areas. Extremity monitoring was not routinely used at K-25. The most likely source of external environmental exposure would be from the cylinder yards.

One interviewee reported that nothing was posted as a radiation area or contamination area in the early days (1970–mid 1980s). In the early days, there was a < 0.1 mr/hour LLDs of the radiation survey meters that were used in the uranium production areas; < 0.1 mr/hour was considered to be comparable to ~10,000 dpm for uranium contamination.

Radiation surveys were done by radiation monitors. Prior to the 1980s, the Supervisors were trained, but the operators who usually did the surveys were not always trained. Sometimes the Supervisors did the surveys.

When asked about movement between K-25 and other Oak Ridge sites, one interviewee indicated that some personnel traveled, as well as transferred, between sites a lot. Fire and security personnel move around the sites a lot. Their film badges and later their TLDs were combined to their security badge, so they had to have them with them as they moved around.

Radiation surveys were done, but the guidelines kept changing. One interviewee remembered a spot survey on an old capped drain where contamination was detected. In the late 1980s, the guidelines were cut in half.

From the 1980s on, workers performing a similar task were all monitored. Workers were trained as to what type of PPE to use in contamination areas, even before 1980. The use of PPE, however, according to one interviewee, was not consistent between different areas. The use of coworker assigned dose at K-25 was not a common practice. Most workers had their own dosimeters or received urine bioassay, when needed.

Dosimetry badges went with the employees from one place to another. Each site read its own dosimeter. Workers were notified only if there was a positive reading or something was wrong. For some time now, each worker has been receiving an annual report of his or her radiation exposure. Whole-body counts were also conducted. The whole-body counter was in a portable trailer at K-25. Later K-25 workers were sent to ORNL for their whole-body counts. Whole-body counting was generally done every 2 years.

After 1990, dosimeter and bioassay results were provided to each worker annually. The interviewees reported that they did receive an annual personal radiation exposure report.

Logbooks were kept that showed daily the date, location, and job of individual workers, which included notes on type of PPE worn, contamination levels on the floors, and any air-sampling data.

The highest external dose occurred in areas around the compressor seals. They did use dosimeter rings when doing these tasks.

When asked about potential exposure from other radiation sources, it was indicated that there are none now. Since those being interviewed were not there in the earlier days, they had no additional information to offer.

Neutron monitoring was done in some of the cylinder yard areas, in the non-destructive assay (NDA) open areas, and parts of K-25 wherever a cylinder was stored.

Higher external doses were found around the cylinder yards or in the cylinder building. Now that the cylinders are gone, there is no longer much potential for external dose.

In regard to contractor and subcontractor dosimeter monitoring, it as explained that Bechtel Jacobs badged contractor and subcontractors like everyone else. Prior to 1989, these workers got only accident dosimeters. These accident dosimeters were not read unless there was a criticality accident. Not many visitors, however, went into areas where the dose could exceed 50 mrem. It was recalled that the Dose Reconstruction System (DRS) may have data on a monthly basis.

Individuals were directed to wear their dosimeters on the upper torso at chest level. If they were issued a neutron albedo dosimeter, they usually wore it on their belt at the midline of the body. UT-Battelle does the TLD readouts. Currently workers are allowed to take their TLDs home with them. Health Physics could tell if they took their badge home or not. If a worker forgot his/her TLD, they were issued a temporary TLD, and once they returned their issued TLD, the results of both were merged. Some unread badges were held in the Dosimetry Office. At designated intervals, the TLDs were shipped to UT Battelle and the K-25 Site followed UT Battelle external dose procedures.

There were two sources of neutron exposure. There was some neutron exposure in the gaseous diffusion plant around the cylinders. In addition, there was a Co-60 source that had a high curie content. The neutron-to-photon ratio, where applicable, is documented as a part of the As Low as Reasonably Achievable (ALARA) reviews. The approximate ratio is 5:1 photon to neutron. There was also a PuBe source that was stored in a big can of paraffin. The interviewees never saw it used much.

Currently K-25 is using the Harshaw TLD. For those workers suspected of being exposed to neutrons, the TLDs are done quarterly.

In addition, there was an iridium source that was used extensively for radiography. Building K-1401 was where the whole radiography group was located and did their radiography. This work was done under the auspices of a Nuclear Regulatory Commission (NRC) license, and in more recent years, NRC came in to review the doses.

One interviewee remembers an old Photo badge with a hole in it and the film packet hung behind the hole. The worker wearing it was decontaminating an area/equipment. A contaminated chip of uranium stuck in the hole. The radiation exposure the worker received resulted in a blackening of the film under the area of the hole in the film badge packet. This was determined by a RadCon investigation.

There were sealed sources on the K-25 Site. More details of this should be in the records in the K-25 records archive, or in the records sent to the Atlanta Archives. The Records folks know where they are.

A radiation dosimetry specialist looked at the dosimeters regularly, and it was he who developed the foil dosimeters.

POTENTIAL MISSED DOSE

The two worst buildings for exposure to radioactive material were K-1131 and K-1420. K-1131 was the feed building, and exposure was of particular concern when processing reactor returns. Building K-1420 housed pickling operations, an acid bath, a decontamination facility, and operations of various types. Work was finished in K-1131 in 1999. Work there (when it was in operation) was nasty. Work during the D&D of K-1131 was controlled with engineered controls, administrative controls, and the selection of proper PPE. No internal doses were received and any external dose would have been minimal (10-20 mrem). Work on environmental cleanup of K-1420 was to be completed on December 20, 2006.

Another hot facility not on the K-25 Site Profile building list is the centrifuge facility. They did some hot runs that resulted in some hot steam releases. These were the K-1200, K-1210, and K1220 facilities. The K-1210 facility is still on the K-25 Site.

There is missed dose in K-33. PCB oil accumulated in the troughs installed along the seams of the building air ducts. When the workers drained the troughs, this PCB fluid, with concentrated radiological contamination, dripped onto the floor and workers walked through these areas where it could be tracked. The whole building ventilation came through these vents. Also, the management staff often gave away small cards with uranium samples attached to the cards as souvenirs.

It was not uncommon to see yellow power on the floor and working surfaces (ammonium diuranate, the precursor to yellow cake). This was not regulated before 1976—until the implementation of the Uranium Mill Tailings Remedial Action (UMTRA) Program.

There were contamination problems in K-131 and K-633, which had the test loops. Radioactive contamination was common in K-1030, K0135, and K-1024. K-1413 did radioactive material experiments and served as one of the development labs. These activities resulted in frequent contamination problems.

Frequent airborne contamination problems were common while doing cell change-outs in the CIP/CUP. Some maintenance jobs had airborne contamination problems.

Workers, especially in the earlier days, worked all across the K-25 Site.

K-1121 and K-1131 had a lot of contamination and were the first ones to be torn down. K-1420 had two large rollup doors at opposite ends of the building. There were times when you looked down the aisle between these two doors that you couldn't see from one door to the next, because of the urynal nitrate fog that often hung up near the ceiling and sometimes settled near the working areas. Conolux paint was painted over the floors to seal the contamination under the paint layer. One of the painters at the time would also put some Americoat epoxy paint down. It had to be periodically stripped and reapplied. They used blowguns to blow off the paint and chunks went all over K-1420. This occurred around the 1975 time period. The K-1401 ceiling was cleaned with blowguns; painters did not wear respirators while blowing down the ceilings. Painters applied Americoat epoxy paint after ceilings were cleaned.

There was an incinerator (K1421) behind Building K-1420. Plastic garbage bags containing contaminated waste were burned in this incinerator, usually in the evening hours after sundown. This produced a thick black smoke. All that kept the plastic bags closed was a yellow shaker-like wire around the neck of the bag. These bags were staged in the SW corner of K-1420 Building awaiting incineration. This incinerator was operated as late as 1985. The TSCA Incinerator replaced this operation and it went into operation about 1990s.

L Lab was a hot area. One of the interviewees who worked in L Lab in 1984 stated that he only wore coveralls, but was not told to wear a respirator during his work activities. He did wear a TLD on his chest above waist level. At that point in time, it was the bubble albedo TLD dosimeter that was issued in the late 1980s. He received no special instructions, however, on how to protect himself from radiological contaminants in L lab.

There was waste disposal stuff all over the site.

Workers had to clean out the K-1420 sludge ponds by dredging dirt and sludge out of them. This dirt and sludge was then mixed with concrete and put in plastic-lined, metal 55-gallon drums. These drums were then sent to an area called the "Valley of the Drums." At one point, workers were asked to double the production of processed waste drums and as a result, the waste drums often did not get a plastic liner installed before the sludge and concrete was put into them. As a result, some of these waste drums started leaking. The drums were eventually moved to a landfill site. This drum processing area no longer exists.

It was mentioned that X-10 had things a lot more dangerous than that at K-25, which, in the opinion of the interviewees, are not well recorded.

One interviewee told of a claimant's wife who was told that there was no Pu at Paducah. After he passed away, there was an analysis of his bones and they found Pu at levels 2,000 times the limit. Y-12 was also reported to be worse than K-25.

In the K-25 machine shops, five out of the five workers that were assigned a particular tool-grinding job have subsequently developed brain cancer.

In the early days of the 1970s, there were no posted radiation areas. There were heavy-duty gamma exposures in the cylinder yards, as well as some neutron exposure.

One interviewee indicated that there were lots and lots of UF_6 in the K-25 plant and at other locations as well. The reactor returns in K-33 represented another potential for radiation exposure. Tc-99 was also present. When they fed in the uranium, it came out in various enrichments. These were then fed into the cascades and then all were finally hooked together.

There was no highly enriched uranium (HEU) office in 1964. Prior to 1964, there was HEU present in K-25 Building and it had to be constantly cleaned up. Around 1985–1986, the Facility Safety Representative (FSR) started to oversee these areas. Currently, there are Technical Safety Reviews (TSRs), Accelerated Safety Analyses (ASAs), and Preliminary Hazard Screenings (PHSs), but these did not begin until after most of the production had closed down.

One interviewee remembered that he and other workers sweated so bad that they got green stains around their wrists. The work was hot and nasty and involved working in environments with a lot of powder dust.

In K-1074 where the cascades were operating, there was lots of hydrogen fluoride and uranium. One interviewee thought the cylinder yards were not too bad for presenting any problem with high doses.

When they took cells off line or worked on the wet air pumps, they pulled an exhaust on the seal to keep the seal pressure lower. If there was uranium present, it would get mixed with the oil and would be hard to clean out. Liquid freon was also leaked. The most contaminated area for this kind of work was in K-33.

It was pointed out that every time workers took a cell off line, if the pressure was too high, there would be a puff of smoke coming out of it. If the pressure was negative, then wet air went into the cell.

CONTAMINATION

K-1420 was the most contaminated place on the K-25 Site. This was where all the decontamination and uranium recovery was conducted. In the early days, workers just wore coveralls and dusted them off before leaving work areas. The floor in K-1420 was so contaminated that it was hard to clean off the contamination. Painters, therefore, just painted over the contamination to fix it in place. They used red lead paint coating. In the mid 1980s, workers began to use lapel monitors and air sampling became more routine.

Building K-1410 housed a small equipment decontamination facility. This was the decontamination facility for the entire plant site in the 1950s and 1960s. K-1410 was also involved in decontamination of equipment for K-25, K-27, K-413, K-1131, and K-1231 Buildings. A lot of the decontamination operations were done on the outside of the 1410 Building. Drains within the building and soil surrounding the area were assumed to be contaminated. Building K-1410 was not large enough to handle some of the converters, so the K-1420 facility was built. Building K-1420 was involved in converter disassembly, or de-heading of converters, and decontamination of this equipment.

There were also issues associated with the leakage from cylinders that were in storage.

In the K-1420 decontamination facility in the 1970s and even into the 1980s, if a worker got his hand contaminated, he did not know it as there was no monitoring for contamination at that time. British Nuclear Fuels (BNFL) surge drums were usually pretty tight. Contamination just was not measured. If you needed a part, a worker would just go over to the K-1420 Building or to K-33 and get the part without any survey being done. In the old jet cells, uranium was found around the roof. It wasn't until 1986–1987 that they started to "green tag" parts to indicate they could be released for public use.

In the early days, the use of change rooms and showers by non-craft workers was minimal. The craft folks were generally the only ones to frisk themselves prior to leaving the areas. The non-craft workers wore personal clothing and often did not have coveralls. Coveralls came in later and in the mid-1980s, these non-craft workers were issued khaki work clothes. The khakis were laundered and cleaned by C&S. The RadCon group monitored these workers to ensure their khakis were below prescribed release limits before they left for the laundry facility. At ORNL, everyone had khaki work clothes.

The types of operations at K-25 that involved radionuclides, where the potential for contamination existed, were primarily from uranium and Tc-99. Uranium was stored in the K-25 building. Contamination problems did occur in the equipment and utilities areas. Materials removed from the reactors (reactor tails) were taken to the cascades. There were fission products from the cascade process. During the fluorination process (HF_4 to HF_6) radium did come out. They identified the fluorination area as one area with contamination problems. Field characterization started in the late 1980s.

Workers in the blend tower in K-1037 were not required to take showers in the early days. In 1960–1962, it was reported by one interviewee that workers went on strike, because they wanted to have company-issued shoes and coveralls. As a result of the strike, they finally got coveralls. Another interviewee said he wore company coveralls, as did all the operators, and that he never left the site without showering. He recalled that later, in the 1979–1989 timeframe, the HPs and the environmental engineers wore company-issued khakis.

If there were contamination incidents, the workers were either brought to the decontamination facility (Building 1008D) or taken to the Medical Department, if there were injuries associated with the incident.

Starting in the 1980s, shoe surveys were done for workers in contaminated areas to prevent the tracking of contamination into clean areas. There were routine radiological monitoring surveys in the cafeteria. In about the early 1960s, there was unmonitored tracking of uranium contamination out of production areas. This, however, was not a problem in the 1980s.

Assigning respirator use for workers evolved from multi-user, to single user, to single use. In the early years workers would reuse their respirators. Respirators were stored in cabinets. There was intermittent cleaning of respirators between uses. In the early days, workers kept their respirators around their neck.

Coveralls were the primary PPE, along with the use of respirators, welding masks, aprons, and gloves. One interviewee recalled inspecting motors and seal failures while only wearing street clothes.

As time evolved, PPE requirements became more controlled, single-use more common, and Rad Safety began to monitor its use in controlled areas.

PPE and safety requirements were communicated daily to workers. There were some special briefings as well. This all evolved into the current radiation protection program. PPE requirements were not always consistent between different departments.

When asked about situations where workers were in the immediate vicinity of areas where work required PPE, one interviewee responding by saying that this was a tricky question. He indicated that they have people today in Level B wearing PPE, and people 6 feet away across a radiation warning rope in Level D not wearing PPE. It's always been that way. The safety professionals established the job requirements and the boundaries. They determined the appropriate actions to take. He remembered being 10 feet away from mechanics in respirators doing seal changes, and wearing his work clothes. The primary change has been in contamination control and monitoring. The practice still occurs, but it's currently better controlled.

It was indicated that showers and change room facilities were available to the workers, and that showers were mandatory for certain workers.

When asked about eating, drinking, and smoking in the immediate vicinity of radioactive material, one interviewee noted that he remembered that the term "contamination area" is relatively new. People ate in lunchrooms and offices throughout the process buildings, drank from water fountains and coolers on the process floors, and smoked everywhere. This ended in the 1980s. When asked if workers were allowed to have food or beverages at their immediate work location, the response was generally no, although some (very few) did eat at their workbenches.

In Building K-1423 during a release, there was yellow cake that leaked on the floor. A supervisor was on his way out to evacuate the area and walked over the yellow cake, tracking contamination down the hall. The tracking path was surveyed by RadCon personnel, and it was determined that the contamination levels were below limits for the hallways. This faded away fairly soon, however.

One interviewee reported that there was contamination in L Lab and in the analytical laboratories.

The ventilation ductwork was contaminated in Building 1401.

Friskers started to be used in the late 1980s in some areas. By the early 1990s, when the new DOE Order took effect, Rad Safety began to rope off any area that was a contamination area.

Personnel contamination monitors (PCMs) were used starting in the 1990s with the introduction of the Berthold. Prior to the implementation of PCMs, a Model 177 alpha/beta/gamma instrument was used to frisk worker's hands and clothing prior to exiting work areas. If contamination was found, they had to go back and clean up before leaving the site. Many people were found with contamination on their hands.

There were contamination problems in K-131 and K-633, which had the test loops. Radium was common in K-1030 and K-1035, as well as in K-1024. K-1413 performed radiation experiments and served as a development lab. These activities resulted in frequent contamination problems, especially for workers.

Fluorine leaks occurred at the end of the uranium enrichment process, which involved uranium contamination. This was during the stage when UF_4 (Green Salt) was being converted into UF_6.

Building K-1420 was the decontamination facility. In the 1980s, the HP Group did routine floor surveys. They had a lunchroom in K-1420, and they kept it clean; however, the break room in K-1420 was found to be contaminated at one time.

One habit of workers was to cook their food on top of the incinerator, which was a "High Contamination Area."

Respirators were assigned for use in areas of frequent airborne radiological contamination. Based on the level and type of air contaminant(s), half-mask respirators were used in lieu of full-face respirators. Respirators were cleaned and issued on site, and were distributed from a controlled issue point.

Personnel protective equipment (PPE) used for the various K-25 operations were usually coveralls, gloves, safety shoes and glasses, and hearing protection (i.e., ear plugs) in the early years. Use of PPE was more or less job-specific, and depended on specific IH or HP instruction.

Showers were used at the end of each work shift. Most workers did shower and change into personal clothing before leaving for home.

Material got a green tag (called the radiation clearance tag) if it was shown that the exposure level was <0.1 mr/hr. In order to release equipment and objects to the public, it had to be less than 5,000 dpm or less than 1,000 transferable dpm.

It was not until the mid 1990s that RadCon and their contractor support staff posted and roped off contamination in areas that up to that point had not been posted or controlled. This was based on the old guideline limits.

Dust masks were usually worn in the 1980s, but not for work in radiologically contaminated areas. They were worn more to prevent inhalation of mold. There were bird droppings and dead birds on the plant floor. Histoplasmosis, however, was not much of a problem.

Most early workers started wearing a half-face mask for most jobs. If the job required greater protection, then they would put on their full-face respirator. If HP required the use of full-face respirators, then they were worn.

One interviewee indicated that he worked daily in contaminated areas while he was performing his HP duties.

Technicium-99 was tracked easily. Technicium-99 leaked from the seals when a mechanic changed them out. The worker would put his tools into his toolbox, and it would be picked up later in non-contaminated areas and spread Tc-99 contamination there. Rad Safety corrected this, when it was realized this was happening, by creating the concept of a "dedicated" contaminated work place toolbox. The toolbox was not removed from the contaminated area. The changed part was placed in a sealed package before it was brought out. Technicium-99 was only a leakage problem in the end room of K-27 Building and K-29 Building. Later, this also became a problem in K-31 and K-33.

Cross contamination of groundwater lines contributed to contamination of drinking water fountains, which contributed to uranium ingestion and ingestions also resulting from intake associated with cesium-137 and strontium-90 from the X-10 releases into the K-25 sanitary water system. Also, there were several incidences of cross-connections between sanitary (drinking) water and cooling water from the uranium enrichment processes.

In the 1970s and 1980s, workers were allowed to eat, drink, or smoke in the immediate vicinity of the radioactive materials (e.g., contamination area) and were allowed to have food or beverages at their immediate work location.

When exiting from the process areas, workers were directed to wash their hands. Some personnel were required to shower at the end of the day. Showering was optional for others. At K-25, there were showers and change rooms in those facilities that had contamination problems. Workers changed into personal clothing (including shoes) before leaving for home.

A pilot study on contamination control was initiated in Building K-1420. This involved donning and doffing anti-contamination clothing and exit monitoring.

There were some fires and explosions that occurred at K-25 that did result in contamination incidents.

In K-33, they used sanitary waste water as the feed for their water needs. In one situation, the backflow valve failed and some of the facility coolant water that got too hot in temperature and could not re-circulate ended up going back into the storm drain. In K-33, they had to pump a lot of air through the facility all the time. In these situations, they did not use lapel air samplers.

In K-33, there were seal blowouts when they were trying to see how much pressure the seals could hold. Other people were around the worker testing the seal and would get exposed during the blowout. They tried to shut it down, but the brakes didn't work. There were 3,300 motors that had these kinds of seals.

Seal exhaust pumps often leaked, and workers would have to paint them to fix the contamination. In K-31 and K-33, there wasn't much of this painting done. The building was just too big and too long. In K-1420, they painted the floor a lot.

When asked about the kinds of egress monitoring that had been implemented historically, it was mentioned that firemen and guards had their own uniforms. Supervisors would keep their respirators in their offices and wore their own street clothes. Most workers did change their respirators every 30 days. One of the interviewees said he cleaned his respirator with alcohol to clean it up. He always used a full-face respirator, but could get a half-mask, if ever needed. Workers on the crawling line or those that went in to stop leaks wore full-face respirators. If a worker was just pulling a sample, then he often did not wear a respirator. No gloves were worn if they did not suspect contamination to be present.

In the cascades, UF_6 was a problem when valves were closed. Sometimes a light gas would bubble up. It was soon realized that value control procedures were needed if UF_6 was involved.

In 1978, the potassium hydroxide (KOH) scrubbers would fill up with UF_6 gas and the workers would have to burp it to prevent buildup. In the late 1980s to early 1990s, TSCA began to change things and more sampling was done around the scrubbers.

Sometimes contamination occurred when taking down the cell to remove the D-Blade. These events were usually written up in the area control room logs. Contamination occurred to some extent every time a worker shut down a cell. There were disk brakes involved and asbestos was released. The disk brakes had a gas bearing seal, which only had a life span of 10 years or so.

In regards to a question about types of posting designations, one interviewee recalled a job where it was necessary to cut holes in the lines to the stacks. The worker would have to use a 40-foot line to get the pieces out of the line.

In one operation, one interview recalled a situation where they were purging a cell and a worker had to crawl back into the cell where there were concentrations of hydrogen fluoride. He remembered they had to sweep up all the HF. The dust was so thick, it would almost knock you down. They had to use a fan to help blow it all out. There were three 30-foot openings. All you could do was blow away the HF and thus help to dilute it.

In one incident, a hole was punched into an expansion joint and white UO_2 smoke filled up the entire building.

Old fly ash often went into a pile – it was a different world in those days.

One skin burn incident occurred with a worker. The worker was lowered by a rope around his ankles to allow him to put a pipe wrench on a handle and close it. He received hydrogen fluoride burns on all exposed areas of his skin. He retired a while back and now is deceased.

One current Bechtel Jacobs's employee used to work on feed in the K-1131 Building and could tell you more about his experiences.

Leaks were common when workers were pulling samples.

There was a big spill in K-27; however, one interviewee could not remember any big events in K-33.

When asked about containment failures, one interviewee recalled a situation where a worker was pulling a sample. The job required the wearing of a respirator. He was in the pipe gallery without a respirator when the event took place. The worker had to come out quickly, dry off, don his respirator, and clean up the spill. When he had finished the cleanup, he then took a shower.

When there was a big environmental release at one of the other Oak Ridge sites, the environmental engineers found that there was a notable increase in radiological contamination found in the potable water for the K-25 Site, since their source of water was the Clinch River. As soon as it was noted, the water intakes into the K-25 Site were closed down, and clean potable water was brought into the K-25 Site for employee use until it was safe to go back on water intake from the Clinch River.

There was an analysis of the drinking water at K-25, which found that it was not contaminated.

DECONTAMINATION AND DECOMMISSIONING

It was explained that the extent of D&D operations at K-25 involved contaminated facilities or portions of facilities that have been decontaminated and decommissioned routinely since the 1940s. There have been capital projects since day one at K-25 that removed, covered, or decontaminated equipment and structures at this site. Only beginning in the 1990s was this considered D&D. Prior to that, it was considered demolition in preparation for new construction.

When asked about the type of environmental restoration and waste clean-up operations that occurred at K-25, the following were recalled. The first environmental restoration project that was recalled was the "Environmental Protection and Safety Modifications, Phase I" project in 1981. This was the start of the Batch Plant for K-1407-B&C Ponds cleanup and the Central Neutralization Facility. There have been many since. When asked about the methods of contamination control that were used at these facilities, one interviewee responded that his first radiation protection course was on March 16, 1989. It was recalled that this was the day, approximately, that the K-25 Site began working under the new radiation protection regulations that are known today as 10 CFR 835. Before then, you would have to talk to the radiation technicians. Personally, the interviewee recalled that he had worn a dosimeter every working day of his career, had two baseline bioassays, but never had a whole- or partial-body count. Another interviewee recalled that he did not have any baseline bioassays that he recalled. His primary years of exposure (1975–1980) never resulted in a request for these special exams or any notification of his external exposure from the dosimeter. He remembered that in the late 1970s, many of the Operations and Maintenance personnel were on a routine bioassay program (depending upon their job duties), but he did not remember if people were sent for whole-body counts.

In response to a question about burning or incineration activities at K-25, one interviewee responded that there were such operations. There was the K-1421 Incinerator, the K-1420 Flame Tower, and something in K-101, K-131, and K-601 in the early days (1940s).

WASTE DISPOSAL

In response to a question about treatment and disposal activities for radioactive waste one interviewee provided some detailed information. Disposal of radioactive waste went to K-1070-A, which was the burial ground for most radioactive waste. K-1070-F was the waste site for clean construction debris. K-770 was the scrap yard for radioactive scrap metal. K-1093/K-1094 received the clean scrap metal. There were also some other debris sites around the plant that were remnants from the original construction days (JA Jones Area, Demolition Placement Area) and other construction times (K-901-A Construction Debris). Also, K-1407 waste ponds were the disposal basins for radioactive sludges. The White Wing Scrap Yard was used for clean scrap metal, until it was shutdown and K-1093/94 opened. A few cylinders were also disposed of (shot with a rifle) in K-901-A Pond. Other places for waste storage were K-720 Slough–Powerhouse Ash, and K-901-A, the Holding Pond for RCW sludges. Treatment was a nebulous term used at K-25. K-1407 was a Pit, radioactive acids neutralization area. Several facilities that treated RCW and made sludges/sediments of various types included sewage treatment at K-1203 and K-7 10. The Central Neutralization Facility is the current treatment system.

Disposal criteria did change significantly over time. In the early years radioactive waste was buried with no containers, and then later went into drums and boxes (wood, cardboard, and metal).

When asked if there was a hold up of radioactive material in piping and ventilation, one interviewee indicated that this was a problem. It was detected via NDA and visual observation. Sometimes it was detected by instrumentation.

INCIDENTS/UNUSUAL OCCURRENCES

Accidental releases and equipment repairs often lead to injuries and excessive exposures, which resulted in burns and respiratory complications. Workers often went home with contaminated clothing, because they were never warned of the dangers.

The K-1401 Motor Shop was the place you went to when you wanted something fixed. K-31/33 was another location for motor repairs. When they tore down these motors, there were all kinds of yellowcake powder (ammonium diuranite) that fell out and piled up to 1-inch thick. Folks, however, did not stir up too much dust. No one wore respirators in these areas. In the motor shop over a 7-year period, over 600 motors were brought from K-31 and K-33 process buildings to K-1401 for repairs or preventative maintenance. The motors were not repaired in the process building, but only in K-1401. These Motor Shops were the most up-to-date motor repair shops in the Eastern United States.
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Motors were then taken to a degreasing tank, and would come back nice and clean. The starter and rotor would be dipped in cleaner to remove the oil and grease. Then they would use cranes to lift them into a spraying booth. At this point, workers would don their respirators. They would use plant compressed air with water running in from the back to clean the parts. After they dipped the parts, they would dry it with plant air. At that point, a HP would come in and the instrument would peg. So he got another and it pegged, too.

There was a means of documenting incidents and/or non-routine occurrences. The Information Corrective Actions Tracking System (ICATS) was used to document such occurrences. The interviewees assumed that any dose received and reported could be traceable. In terms of off-normal situations, IH didn't monitor for personnel radiation exposures, but focused on monitoring for chemical and physical agents.

Not much could be recalled on the threshold for incident reports. It was assumed that such thresholds were the maximum permissible concentrations (MPCs) or the DACs.

The interviewees indicated that there are databases compiled of incidents at K-25, and they felt that this data is generally available through the QA Group.

In 1981, there was a converter fire in the K-29 Building. A lot of workers were involved. Phosgene gas was released. There was crossover in the respirator air input line and the worker started breathing pure nitrogen.

Transformer fires occurred at K-1420. When one transformer blew, it was so extensive an explosion that it blew out the sides of the containment fence.

One interviewee reported that there were releases of airborne uranium in K-1131, but they were not particularly high.

The biggest concern for internal dose involved an airborne release and inhalation of uranium.

There was an incident in Building K-1200 (the Centrifuge Building). In a room that was lined with lead sheetrock wall, the door was not properly secured, and the source beam got past the leaded door and hit a meter on the desk of an HP worker.

There was a dumpster fire in K-1037. Building K-1037 housed the AVLIS Program. ORNL personnel brought over a uranium sample to use in the AVLIS project. After use, they threw it into a dumpster for disposal, and the uranium oxide caught fire.

In the northwest corner of K-1420, they burned contaminated clothing in an incinerator. This area often had a lot of radiological "hot" spots.

The documentation of incidents and/or non-routine occurrences in the early days often meant reporting it to the Plant Shift Superintendent (PSS). One interviewee remembers being at a PSS morning meeting (sunrise service) called when he was informed that there had been an incident. He immediately went over to see what had happened. Such incidents were recorded in logbooks. These logbooks are no longer around in the local work areas and are likely over in Archives. A look through these log books would provide some interesting reading, and would reveal a lot about what releases occurred and the contamination levels involved.

Incidents and/or non-routine occurrences were logged into logbooks, maintenance records, safety reports, quarterly reports, etc. These records are maintained in active and inactive records, at least those that are left. Clean-up operations were conducted after the incident as much as was necessary to remove the contamination.

Documentation of off-normal situations (e.g., spills) documentation depended on the person spilling the materials or witnessing it.

ICATS is the system that records incidents and unusual event reports. This may include survey or field data, or formal incident reports. If there are issues associated with personnel exposure, that data that will find its way back into the individual worker file, as well as the dose determined for the individual. Where the only data comes from an area monitor but individuals received no dose, the information would not get into the worker's individual file. Such non-routine files exist back to 2001.

One group of interviewees indicated that there were plenty of fires and explosions at K-25. Another interviewee indicated that there were not too many fires or explosions. One interviewee advised that if more information is needed on fires, the Fire Department should be consulted. He indicated that they keep good records. But the interviewee did not remember any specifically. The big fire in his career was the K-29 converter fire.

There was one fire in K-33. A transformer blew and the fire storm blew off the door panels of the transformer. One interviewee said he was close to it, but he was leaving when it happened, just saw it, and was not hurt.

An additional report on off-site emissions is a report, entitled *Oak Ridge Health Studies, Phase I, Feasibility Study, A Summary of Historical Activities on the Oak Ridge Reservation*, published in April 1993 (Copy not provided during the K-25 Site Visit.) This includes information concerning off-site emissions of hazardous materials. It was published by Chem Risk (A Division of McLaren and Hart). It can be ordered by writing to 113 Atlanta Avenue, Alameda California, 94501.

There was a fire in the K-31 ventilation ducts in the 1972–1973 timeframe. These ducts supplied fresh air to all areas of the K-31 operating floor. Over the years, waste oil had accumulated in the air ducts, and during a job that required the use of oxygen/acetylene torches, oil in the ducts caught fire. The ventilation fans blowing fresh air through the ducts caused the oil fire to spread smoke throughout the building. The oil in these ducts was PCB-contaminated. Workers breathed this contaminated smoke. After 2 days, there was fallout detected in Berea, Kentucky, over 100 miles away.

There were fires at the K-25 Site in K-25, K-315, K-310 (took the roof off the building), K-29, and K-413. In K-413, a worker cut the wrong pipe and the resulting fire created a glowing chuck of metal.

In K-335, a hole was opened in a compressor and a fire ball (C-fire) ensured that took the roof off. This C-fire involved three cells with release of CF_3. The explosion was created by a spark that came out of the cell.

AUDITS

Internal DOE audits began in the 1980s. In the late 1980s, Tiger Team Audits were conducted at K-25. Nuclear safety concerns hit the fan in a big way in 1989 as Admiral James Watkins, then the DOE Secretary, initiated a rapid tightening of the regulations and radiation safety controls. It was pointed out that in more recent years, DOE has conducted an audit of the Health and Safety program at K-25 every 2 years. There were routine audits internally at K-25, as well as those done by DOE.

There was a recent DOE Inspector General audit of records that began in January 2006 and is still ongoing. It involved looking at how things are being done now in the bioassay program (i.e., are bioassays being done and are we DOELAP-accredited).

The interviewees stated that the K-25 Site did not destroy any safety-related records in the past.

Procedures and documents were available to workers who were expected to enter radiological contamination areas, chemical areas, and/or physical hazard areas.

ENVIRONMENTAL DOSE AND MONITORING

Environmental Dose

In the 1970s, there was no monitoring done on stack releases. Incidents at Paducah finally alerted the K-25 Rad Safety staff that these needed to be monitored. It wasn't until the late 1980s or even the early 1990s before stack monitors started to do a good job of monitoring stack releases. At this point in time, the Rad Safe staff put up air monitors and began to do water sampling.

If a worker needed to purge a cell, he had to vent it out the stack.

If waste drums became full in the decontamination facility, construction engineers would just dig a pit and bury the waste there on site. Some of the liquid coming out of the cylinders also had to be drained into these ponds and it reacted with the water. There were lots of this type of radioactive waste and no record kept of what was used. For many years, this waste was not labeled and no one tracked where it was going. If it involved the R&D facilities, we didn't ask, and they would say, "Let's try this," and we did it.

From 1963–1993, if a piece of equipment or part was needed, workers would just cut them out, not knowing if they were contaminated or not. This didn't change much until monitoring started in the late 1980s.

One interviewee remembered a hands-on operation involving uranium at the K-770 radiation waste yard. A compressor, with only a canvas cover on each end, was being loaded onto a truck. The compressor was covered with a tarp. It was taken to K-1420 Building where something hit it and waste water from the compressor drained into columns at the bottom of the K-1420 Building. In Building K-1401, it was later disassembled and then put back together again.

Another incident remembered involving hands-on operations with uranium involved a K-25 Site known as the "Valley of the Drums." This disposal area never worked very well. Workers would take sediments and put them into drums. When the drums later rusted, they began to leak.

In the 1970s and 1980s, there was little effort to monitor releases from the K-25 Site incinerators. In these early days, whatever was thought to be capable of being burned was incinerated. It wasn't until the TSCA Incinerator was completed and received its certification that monitoring of the incinerator releases became much more closely controlled and monitored.

Environmental Issues

The Pond Waste Management Program ensured that pond waste areas were posted with air monitors. If Rad Safety personnel detected elevated levels, they would investigate the source of the problem.

The incinerator in K-1421 had few controls in the early days, and anything that could burn was incinerated there.

There were a few minor incinerators in operation over time at K-25. The interviewees all presumed that these were used for waste materials. The TSCA Incinerator was the major one at the K-25 Site.

The interviewees did not have much to offer on any situations where a major environmental release occurred at the site that resulted in an evacuation.

There was a problem with cross connections of potable and process water lines (e.g., K-1401), which was discovered in 1986. Sr-90 and Cs-137 were detected in the drinking water as a result of contamination with process water. The company made an announcement that personnel were not to drink the water. Pregnant women were further instructed to wash their hands. Bottled water was brought in to serve as drinking water. The problem was resolved by a change in the engineering design of the system. Around the same time period, plastic covers were put over drinking fountains in the process areas.

There were routine releases on a weekly basis as a result of purging the cascades. The process buildings had a 30-ft stack. On humid nights, the off gas from the stack would flow downward to the ground adjacent to the building. Off gas could be seen up to ¾ of a mile away. As a result of these releases, some of the buildings' roofs were found contaminated (e.g., K-25, K-31, and Pump Station).

There are underground and street-level steam lines running between the buildings. Cooling towers, as well as manholes, often released steam. The manholes were positioned on the sidewalks, where workers often walked during breaks and/or lunch.

TSCA was originally designed to handle low-level radioactive waste, but was expanded to include other toxic materials and mixed wastes.

K-25 had numerous disposal areas and burial grounds, including the areas near K-631, K-1007, K-1070A, and K-1420. K-770 was a dumping site for contaminated debris. There were several waste ponds located onsite containing radioactive and chemical waste. Barrels with waste were stored on the east side of the K-25 plant.

Radionuclides identified in the outside areas of K-25 include uranium, technetium, strontium, cesium, thorium, and plutonium. These are related to the releases over the years including airborne releases and spills. Material has contaminated the waterways. A few cases of contaminated deer are identified each year, when deer are monitored after hunting. The deer are monitored for surface contamination, as well as deposition of material in their organs.

In 1984, there was a fire in Building K-29 that resulted in a large release to the atmosphere. Workers recall the plume was yellowish in color.

Due to the large number of operations and facilities at K-25 over its entire period of operations, and due to incomplete records, the interviewees felt some potential hazards may not have been identified.

Hundreds of accidental releases of UF_6 and other hazardous materials probably occurred, often resulting in releases to the environment. Some contaminants may have migrated offsite.

There were broken windows in the process buildings.

Environmental Monitoring

Pre-1970s, there was little environmental monitoring performed. Environmental monitoring reports started in the late 1970s and increased through the 1980s.

There are currently 6 to 8 air monitors around the K-25 Site. The Annual Site Environmental Report (ASER) tells exactly where these air monitors are positioned. Some of the more current of these reports (within the past 10 years) can be viewed on the web at http://ornl.gov/sci/env_rpt. As a general observation, most current environmental monitoring is done for compliance (environmental regulations and DOE Orders) and to properly record dose to public (as opposed to employee exposure). This is based on data from the mid-1980s on. There is not much historical data prior to that.

The 2006 Annual Environmental Monitoring Report is very similar to the 1995 Annual Environmental Monitoring Report. Not much has changed during these years. An individual was assigned as the interface to ORNL UT-Battelle (UT-B) who had the responsibility reservation-wide to develop the Oak Ridge Reservation Environmental Monitoring Plan and the annual report. This interface manager is one of Bechtel Jacobs's Environmental Compliance and Protection Leads assigned to ETTP. A female manager at ORNL is in charge of the reservation-wide environmental monitoring program. She is the Program Manager and is responsible for preparing the Oak Ridge Reservation Annual Environmental Report.

In the earlier years, Lockheed Martin pulled all the site environmental monitoring data together into the annual environmental monitoring reports. Now, ORNL UT-B Environmental Compliance on behalf of the DOE Oak Ridge Reservation Environmental Compliance office coordinates the reservation-wide reporting, trending, and dose assessments. The ORNL UT-B Program Manager is interested in dose assessments and any important environmental changes at all the Oak Ridge sites. ORNL UT-B Environmental Sciences Division oversees the environmental data/fish populations in Mitchell Branch, in accordance with a subcontract with BJC. Improvement has been noted within Mitchell Branch over the past number of years. Most environmental monitoring currently is done for environmental compliance (e.g., to meet the

NESHAPs level of 10 mrem/year and DOE Order 5400.5). Main effluent charges are currently below the decontamination guidelines (DCGs) and are compliant with DOE Order 5400.5.

BJC environmental compliance, BWXT-Y-12 Plant environmental compliance, and the UT-B ORNL Program Manager work together to develop the reservation-wide environmental monitoring plan in support of the DOE Federal Building environmental compliance staff. Permit-required monitoring has changed over the years. For example, prior to the mid-1980s, there were only three outfalls on the Y-12 NPDES permit. Today, there are probably over 200 outfalls being monitored at Y-12.

After 1998, Bechtel Jacobs beefed up the radiation safety and industrial safety/hygiene program.

The Tennessee Department of Environment and Conservation/DOE environmental oversight office (TDEC DOE Oversight) handles overview and reporting mostly offsite, and monitors dose around the cylinder yards.

Environmental monitoring stations located on the K-25 Site have stayed about the same over the years. ORNL also manages some monitoring stations around the K-25 Site for use in the reservation-wide reporting.

Significant Episodic Releases

There have been two episodic releases in the past several years that involved activation of the Emergency Operations Center (EOC). In the early 2000s, there was a small fluorine release. There were no reportable quantities, according to the Environmental Protection Agency (EPA) standards, and the EOC was involved in the response. The State EOC was also involved. In 2004, there was also a Na release at a site managed by a reindustrialization tenant (TOXCO). Again, the emergency response effort was handled by the EOC.

There have been no substantial spills of radioactive materials, at least during the Bechtel Jacobs period of operations. There was an incident that occurred about 2003, when some radioactive material was released on a public roadway while transferring waste from ONRL to the EMWMF. The roadway had to be closed until it could be resurfaced or decontaminated. There have been periodic thermal relief vent openings at the TSCA Incinerator typically caused by power failures, but releases from these events are very low.

From a historic perspective, there may have been other releases at the site such as UF_6, but the interviewees had no first-hand knowledge of these events. K-25 doesn't currently monitor for hydrogen fluoride.

In the recent past, the highest reportable dose to the public was 2–3 mrem from site radionuclide air emissions. This is compared to the EPA standard of 10 mrem/year (air pathway) and DOE standard of 100 mrem/year (for all pathways).

About 2–3 years ago, there was an incident that involved the release of more than a reportable quantity (greater than 1 pound) of asbestos that fell from insulated piping.

Routine Environmental Releases

NESHAP requires monitoring if a point source's potential emissions exceed 0.1 mrem/year. The ORR ambient air-monitoring program converts air concentration data into dose to demonstrate that a member of the public will not receive dose from the release of unmonitored and fugitive emissions. There is no real-time monitoring for folks outside the site near such releases.

During D&D operations, there is, of course, potential for releases. The HP personnel have been able to show that these doses are not significant, and these low levels are confirmed through the Environmental Compliance ambient air monitoring stations. Any environmental accidents are reportable under NESHAP as well. NESHAP is based on dose to the members of the public. At the TSCA Incinerator, they do a full sweep and monitor for all radionuclides that make up nearly 100% of the total dose that might occur.

Control of Environmental Releases

HP data is used to estimate fugitive releases from buildings that may occur through building ventilation systems. Area monitors are used to detect radionuclide concentrations inside the buildings. If the concentrations exceed 10% of the DAC, emissions from the building are calculated using the measured concentrations and the building ventilation rates.

Types of sampling done include TLD monitoring near cylinder yards, water monitoring, air samples, stack samples, and groundwater samples. From this data, dose calculations are performed.

Before waste is brought onto the site for incineration, it must be analyzed to the waste acceptance criteria. This analysis can cost as much as $50,000 per shipment coming in.

TSCA Incineration currently uses state-of-art stack monitors. Stack sampling is done isokinetically. However, in D&D areas, there are no stack monitors, because the emissions are fugitive in nature. Ambient air monitors are used to demonstrate that fugitive emissions are not significant.

TSCA Incineration operations are highly regulated. The TSCA Incinerator over time has gotten a lot of scrutiny.

RadCon does not routinely calculate environmental doses. They do calculate doses to workers from employee monitoring. The interviewee's work scope addresses potential dose to the public and insuring compliance with regulations. RadCon addresses worker exposures.

There are aerial fly-over surveys conducted periodically that can be used to identify hot spots.

External environmental radiation levels are/have been monitored, and the TDEC DOE-Oversight Office also collects external radiation data.

Disposal criteria have changed over time at K-25. Prior to the early 1980s, rad wastewater went into ponds that were later buried. Currently, wastewater has to go to a NPDES-permitted or RCRA facility and be actively monitored. Solid D&D waste goes to DOE Environmental Management Waste Management Facility (EMWMF) (onsite CERCLA disposal cell) and the Y-12 landfills. Most incinerator ash is inorganic. Most legacy waste at the K-25 Site is now gone.

Audits and Environmental Compliance Reviews

Bechtel Jacobs gets at least nine TDEC Inspections per year. The inspections include Resource Conservation and Recovery Act (RCRA), the Clean Air Act, and the Clean Water Act. There are also DOE audits that are done periodically. The TDEC DOE Oversight Team also conducts walkdowns onsite on a periodic basis. The TDEC also monitors offsite releases to the public, as well as some TLD measurements around the cylinder yards. The TDEC DOE Oversight office reports to the Environmental Enforcement office in Knoxville, Tennessee. There is also a Site Specific Advisory Board that monitors the environmental programs in Oak Ridge, including ETTP.

INDUSTRIAL HYGIENE/CHEMICAL EXPOSURES

The K-25 safety organization did interact with subcontractors when they came on site. The IH group had the responsibility to monitor their activities. Safety issues were enforced and IH was aware of what was going on. IH coverage was during the day shift only, but they were on call, if needed. Dosimeters were distributed to employees by the HP organization, and the dosimeters were exchanged quarterly. Finger dosimeters and other types of dosimeters were issued for individuals working in specialized activities as needed for monitoring purposes.

Periodically, professional assistance was provided to other Oak Ridge, Paducah, and Portsmouth sites. For example, some K-25 industrial hygienists were sent on loan for short periods of time (1–2 weeks) to assist with assessments and provide subject matter expertise. While away from the site, K-25 Site radiological dosimeters were worn. Some of the K-25 workers were also lent out to work primarily at either X-10 or Y-12, and rarely at Paducah and Portsmouth.

Over the years, K-25 in some situations received assistance and support for health and safety professionals and craft labor fromY-12 and X-10.

All IH interviewees reported that their job responsibilities took them all over the K-25 Site. Their jobs usually did not involve radioactive materials, but they were measured and monitored. Health Physics did ensure that they were monitored with uranium bioassay. They worked mostly with toxic substances and non-radiological materials. The interviewees of the IH Group reported that the radionuclide program at the K-25 Site was managed by the HP Group. In regard to a question about uranium being handled in the immediate vicinity of beryllium, the interviewees stated that beryllium was rarely used at the K-25 Site, primarily as a part of a metal alloy in some specialized equipment parts.

The IH personnel did not do radiation monitoring. The HP Group did the radiation monitoring in those situations.

Beryllium was a problem at K-25. Beryllium was stored in K-25 in the early days. All of the compressor blades used in the Process Compressors were alloyed with beryllium. During the "tipping" operation, where the compressor blades were machined to specified size, machining dust from this operation migrated throughout K-1401. Workers developed chronic beryllium disease (CBD). There was also a beryllium problem in K-701, where there was a pile up of beryllium powder. A beryllium prevention program was started in 1995–1996. Today we know of six workers who have chronic beryllium disease and 23 are sensitized.

Lapel/breathing-zone air monitoring was the primary method for industrial hygiene sampling.

There were very few real-time monitors to detect airborne radiological contaminants in the early days.

Chronic beryllium disease was long fought at the complex. Now DOE at K-25 recognizes the problem, and has designed a program to detect and diagnose beryllium among current and former workers.

MAINTENANCE/CRAFTS/UTILITIES

Maintenance work involved compressors, valves, seals, machines of all kinds, and working in and on gaseous diffusion process equipment and systems; also repair, removal, and replacement of pumps, pipe lines, and all types of mechanical equipment in air, chemical, process, sewer, sanitary, and cooling water systems inside, outside, and atop of most of the buildings on the K-25 Site. Exposures included radiation (internal and external), especially uranium and its daughter products; and a plethora of chemicals, dusts, fumes and mists. K-25 was involved in hundreds of different research programs and projects other than enriching uranium. Maintenance mechanics were closely involved in fabricating, installing, and maintaining equipment used by various scientists in carrying out their research.

K-25 and K-27 enriched uranium to greater than 20%. As a result, maintenance workers were required to have an escort when entering these areas.

Firemen and security guards sometimes went into radiation areas without their TLDs on. Sometimes they missed being monitored by urine bioassay. Firemen and security guards did wear respirators in some areas, but when a guard showed up, he may not have had a respirator with him. They usually did wear at least a dust mask, coveralls over their street clothes, and booties. When they took their coveralls off, however, they did not shower. In K-1420, there were showers that were regularly used. Construction workers were one of the biggest problems.

Crafts personnel had the greatest tendency to move around a lot.

Security guards and firemen provided coverage to the entire site and, therefore, could have entered any building. Maintenance personnel were shifted between Oak Ridge sites, depending on the work and their seniority.

Building K-1401 was the Machine Shop. It included the Jig and Fixture Shop and the Converter Shop. When working on the converters, one interviewee reported that there was a "scarfing off from the welds" and contaminated materials during this process went airborne. Workers were often sitting in those areas eating and drinking, dressed out in coveralls. There were contamination release episodes. This material was released in K-1401 in the Converter Shop. Equipment was sent over from K-1420 for machining in the K-1401 machine shop. At this point, there was no visible or removal contamination on the surface that did not exceed 2 mr/hr.

Painters wore respirators and used gloves. They needed the proper safety gear. They painted over contamination on floors with magenta paint. In K-1301 (Nitrogen Plant), there is a large area painted with magenta paint, and signs are posted that read "Do Not Disturb."

Maintenance personnel worked in all buildings throughout the K-25 Site protected areas and also worked outside the facility fence line, such as at the Power Plant and the Central Water Plant.

There were always high expectations to maintain production quotas. If an individual was assigned a task for a defined time and didn't complete it on time, he was told it would be written up and reported.

Routine and corrective maintenance were conducted on storage tanks, motors, pumps, etc. Maintenance personnel were often involved in retrofit activities that were done as frequently as daily on the cell equipment. For example, compressor seals had to be replaced very often.

Respirators used by maintenance personnel were equipped with dust filters.

There were additional shops and maintenance offices in K-131.

Filter changes of the air-handling system, because of inherent radiation hazards, required job coverage by Radiation Monitors.

After working on jobs with high-exposure potential, maintenance personnel were reassigned to a cold area for a period of time.

Maintenance personnel often accessed areas that were normally inaccessible to production workers. For example, when a compressor de-bladed, a hole was often cut in the piping, and maintenance personnel crawled into the pipe to retrieve the metal pieces.

DOSIMETRY RECORDS

General

K-25 records are filed by system number, but they only go back to 2001. These documents are searchable sometimes back to 1989. Hardcopy files are maintained in the library of K-1007. They are still in the process of collecting records as facilities onsite are being closed out. The library is archiving inactive files. Pre-1989 records during the era of Lockheed Martin have been sent to the St. Louis National Archive.

Bechtel Jacobs has computerized records that can be searched electronically. Bechtel Jacobs's electronic system has tried to pull together all payrolls, medical, IH, and radiation-related files into one database.

Individual worker radiation exposure files are maintained by the Dosimetry Department, and are filed by SSN and case number. There is restricted access to these personnel radiation exposure files. Hard copy data is available back to 2001. Electronic dosimetry information is available back to 1989. Records prior to 2001 are located in archives. Some have been sent to the Federal Records Center. It was explained that if an individual has been employed at the K-25 Site for a continuous period of time and did not have a break in employment of more than 5 yrs, then there is hard copy data for them. Unfortunately, records were archived a few years back for individuals who had not been here for more than 5 yrs or were deceased.

If an individual worked at either Y-12 or ORNL prior to Bechtel Jacob's contract, and then took a position with Bechtel Jacobs or one of their sub-contractors, then the records prior to Bechtel Jacobs stayed with the site. All records after Bechtel Jacob's contract were Bechtel Jacob's. If the individual was at K-25 and remained at K-25, then all electronic records were maintained by BJC.

Bechtel Jacobs took control of the site in 1998. At this time, there was a large shuffle of employees between X-10, Y-12, and K-25. It is important to be aware that an individual's exposure records on the K-25 Site only contain information from K-25. If they worked at the other facilities, records would also have to be obtained from these facilities.

USEC workers are monitored by USEC under their own Radiation Protection Program (RPP). Separate requests are required to obtain dosimetry information for these individuals. The first year that USEC came back to this site, they were monitored by Bechtel Jacobs. Bechtel Jacobs's management did not want to pay for their Dosimetry services, so they made DOE force USEC to work under their own RPP. At that time, they subcontracted with UT-Battelle for Dosimetry services (2004).

When NIOSH requests the records for an EEOICPA claimant, the following records are provided:

- All hard copy records – this includes what is in the worker's dosimetry file.
- These are delivered to C.J. Enterprises.
- There is gap in data in the 1996–2000 timeframe, and we can't find these records. These are the records for the old Decontamination Recovery System (DRS) in the old K-1420 building. These records were maintained in a DRS Database that had data, but we no longer have access to that system of records.
- All internal dose files.
- All external dose files.
- All hard copy records pertinent to the individual.

There are no dosimetry records contained in the Medical records.

Radiological Exposure Records

Shallow dose currently is just beta/low-energy gamma (neutron dose is included if an individual had neutron dose). It has been that way since the late 1980s. Beta is determined from the open window but some is taken from the open window, and the slightly shielded area. There are very few neutron dosimeters processed at K-25. Up to the late 1980s, the shallow dose was equal to the beta plus photon dose. Deep dose was the sum of the photon and neutron dose.

Field radiological records consist of air-sampling data, surveys, log sheets, and other field data. Manual surveys are stored by month, year, and survey number. There is now an electronic database used to maintain survey data.

There are very few records of extremity monitoring. Multiple dosimeters were not generally used at K-25. There are some extremity badges, but these are only issued when special experiments are being undertaken.

Pocket Ionization Chambers (PICs) were used at K-25, and can be filed either with the RWP or on manual log sheets in the personal dosimetry records. Manual login sheets are not in the Dosimetry Records.

There is incident exposure data that includes internal dosimetry data, external dose data, and contamination data.

The same system of records is maintained for subcontractors as are maintained for K-25 workers; however, we only forward any dose received by a subcontractor if a request is made to the K-25 Records Manager. Everyone monitored by Bechtel Jacobs receives an Annual Report of their dose. That includes sub-contractors, as well as Bechtel Jacobs' employees.

Health and Ecology records fall under the CJ Enterprises responsibility, and are stored at Central records.

Subcontractors are treated the same as all other employees with regard to monitoring. These records are maintained for the subcontractors at K-25 and are only provided upon request. Visitors are also monitored per the same criteria as employees. One difference with visitors is that prior dose history is not requested for these individuals. Visitor dosimetry has to be requested by the onsite person hosting the visitor.

Union Carbide left all records at the site when they ended their contract.

Field radiological records may be stored in the records vault at Building 1034A; however, many of the older records were shipped to the Federal Records Center in Atlanta. The records were not organized in any specific manner and would be difficult to find. K-1034-A is the inactive records vault. The active records vault is in K-1007.

Emergency Management documented fires and kept records in the 1980s and 1990s.

One interviewee said he always wore his film badge and later his TDL got exposed, but he never got a report on his radiation/contamination exposure in the early days. Currently he does get an annual report summary of his radiation exposure history.

Another interviewee indicated that Emergency Management should have good records on who responded to emergencies/incidents. The Fire Department also has logs on their response to incidents.

Y-12 took over the old ANALIS laboratory database from the K-25 Labs for analytical samples prior to Project Environment Management System (PEMS) coming on board.

In regards to a question about field characterization data, one interviewee responded that this was too big a question. There is much radiation data in the historical records, and numerous radiation survey reports and summary reports. RadCon has much of it, but there's been a lot of it archived in K-1034. Some of it may have been sent to Inactive Records offsite.

One interviewee indicated that K-25 has lost Maintenance Records, Maintenance Work Orders, Engineering Service Orders, many logbooks (maintenance, operations, laboratory, safety, etc.), and big bunches of drawings.

MEDICAL EXAMINATIONS

K-25 employees were offered the opportunity to get an annual physical along with a chest x-ray, which could be declined on an individual basis. The Medical Department informed the workers of any health concerns.

Workers were given routine annual physicals, which included a chest x-ray. Bechtel stopped the program in 1998. Medical services were reduced, except for emergencies or first aid. This was a management decision. Other DOE contractor sites in Oak Ridge continued full onsite medical coverage.

Workers did receive annual physicals with a chest x-ray. In addition, their respirator was fit-tested and x-rayed at the same time. Hazmat/Asbestos workers received a chest x-ray twice a year; one time during their annual physical and another one 6 months later. They were not sent offsite to get their chest x-ray. The x-ray machine was mounted, so that the worker stood against the wall. The bucky system made a noise, so you knew when the unit was in operation. The same x-ray machine was used each year.

If you were an asbestos worker, you got a chest x-ray during your annual physical, and another chest x-ray 6 months later. The asbestos testing was based on the Electrical Code. In 1979 and 1980, the K-25 Site had to do asbestos fireproofing on 17 miles of underground cable, thus resulting in more potential for asbestos exposure. They would use a glove bag to take the asbestos off the rolls.

Workers were periodically called over to Medical and asked to have a whole-body count. This started in the early 1990s, but it was pointed out that not everyone had whole-body counts performed.

X-rays were also given for respirator fit testing.

Due to switching between K-25, Y-12, and X-10, medical records sometimes were not always centralized in one place. This was somewhat due, as well, to outsourcing mandates by DOE. Since 1989, when Bechtel Jacobs took over, medical records have been maintained and stored in Building K-1007.

Workers got a physical examination each year, where you received an annual chest x-ray. One interviewee only remembered getting a physical with a chest x-ray once every 2 years. It was pointed out that much later, the interval for a chest x-ray became less frequent, depending on the age of the worker. In addition, if you were in jobs that required a respirator, you also got an x-ray fit test at the same time as the physical examination. Asbestos workers currently are not site employees – this work is done by contractor employees.

One interviewee remembered going to the Medical Department twice, one time when he punctured his glove and the other when he caught his finger on a hook.

One interviewee reported that he had an annual medical physical examination once each year, including a chest x-ray. The other interviewee said he received an annual physical only once every 2 years. This latter interviewee said that he did not wear a respirator, and did not get a chest x-ray for respirator fit testing. He did verify that those in the respiratory protection program did an x-ray for their fit test, as well as a chest x-ray, during their annual physical examination. After age 40, workers got 1 chest x-ray per year. As the new regulations were issued in the late 1980s, there were fewer chest x-rays done.

Another interviewee recalled receiving a medical examination with chest x-ray annually. Medical also did do x-rays for fit testing. In 1989, Bechtel Jacobs scaled down the Medical Program. Emergency personnel do, however, continue to receive annual medical examinations. Nurse practitioners now try to do many of the things that physicians used to do, but their scope is much more limited.

A physician interviewee, who had been the physician at K-25 in the past, established the minimum physical requirements for the K-25 Site when he was staff physician. He carried those requirements with him to Concentra, and is using most of the same programs that he used at K-25.

For the early years at K-25 (1946–1989), medical exams were done every year for radiation workers and included a chest x-ray. In the early years, physical exams were optional, but most workers felt it was a good program and had regular annual physicals. One interviewee stated that at K-25 from 1987 to the end of 1998, HazMat, Asbestos, Respirator, and other program physicals were required physicals, whereas personnel not enrolled in these programs were offered voluntary physicals. The offering of voluntary physicals may have been withdrawn at a later date, as the Medical Program had been scoped down to meet the realities of DOE mandates and funding levels for the K-25 Medical Program. The minimum requirements established, according to more recent guidelines, call for a chest x-ray once every 5 years for workers under age 40, and every 3 years after age 40.

No interviewees could remember having lumber spine x-rays as a screening exam.

If there were injuries onsite that needed x-rays, they were done onsite. If they needed a specialist, they were referred to the Oak Ridge hospital or a private physician.

HazMat physicals were more intense and required additional medical testing.

X-rays were also done for asbestos workers and beryllium workers. The schedule for chest x-rays for asbestos was as follows:

- Every 5 years for ages 15–30
- Every 2 years for ages 35–45
- Every year after age 45

One of the interviewees stated that one or two K-25 workers have been diagnosed with berylliosis, though he could not remember how that diagnosis was made. B-readers were used for backup reading of x-rays for persons on the Asbestos program. ONRL did the LPTs—they used both the National Jewish and University of Pennsylvania laboratories. If a worker got a positive on his/her LPT, they were sent to a specialist to diagnose for CBD.

Security guards and Security Inspectors had stress electrocardiogram (EKGs) done routinely.

The medical department personnel indicated they saw very few contaminated workers – maybe 1–2 per year.

One interviewee noted there were reported problems with Tc-99 getting matted in the hair of a worker. In this case, they had to use scissors to cut the Tc-99 matted material out of a worker's hair. Medical personnel who needed to decontaminate workers did so in a designated building and wore Tyvac suits. Contaminated workers were surveyed prior to and during decontamination efforts.

None of the interviewees could recall the need to treat any skin burns due to exposure to Tc-99.

Acid burns were not frequent, but did occur rarely. There was one situation where a worker was brought in with an irritated eye, due to exposure to hydrogen fluoride. There were also some skin irritations from hydrogen fluoride and nitric acid.

Medical Records

Chest x-rays taken at K-25, as well as other x-rays for asbestos and respirator fit testing, are maintained in charts still stored in K-1007 for current Bechtel Jacobs employees back to 1989. This included pre-employment physicals and annual physical exams.

Medical charts for workers in the 1940s to 1960 may have been microfilmed. After 40 years, such medical data can be put into retirement.

MEDICAL X-RAY PROCEDURES

General Medical X-ray Policy

For many years, workers got an annual physical with a chest x-ray. It was a voluntary program, but was well received by the K-25 workers. HAZWOPER workers were required to get an annual physical.

Before Bechtel Jacobs took over in 1989, the Medical Department did non-occupational x-rays at the request of the worker. It was considered better to keep the worker onsite at his job than to send him to his physician offsite. These were always recorded and kept in their records.

For asbestos and beryllium workers, an initial pre-employment physical was required; and if an active worker, an annual physical with chest x-ray each year. If they were inactive workers, they got a chest x-ray every 36 months. If they became sensitized to beryllium, they went on a different physical examination schedule. The latter was true if they developed CBD.

Full-face respirator x-rays were done on workers who needed fit testing on an annual basis.

Some pre-employment examinations were done at Medical Methodist Health Works downtown in Oak Ridge to take some of the load off the K-25 Medical Department. Some x-rays were done at the Oak Ridge Methodist Medical Center (MMC), particularly if there were serious injuries involved.

At K-25, PA and LAT x-rays were always done. This was also true at ORNL. At Y-12, however, they only did a PA film.

An age test later was recommended. If the worker was less than 45 years of age, he/she received a chest x-ray only once every 2 years. After age 45, a chest x-ray was done annually.

X-rays were taken for other occupational reasons. The K-25 Medical Department did some injuries that were thought to be occupationally related. These injuries, however, were few (maybe 2 injured/week) and usually involved just fingers, toes, and sprained ankles. If there were minor injuries onsite that needed x-rays, they were done onsite. If the injuries were serious, the worker was sent to the Oak Ridge Hospital for their x-rays. If they needed a specialist, they were referred to the Oak Ridge hospital or a private physician.

HazMat physicals were more intense and required additional medical testing.

Retakes were minimized as much as possible. The retake rate at K-25 was monitored closely and was kept at a level that was considered the acceptable norm for the industry.

Only one patient was allowed in the x-ray room while having the x-ray taken. The technician closed the door to the room before taking an x-ray, and she stood behind a lead shield when taking the x-ray.

All chest x-ray films are maintained in the individual's medical record.

Calibration of the X-ray Machine

The HVL for the x-ray machines was measured by a known, licensed, and respected health physicist.

X-ray Machines Used at K-25

1947–1987: Westinghouse XM Machine with a manual collimator that needed to be set. This machine was inspected annually under the FDA contract, until the agreement between FDA and DOE dissolved.

1987 to Present: Bennett D-5251 Unit with a Eureka Tube (Inovision Model 4000) with an automatic collimator. X-ray output is 500 mA, but it is run at 300 mA. It was explained that 300 mA is stronger than 500 mA.

Both x-ray machines were reported to function well by the K-25 medical x-ray technologist.

The processor and film developer have continuing maintenance to keep them clean. If the retake rate looks abnormal, they would do an additional cleaning prior to taking more x-rays. They have an outside contractor come in monthly to clean the processor and film developer.

Inspection/Certification of the X-ray Machines

In-house inspections have been done on the x-ray machine being used at K-25 at least since 1977. A medical health physicist checked the Westinghouse XM machine until 1987. The machine was inspected twice a year. They would be provided a report showing the mR readings, which were about 17 mR reading in air at 10 mA and 60 kVp, and up to 154 mR mrem/film at 20 mA and 120 kVp. These values are part of a known, respected, and certified health physicist medical x-ray unit Inspector memo to the K-25 medical x-ray department dated April 20, 2006. The HP would check their techniques to see if the mR was where it was supposed to be.

The medical department provided copies of the *Radiation Protection Survey of X-ray Equipment at ORGDP* dated January 3, 1977, and certified by the certified health physicist medical x-ray unit Inspector, which indicates that the survey was being done semi-annually.

The backup documentation of what was provided during the interviews with the medical department personnel is available in a backup PDF file, if needed.

The surveys, done by a certified health physicist, included a survey of medical x-ray units, exposure in air data, and entrance at skin data provided for various x-ray examinations.

Once a year since 1990, a certified health physicist was brought in as an outside inspector. This was necessary, since the HP staff at K-25 was being reduced as a result of the end of production of the plant in 1985.

Retake rates have been inspected since 1985.

The medical department provided copies of the reports of some of the x-ray unit surveys.

mm Al used

The mm of Al used were within specifications. The maximum kVp used was 125 kVp. The mm of Al was based on the kVp setting according to the following rule, which was demonstrated on a 5/9/06 Year 2000 Medical HP Survey Sheet done on the K-25 x-ray machine:

- 3.0 mm Al - 60 kVp
- 3.5 mm Al – 80 kVp
- 4.6 mm Al – 100 kVp
- 5.8 mm Al – 120 kVp

After 1985, the x-ray films were looked at even more carefully than in the past. The films were now read by a radiologist downtown, and they dictated the retake rate.

In the mid 1990s, x-rays were also done for asbestos workers and beryllium workers. The schedule for chest x-rays for asbestos was as follows:

- Every 5 years for ages 15–30
- Every 2 years for ages 35–45
- Every year after age 45

NIOSH Visit to the K-25 Site

NIOSH spent 2 weeks at the K-25 Medical Department complex. “The purpose of their visit was to obtain historical information on the medical surveillance program at the site since the early 1940s.” The information, it is stated, “will be used to help estimate active bone marrow doses the workers may have received during routine x-ray examinations of the chest and lower lumbar regions during their careers at the site.” They went into the Records Vault in K-1034. They told the medical department personnel that they could tell the voltage used and how much the dosage was by looking at the x-ray films. They tried to determine if claimants could have gotten a higher dose than reported. Their visit is documented in a July 14, 1999, report sent to the

Medical department. NIOSH contractors were working on the exposure assessment portion of a then-current NIOSH Multiple Myeloma case control study.

Medical Records

Chest x-rays taken at K-25, as well as other x-rays for asbestos and respirator fit testing, are maintained in charts still stored in K-1007 for current Bechtel Jacobs employees back to 1989. This included pre-employment physicals, and annual physical exams.

Medical charts for workers in the 1940s to 1960 may have been microfilmed. After 40 years, such medical data can be put into retirement.

UNION AND SAFETY CONCERNS

Union Health and Safety Representatives interface with all levels of workers, managers, health and safety professionals, and experts (both internal and external to the site) in industrial safety, industrial hygiene, and health physics.

The Union's Worker Health Protection Medical Screening Program assists in obtaining medical exams for former and current K-25 employees, and with follow-up help with compensation claims. Several hundred of these people are eligible for state workers compensation, as well as EEOICPA compensation, as a result of their exposures to radiation and toxic substances at K-25.

Supervisors generally described a "good man" as one who kept his mouth shut around the safety people, and did not ask questions! It should be remembered that DOE told their contractors that they didn't want to see incidents; especially involving contamination exposures. The contractors made every effort to "clean up" and carefully wordsmith ALL reports going to the DOE.

COMMUNITY AND HEALTH CONCERNS

Some interviewees were told that the K-25's Centrifuge Workers Study reported that the incidence of bladder cancer among workers is 7 times higher than the general population. Other studies showed 84 cases of Multiple Myeloma, significant increases in lung cancers, non-malignant diseases of respiratory systems, and cancer of the large intestine. The centrifuge workers were supposed to have medical screening for the rest of their lives; but since Lockheed Martin is no longer operating K-25, several interviewees felt that DOE has not imposed that screening be completed by the new contractor.

A copy of a July 26, 1945, memorandum (Close 1945) includes a report of concerns by one K-25 employee that radioactive exposure is the probable culprit of occupational diseases, including nephritis, and raised the employee's concerns of legal implications.

The interviewees did not remember a K-25 Site employee's newsletter, but there was an employee's Energy Systems and Union Carbide newsletter that was sent to each K-25 worker's home address. Another interviewee indicated that there is a PDD Daily report, and that there were weekly or monthly publications for the employees in the 1980s.

An interviewee indicated that she has been supportive in setting up the Coalition for a Healthy Environment, the Alliance for Nuclear Workers Advocacy Groups, and the Oak Ridge Communities Allied, and has advocated for sick workers.

During the period of 1999–2004, a contract with the Community Partnership Center at the University of Tennessee had existed. Oak Ridge Communities Allied was awarded a technical assistance grant by the United States Environmental Protection Agency to study clean-up issues, and specifically the re-industrialization program at the K-25 Site in Oak Ridge. About 25 of the then K-25 Site workers were interviewed, and an analysis of site documents was completed. The completed document was published, but not released, in May 2004. A copy was provided during this interview for use by the SC&A K-25 audit team. A reference is cited for this document at the end of this interview summary.

One interviewee noted that at various times, they may have entered areas where workers were required to use booties, safety shoes, and safety glasses without PPE equipment being used.

One interviewee was concerned that they may have been exposed to cyanide at K-25. A group of 80 people, both from K-25 and in the community of Oak Ridge, similarly felt that they had suffered potential cyanide poisoning and were the instrumental group that formed the Coalition for a Healthy Environment. All of them reported high urine thiocyanate levels during the period of 1995–1996.

In 1995 at K-25, a sewer relining project was underway that used a hot blast of air to cause the lining to adhere to the walls of the old sewer. This process caused a cyanide gas compound to be released into the atmosphere. Upon request from the workers, NIOSH came to perform a Health Hazard Evaluation (HHE). K-25 Plant Management had new radiation signs erected to preclude anyone from going into certain areas. Hence, NIOSH was prohibited from performing a complete investigation. The University of Alabama was brought in to review the situation and found the HHE lacking.

It was noted that according to a report completed by the PACE union, that in K-1037, there is a high risk of exposure to nickel and mercury. Also, because of the development work on circuit boards in K-1037, there could have been exposures to gallium. An interviewee also reports exposure to gadolinium.

Radiological Exposure

One interviewee recalls a situation where they turned off the monitors for the TSCA incinerator because the alarms had been going off too frequently. In the early years, workers were not monitored consistently (mostly external doses) and workers were never monitored for exposures to anything but radiation.

An interviewee recalled that after 1992, some workers who were not wearing PPE, went into sites where pollution prevention projects were underway. When the interviewee was on the site, it was customary to use just booties, eye protection, a hard hat, and safety shoes.

At ORNL, an interviewee saw workers loading low-level waste into containers, and those watching were not wearing PPE.

Radiation Monitoring

One interviewee indicated they did have a TLD badge, but stated that it was only changed once a year. The interviewee stated that they did go into the cylinder yards and the fluorination areas, where there is a potential for high gamma dose. They were instructed to wear their dosimeter above the waist. It was reported that they received an annual dose report that always showed "zero" exposure to any radiation. The interviewee never had a respirator assigned.

An interviewee reported that they did have change rooms and showers in K-1037. They were allowed to eat, drink, and smoke in the kitchen, and anywhere in K-1037 or the entire site.

One interviewee noted that they had no training in HAZWOPER or radiation safety. They reported that they only had the TLD changed annually while at K-25.

Environmental Characterization

From 1994 to 1996, a great deal of environmental characterization occurred at the K-25 Site. They used dye in wells to trace the flow of groundwater contamination.

Worker Death

There was one fatality on the K-25 Site that involved a foreman who insisted on doing a job himself, realizing that it was a hazardous situation. He was working on a rack during lunchtime and fell to his death.

SECURITY

Security Policemen (SP) at K-25 were responsible for the physical protection of the entire facility. SPs were responsible for protecting sensitive and classified assets, including assignment to close in patrols and verification of integrity. This required the physical presence of the SP at the asset location, which potentially exposed SPs to hazards associated with the location. The responsibility of the job required access all around the K-25 facility (e.g., process buildings, laboratories, dump sites, incinerators, support buildings, and areas immediately surrounding the site). SPs at K-25 worked on a rotating shift basis, along with a rotating assignment schedule.

Tactical drills often required that SPs go into areas not normally occupied by employees (e.g., the pipe gallery). These areas were not known to be decontaminated prior to entry. SPs entered these areas to get the best line of site view for the exercises. SPs from K-25 were often assigned to drills conducted at Y-12 and X-10.

There was a common firing range used by security personnel from X-10, Y-12, and K-25 on Bear Creek Road. Among the activities that took place at the range was the purging and blowing up of discarded UF_6 cylinders. There was also a burial site at this general location. Duratek, a private entity, also operates a Hazardous Waste Processing Area adjacent to the range.

Security personnel were often called upon to respond to emergencies and incidents at the facility and around the site. They provided asset protection when necessary, traffic control, and people control during this time. During the initial response phase, SP were often very close to the incident.

Security personnel also routinely visited other DOE sites while on special assignments. For example, if a guard union went on strike at one DOE site, K-25 security staff may be relocated to replace the striking staff. Some of the sites visited by those interviewed included Y-12, X-10, RFP, Hanford, Nevada Test Site (NTS), Paducah, Portsmouth, Sandia, and Pinellas. These assignments could last a few days up to months. While on temporary assignment, they essentially performed the duties similar to their regular duties at these sites. Some security personnel worked with subcontractors prior to being hired by the site contractor (Union Carbide).

There was no requirement for frisking in and out of areas prior to the 1990s. The site was not managed to control the spread of contamination. For decades, when workers, including SP, had a need to leave a hazardous work zone, they simply left without any controls in place, thereby creating the possibility of spreading contamination into support areas of the plant, such as the cafeteria, medical, and administrative areas. As a result, administrative workers were often also exposed to the same hazards to which the process workers were exposed.

SPs were required to wear uniforms in order to have access to weapons and to be allowed unrestricted movement capabilities. There were some areas where SPs only wore their uniforms, while other workers were required to wear protective clothing. For decades, SPs changed into their street clothes while storing their contaminated uniforms in the same locker. If not soiled, uniforms may be reused for multiple shifts. Many wore contaminated shoes home. Showers were optional for SPs at the end of the shift.

Prior to the mid-1990s, there was some random urine sampling provided for Security personnel. For other non-security workers, bioassay could be collected as frequently as weekly. One individual recalls submitting a urine sample after banging his head while responding to an alarm in a radiological area. He was told to drink plenty of water and come back in 1 week for re-analysis.

Those SPs interviewed received only a single-body count during their entire time at K-25.

Dosimeters were assigned to patrol. However, the Security personnel believe that only some badges were processed for those workers defined by Health Physics to be the most exposed workers (e.g., K-1420 personnel). Security personnel felt their badges were selected and read on a random basis.

The PPE has changed over time at K-25. Personnel originally used half-face respirators, which were carried into the process areas in a duty bag. Respirators were reused more than once.

Filters were not always approved for the contaminants to which they were potentially exposed. Full-face respirators were also used for some jobs.

One of the interviewees indicated he noted an absence of 10 years of dosimetry records in his individual dosimetry file.

SAFETY HAZARDS

K-25 was involved in several activities that exposed workers to chemical hazards. Trichloroethylene (TCE) and rags were used as a cleaning agent. Although the workers wore gloves, they were not effective at keeping the TCE from getting on the skin.

Maintenance personnel were exposed to beryllium while grinding the metal.

MFL oil was used in Building K-413 to trap contaminants, because of its high density and consistency. The use of this oil resulted in evacuations of specific buildings as frequently as daily for a period of time.

The acids used in K-1131 caused etching in the building's windows.

K-1413 was involved in experimental work using a wide variety of chemicals. Some of the work was done for X-10.

There were incidents associated with the internal portion of the fluorine generators exploding. This required that the internal portion of the unit be removed and reworked.

Other hazardous chemicals found at K-25 include mercury, asbestos, picric acid, motor oils, Hexavalent Chromium, PCBs, dioxins, and acids, to name a few. Biological hazards were identified in cooling water.

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ATTACHMENT 3: KEY QUESTIONS AND RESPONSES FOR NIOSH/ORAU REGARDING SITE PROFILE DOCUMENTS

SC&A submitted questions related to the K-25 Site Profile Documents to NIOSH on November 9, 2006. The NIOSH/ORAU team provided written responses to these questions on December 13, 2006. Both the questions and responses have been provided below. A summary of the conference call conducted between SC&A and the NIOSH/ORAU team with regard to these questions is available in Attachment 4.

Responses to SC&A Questions for the K-25 Site Profile Document –
Introduction TBD, ORAUT-TKBS-0009-1
Site Description TBD, ORAUT-TKBS-0009-2
Occupational Medical Dose TBD, ORAUT-TKBS-0009-3
Occupational Environmental Dose TBD, ORAUT-TKBS-0009-4
Occupational Internal Dose TBD, ORAUT-TKBS-0009-5
Occupational External Dose TBD, ORAUT-TKBS-0009-6

Planned revisions of these documents will include additional information collected since the publication of this TBD and any applicable information that comes from NIOSH responses to SC&A questions.

ORAUT Answers to Key Questions
Regarding the K-25 Site Profile
December 13, 2006
[Questions submitted by the SC&A review team, November 9, 2006]

GENERAL QUESTIONS

(1) Please clarify when dose from the Naval Nuclear Propulsion Program is included in a dose reconstruction. For example, would the following be included:

(a) DOE employees working on NNPP tasks;
(b) Non-DOE employees working on a DOE site on NNPP tasks;
(c) Subcontractor employee working on a DOE site on NNPP tasks.

Response *- The statute includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition contains an exclusion with respect to the Naval Nuclear Propulsion Program, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to* *the Naval Nuclear Propulsion Program. As a result, all internal and external dosimetry monitoring results are considered valid for use in dose reconstruction.*

(2) Were classified records considered in the site profile development? If so, what were these documents?

Response - *No classified documents were reviewed prior to the development of the K-25 Site Profile.*

(3) Is there a classified version of the site profile?

Response - *No, a classified version of the Site Profile was not developed.*

(4) In general, what areas could not be included in the TBD for National Security Reasons? How were these compensated for in the TBD?

Response - *Specific procedures and descriptions of process equipment were not available for review in unclassified documents. Details about the separation of uranium isotopes and the equipment used to enrich uranium 235 were not available to develop the Site Profile. However, personnel exposure to ionizing radiation, both internal and external exposure, was documented using the technology and criteria approved for that period of time. There was sufficient information to establish radiation exposures for personnel working with classified materials. The current Site Profile addresses what is believed to be the major contributors to exposure, but as additional information becomes available and modifications are warranted, the Site Profile will be revised.*

(5) Is any of the work history, medical or radiation exposure data for claimants classified? Are claimant files being redacted for national security reasons?

Response – *We are not aware of any claim files that are classified or being redacted for national security reasons.*

(6) The TBDs have mentioned several times that the TBD has addressed Worker Outreach comments. Please provide SC&A with the contents and respective NIOSH responses.

Response – *These are located in Attachment A.*

(7) Which TIBs are used to supplement the TBDs in the dose reconstruction process?

OTIB-0002, Maximum Internal Dose Estimates for Certain DOE Complex Claims
OTIB-0018, Internal Dose Overestimates for Facilities for Air Sampling Programs
OTIB-0020, Use of Coworker Dosimetry Data for External Dose Assignment, 2004.
OTIB-0035, Internal Dosimetry Coworker Data for K-25, 2005.
OTIB-0026, External Dosimetry Coworker Data for the K-25 Site, 2006.
OTIB-0052, Parameters to Consider When Processing Claims for Construction Trade Workers, 2006.

(8) With whom did NIOSH conduct site expert interviews during the development of the site profile? Please provide the names of individuals.

***Response** – Contributions on internal dosimetry, external dosimetry, and medical exposures were incorporated based on discussions with current and former staff. These contributions are referenced in the Site Profile.*

(9) What types of claims have been evaluated to date? Without a complete dataset, how is NIOSH/ORAU sure the doses are bounded?

***Response** – Cases with both monitored and unmonitored workers have been evaluated with numerous cancer types. The analysis performed to generate OTIB-0026, OTIB-0035 and OTIB-0052 support that the doses are bounded.*

(10) How has NIOSH/ORAU verified the completeness and accuracy of the data provided by K-25 Site?

***Response** - The Site Profile was developed using documents that were developed by K-25 and reviewed by the DOE. When available, multiple documents were referenced to provide consistency.*

(11) How have you integrated site expert input into the TBD?

***Response** – Contributions on internal dosimetry, external dosimetry, and medical exposures were incorporated based on discussions with current staff. These contributions are referenced in the Site Profile.*

SITE DESCRIPTION (ORAUT-TKBS-0009-2)

(1) Explain why the Site Description did not address the cascade improvement efforts at K-25.

***Response** – From review of the available literature it appears that the cascade improvement efforts continued over much of the operating life of the K-25 facility. It appears that these efforts were part of the ongoing activities at the site. If significant events within the cascade improvement effort are identified which have the effect of causing significant unmonitored dose which isn't otherwise addressed by the site profile, it will be included in a document revision.*

(2) Has NIOSH identified any special projects or facilities that handled other radionuclides than those handled in the uranium enrichment and recycling processes?

***Response** - Other projects were mentioned in Worker Outreach meetings. However, no definitive documentation was found during data capture to detail other activities. It is assumed that uranium was the primary source of exposure. Impurities in recycled* *uranium are also addressed, and a Tc-99 campaign was included in the internal dose coworker OTIB.*

(3) NIOSH discusses the U:TRU activity ratios in several sections. Is this referring to the total TRU activity or that of a specific TRU radionuclide? If this is total TRU activity, NIOSH ought to identify which TRU radionuclides make up this group.

***Response** – Section 5, Occupational Internal Dose, Table 5-6 lists the default isotopic distribution.*

(4) Should NIOSH be identifying ^{242}Pu as one of the TRU radionuclides in the facility?

***Response** - Pu-242 is identified as being present at K-25 in Table 5-5 of ORAUT-TKBS-0009-5.*

(5) $^{242/244}$Cm are listed in Table 2-1, but not discussed as being in any of the facilities discussed. Please explain.

***Response** – Although reference to $^{242/244}$Cm was not found specifically in the documents researched for K-25, it is a contaminant of recycled uranium. It is provided in the table to give the dose reconstructor an assumed solubility type if it is referenced in a worker's records.*

OCCUPATIONAL MEDICAL DOSE (ORAUT-TKBS-0009-3)

(1) What type of special medical chest x-ray examinations have been documented in the individual medical record and are included in the K-25 worker's occupational medical dose?

***Response** - No special medical X-ray examinations have been noted in the individual medical records for K-25. Per 42 CFR 81 and 82, the only occupational medical dose eligible to be included in dose reconstruction under EEOICPA is dose from x-rays that were required of employees, as part of medical screening and surveillance programs. The Occupational Medical TBD addresses organ dose from these procedures, and these procedures only, as prescribed by 42 CFR 81 and 82.*

(2) If the individual medical record and CATI do have specific information on the frequency, reasons for and type chest x-ray, how is NIOSH/ORAU handling the assignment of dose when it is evident that these types of chest x-rays were commonly being given?

***Response** - [The responder infers that "do NOT have" is meant in the first line of this question.]*

Section 3.2 in the TBD states, "The reconstruction of occupational dose should include all occupational X-rays according to the frequency listed in Table 3-1 unless the individual-specific frequency is known and is more frequent than that in Table 3-1." This *is the approach taken when a dose reconstructor uses an "overestimate" approach in the dose reconstruction. When a "best estimate" approach to the dose reconstruction is necessary, the actual x-ray records are requested from K-25, if not already provided, and used for X-ray dose assignment. K-25 has been responsive to such requests. These approaches are documented in Procedure 61, Occupational X-ray Dose Reconstruction for DOE Sites.*

(3) Did worker's have dose estimates in their medical records for chest x-rays taken for respiratory protection, beryllium work, asbestos work, food handling and, radiographic operations?

Response - *No dose estimates from X-rays are included in the records provided by the K-25.*

(4) Table 3.1-2 (Turner 2004 – pg. 9) indicates that during the period from 1944 to 1945 some uranium dust workers were getting chest x-rays monthly and during the period from 1946 to 1959 every few months. What is the default number (i.e., 12) for uranium dust workers when there is no evidence in their medical record that this many chest x-rays were given. Likewise, how is NIOSH handling chest x-rays every few months for those uranium dust workers from 1946 to 1949?

Response - *[The responder believes that the question refers to Table 3-1 (not 3.1-2) at the beginning and to 1959 (not 1949) at the end.]*

Section 3.2 in the TBD states, "The reconstruction of occupational dose should include all occupational X-rays according to the frequency listed in Table 3-1 unless the individual-specific frequency is known and is more frequent than that in Table 3-1." K-25 usually provides the actual x-ray records with the individual dosimetry data. The dose reconstructor assigns dose from the X-ray examinations found in the medical records. If the actual records indicate that monthly X-rays were not provided, then dose from monthly exams is not assigned.

(5) How is NIOSH/ORAU assigning dose for K-25 workers who worked with uranium dust? How are these uranium dust workers differentiated from other workers to ascertain whether to assign annual or more frequent x-rays?

Response - *This response addresses only the medical dose for uranium dust workers.*

Because there has been no indication in the medical records of X-rays provided on a monthly basis, an assumption has been made to assign X-rays on an annual basis and to request actual records when there is a question as to the appropriate X-ray frequency. As mentioned previously, K-25 usually provides the actual x-ray records with the individual dosimetry data, and they are responsive to requests to provide it, in case they did not to begin with.

(6) If some workers received more chest x-rays than Table 3.1-1 (Turner 2004 – pg. 9), how is this being determined? Is there any other evidence of frequency other than the individual medical record and the CATI and are such workers assigned dose for these more frequent x-rays?

Response - *There is no documentation or other indication that chest X- rays were given more often than according to the frequencies shown in Table 3-1. In any case, doses would be included for all such examinations shown in an individual's medical or other personal records.*

(7) The Occupational Medical Dose TBD (Turner 2004 – pg. 4) states that "…chest x-rays were no longer required for non-radiation workers after 1950…" Have the individual medical records of non radiation workers been reviewed to validate this?

Response - *In the citation, the year is 1959, rather than 1950. This has not been validated; however, a claimant favorable approach has been used to assign annual X-rays unless the actual records indicate a lesser frequency.*

(8) The Occupational Medical Dose TBD (Turner 2004 – pg. 5) states that "The K-25 site used only the conventional PA chest X-ray technique for routine examinations after the early 1950s…" Up until what time are K-25 workers, who received PFG exams, being assigned the higher dose associated with PFG examinations?

Response - *See response to item 10, below. Until the end of 1956, the higher PFG doses are to be assigned in the absence of information to the contrary. As evident from Table 3-3, the organ doses for PFG examinations are considerably higher than the other values.*

(9) Will subsequent updates of the K-25 Site Occupational Medical Dose TBD incorporate the additional new information in OTIB-0006 (Kathren and Shockley 2005) and will the 3.0 rem/PFG exam be utilized in determining dose for K-25 workers in the period up to the early 1950s?

Response - *In effect, for the pre-1970 time period, the TBD is almost entirely consistent with OTIB-0006 (Kathren and Shockley), which was available and consulted in advanced draft form prior to its issuance. The site specific documented skin entrance kerma, 2.488 cGy, for the K-25 PFG exams (Table 3.2-1) was utilized in the TBD rather than the generic default value 3.0 cGy from OTIB-0006. (ORAUT-OTIB 0006 was developed to provide default values for entrance kerma and organ doses when specific X-ray machine data from a site was either not available or suspect.)*

(10) The Occupational Medical Dose TBD (Turner 2004 – pg. 7) states that "The type of X-ray machine was probably recorded, so organ dose can be extracted directly from Table 3.3-1." Has the NIOSH/ORAU review of the claimant's individual medical record documented that this is indeed the case and if not, what other documentation has been found to establish this?

***Response** - As stated in the TBD along with the above quotation, Cardarelli (2002) estimates that, from 1944 to 1956, when both machines were in use, 86% of the examinations were performed with GE KX-10 PFG exposures. If the medical record does not identify which machine was used, the claimant-favorable assumption would be that it was the GE KX-10. This is consistent with a recommendation given (p. 18) in Winslow 2006 (ORAUT-PROC-0061). In most cases, the individual medical records do not include the information to ascertain the type of X-ray machine used, and the latest revision of the TBD (2006) does not contain the statement quoted above.*

(11) How is NIOSH/ORAU handling the assignment of dose for upper GI fluoroscopy and lumbar spines done on some K-25 workers?

***Response** - Per 42 CFR 81 and 82, the only occupational medical dose eligible to be included in dose reconstruction under EEOICPA is dose from x-rays that were required of employees, as part of medical screening and surveillance programs. The Occupational Medical TBD addresses organ dose from these procedures, and these procedures only, as prescribed by 42 CFR 81 and 82.*

Evidence has not been found to indicate that upper GI (UGI) fluoroscopy exams were performed for medical screening at K-25, nor does the relative infrequent occurrence of UGI exams in the K-25 worker records support the indication that UGI fluoroscopy was used for medical screening. Lumbar spine exams, however, are well known to have been performed for medical screening of certain groups of workers, and OTIB-0006 provides guidance for the assignment of lumbar spine doses, should they be indicated in the workers' medical record to have been performed for medical screening (i.e. not for work related or personal injury).

(12) As noted in the discussions with NIOSH/ORAU regarding ORNL workers, does NIOSH/ORAU still plan to limit occupational medical exposure to pre-employment, annual, health monitoring examinations and termination chest x-ray examinations except for some lumbar spine examinations in the 1950 to 1953 timeframe and to include all other exposures (including screening examinations) as part of worker non-occupational medical dose?

***Response** - Per 42 CFR 81 and 82, the only occupational medical dose eligible to be included in dose reconstruction under EEOICPA is dose from x-rays that were required of employees, as part of medical screening and surveillance programs. The Occupational Medical TBD addresses organ dose from these procedures, and these procedures only, as prescribed by 42 CFR 81 and 82.*

(13) Can NIOSH/ORAU provide more definitive information to establish beam quality for x-ray units used for K-25 worker chest x-rays?

***Response** - Beam-quality assignments in the TBD are probably reasonable, especially for later times. As pointed out above (question 9), the pre-1970 organ doses are close to the* *claimant-favorable default values in OTIB-0006. Beam quality appears to be adequately established.*

(14) Has NIOSH/ORAU been able to find documentation to support the assumed techniques and protocols applied to calculate the dose for K-25, which is mainly derived, in general, from ICRP Publication 34 (ICRP 1982)?

Response *- Use of the dose conversion factors (DCFs) in ICRP Publication 34 (ICRP 1982) is a widely accepted method of x-ray dosimetry, once entrance kerma and half value layer are known or can be reasonably estimated. NIOSH has used "substitute" DCFs from ICRP Publication 34 (ICRP 1982) in some circumstances when it can be reasonably postulated that actual conditions at DOE sites were such that substitute DCFs were warranted. For example, it can be reasonably postulated that x-ray beams prior to about 1970 were not as well collimated as the beams in 1982 when ICRP Publication 34 (ICRP 1982) was published, meaning that additional organs were likely to have been irradiated in a poorly collimated x-ray beam. The K-25 TBD and OTIB 0006 both assume a poorly collimated beam prior to 1970, and use substitute DCFs to account for this. The substitute dose conversion factors are chosen (and documented in ORAUT-OTIB 0006, 2003 and 2005) to include more organs in the primary beam than would be the case for a properly collimated beam.*

OCCUPATIONAL ENVIRONMENTAL DOSE (ORAUT-TKBS-0009-4)

(1) The K-25 Occupational Environmental Dose TBD (East 2006, pg. 7, Section 4.2, Internal Dose from Onsite Atmospheric Radionuclide Concentrations) states the following.

> *…Unmonitored workers can be exposed to occupational doses internally from onsite releases to the air and from the resuspension of radioactive materials in soil, and externally from ambient radiation and releases of radioactive noble gases to the air.*

There is no other mention of noble gases elsewhere in the TBD. Is this a generic statement or has NIOSH/ORAU identified radioactive noble gases that may have contributed to the external dose of unmonitored workers?

Response *- There was a potential for the presence of noble gases released after the processing of recycled uranium. The exposures that were evaluated in Chapter 5 of the K-25 TBD were associated with the presence of transuranics, including neptunium and plutonium and mixed fission products including technetium. There was no specific evaluation of noble gases rather the pathway for exposure from noble gases was external radiation and the assignment of external exposure to unmonitored workers. External exposure to monitored workers was evaluated using the external dosimetry available in the claim files.*

(2) The K-25 Occupational Environmental Dose TBD (East 2006, pg. 7, Section 4.2.1, Onsite Release to Air) states:

…A calculation was performed using well-documented source terms developed for the Oak Ridge Dose Reconstruction (ORDR) (Burmeister 1996, 1997, Burns 1997), coupled with some documented environmental monitoring data, to estimate radionuclide-specific airborne concentrations for $^{234, 235, 238}$U, $^{238, 239, 240, 241, 242}$Pu, ^{237}Np, and ^{99}Tc (Shonka 2003). These radionuclides were determined to account for the majority of the potential missed dose from inhalation and submersion pathways.

By comparison, the K-25 Site Description TBD (Szalinski 2006, pg. 7, Section 2.2, Site Activities and Processes) states

…Process operations primarily resulted in ^{234}U, ^{235}U, and ^{238}U contamination. Characterization of the recycled uranium included in the Recycled Uranium Mass Balance Project Oak Ridge Gaseous Diffusion Plant Site Report indicate the primary contaminants incident to the recycled uranium are technetium-99 (^{99}Tc), neptunium-237 (^{237}Np), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), $^{239/240}$Pu.

Has NIOSH/ORAU considered including ^{241}Am as a contaminant of concern for potential missed dose?

Response *- As described in Chapter 5 of the K-25 TBD, the potential exposure to various isotopes in recycled uranium were evaluated. While several isotopes were potentially present, the major contribution to radiation dose was associated with plutonium and neptunium. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

(3) The air concentrations used to calculate annual intakes for the included contaminants of concern are provided at the 50th percentile. By comparison, the K-25 sister facility (PGDP) has provided maximum reported air concentrations to calculate annual intakes. Has NIOSH/ORAU considered the difference in these two approaches? Is the use of the 50th percentile air concentration values claimant favorable?

Response*- The environmental data provided in the K-25 TBD were derived source terms calculated for the Oak Ridge Dose Reconstruction (ORDR) by Burns and Shonka. Results from the air monitoring stations were modified to account for dilution and an estimate of maximum ground concentrations. In short, the use of the 50th percentile result is considered to be a claimant favorable approach given the modifications required to convert the data into a useful representation of potential radiation dose. In contrast, the results at PGDP required fewer modifications and were considered to be more representative of potential exposure to unmonitored workers. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

(4) Is there any wind study data (wind rose) to support the use of the environmental monitors chosen for maximum ground level concentrations? Where is the administrative area (Figure 4-1, pg. 8) in relation to the identified release points?

Response - *There was no wind study data available at the time of the development of the environmental dose for the K-25 TBD. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

The administrative area was a significant distance (more than 2,000 meters away) from the air monitoring stations depicted in Figure 4-1. For that reason, the results from the monitoring stations were modified to address potential dilution and estimate the maximum ground level concentrations. A description of the modifications is provided in Section 4.2.1 of Chapter 4 of the TBD.

(5) The K-25 Occupational Environmental Dose TBD (East 2006, pg. 8, Section 4.2.1, Onsite Releases to Air) states:

> *…To provide a conservative estimate, environmental monitors were chosen that were adjacent to the K-25 Site and generally located in upwind and downwind locations relative to release points. These were where maximum ground level concentrations from the site would occur.*

Has NIOSH/ORAU considered that an upwind location would provide release data and ground-level concentrations that are lower than those observed at the downwind location and not be conservative or claimant favorable?

Response - *It is not clear that this potential situation has been considered. This TBD should be revised to clarify that the downwind sampling locations be given primary consideration when determining environmental occupational dose. Also, given the new documents that are available for K-25, it may be appropriate to update this chapter.*

The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.

(6) Has NIOSH/ORAU taken into consideration acute or episodic releases (other than uniform releases) that might contribute to missed internal or external dose of the unmonitored worker?

Response - *No. As described in Section 4.2.1, source terms were established using the reports published by the ORDR in 1997. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

(7) The K-25 Occupational Environmental Dose TBD (East 2006, pg. 11, Section 4.3.1, Ambient Radiation) states:

> *…The ORR Annual Environmental Report for 2003 (DOE 2004) reports a dose from the K-25 cylinder yards to a nearby parking area at 4.75 mrem/125h (75 mrem/200h).*

Has NIOSH/ORAU considered that doses received by unmonitored workers working near the cylinder yards would be potentially higher than doses measured in the parking area?

Response *– Access to the cylinder storage yards was limited and the parking lot represents the closest location where unmonitored workers may visit. Workers assigned to work in the cylinder storage yard were monitored. For the purposes of unmonitored workers, the exposure in the parking lot is a claimant favorable assumption.*

(8) The K-25 Occupational Environmental Dose TBD (East 2006, pg. 11, Section 4.3.1, Ambient Radiation) states:

> *…Uranium cylinder storage yards remain the only significant source of external exposure at K-25. Surveys in cylinder yards at the sister plants show dose rates up to 200 mrem/2000h.*

The PGDP Occupational Environmental Dose TBD (East 2006, pg.12, Section 4.3 External Dose) states:

> *…Unmonitored workers in the early years did not have significant inventories of depleted uranium to contribute to external dose. Later, unmonitored workers would not spend their entire work year at the depleted cylinder yards and, therefore, would not reach the maximum dose recorded by fence line monitoring. No other significant sources of external exposure are associated with the PGDP operations. An assumed deep dose equivalent rate of 200 mrem/yr for all years would be reasonable, and deficiencies in earlier measurement techniques thereby become immaterial.*

The recommended 200 mrem/2000h for PGDP is quoted yet 75 mrem/2000h is used as the recommended external dose from the uranium cylinder yards for K-25. Has NIOSH/ORAU considered the difference in these two approaches? Is the use of the 75 mrem/2000h claimant favorable?

Response *- The assumptions for potential external exposures at PGDP may not be applicable to the potential exposures at K-25. It is not clear that this potential situation has been considered. This TBD should be revised to clarify the potential for external exposures to unmonitored workers given primary consideration when determining environmental occupational dose. Also, given the new documents that are available for K-25, it may be appropriate to update this chapter.*

(9) The background gamma radiation levels provided in Table 4D-4 of the K-25 Occupational Environmental Dose TBD (East 2006, pg. 21) are those reported at the two perimeter ORGDP stations, HP-33 and HP-35. Has NIOSH/ORAU considered that doses to unmonitored workers working outside buildings might receive doses higher than what are reported at the site boundary?

Response - *There is a potential that unmonitored workers received an external dose higher than those reported at the site boundary. This TBD should be revised to clarify the potential for external exposures to unmonitored workers given primary consideration when determining environmental occupational dose. Also, given the new documents that are available for K-25, it may be appropriate to update this chapter.*

(10) Note that for estimated air concentration data used to calculate intakes, the distance was adjusted (reduced) to account for intakes near the release points. Has NIOSH/ORAU considered performing a similar exercise to account for ambient radiation doses to unmonitored workers outside of buildings within the site boundary?

Response - *As stated in Question 9, there were no modifications of the external dose to unmonitored workers; the radiation dose reported by the perimeter monitors was used for the potential environmental exposures. This TBD should be revised to clarify the potential for external exposures to unmonitored workers given primary consideration when determining environmental occupational dose. Also, given the new documents that are available for K-25, it may be appropriate to update this chapter.*

(11) Did a Cascade Improvement Program or Cascade Upgrade Program exist at K-25 similar to that at PGDP resulting in releases that may have contributed to unmonitored worker internal and external dose?

Response - *Information about the changes to the K-25 Cascade were not available at the time that Chapter 4 of the TBD was developed. It is possible that the changes to the cascade may have contributed to the radiation dose of the unmonitored workers. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

(12) What exposure routes are included in the dose reconstruction for environmental dose (e.g., stack releases, direct exposure, soil resuspension, etc.)?

Response - *As described in Chapter 4 of the TBD, the pathways for exposure are inhalation and external exposure. Source terms were used from the ORDR to estimate the environmental airborne concentrations and the basis for potential exposure to unmonitored workers.*

(13) How did NIOSH define the site boundaries verses the site fence line?

Response - *As stated in Section 4.2.1, the monitoring stations were located at the boundary of the Oak Ridge Reservation, approximately 2500 meters from the center of the K-25 plant. The K-25 site fence line is generally less than 100 meters from the process buildings.*

(14) Which environmental results are in K-25 reports and which are in ORNL reports?

Response - *There were no environmental results specific for K-25 available at the time that the TBD was developed. The estimate of source terms for K-25 were published in the ORDR and modified to estimate the potential exposure to unmonitored workers. The current TBD addressed what is believed to be the major contributors to exposure, but as additional information becomes available and if it indicates modifications are warranted, the TBD will be revised.*

(15) Please explain why NIOSH has concluded that air concentration levels were not associated with releases from other than K-25 operations?

Response - *It is likely that the air concentrations detected at the reservation boundary were the combination of K-25 as well as other Oak Ridge operations. There was no defensible manner to segregate the releases from K-25 from the other operations at Oak Ridge. In a manner that was claimant favorable, it was assumed that all activity detected at the monitoring stations was associated with K-25.*

OCCUPATIONAL INTERNAL DOSE (ORAUT-TKBS-0009-5)

(1) How will NIOSH review the bioassay database for accuracy (verification and validation)?

Response – *ORAUT-RPRT-0022, Analysis of Electronic Personnel Exposure Data from Y-12, addresses the issue of Y-12 data, which are maintained in the same database as K-25 data. While K-25 data are not specifically verified in this report, they are mentioned in the document because many people worked at both facilities. The report also states that a similar analysis (to that done for Y-12) will be performed for the K-25 data. This analysis is pending.*

(2) For bioassay of radionuclides that occur naturally (uranium, thorium, etc.), how will NIOSH handle the determination of the occupationally contributed component in the bioassay sample in a claimant-favorable manner? Should the average background for the population be used or an individual specific background (if available)? Is the average value the most appropriate to use or the –1 standard deviation (σ) value for background subtraction?

Response - *When assessing intakes based on uranium urinalyses, our standard procedure has been to assume that the entire result is due to occupational exposure because of the* *large variability in the natural background and its dependence on personal habits (such as drinking water source) of the individual. No background subtraction is performed.*

(3) Is NIOSH going to investigate if there is any site-specific airborne radionuclide particle size analysis data available (determination of actual activity median aerodynamic diameters) that will result in more claimant-favorable assessments?

Response *- Particle size distributions are generally specific to operations and physical conditions in the locations where work is performed. It is not reasonable to assume a measurement of particle size in one location is universally applicable to other locations. Therefore, as instructed in Section 5.4 of the TBD, a particle size assumption of five (5) micrometer AMAD is assumed by the dose reconstructors unless there is site-specific information to the contrary.*

(4) NIOSH does not identify any use of radionuclide intakes for medical intervention in the TBD. This infers that there were no major radionuclide intakes requiring medical intervention in the history of the site. Does NIOSH plan to investigate this further? How will NIOSH handle dose reconstruction for any workers that had medical intervention treatments for minimizing internal dose?

Response *- The primary nuclide of interest at K-25 is uranium. DTPA is not approved for use for mitigating uranium intakes. Sodium bicarbonate can be used; if noted in the claimant file the dose assessment would take this into account.*

(5) No information on radiological surveying, air sampling data, use and evolution of applied air concentration limits / action levels, or use of respiratory protection are discussed which would give information on the radionuclide air concentrations and surface contamination that workers could have been exposed to. Has NIOSH reviewed any monitoring data and respiratory protection program information to determine if it has any usefulness in the internal dose reconstruction effort?

Response *– The dose reconstructions use individual monitoring data as the primary method of evaluation because it is more representative of a given individual. Because uranium has a long half life, just a few measurements are adequate to approximate the exposure, provided there are results through the end of employment. There is a coworker study that spans most of the history of the site (recent years have not yet been modeled); if it is determined that additional information is necessary, area monitoring information will be reviewed.*

(6) NIOSH states that there are no incident reports where there was a potential for internal doses available. Does NIOSH plan to do a thorough search of the incident information available in order to identify as many incidents with internal dose significance as possible to assist the dose reconstructors? Incident reports often provide very useful information for accurate dose reconstruction.

***Response** - Section 5.7 of the TBD acknowledges that no incident information is currently available. The CATI provides another opportunity for claimants to give information on incidents. As incidents are identified, they may be captured in future revisions of the TBD.*

(7) Has NIOSH reviewed any contamination monitoring (air and/or surface) that may have been done in areas around the perimeter of airborne and surface contamination areas to determine if workers in these areas may have had intakes at some frequency without being participants in bioassay?

***Response** - This issue is addressed in K-25-4, "Occupational Environmental Dose."*

(8) Has NIOSH identified any ^{226}Ra or ^{228}Ra sources of significance handled in the site history that would require assessment of doses from radon or thorium?

***Response** - No information on the presence of radium sources at the site is currently available.*

(9) The Site Description TBD identifies 1977 as the last year of uranium recycling from reprocessing spent fuel, but this TBD identifies 1976. How will NIOSH decide which year is correct? This can be critical for assessing intakes that occurred in 1977 in order to provide claimant-favorable assessments.

***Response** - Table 3.4-1 of the "Recycled Uranium Mass Balance Project", referenced as (BJC 2000) in the TBD, states that recycled uranium was received at K-25 from 1952 through 1988. For clarity, however, the first paragraph of Section 5.3 of the TBD will be revised to include the entire time period when recycled uranium was received, rather than just the start date.*

(10) Tables 5-4 and 5-5, which list source terms and facility-specific radionuclide conversion factors (respectively), do not cover all facilities in Table 2-2 of the Site Description TBD. Will NIOSH add more facilities to Tables 5-4 and 5-5 to assist the dose reconstruction accuracy?

***Response** - At this time, the only source term information available is that shown in Tables 5-4 and 5-5. If additional source term information should become available, the TBD will be revised accordingly.*

(11) Table 5-4 (Source term summary by location) does not show any ^{241}Am, ^{242}Cm, or ^{244}Cm at any facilities and these are shown in Table 5-2 as principal radionuclides. Does NIOSH have a reason for this apparent inconsistency?

***Response** - At this time, the only facility-specific source term information available is that shown in Tables 5-4 and 5-5. If additional source term information should become available, the TBD will be revised accordingly.*

(12) Is the default isotope distribution in Table 5-6 claimant favorable? The ^{99}Tc looks low when compared to the ratios of uranium activity to 99Tc activity discussed in the Site Description TBD. Higher enrichments and the addition of other radionuclides (^{238}Pu, ^{242}Cm, ^{244}Cm) that were identified as principal radionuclides at the site (Table 5-2) would increase doses. Note also that ^{242}Pu was identified in the Paducah Internal Dose TBD as a radionuclide of concern which came from spent fuel reprocessing and could be assumed to be present at K-25 from the same type of source.

Response - *At this time, the only facility-specific source term information available is that shown in Tables 5-4 and 5-5. The default distribution in Table 5-6 was drawn from the same references. If additional source term information should become available, the TBD will be revised accordingly, as will the default isotopic distribution.*

(13) Has NIOSH determined whether the urine bioassay results may need adjustment before input into IMBA to account for the variability of spot samples compared to 24-hour samples, and how will NIOSH adjust these if needed?

Response - *As described in Section 5.5 of the TBD, urine samples were collected as both "spot" samples and as 24-hour collections, with the latter the standard procedure after 1950. If the measurement results are given in units of concentration, the dose reconstructors will convert them to 24-hour-equivalent excretion rates by using the Reference Man volume in ICRP Publication 23. If results are given in units of activity only, a 24-hour collection may be presumed if the date of the analysis is after 1950.*

(14) Has NIOSH looked at any other uranium bio-kinetic models for UF6 to determine if these could be more claimant favorable (Fisher et al. 1991)?

Response - *No, this has not been reviewed.*

(15) Has NIOSH determined the frequencies of sampling throughout the history of the bioassay program and how to determine potential intake dates for long periods between samples?

Response - *The frequency of sampling as a programmatic issue is not a useful piece of information; the worker sample results are in the DOE files so the required frequency is irrelevant after the fact.*

Because uranium is long-lived and long-retained, a dose reconstruction can be performed with very few results. Chronic intakes are assumed for the majority of workers (at all sites) and a gap of many years does not affect the assessment.

(16) Does NIOSH have a process of determining which enrichments a worker could have been exposed to for their intake assessments? This is critical because the doses can vary substantially depending on the enrichment assumed when interpreting mass concentration (μg/liter) bioassay data.

Response - *As described in Section 5.3 (footnote 2) of the TBD, the predominant enrichment level at K-25 was 3%, except for the period of time when reprocessed fuel was used as feed. The dose reconstructors will select the input parameters on enrichment based upon the dates of exposure for each claimant.*

(17) What is the basis for assuming 2% enrichment as a default for isotopic fractions? When is the default isotopic fraction used in dose reconstruction? How does NIOSH determine whether an alternate isotopic fraction should be used?

Response - *Because the predominant enrichment level at K-25 is described in Section 5.3 as being 3%, Table 5-1 will be revised to capture this level as the default.*

(18) Please provide more detail and the basis why the Y-12 monitoring history was assumed for K-25 rather than using K-25's monitoring history as it's not explained well in the TBD.

Response - *The availability of records and documentation for K-25 was limited as of the current revision date of the TBD. Therefore, and as stated in Section 5.5, the programmatic elements of the Y-12 monitoring program was assumed because there was evidence of professional interactions between the two organizations and the two plants were in close proximity. If K-25-specific records showing deviations from the approach described in the TBD should become available, the TBD will be revised accordingly.*

(19) Table 5-3 lists seven chemical forms of uranium, yet the TBD does not provide a correction factor for situations where samples were collected after two days. This is particularly important in detecting acute intakes. Why has a correction factor not been considered?

Response - *Table 5-3 contains the absorption factors for the various chemical forms of uranium present at the site. If a claimant has knowledge of the chemical form of the materials with which he/she worked, the dose reconstructor will use that information, along with the relevant assumptions on monitoring frequency and intake pattern, to reconstruct the dose. If information on chemical form, monitoring frequency and intake pattern are unknown, the default assumptions described elsewhere in the TBD would be applied in a manner which is favorable to claimants.*

(20) Has NIOSH investigated the calibration procedures for the Y-12 mobile in vivo counter, apparently used at K-25 and whether these calibrations were accurate?

Response - *No data, information or documentation exists at this time that would offer a means of "correcting" the in-vivo results obtained using the Y-12 mobile counter even if evidence exists that its calibration factors were questionable. If such data, information or documentation should become available, the TBD will be revised accordingly.*

INTERNAL DOSIMETRY COWORKER DATA FOR K-25

(1) Is NIOSH considering the use of any air sampling or surface contamination data to reconstruct doses for the pre-1948 period?

Response - *The OTIB has been extended back to the start of the site.*

(2) Has NIOSH tried to determine if the radiological controls in the pre-1948 period were significantly less stringent and exposures could have been higher than after this period? Were processes and production levels the same? This may require consideration of a multiplier to adjust the extrapolated data for significant differences if these exist.

Response - *This information was not available, so other approaches were used to extrapolate to that time period (see Attachment C of the coworker OTIB for complete details). Most significantly, a review of the urine data from 1948-1988 for 120 of the workers who were working at K-25 from 1945-1947 confirms the fact that they were indeed typical workers from 1948-1988, which supports the belief that they would have been typical workers during 1945-1947. Had they had larger intakes in the early years, their bioassay results would have reflected this in the years when bioassay samples were collected.*

(3) Is the assumption of modeling chronic intakes appropriate? Note that the Internal Dose TBD states, “The expected intake pattern in most cases is acute.” Will acute intakes give more claimant-favorable assessments?

Response - *Because it is not possible to model all possible intake scenarios, the default assumption of chronic intakes has been applied across the complex when there is not specific information for a given individual. This assumption can be used to approximate a series of small acute intakes, which is likely more representative of the actual pattern.*

(4) Why are assigned doses calculated from the 50th-percentile intake rates rather than the 84th-percentile (+1 standard deviation) intake rates? Is there a rationale to justify not using the higher possible intake rates?

Response - *It is assumed that an individual who was never monitored did not have the potential to have received larger intakes than the majority of those who were monitored. It is assumed that the coworker distribution is representative of their intakes; the median dose is therefore assigned as a lognormal distribution and the associated GSD is assigned to account for possible larger intakes and the uncertainty associated with the distribution.*

(5) Has NIOSH determined the appropriate enrichments to assume during this period, which will control the total U activity for intakes?

Reference:

Fisher, D. R., Kathren R. L, and Swint, M. J., 1991, *Modified Biokinetic Model for Uranium from Analysis of Acute Exposure to* UF_6, Health Physics. 60(3):335-342, March 1991

Response - *Not certain what is meant by "this period." However, only gross alpha (units of activity) results were used for the history of the site in the coworker evaluation so the enrichment does not affect the outcome. The total uranium activity is assessed as U-234.*

OCCUPATIONAL EXTERNAL DOSE (ORAUT-TKBS-0009-6)

(1) Different documents refer to the NTA dosimeter neutron having a cutoff at energies varying from 0.5 MeV to 1.0 MeV. This may be significant for neutron fields anticipated at K-25. The Occupational External Dose TBD (Miles 2006 – pg. 8) points out that "The dosimeter response for photon energies greater than 0.06 MeV is of primary interest for K-25 workers." How is the threshold considered and applied at K-25? Is there data to support the value being applied at K-25 over the extended timeframe and workplace conditions that NTA was in use?

Response - *Personnel external dosimetry at K-25 was provided using what is termed the ORNL personnel dosimeters as described in the Site Profile. The photon energy response of this dosimeter type is illustrated in Figure 6-1 showing that it is capable of reasonable response to K-25 photon fields. Confirming documentation of the response of this dosimeter design to selected photon beams is presented in publications by AEC (1955), Parish (1982), Wilson et al. (1990) and Thierry-chef et al. (2002). The missed neutron dose, as applied by the dose reconstructor based on considerations from the claim, CATI and Site Profile, is estimated by applying a neutron to photon dose ratio of 0.2 to the measured and missed photon dose. There is no consideration in this approach of the NTA neutron energy threshold.*

References;

AEC (U.S. Atomic Energy Commission), 1955, "Intercomparison of Film Badge Interpretations," Isotopics, Volume 2, number 5, pp. 8–23.

Parish, B. R., 1982, Evaluation of External Personnel Monitoring Devices and Data for Oak Ridge National Laboratory Epidemiological Study, University of North Carolina, Chapel Hill, North Carolina.

Thierry-Chef, I., F. Pernicka, M. Marshall, E. Cardis, and P. Andreo, 2002, "Study of a Selection of 10 Historical Types of Dosimeter: Variation of the Response to $H_p(10)$ *with Photon Energy and Geometry of Exposure," Radiat Prot Dos, 102(2): 101-113.*

Wilson, R. H., J. J. Fix, W. V. Baumgartner, and L. L. Nichols, 1990, Description and Evaluation of the Hanford Personnel Dosimeter Program From 1944 Through 1989, PNL-7447, Pacific Northwest Laboratory, Richland, Washington.

(2) Have any “slow cooker” events been documented or postulated at the K-25 site? If so, what doses have been assigned to individuals and various cohorts? (See HETA 96-0198-2651 report on Portsmouth Gaseous Diffusion Plant for description of potential problems.) If not, what evidence is there to support the lack of this kind of event at K-25?

Response - *Slow cooker effects were considered during worker outreach comment review. Neutron exposures were monitored and there is guidance in the TBD section 6.7.3 for estimating missed and unmonitored neutron dose using the neutron-to-photon ratio of 20% for dose equivalent.*

(3) What type of incidents have occurred over the years that may have impacted external doses, and how would those dose estimates, if any, be assigned to individual records?

Response - *Incidents were reviewed during the research for the TBD. DOE 2000b, Independent Investigation of the East Tennessee Technology Park [SRDB Ref ID: 13787] notes that there were numerous spills and releases but that these were not always well documented. The CATI would reveal information about specific individual’s exposure. In addition, Incident Investigation Reports are requested during the NIOSH Request for Exposure Information.*

(4) Was industrial radiography performed on site during construction, maintenance, modification or QA inspections? If so, what procedures were in place to prevent inadvertent entry to radiation areas?

Response - *Industrial radiography was likely performed at K-25. Information was not found during site research about specific procedures used to control areas during radiography. It is presumed that the then current industry standards were applied to control of areas during radiography.*

(5) In Section 6.5.2.1 of the Occupational External Dose TBD (Miles 2006), under response of dosimeters to photons of <60keV, they are considered to be of no consequence. Is this assumption valid, given that some operators are exposed to extended, unshielded sources of material during contamination incidents, maintenance or other routine activities such as cylinder washing?

Response - *The ORNL type film dosimeter used at K-25 had an open window with minimal filtration that would significantly respond to lower energy photon radiation as illustrated in Figure 6-1 whereas the filtered region of the film would have had a decreasing response as the photon energy decreased. The combination of the open* *window and filtered response of the film would assure that no significant photon dose would be missed.*

(6) What efforts have been made to identify whether experimental or non routine R&D type activities were performed throughout the site evolution?

Response *- Special dosimetry considerations for experimental or non routine activities would have been addressed by the health physics job planning and practices in place at the time. It was noted that as early as 1949 finger rings were used [Levine 1949].*

Levine 1949, Dr. H.V., Ring Film Processing [SRDB Ref ID: 864]

(7) Section 6.5.2.2 of the Occupational External Dose TBD states that neutron doses ranged up to "*less than 0.05mSv/hr…*" It also states in the same paragraph that there was minimal potential for significant neutron doses. Given that 2000 hours/year at the upper bound of the "minimal" dose rate would result in an annual neutron dose of 100mSv, or 10 rem, how is this statement supported?

Response *- None of the documents reviewed indicated that individuals were exposed continuously to neutron fields of 0.05mSv/hr. The upper range of the neutron dose rates cited in ORAUT-TKBS-0009-6 was not meant to define minimal dose. Neutron monitoring results reviewed in the NOCTS claim files do not support high neutron exposures; the individuals with the highest potential for neutron exposure were monitored.*

(8) Section 6.5.3.1 of the Occupational External Dose TBD states that all beta dose determinations were for a uranium slab calibration. Where are the supporting references to show that any errors associated with this assumption are reasonable and claimant favorable?

Response *- Calibration factors established from a depleted uranium slab are assumed to closely match the radionuclide beta energies at the K-25 gaseous diffusion plant and represent the appropriate selection for determining the shallow dose equivalent Hp(0.07). As noted in Figure 6-1, the open window response to lower energy photons will substantially over-estimate the shallow dose based on a uranium shallow dose calibration.*

(9) Section 6.5.4 of the Occupational External Dose TBD discusses ^{99}Tc betas (maximum energy 294 keV). The claim is made that film dosimeters and TLDs will not detect ^{99}Tc betas efficiently and that only skin contamination could cause significant shallow dose. As it is a given that the dosimetry would not detect the betas, what evidence is there that workers were never exposed to large extended sources of ^{99}Tc? What are the typical and largest Curie amounts of ^{99}Tc that the workers encountered during normal operations and what would the resultant radiation dose rates have been? (Beta and bremsstrahlung fields)

Response - *The primary means to detect and measure ^{99}Tc was through radioanalyses of samples because of the low-energy beta emission. The highest concentrations of Tc-99 were found in the ORGDP Stream 21 - Cascade Accumulation Stream. Information to answer the specific question about defining the "typical and largest Curie amounts of Tc-99 that workers encountered during normal operations…" was not found in the site research.*

Bechtel Jacobs 2000, Recycled Uranium Mass Balance Project Oak Ridge Gaseous Diffusion Plant, provides "estimated levels" of Tc-99 at various locations in the plant. Tables 5-4 and 5-5 of the internal dose technical basis document (ORAUT-TKBS-0009-5) provide the relative concentrations of the radionuclides at various locations. Tc-99 will not produce significant bremsstrahlung radiation due to the relatively low energy beta radiation emission.

(10) Section 6.5.4 of the Occupational External Dose TBD states "*…^{99}Tc was concentrated at K-25 for the purposes of recovery and removal.*" What processes were involved and what Curie levels and concentrations were typically and potentially encountered? What potential dose rates due to wide area beta sources (peak energy 294 keV) were present?

Response - *^{99}Tc is considered a potential significant nuclide associated with recycled uranium to provide a major source of bremsstrahlung radiation from the beta radiation emission, if present in significant quantity. Based on the NIOSH review of Portsmouth (Cardarelli, 1996), very low rates of gamma and bremsstrahlung radiation were found with the highest levels found in feed cylinder handling areas. The precise activity levels are not known, at least in the context of the K-25 TBD.*

(11) Section 6.5.4 of the Occupational External Dose TBD (Neutron Fields). Where is the supporting evidence for claiming that the neutron-to-photon measured ratio at Paducah during a single project is applicable to the entire history of K-25? Likewise what is the basis for the Y-12 small cylinder measurements as stated in Section 6.5.3.2?

Response - *The Paducah neutron:photon ratio and the Y-12 measurements were provided as related technical information that was available to determine a realistic neutron to photon dose ratio because of the similarity in handling enriched uranium among these plants. As described in 6.5.3.2, measurements with a tissue equivalent proportional counter (TEPC) at Y-12 were supported by similar (although qualitative) measurements made in 1993 with a TEPC at the K-25 cylinder yard. Discussions with ORNL staff involved in these measurements confirmed that the neutron dose rates were very low, necessitating long measurement periods with associated greater uncertainty.*

(12) Section 6.5.2.2 of the Occupational External Dose TBD states that neutron capable TLDs were provided from around 1988, but read on an "*as needed*" basis. What criteria were used to determine when the dosimeters were read and what evidence is there that this policy and procedure were adequate and claimant favorable?

Response *- The TLDs were processed using a fully automated reader system. The TBD should likely have stated that the neutron dose was not fully evaluated because of the difficulties associated with the low dose rate, the neutron spectra and the selection of an appropriate neutron dose calibration. The criteria to assess the neutron dose may have been different during different time periods. The TLD neutron dose was available for evaluation in the event of an incident.*

(13) Section 6.5.2.2 of the Occupational External Dose TBD also states that "*higher neutron sensitivity*" TLDs were used in some cases. Given that neutron fields were stated to be "minimal" why was this done? What types of dosimeters were used and what is the impact of this information on decisions affecting dose determinations?

Response *- The types of neutron badges are presented in Table 6-1. The neutron dose rates are typically so low that accurate measurement of the actual neutron dose has been a challenge. The Harshaw TLDs are available in different models with some models having a higher neutron sensitivity.*

(14) Section 6.5.3.1 of the Occupational External Dose TBD states that the move to phantom based photon calibration would have resulted in overestimated doses. Please explain the thinking here as to why this is not taken into account in the full calibration system.

Response *- Section 6.5.3.1 should be revised to say, "Photon calibrations without the use of a phantom tended to cause overestimated doses…"*

In the 1980s, studies at a number of laboratories assessed changes from the on-phantom calibration mandated by the DOELAP testing criteria (Fix et al. 1982; Wilson 1987; Wilson et al. 1990; Taylor et al. 1995).

Fix, J. J., J. M. Hobbs, P. L. Roberson, D. C. Haggard, K. L. Holbrook, M. R. Thorson, and F. M. Cummings, 1982, Hanford Personnel Dosimeter Supporting Studies FY-1981, PNL-3736, Pacific Northwest Laboratory, Richland, Washington.

Wilson, R. H., 1987, Historical Review of Personnel Dosimetry Development and its Use in Radiation Protection Programs at Hanford, 1944 to the 1980s, PNL-6125, Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington, February. [SRDB Ref ID: 262]

Wilson, R. H., J. J. Fix, W. V. Baumgartner, and L. L. Nichols, 1990, Description and Evaluation of the Hanford Personnel Dosimeter Program From 1944 Through 1989, PNL-7447, Pacific Northwest Laboratory, Richland, Washington.

Taylor, G. A., K. W. Crase, T. R. LaBone, and W. H. Wilkie, 1995, A History of Personnel Radiation Dosimetry at the Savannah River Site, WSRC-RP-95-234, Westinghouse Savannah River Company, Aiken, South Carolina.

(15) Section 6.7.1 of the Occupational External Dose TBD refers to use of the (MDL)/2 approach to estimate missed doses. How does this comply with the decision to use the claimant favorable 95th percentile approach?

***Response** - Using ½ the MDL for "missed dose" is described in OCAS-IG-001, External Dose Reconstruction Implementation Guideline. This guideline goes on to describe the method to calculate the 95 % dose estimate for missed dose; generally by multiplying the (MDL) times the number of zero measurements.*

Please note that the Technical Basis Document does not provide instruction about performing the dose reconstruction, but as described in the purpose, the TBDs are "general working documents that provide historical background information and guidance to assist in the preparation of dose reconstructions for particular sites….. The documents will be revised in the event additional relevant information is obtained about the affected site(s)."

(16) Section 6.7.1 of the Occupational External Dose TBD discusses averaging the doses for monitored workers. The claim is made that those that were badged were the most likely to be exposed. Please provide procedural, anecdotal and other supporting information to support this claim. For instance, how do we know that management did not choose to sample a representative cross section of workers and jobs with a range of exposure conditions?

***Response** - DOE 2000b, Independent Investigation of the East Tennessee Technology Park [SRDB Ref ID: 13787] notes that "exposures were primarily monitored by the use of film badges assigned to personnel based on their anticipated tasks and work areas." This same document goes on to say "A 1977 study of the lifetime health and mortality experience of employees of ERDA contractors noted that the ORGDP procedures from 1945 to 1974 called for routine monitoring only for employees who worked or entered areas with a potential for exposures…"*

(17) Section 6.7.3 of the Occupational External Dose TBD suggests that Paducah data be used to define missing neutron dose N: P ratios. What basis is there for relying on this data, especially for the early years? Is this approach assumed to be claimant favorable?

***Response** - The Paducah neutron:photon ratio was provided for dose reconstructors to estimate the K-25 neutron dose due to the similarity in the plants. If better information (neutron:photon dose equivalent ratio) specific to the K-25 plant is obtained ORAUT-TKBS-000906 should be updated.*

(18) What is the basis for applying a single neutron-to-photon ratio from a specific work task at a sister facility? The enrichments of uranium differed between K-25 and Paducah with K-25 handling higher enrichments. The alpha, n reaction for higher enrichments by weight would increase as the enrichment increases.

Response - *Dose reconstruction practices at K-25, Portsmouth and Paducah Gaseous Diffusion Plants are similar in that a neutron-to-photon dose ratio is applied to measured and missed photon dose for some workers depending upon work activities. The studies of neutron doses by Cardarelli (NIOSH Health Hazard Evaluation Report 96-0198-2651), PNL (1990) and ORNL (1993) as noted in the K-25 TBD all indicate very low dose rates to the extent that accurate measurement of the neutron dose component is uncertain. ORNL has provided TLD dosimetry at various times to Paducah and Portsmouth in addition to their monitoring at Y-12, K-25 and X-10. The TLD measured neutron doses are comparatively low. The neutron dose component is certainly associated with the enrichment, the chemical form and configuration, and primarily associated with uranium storage and locations in the process where uranium residues can concentrate (i.e., slow cooker phenomena).*

Attachment A
Responses to Worker Outreach Comments at K-25

Comment: How often is the urinalysis test required?

Response: Frequency was added to Section 5.4 of ORAUT-TKBS-0009 Rev. 0 PC-1A

Comment: The thermoluminescent dosimeters (TLDs) for guards at K-25 always read zero. Because guards have worked and continue to work in every building on the site, the guards do not believe the paperwork that they receive regarding their exposures.

Response: Guidance for external dose reconstruction is provided in OCAS-IG-001 and ORAUT-OTIB-0020, *Use of Coworker Dosimetry Data for External Dose Assignment* and ORAUT-OTIB-0026, *External Coworker Dosimetry Data for the K-25 Site*

Comment: At East Tennessee Technology Park (ETTP), we have quite a few new concerns about possible worker exposures. People wonder why you need a TLD or Personnel Nuclear Accident Dosimeter (PNAD) when you go past Portal 11 into limited areas. We do have areas that contain numerous UF6 (uranium hexafluoride) cylinders. Many of the UF6 cylinders that they are receiving in Paducah are coming from our site.

Response: The use of TLDs and/or PNADs is governed by site procedures for access to radiologically-controlled areas. UF6 cylinders are discussed in Section 6.5.4, Workplace Radiation Fields, in ORAUT-TKBS-0009 Rev 0 PC-1. The receipt at Paducah of K-25 cylinders is discussed in the Paducah Site Profile.

Comment: In times past, a dried up vial of a cousin to the West Nile Virus was found in K-25. When they were doing the clean up on K-31 and K-33, they found things that were not supposed to be in those buildings. I have also heard stories from guards who said that years ago they would have releases at night so that the releases would not be seen.

Response: Discussion of non-radiological hazards is not appropriate for this Site Profile. Atmospheric releases of uranium and other radioactive materials are addressed in ORAUT-TKBS-0009-4.

Comment: Using data from Portsmouth and Paducah to write the K-25 Site Profile is not appropriate. There are huge differences in the percentages of enrichment. It is also important to remember that K-25 was more experimental than Paducah and Portsmouth.

Response: As gaseous diffusion plants, these sites share similarities in processes. The Site Profile contains K-25 specific material.

Comment: I remember traps and converters starting on fire. Men died in their 40s and 50s due to exposures working at K-25.

Response: No discussion of fires in traps or converters was found in K-25 documents. Fires are discussed in the reference ORAUT-TKBS-0009-4 - "DOE (U.S. Department of Energy), 2000b, *Independent Investigation of the East Tennessee Technology Park*."

Comment: The Uranium Mass Balance Report only considered production/process buildings.

Response: The Mass Balance Report is only one of many references used.

Comment: The J Lab Facility had a Plutonium Program which processed plutonium.

Response: The processing of transuranic elements is discussed in ORAUT-TKBS-0009-5.

Comment: We know that there were specific operations occurring throughout the gaseous diffusion plants (K-25, Paducah, and Portsmouth) that would be useful to the dose reconstructors. Some areas had different ratios. If you get this type of information and it is verified, will the site profiles change to reflect the new information?

Response: Yes, the site profiles are revised as new information becomes available. The ratios you mentioned are discussed throughout the site profiles for the gaseous diffusion plants.

Comment: Transuranics plate out in various stages of the cascade. The Operational Report from Portsmouth only checked for UF6, not for solids. There would be different transuranics depending on where you are cutting into the system. Different ratios affect exposures.

Response: ORAUT-TKBS-0009-5 discusses transuranics at many stages of the enrichment process not just Paducah UF6.

Comment: Workers are very concerned that NIOSH is only looking at data that are being provided directly to them. We have heard countless stories about workers who were removed from a job because their badge readings were so high. However, when these same workers got their badge reading reports back, they had zeros. In addition to the false zeros, many workers cannot locate their medical records. This all seems like a cover-up.

Response: The intent of the Site Profile is to provide a facility description based on the best availble information. Reconstruction of dose is covered by OCAS-IG-001 and OCAS-IG-002.

Comment: Documented calibration procedures, instrument types, and monitoring frequencies for the K-25 site would help out with the dose reconstruction calculations.

Response: These are included throughout the K-25 Site Profile.

Comment: Have you seen any procedures regarding the TLDs for K-25?

Response: Yes. Bechtel Jacobs Procedure EH-4511, "External Dosimetry" was reviewed in preparation of the Site Profile.

Comment: Page 5, Section 2.2—References "characterization studies to date," what are these characterization studies?

Response: The text was changed to list the source of the studies (Bechtel Jacobs Mass Balance Report.)

Comment: Page 7, Section 2.2.2—References "characterization studies." I think that you are referencing one survey and basing all of your information on that one survey. Please find out if this is the case.

Response: The text was changed to list the source of the studies (Bechtel Jacobs Mass Balance Report.)

Comment: The External Dose section of the K-25 Site Profile does not mention slow cooker effects.

Response: Slow cooker references were reviewed and it was determined that their mention did not add any beneficial information for the dose reconstructors.

Comment: There was a Deposit Removal Project that took place at K-25 in which highly enriched uranium deposits were removed. I am not sure if this is noted in the K-25 Site Profile or not.

Response: Uranium recovery is discussed in ORAUT-TKBS-0009-2.

Comment: NCS documents as well as other references could provide another source of validation for K-25 data.

Response: All available documents including Nuclear Criticality Safety (NCS) are reviewed to develop the Site Profiles.

Comment: Building 1401 had a compressor shop and a converter maintenance shop. The southwest corner had ovens that recovered highly enriched uranium from converters. I believe that Building 1401 had to contain transuranics. I checked vent stack information and found out that 58 pounds of uranium-containing material were removed from one vent stack in a single 24-hour period.

Response: The presence of recycled uranium and transuranics is diiscussed throughout the site profile. In particular, the presence of TRU in Building 1401 is mentioned in ORAUT-TKBS-0009-2.

Comment: After dark, the incinerator in Building 1421 was used to burn anything and everything (rags, clean up materials from spills).

Response: Atmospheric releases of Uranium and other radioactive materials are addressed in ORAUT-TKBS-0009-4.

Comment: Building 1405 was a High Temperature Laboratory andI have been told that lots of highly enriched uranium was used in that building.

Response: Highly enriched uranium at K-25 is discussed in ORAUT-TKBS-0009-6.

Comment: The 131 Pipe Shop Maintenance building rebuilt parts. Parts were robbed from the K-25 building itself and used throughout the plant and then machined in Building 1401.

Response: Documentation was not found in the Site Research Data Base. Due to the Site Profile's consideration of wide spread contamination and elevated dose rates throughout the facility it is unlikely that this would have significant impact on dose reconstruction.

Comment: Building 631 was the "Test Loop" Tails Withdraw Facility.

Response: Documentation was not found in the Site Research Data Base. Due to the Site Profile's consideration of widespread contamination and elevated dose rates throughout the facility, it is unlikely that this would have significant impact on dose reconstruction.

Comment: The sanitary water system was crossed with the fire water system resulting in the sanitary water containing strontium and cesium.

Response: Documentation was not found in the Site Research Data Base.

Comment: The K-25 Site Profile does not discuss vaults. We had hot vaults at K-25.

Response: Documentation was not found in the Site Research Data Base. Due to the Site Profile's consideration of widespread contamination and elevated dose rates throughout the facility, it is unlikely that this would have significant impact on dose reconstruction.

Comment: Section 6.5.3—Are there any other data sources available regarding neutron exposure before 1989? Has there been any attempt to correlate information?

Response: Section 6.7.3 of ORAUT-TKBS-0009-6 discusses assesment of missed or unmonitored neutron dose.

Comment: The Blair Gate/Gallaher Gate Monitoring Stations kicked on once a week for 24 hours. This could have been done on Sunday when there would have been less to monitor.

Response: Because of the known limitations of air monitoring, ORAUT-TKBS-0009-4 calculates environmental intakes based on releases of materials.

Comment: A word of caution regarding using environmental data for validating – the environmental badges did not pick up neutron exposures because there was no phantom in place, so no whole body dose could be measured. Neutron monitoring was not being done as properly as it should have been.

Response: As documented in ORAUT-TKBS-0009-4, neutron exposures were not reported for environmental results until 2003.

Comment: Workers question whether instruments were calibrated correctly, so please check into the procedures used, especially for cesium-137.

Response: Review of records availble in the SRDB gived no indication of what source(s) were used for photon calibration; only that they be "NBS" traceable.

Comment: Section 6.5, Page 13—approaches for estimating missed dose. What source document did you use for Tables 6.4 and 6.5? Has this been validated against source records?

Response: Tables 6-4 and 6-5 were deleted from ORAUT-TKBS-0009-6 and replaced with Table 2 from ORAUT-OTIB-0026 which was developed from data from the Comprehensive Epidimiologic Data Resource (CEDR).

Comment: There were a lot of system breaks with the Toxic Substances Control Act (TSCA) Incinerator. For example, one employee was told that the system was depressurized when it was not. Another employee was never told that he was in contact with transuranics until after his exposure.

Response: Specific incidents are covered in the computer-assisted telephone interview (CATI). No specific references to incidents at the TSCA incinerator were found in the SRDB.

ATTACHMENT 4: SUMMARY OF CONFERENCE CALLS ON SC&A QUESTIONS PROVIDED TO NIOSH

INTRODUCTION

SC&A submitted written questions to NIOSH pertaining to the K-25 Site Profile on November 9, 2006. NIOSH/ORAU provided written responses to these questions on December 13, 2006, in preparation for a conference call with SC&A. The questions and responses are provided in Attachment 3. Information provided by NIOSH/ORAU gives SC&A a more in-depth knowledge of the rationale for assumptions made within the TBD and the source documents that provide the basis for the TBD. The summaries below are not verbatim discussions, but include information supplemental to the written responses provided by NIOSH/ORAU. They are arranged by general topics, since there was overlap in discussions conducted during the conference calls. The information provided by NIOSH/ORAU is listed under each topic. SC&A has provided comments toward the end of the summary. Action items resulting from discussions in the conference call are listed at the bottom of each summary. The Issue Resolution Conference Call for the K-25 Occupational External Dose TBD was held on January 18, 2007, and the Issue Resolution Conference Call for the K-25 Occupational Medical Dose TBD, the Occupational Environmental Dose TBD, and the Occupational Internal Dose TBD was held on January 24, 2007.

Conference Call Notes on K-25 Issue Resolution for the Occupational External Dose TBD

Date: January 18, 2007 – K-25 Occupational External Dose TBD

Participants:

NIOSH: Chuck Nelson

ORAU Team: Jack Fix, Paul Szalinski, Betsy Langille, Rob Winslow, Susan Winslow, Elyse Thomas

SC&A: Harry Pettengill, Joe Zlotnicki, Tom Bell

Introductory Comments:

SC&A: We are recording the call. The reason we are doing that, if everyone concurs, is so that we can get what is said documented accurately. In a couple of hours after the call, there will be notation come back to everybody. If it doesn't get back to everybody on the West Coast, I will make sure it gets to you, so that you will be able to go into it and listen to any part of the conversation you want to, if you just want to clarify something. That's the only reason for it. In about 8-10 days, the information will just disappear. Is there any particular problem with tape recording what we are discussing? Hearing none, let's go ahead.

What we are doing today is going over the responses to our questions. We really do appreciate that Jack Fix has made himself available today, since we realize his schedule is full in preparation for his upcoming travel in the next 2 weeks.

What we are doing today is going through these questions as part of our K-25 review. We sent out a number of questions to NIOSH on a number of things in the TBD and your responses. Over the holiday, we are trying to get around to having the opportunity of having a quick conference call to go over the questions and answers with you to see if there is any additional clarification between the questions and the NIOSH answers, and if there are any follow-on items that either we or NIOSH have to take care of.

What we have agreed to today, in light of Jack's travel situation, is that I have Joe Zlotnicki on the line, who is the person who did the review of the External Dose TBD. Unless there are any other announcements, we will turn it over to Joe, so that we can go though the questions that he had submitted and the responses that you, Jack, and others sent back to see if there is anything additional there that we have to sort out.

SC&A: Harry, can I just go over who is on the line. From NIOSH, there is Chuck Nelson, and from the ORAU team, Jack Fix, Rob Winslow, Susan Winslow, Paul Szalinski, Elyse Thomas, and Betsy Langille. On the SC&A side, there is Harry Pettengill, Joe Zlotnicki and Tom Bell.

SC&A: (Tom Bell is asking, because he will be responsible for making sure that we get all the information down, so that an electronic copy can be provided for review and editing.)

SC&A: Joe, do you want to go ahead and kick things off?

OCCUPATIONAL EXTERAL DOSE (ORAUT-TKBS-0016-6)

General:

SC&A: We are going to run through the questions and answers, and will indicate whether the response was satisfactory, and if I have no further questions, we are not going to spend any additional time on them. I think we are going to have a hard time getting through some of them, and this will allow more time to focus on them.

Q.1 SC&A: OK, we are not using the NTA, so the response is fine.

Q.2 SC&A: The slow cookers. The response was that we were using the gamma-to-neutron ratio and that will effectively manage the slow cooker, so that if there is a gamma dose, we are adding a component of neutron to take care of that. My question on this one is still, are we saying that anyone that was exposed to a slow cooker was wearing a dosimeter in the first place? Because the implication there is that they are.

ORAU: Is NIOSH going to take the lead on these? How are we doing that?

NIOSH: What we will do is to have the ORAU person respond if they know. If there is someone else who can add any thing of value, then they can just chime in. If we can't answer it, we will just move on if they can't add anything pertinent. Elyse, you told me that Jack Fix is going to be there as an external dosimetry lead and also, who else from external will be there to follow up on the majority of these questions?

ORAU: Do we have a site profile person?

ORAU: Yes, Betsy is on the line and she, as I understand it, prepared some of the original responses, although Jack reviewed them before we submitted them.

ORAU: Yes, I think the easiest way would to be to let the site profile person take the lead and where I can add additional details, I will. Let's do it that way. Betsy, do you have a feeling on this one.

ORAU: Yes, it is unchanged from what I provided. I guess I'm not positive that anyone who was potentially exposed to slow cooker events was wearing a badge, but I presume that those with the greatest potential for exposure were badged. So, we could add some kind of qualifier, but I think those kind of statements are already in the site profile. I don't think that answers the question exactly, but that is the best I can do.

ORAU: I have to agree with you, Joe, that the implication is that the people who had the potential to be exposed were badged, and if slow cooker events occurred, and I guess there is no question that they did occur, that his dose would be monitored, because they were wearing a dosimeter. It wouldn't be much different than during the routine for other kinds of exposures.

SC&A: OK, I think that we can only go so far on that. I understand that, but the inference is there that we don't have to worry about the neutron, because they were monitoring the gamma. That obviously is an assumption in that point. Let's move on to Q.3.

Q. 3 SC&A: Regarding the incidents, one of the things that concerns me is if there were various types of incidents, and presumably, the earlier you go back in history, the less likely the incident was going to be written up and put into the file. And so, one of the questions I have is the fact that if you don't find documentation of an incident report in the individual file, doesn't mean that there wasn't one. And, one general comment that I would make is that, and this would go beyond K-25, is that if one plotted out just the number of incident reports per year at a particular facility, and see the rapid spike in incidents in a given year, it could be because they opened up a plant or process, or it could be that they were just documenting them better. So, I wondered if this has been done in the case of K-25. If you go back before 1970 or 1949, I don't care what the year is, and you see that there are no incident reports, then the fact that you do not have an incident report in file for the individual doesn't mean they were not exposed in an incident. It just means it wasn't documented.

ORAU: Betsy, do you have any comment on this? I guess we don't disagree with that.

ORAU: We use the information in the CATI. In regard to plotting the incidents in the file per year, I don't know if that's been done.

SC&A: My thought is that it might be quite easy. I may be wrong. There might be a lot of years where there is a zero in the early years. In later years, it would probably be very easy. There may be some interim time in the 1950s and 1960s and 1970s and maybe even into the 1980s, who knows, it might be more difficult. But it's just the thought that it might give someone the picture that there were no incident reports on file for a particular year, so I would have to use some other approach, either told by the worker or by whomever, that there was an incident or that they weren't documenting them at all at the time.

ORAU: I'm not sure what to say. The dose reconstruction is done on a claim-by-claim basis, so the details of the claim are reviewed fairly extensively, and if there are implications in that claim that there are undocumented incidents or that there are some issues in regard to an incident, I think those are taken very seriously, in terms of the radiological considerations. I think that the incident reporting is driven by the policies and what the criteria are for an incident. But that's a good point. I don't know how easy that would be. Betsy, do you have a feel for this? I'm not real familiar with the K-25 facility. Is there, do you have available to you, the incident reports or the frequency of the incidents?

ORAU: No, I couldn't agree that any kind of review of incident report files would provide any information that would be pertinent to the individual. I couldn't see how that would help as far a site profile and general information about the site or how it would help a specific individual if he said I was exposed to a situation where there was an airborne release and it was so many times the MDA or MPC or whatever.

SC&A: I would add to that that is the particular problem, as I understand it. Workers, even those who do not file a claim, would potentially say, yes, I was involved in a fire back in the 1970s. Now the dose reconstructor may not be able to find any information relative to that in the site profile, because it was not able to be picked up, nor any other records that he might have to pursue. I guess the question is, how would that be handled?

NIOSH: This issue came up with Hanford, and is coming up with every site, and I know that the Board and NIOSH are collectively monitoring and tracking this kind of situation with incidents and how far do you look into these incidents and how well we need to document such incidents throughout the site. So, this particular issue is germane to a lot of the sites. Like Jack said, another thing is, if you look at the individual claimant's file, and sometimes based on the type of incident that they may mention in their interview, you can pretty much rule out that they got exposed, based on their external dose and internal dose records. That's my take on it anyways.

SC&A: The point is that if you know that there were hundreds of incident reports documented per year, and someone says there was a fire that year and I got exposed, you are going to treat that very differently than if he says there was such an incident and there is nothing in the record for the whole year for anyone. You are going to treat those two cases differently in terms of how much you are going to dig. That's my point; it's a general point. It doesn't just cover external. It covers all the sites and all types of exposure.

NIOSH: Agree.

ORAU: OK, I agree with you. If you look at some of the other sites, like the criticality incident at Y-12, we actually went back and there was a dose assigned to everybody that was in the facility. So, it is taken very seriously. If it's a significant incident, there is quite a bit of evaluation that is done.

SC&A: Right.

ORAU: I wanted to go back to that first point, because I am gradually getting all my information here. Your concern about the neutron dose from the slow cookers, the site profile does include information that can be used in assessing a dose, a neutron dose, to the workers depending upon their work function that is based on a neutron-to-photon ratio. So the idea is, is to give them the benefit of the doubt that there could be neutrons there and that they would be assigned depending on the details of the specific claim.

SC&A: True, true.

Q.4 SC&A: The industrial radiography question response is OK. I don't think we can take that any further.

Q.5 SC&A: This involves the under-response of the dosimeters. There seems to be a sort of disagreement between the response and the question. The question repeats a statement regarding the occupational external dose in the TBD that says the under-response of the dosimeter to photons of less than 60 keV are "considered to be of no consequence." So, my reading of that is that it says that the dosimeters possibly under-respond to photons less than 60 keV and it doesn't matter. The response says the dosimeter, because of the open window, and the filter and filtered position would have picked everything up. So, I guess there is a disconnect between those two and if the response is correct, then there needs to be a statement that says that we will go back and change the technical basis document and that this was in error.

ORAU: That could be a good point. Maybe we just need to check the text. As I am sure you realize, for this particular dosimeter, the deep dose can be estimated for lower-energy photons that are definitely lower than 60 keV. The significance of that is this dose is picked up in the open window. As you know, the open window film response way overestimated the shallow dose.

SC&A: Right.

ORAU: The people in dosimetry would be aware of what type of radiation (photon radiation) would be hitting the dosimeter.

SC&A: So I guess the question is, in the technical basis document, why does it say that the under-response is of no consequence?

ORAU: I don't know. I would not particularly pick those words, because it depends on the radiation found in the workplace, and that is what the author is thinking. Betsy, do you have any feeling on that?

SC&A: There are two problems here; the first problem is whether or not the dosimeter under-responds or over-responds. And, of course, if it was heavily protected from contamination in some thick pouch or something, at some low energy of x-ray, it's not going to be picking it up. But the bigger issue is that it is considered to be of no consequence. That's the second part to it. OK, and that is why someone might consider that those energies are of no consequence, clearly when the source is inside some kind of thick sealed container or pipe. This is probably true, but in other cases, it may not be so. So, there were several parts to that question. At the end of the day, the response did not jive with the question.

ORAU: Well, Betsy, do you have a feel for this? I'm not sure I do not agree with you. Betsy, do you have a feel for why the term "are of no consequence" got into the TBD? I would assume that it had to do with the consideration of the radiation and the workplace radiation field.

ORAU: No. Looking at it now, I agree that we could change those words to be better. I think it was probably just put in, because most of the photons are greater in energy. So, it would probably be better to say that most of the response of the dosimeter would be to energies greater than 60 keV.

SC&A: But, it's still a bit odd, given that Jack was commenting on the over response. It's still odd to have that statement that even mentions under response. So again, I don't know why that was put in the technical basis document. It, to me, just raises a flag on a couple of levels; one is the dosimetry level itself, and the other is that someone is making a rather broad statement that x-rays for transuranics were never an issue or were of no consequence. So that is the two pieces I read there. I'm still a little puzzled by this one. It may be nothing, but I am not comfortable with the response.

ORAU: This is Paul Szalinski here. I haven't checked with the team leader on this, but I agree. When we get through all of these, this might be driving us to a revision, or at least a page change to the TBD. This is certainly one we would want to clarify. We agree with you.

SC&A: Good, thank you.

Q.6 SC&A: I think this is a nice point to say that they were using finger rings as early as 1949. So, people were thinking about these kinds of things. I mean, it's anecdotal and it doesn't cover everything, but think it is a good example, is very specific, and does give you some small, but some positive, sort of feeling that, yes, we are looking at these non-routine situations. So, I thought that was a good response.

Q.7 SC&A: The issue of neutron dose keeps coming back. I'll explain where I am going with this and that it is that there seems to be a little bit of a circular argument in everything I am seeing on neutron exposure. Neutron wasn't a problem, so that we don't have to worry about it and we didn't worry about it, because it wasn't a problem. And here, I found it was common to say that the highest dose they found is someone who was there for 2,000 hours. And, by the way, some of these people probably worked 2,500 or even 3,000 hours in some years. But let's say its 2,000 hours, that's 10 rem without any gamma dose, internal dose, or any other dose. Clearly that would be significant. And, I am not saying that anyone stood there for the entire 2,000 hours. But, it's not 10 mrem. It's 10 rem, a fairly significant dose. And, that's a pretty big field. Yet, if the assumption is that there is not much neutron, and that you don't need to monitor for it, people could have been getting 2.0 rem (1/5th of that) and you wouldn't even know. So, I just felt that the upper boundary that was measured. But it is far from trivial. It's a pretty big dose. And that's assuming that we got everything right on the measurements and nothing was different from the past. So, I just saw a disconnect there, to say, well, we would have monitored people if they had a high dose, but people at the same time are saying there wasn't any high dose for neutrons, so we didn't need to monitor for it. It just seems that there is back to front logic there.

ORAU: Well, I guess we could make the argument that the neutron-to-photon ratio would be used for anyone who was potentially exposed to neutrons.

SC&A: Well, I guess, that we will be coming back to something on this later. So, let's move on until we get back to the ratio issue later on. That may or may not answer it. But I guess the point is that the 10 rem a year is not a minimal potential for neutron dose. I guess, that is not really the highest. But nonetheless, if someone could have been in the area for a few hundred hours, it is far from a trivial dose, if they did this for several years.

ORAU: I think this underscores that the problem we have in many of these site profiles is certainly the dosimetry, at the time, was not what was used to protect the worker. They had instruments, so they were aware of the radiation fields and the type of radiation. So I guess we agree, obviously, that 10 rem is a significant neutron dose, certainly not a trivial dose. And it probably wasn't the dosimetry that led to them to whatever protective actions they took in the work place.

SC&A: Are we confident that they had suitable neutron dosimetry in the workplace (I'm sorry I meant instrumentation) that they would have been able to measure those? There are also comments about the various responses in the technical basis documents that the neutron dose measurements were so low that they were hard to measure. I mean they are hard to measure, even today. And yet, if someone is in a chronic exposure situation, like .5 millirem per hour, for 2,000 hours, we will know that that's a rem. So I guess the question is, do we have any evidence, given what you have just said, that at the time, they had suitable instrumentation?

SC&A: In our site visit when were we talking to some of the people who worked there in those days, there was a discussion that they had very few health physics people covering the sites, especially in the 1950s and 1960s. And so the likelihood that they had a lot of good instrumentation for that does not seem to be very likely. When they got into the 1970s and 1980s, it started to improve, but even up until the 1990s, they indicated that their health physics staff didn't really shift a lot until Bechtel Jacobs came in about 1989.

SC&A: Yes, I just have a general sense that this is true. A lot of the comments that neutrons are hard to measure and that gammas were there, their instrumentation would be difficult to carry around, even today. So, my sense is that instruments would be lacking. I find it hard to imagine in the 1950s, that workers necessarily knew they were standing in a half an R field of neutrons. Maybe the gammas were even entirely shielded by the containers the uranium was in, or whatever it was, but that there was a general neutron field there. And I just haven't seen anything to say that there wouldn't have been. So anyway, I can't go much further than that, other than to say I just have a sort of discomfort with the premise that people weren't being exposed to significant neutron. And, we are going to come back again, in a moment, to the ratio issue, since I do have some questions on it.

ORAU: I agree that is a topic that we need to examine further, but neutrons were not difficult to detect, they were difficult to measure. They are easy to detect.

SC&A: Right, good point.

SC&A: The other thing I would have to offer is that maybe it's leaning on the words 0.05 mSv/hr. Maybe what it needs is a qualifier to demonstrate that even if it ranged up to those dose rates, it wasn't a routine circumstance. Those fields weren't everywhere. This allows you to understand that you are not going to extrapolate up to 10 rem /yr.

SC&A: Good. Let's go to Q.8

Q.8 SC&A: This has to do with a more technical issue pertaining to the uranium slab calibration for beta (which is a high-energy beta) and the question arises for Tc-99. Now, I am not an expert on what was going on at that site; I have read that there was Tc-99 recovery. Now, whether that really means that there was separation of Tc-99 I don't know. I have tried to read some of the uranium mass balance documents, and so on, it is still unclear to me whether what people may have been exposed to Tc-99 where that was the predominant shallow dose contributor and not uranium. And if so, the dosimetry may have been quite erroneous. Do you have any thoughts about that Jack?

ORAU: No, I guess I would like to listen to those who wrote the site profile. I agree with you that dosimetry calibrated with uranium is not going to measure Tc-99. Paul or Betsy, I don't know if you have any thought on that.

ORAU: I think that there are a select group of workers at the site that would be exposed to the Tc-99, and I think those were the cascade workers. I'm sorry I didn't go back and read the site profile this morning, and the other information, so I think it would be a select group of people that could be exposed to the technetium. It was pretty much caught up in the cascades and I think, I'm not sure, only certain sections of the cascades. So it was only maintenance workers who were exposed.

SC&A: I think you may recall, since you were there as part of the on site discussion; I recall the problem had to do with when they changed out the seals.

SC&A: Yes, that was where the big problem was.

SC&A: So again, I don't know. If the technetium was only 10% of the overall beta dose field or something like that, one could just say, oh well, it's not that significant in the overall dose assessment. But if there were situations where the technetium was reasonably dominant, we may have been missing it with the dosimetry. And yet, there is a statement in the TBD that all beta dose is done with uranium slab calibration. So, a lot of what I focused on was more general, but that is one of the sorts of technical dosimetry concerns that I recall. So maybe for some people, the beta dose needs to be revisited or at least it could be examined for certain job types, if there was significant potential for shallow dose and whether or not the dosimeter in use at the time would even have seen it; whether it's just the case of modifying the shallow dose by some correction factor, or having to do some other assessment because you missed it entirely. So, I would suggest this as an action item.

ORAU: I think use of uranium slab calibrator was pretty much the industry standard until the 1980s.

SC&A: Right.

ORAU: That was when people started to use a technetium source for beta dosimetry.

SC&A: It was considered a uranium plant. As I recall having been there and reading about it in the site profile, they didn't even pick up on the technetium until the 1970s. Isn't that right, Tom?

SC&A: Yes, that's about the right time.

SC&A: And so again, I am not an expert on that plant, so if the technetium was always a trace contributor to the uranium field, then I think things are fine as is. If there are situations where it was chemically extracted, or physically extracted, in the cascade and I read that they were deliberately trying to extract it, for various reasons to do with the clogging of the barrier, and different things, if there is a situation where it became either a significant fraction, which I would say is 10% of 20% or more of the overall beta field, or the dominant factor, then the calibration may have been wrong and the dosimeter may or may not have even picked it up.

ORAU: Yes, I'm sure we agree with you in terms of the technical aspects of this. Like you said, is it a significant contributor?

SC&A: And I think that the only person who would know that is someone who understands the sort of the chemical engineering of the plant, and whether or not technetium was ever sort of isolated as a relatively pure product, or was it always in ppm inside uranium or uranium compound.

ORAU: We agree with you, maybe we need to review this. There is quite a bit of discussion in the TBD about technetium, but whether it's adequate, in terms of a significant potential exposure, we will have to check that. It certainly says right in the site profile that this is a potentially significant source of exposure in terms of an impurity in the recycled uranium.

Q.9 SC&A: OK. The next one sort of continues on with technetium. One of my concerns was that clearly, if for example, technetium was inside a steel pipe, it is not going to cause much trouble – no trouble from a beta and if the pipes are too thick or maybe not even from a bremsstrahlung problem. But, presumably, workers are going in and breaking open pipes, vessels, or containers, and working with exposed and diffuse sources, rather than point sources; extended source of beta as contamination or crud inside pipes or on filters and so on, then they are exposed to extended sources of beta, so the same thing applies as on the previous one. And then, I want to, as part of this talk about the response to item 9, it seems that item 10 and item 9 tend to disagree with each other. If you look at the last sentence in response to item 9, it says Tc-99 will not produce significant bremsstrahlung radiation, due to the relatively low energy beta radiation emission. In the first sentence of the response to item 10, it says that the Tc-99 ... will provide a major source of bremsstrahlung radiation from the beta emission. So, I would suggest, my health physics knowledge, would say that any beta emitter can produce significant bremsstrahlung, even tritium, by the way, if you have enough of it. And so, it all depends upon the situation and nonetheless, those two responses disagree with each other completely.

ORAU: I think we agree with you technically, but the author was thinking probably of the practical significance, but we can agree that we could probably look at this. We all know that we use shielding, that bremsstrahlung is a function of energy and atomic number of the materials.

SC&A: Right. I think the point there is that the Tc-99 in some sort of crud buildup that someone may be exposed to, without a big thick steel vessel or containment around it, then the bremsstrahlung and the beta might be significant. I guess my point is that you can't just dismiss it.

NIOSH: We agree.

ORAU: Well, maybe we need to look at it. I guess I still think it's not significant. Maybe we need to look at quantity of technetium that would be enough to produce, and the atomic number of the material that would be interacting to produce, a significant bremsstrahlung.

SC&A: Absolutely, if you have uCi quantities there, then we are wasting our time talking about it. I did ask that question and the reply on the amount of material was the precise amount of material is not known. My reply to that is that I don't want the precise activity level, but I'm happy with an order of magnitude. I do know that when you look at the mass balance project, they are talking about thousands of curies overall of technetium being released from the site. But given the massive quantity of material processed through the site, this may or may not be significant over many years. And it still doesn't tell me how much was not released that sort of went through the site. So I agree, isn't that correct?

ORAU: Yes.

SC&A: That's an important question for me and knowing how much was there. That's where I started coming from. I've got no sense of this from any of the documents that I have read, and that's part of the problem. And whether there was chemical or physical concentration of the technetium – again, I still do not know when it's concentrated, is it just detected, or was it a problem. The fact that it is mentioned so much makes me assume it was a problem. That's just an assumption on my part.

ORAU: You know, from an interesting perspective, the more bremsstrahlung we have the better off the dosimetry will be. So we agree with you that maybe we just need to tighten this up a little bit because the question, "is this significant," needs to be resolved. I think the site profile tried to address it, but obviously, given the questions that you have, the discussion wasn't fully successful.

SC&A: It may not be a problem, but I don't see anything that tells me it's not a problem.

SC&A: The aspect I would offer is that, from our visit to the site and talking to various people and stuff like that, it wasn't so much an issue of ubiquitous concentration of technetium around the site. I think the point that Betsy made earlier was that it was a small group of workers that really were coming into contact with it when they were changing out the seals and the transport of those materials down to 1104 of 1140—wasn't it Tom?

SC&A: Yes, it was somewhere in those buildings.

SC&A: They would have been the ones who that really got any significant (potentially significant) exposure.

SC&A: I agree. It's clearly not a site-wide problem, because it would have been diluted in the stream. It's only in those situations where it was accidentally or deliberately concentrated (and by the way I get the impression it was deliberately concentrated) to remove it for various reasons for some places and some points. The fact that it was concentrated does not necessarily mean that it was a significant hazard. I think everyone is in agreement on this.

Q.11 SC&A: Item 11, the use of the ratio of neutron-to-photon fields and the use of the Paducah data – the concern I had and still have is were there similarities between the two plants? There were clearly differences between them, especially early on when K-25 was an experimental facility. The enrichments were different. And also, forgetting Paducah for a second, K-25 over its lifetime and while using recycled uranium; with different enrichments; the special projects going on over the life of the plant; I don't see where there is any documented justification for the 0.2 ratio to be used over time and over geography (both to be the standard number). It may be that it's very conservative and already covers worse-case scenarios, but if it does, it doesn't say that. It just says we are just using a 0.2. And the key question that I have for the site profile is that surely there would be situations where there would be a container that emitting some x-ray or beta/gamma or material that emits x/or beta/gamma and some neutron field, but the container is thick steel, as an example, and clearly attenuates most all of the photons, yet there is no lower atomic number present and the neutron field becomes dominant. And I see no discussion of that at all. I know, from my own personal experience, I have seen that sort of situation, where people didn't even know there were neutron fields and the containers shielded the x-ray and beta/gamma. They were actually storing some of these containers in someone's office and yet they were sitting in a neutron field of about 30 mrem/hr, because the gamma could be successfully shielded. So, I just don't see any support for that blanket assumption; although it may be valid, it may be that the 0.2 was the worst thing that was ever found. I didn't find the support for that.

ORAU: Well coming up with a good source of information, when you can't use the facility-specific information for a surrogate for the neutron-to-photon ratio is a challenge. Do you have any recommendations as to what source of information you would use?

SC&A: Well, I guess clearly going and measuring it would help. I think there has been some modeling done (computer modeling), and there have been some measurements. I think those are certainly on the right path. And then, I think some sort of learned discussion among some experts would be helpful. With yellow cake, the dose would be higher if it's empty than if it's full. I think some people who know these facilities, even in the present day, could ascertain if there would be situations where the neutron field is significant or not and dominant in terms of the neutron field. My gut reaction is that there would be. I may be completely wrong on that. And then, the other thing is that a lot of the numbers (you know- we know how thick a number of these containers were or are), a lot of this could be reconstructed without too much work, in terms of at least relative dose rates for the photons and the neutrons. And then again, it may be very conservative – it may not be. My gut reaction is that it is a pretty broad brush.

ORAU: Well, speaking for the site profile team, we can certainly look at this further. These are good points. We will be in Oak Ridge next week; maybe we can corner someone at the meeting and ask them about it (or in Knoxville).

SC&A: Yes, well maybe again, the one that is most likely is the one where there is no beta/gamma to speak of, so using a ratio just doesn't have any meaning in those situations.

ORAU: We have seen that in fuel casks. It's somewhat different than this, however.

SC&A: Good. Thank you.

Q.12-Q.15 In regards to these next few responses, I didn't have any additional things to discuss other than the correction in Q.14.

Q.16 SC&A: This was the concern (were the people with the highest likely exposure badged?) or was it a cross section of the workers badged, including those who were most likely to get high doses, intermediate and low doses? There are different reasons for doing these two approaches. I guess there are different reasons for doing those two approaches, of course. And one example that was brought up in a 1977 study, where people were stated as having routine monitoring was used for workers when they entered areas with the potential for exposures. I guess it comes down to how comfortable we are with that one report. Is that valid? I'm too new to this to know whether I would hang my hat on this one study or not, so I will leave that to others to decide if that is an adequate answer. It still leaves me with an uncomfortable feeling. You are talking about a big plant with many different people with lots of different managers and contractors – does that study really hold is my question. I don't have any evidence that it was done in any other way, but I do know that people did have reasons to badge other workers other than just the highest workers to get a cross section of the data and so on. Harry, I don't know if you have anything to add to that?

SC&A: No, other than I think Chuck would agree that this issue has come up at other sites. Isn't that correct, Chuck.

NIOSH: I've been involved at the Hanford site thus far. I'm not 100% sure whether this is true for other sites. Jack has sat in for other sites; perhaps he has a comment. Who would be a better person to ask that question to?

SC&A: Well, in my mind, it came up often in the how they handed out dosimeters to a representative group.

ORAU: Well, I think it depends a lot on who has the potential for exposure. In many cases, at many different sites, they have essentially monitored a sampling of workers to assess what the situation is. There are many instances where they have assigned dosimeters and after 3 or 5 or 6 months, have taken the dosimeters away because there didn't seem to be enough exposure. At LANL and many other sites (e.g., Iowa), this was common practice to see what the potential might be. For some sites where there is a significant potential for incidents for very high exposure, and where there were security issues, like at Hanford, there was a tendency to require everybody to be badged when workers entered a radiological area, it was typical to have them monitored. It's very site-dependent.

SC&A: Yes, the issue here was two-fold. First was, were people wearing a badge at all, and second, people who were likely to get zero or who were expected to get zero, was it likely to issue them badges and then use some kind of averaging or coworker type of data manipulation—you are always at a risk of diluting the average of those that were exposed.

ORAU: You bet. I agree with you totally.

SC&A: So, that's a hard one to manage and I think that the reply that was given to the question was a good start in my opinion. It was one example. But I don't know if I would hang my hat on that one example that covers a range from 1959 to 1974. But one of the questions is how well respected is that study and how thorough was it. It may be all that is needed. I just don't know.

ORAU: I don't know either. One thing nice about the health effect study is that they are typically looking at each subject. I suppose in some cases like collective dose, such a health effects study is particularly meaningful.

SC&A: Tom, I don't remember any discussion while we were on site that any representative dosimetry was used, or selective dosimetry, if you will.

SC&A: No, that didn't seem to come out. They either had a badge or were in an area where they didn't think they would need a badge.

SC&A: Yes, I didn't get much of an idea that they used coworker badging.

SC&A: Yes, coworker badging, it wasn't as predominant at K-25 as at some other sites.

ORAU: I'm thinking that for all the documents that I have reviewed, I don't remember seeing any words like that – that they were going to monitor 25% of the population and then use that.

NIOSH: If we are going to do a dose reconstruction on a person at K-25 and they had no dosimetry, based on their job function, and it looked like they were potentially exposed, then you would assign them a coworker dose. That's how you would pick that person up.

ORAU: Right.

Q.17- Q.18 SC&A: On the last couple of questions really needed, probably from our side, could have been edited better on my part – a couple of questions were repetitive – or were nibbling around the same general question on the neutron-to-photon ratio subject – we have already agreed we need to look at that. So Q.17 and Q.18, I don't have anything else. So, I think I am done with my comments on the responses.

SC&A: Well, that's what we have from our end. Chuck, is there anything you want to go back and review or actions and follow-up, and clarifies what you are going to look into?

Actions for Follow-up for NIOSH/ORAU from the Conference Call

NIOSH: Let's recap and clarify what we need to follow-up on.

(1) Ensure that areas we agreed changes were needed are updated in the next revision of the K-25 External Dose TBD.

(2) Q 5 – The statement that the dosimeter doesn't respond to < 60 KeV and then the response that it over responds to 60 keV. Also, the point that it is "of no consequence" needs clarification in the TBD.

(3) Q.7 – TBD's claim that 'dose less that 0.5 mSv/hr is not significant' needs to be qualified. (How much it was and what it related to)

(4) Q8 – TBD needs to clarify the utilization of the uranium slab as a calibration source for potential Tc-99 exposure. (What it applied to and what it didn't apply to)

(5) Q.9 – Need to tighten up the Tc-99 issue relative to the concentration and the potential number of workers who might have been exposed to significant concentrations – determine certain job functions and locations that may need to be looked at further.

(6) Q 9 and 10 – Need to tighten up the discussion about bremsstrahlung exposure. (May not be a problem, but there is some inconsistency that needs to be worked out between Q.9 and Q.10.)

(7) Q.9 and Q.10 – TC-99 potential dose needs to be evaluated further for certain job functions or locations. It was agreed that certain jobs could be an issue and need to be reviewed.

(8) Q11 – The neutron-to-photon ratio issue needs to be looked at. Did it come from Paducah? Did it come from Cardarelli's Portsmouth study? If you use one number, then the TBD needs to justify that and determine if that is the right number that can be used in all situations. Follow-up at the Knoxville mid-year HPS meeting was mentioned as a way to follow-up on this.

NIOSH: In responses where we need to modify those, should we do that at this point, or is this all going to feed into the SC&A audit report?

SC&A: Tom, we can just cover that in our report, can't we?

SC&A: I would think so. Yes, we will summarize these in our report.

SC&A: It will be in the summary conclusions of our audit report and that would leave it to you to resolve the intended actions and updates to the External Dose TBD. The good news is that this has all been recorded in a conference call recording tape and in the next few hours, it will be available if anyone wants to review it. What will happen, Tom will be writing this up as a summary in our report.

SC&A: Yes, that is correct.

SC&A: The fact that you have agreed to make those changes will, therefore, be included in our report. If no one has anything else, we appreciate your attendance and involvement and we will get back as soon as we can on it.

Conference Call Notes on K-25 Issue Resolution for the Occupational Medical Dose TBD, the K-25 Occupational Environmental Dose TBD, and the K-25 Occupational Internal Dose TBD

Date: January 24, 2007

Participants

NIOSH: Chuck Nelson

ORAU: Susan Winslow, Bill Thomas, Carol Berger, Liz Brackett, Jim Turner, Elyse Thomas

SC&A: Harry Pettengill, Tom Bell, Eric McKamey, Bill James

INTRODUCTORY COMMENTS:

SC&A: We have followed what we did before for the K-25 Conference Calls. We already have completed the one conference call on the K-25 External Dose TBD last week. What we hope to do is follow the same kind of format today for the Occupational Medical Dose TBD, the Environmental Dose TBD, and the Internal Dose TBD.

If you noted when we chimed in, we are recording this conference call. The only purpose of recording the call is to help us recall and get down the essential points. It will be available to everybody who is plugged into the call, and we will make sure that information gets through to you. So if you want to go back at a future time in the next few days, you can listen to any of the conversation to clarify anything that was said and to verify points. This is something that is available to everybody. Then, after about a week or 10 days, it goes away. If you want to keep it, you will have to download it to your computer.

The process we will follow is that we will go through the sections and the questions, and we will indicate from our end where the response doesn't quite answer the question for us and ask for clarification and any additional questions we would like to ask. I would like to use this opportunity to get clarification on any lingering issues in terms of, "Is that really what we meant by the questions?"

We will take the responsibility of making sure the summary notes of the call get written up. Now the one thing we would tell everybody, and NIOSH has already agreed, is that what SC&A did the last time was too much verbatim. So we are going to try to cut back and shorten these summary notes, so that we just hit the salient points to reduce the information coming back to you. We will ask for your end to turn it around as quickly as you can, because this is an opportunity for you to clarify anything you feel is needed.

ORAU: We do have a question. In regards to responding to your questions and comments, do our comments to change the summary go back to Elyse? Who should we send our comments back to?

SC&A: You will respond back to Tom and I for SC&A, and I will send them over to Chuck and Elyse, who will coordinate and respond from their side.

NIOSH: As the questions come up, they will be done by discipline or section, and the ORAU point of contact will chime in as best they can. If I have anything to add, I will add it in. If anybody else might have that expertise, just jump in and add anything, as needed.

ORAU: Bill Thomas offered to cover as many questions as possible, and where he could not, he will get back to Paul Szalinski, who has other commitments today, for any additional input that is needed and can be included in the summary.

GENERAL COMMENTS AND SITE DESCRIPTION

SC&A: In regard to the General Questions and the Site Description responses, we found in most of the responses we have no problem with your answers at all. We will just accept them as written. The only comment that we have is on item 10. The question in item 10 is "How does NIOSH verify the completeness and accuracy of the data provided by the K-25 site? In your response, you indicated that the Site Profile was developed using documents that were developed by K-25 and reviewed by the DOE. When available, multiple documents were referenced to provide consistency. The only question here, and it came up from another site as well, is that in the course of the SC&A review, we found that almost verbatim, the information in the TBD, had been written by the site contractor. Is the wording "developed by" an overstatement of who wrote the TBD section?

ORAU: The technical documents reviewed were provided by the K-25 contractor. We would look at those and retrieve paragraphs or summarize the elements of their program in the specific TBDs. For K-25, they had not been in operation for some time and the people working there did not participate in the development of the TBD, and they did not actually write the TBD.

SC&A: Then we accept it as written for the responses that NIOSH/ORAU has provided for General questions and the K-25 Site Description section of the TBD.

OCCUPATIONAL MEDICAL DOSE (ORAUT-TKBS-0016-3)

General:

SC&A: We want to thank the responders for their most helpful responses. For the most part, they answered our questions most thoroughly. There are still some issues that we would like to get some clarification on, and we can address these as we go through the questions and the responses.

First off, we apologize for the confusion in the Table numbers. As we were reviewing the Medical TBD, we were continually aware that the K-25 Medical TBD was the only TBD document that had not been updated in 2006. We periodically checked the update page, to ensure that a more current update had not been published. Our comments were sent out to you on November 8, 2006. We didn't catch that an update had just been released on November 7th until we looked at the OCAS update page on November 9th.

As a consequence in using Turner (2004), as I noted in our questions, the tables were in an appendix at the back and were titled Table 3.1-1, 3.2-1 and 3.3-1 in the earlier TBD version. In the Turner 2006 update version, the tables were integrated into the text of the report and were entitled Table 3-1, 3-2 and 3-3. For the purposes of our discussion this afternoon, we will use these later table designations. The contents are identical as far as we can see.

Secondly, if the response is OK, we will just say it's OK and to save time, we will move on to the next question.

Q.1 SC&A: This question had to do with any evidence found for special medical x-rays. Your response seems OK for the most part. However, when interviewing the medical x-ray department personnel we found they had medical records for all K-25 and their individual x-ray files on file back to 1989. They also stated that the medical records for the 1940s and 1950s were thought to have been microfilmed, but they did not have them available.

In your review for special medical x-ray examinations, were you able to verify that there were no special medical x-rays by reviewing those microfilmed medical records?

ORAU: We did not personally review microfilm copies of claimant medical records. We relied on K-25 to provide pertinent information that they had access to when we made the request for their records. ORAU said that in reviewing some of that data, they did see documentation of x-rays being taken in the 1940s and 1950s, and they had not seen any evidence of any special medical examinations. NIOSH acknowledged that, if data doses exist on microfilm files, and it can be documented that the K-25 site personnel did not forward these, this data should then be looked into.

Q.2 SC&A: In this question, we were concerned that the general rule on chest x-rays done annually might be used by the dose reconstructor as a default without a thorough check of the medical record to see if information on frequency, reasons, and types of x-rays might have picked up additional x-rays for the claimant. Your response addressed this well by stating that the frequency in Table 3-1 is used unless the individual-specific frequency is known and is more frequent than that in Table 3-1.

Your response indicates that, when a "best estimate" approach to the dose reconstruction is necessary, the approaches used are those documented in PROC-0061. This is not mentioned anywhere in the updated Turner 2006 TBD, nor is the use of PROC-0061 mentioned. Will this be added to the next update of the K-25 Medical TBD?

NIOSH: In the next future update of the K-25 Occupational Medical Dose TBD, PROC-0061 will be addressed and its role in DR will be explained.

Q. 3 SC&A: This response regarding whether dose estimates for the dose delivered by each chest x-ray was found in the individual claimants record is OK. When we talked with a medical x-ray technologist, during our interview it was verified that the dose delivered was consistent with good practice at the time, at least as far back as 1977.

Q.4 SC&A: The issue of the possibility of some workers who worked with uranium dust getting monthly x-rays (mentioned in footnote to Table 3-1 in the period from 1944 to 1945) is still a concern to me. Footnote b, Table 3-1, as you pointed out, also states that some workers got chest x-rays every few months with potential for uranium dust exposure in the 1946–1959 time periods. We just want to make sure that your review of claimant medical records is thorough enough to ensure that the claimant's file is complete with all these either monthly x-rays in 1944–1945 or every few months in the 1946–1959 periods, and that they are being included in the individual claimant's dose reconstruction.

ORAU: We believe that the data we received from the K-25 site does not support this, and also based on claimant data submitted thus far, workers were not receiving monthly x-rays, and ORAU has found no other documentation of monthly x-rays for workers exposed to uranium dust in the 1944 to 1959 timeframe.

Q.5 SC&A: This question was related on questions 4 above and has been resolved by our discussion above.

Q.6 SC&A: This is similar to questions 4 and 5 above and has been covered.

Q.7 SC&A: This response is OK. Your assignment of an x-ray dose on an annual basis after 1959, even though chest x-rays were no longer required for non-radiation workers, is conservative and claimant favorable.

Q.8 SC&A: Your response was reassuring in that you are assigning the higher PFG doses until the end of 1956 in the absence of information to the contrary. This response is OK.

Q.9 SC&A: This question also had to do with assignment of a dose similar to the dose of 3.0 rem recommended by OTIB-0006 (Kathren and Shockley 2005) for PFG examinations. As the TBD points out, these were done on K-25 workers from 1944 to 1956 using the GE-KX-10 x-ray machine.

We were concerned that even the K-25 Medical TBD (Turner 2004) did not mention OTIB-0006. Your response validates that Table 3-2 documented skin entrance kerma of 2.488 cGy for these early PFG x-rays used, but it is not clearly explained in the text that this was being used in lieu of the generic default value of 3.0 cCy for OTIB-0006.

Even in the updated Medical TBD (Turner 2006), OTIB-0006 and PROC-0061 are neither mentioned in the text of the TBD nor in the Reference section. Do you plan in future updates of the K-25 Medical Dose TBD to better explain this, and add some discussion about OTIB-0006 and PROC-0061 and add them to the References?

ORAU: We did have access to near-final copies of these two documents and have already incorporated the pertinent procedures into the DR process for K-25 occupational medical dose.

NIOSH: In future updates of the K-25 Occupational Medical Dose TBD, there will be some discussion of the use of OTIB-0006 and PROC-0061 in the K-25 DR process.

Q.10 SC&A: Our discussion in question 9 above covered this question as well. I have only on additional thing to note. Our question quoted something from (Turner 2004, pg. 7) that stated, "The type of X-ray machine was probably recorded, so organ dose can be extracted directly from Table 3.3-1." Your finding that from 1944 to 1956, 86% of the examinations were performed with the GE KX-10 PFG exposures was most interesting. It was reassuring to note that if the medical record does not identify which machine was used, the claimant-favorable assumption would be that it was the GE KX-10 x-ray machine. The latter part of your response, however, states that, "In most cases, the individual medical records don't include information to ascertain the type of X-ray machine used, and that the latest revision of the TBD (2006) doesn't contain the statement above." If it was your intent to remove the quote in our question, I just wanted to point out that it is still in (Turner 2006) in Section 3.6, page 9, middle of the first paragraph.

SC&A: Acknowledged that the assignment of 86% of the workers receiving the GE KX-10 PFG dose was claimant favorable.

Q.11 SC&A: This response of documentation to support the assumed techniques and protocols applied to calculate dose for K-25 is OK.

Q.12 SC&A: This question was answered in Q.11 above.

Q.13 SC&A: This response is OK.

Q.14 SC&A: This response if OK. A medical x-ray technologist interviewed during our K-25 Site visit pointed out and provided documentation that in 1977, the Westinghouse 300-mA x-ray machine was inspected and certified by a known, licensed and respected health physicist.
A medical x-ray technologist at the K-25 Site pointed out that from 1987 to present, the K-25 Medical Department has been using a Bennett D-5251 Unit with a Eureka Tube (Inovision Model 4000) with an automatic collimator. X-ray output is 500 mA, but it is run at 300 mA.

ORAU: ORAU stated that, "The K-25 TBD and OTIB 0006 both assume a poorly collimated beam prior to 1970, and used substitute DCFs to account for this. The substitute dose conversion factors are chosen (and documented in ORAUT-OTIB 0006, 2003 and 2005) to include more organs in the primary beam than would be the case for a properly collimated beam."

NIOSH: Indicated they would incorporate it into the next updated K-25 Occupational Medical TBD.

OCCUPATIONAL ENVIRONMENTAL DOSE (ORAUT-TKBS-0016-4)

General:

SC&A: We also do appreciate the responses and have very little on which to comment.

Q.1 SC&A: Because of a generic statement about noble gases in air, we felt this is one thing that needs to be investigated. We are OK with the response.

Q.2 SC&A: There were two different references in the TBD that identified americium-241 as a contaminant. But given the response that the major contributors are what's included in the table, we can accept the response.

NIOSH: There were two references?

SC&A: Yes, located in two different Sections in the TBD – Section 2.2 and the other in Section 4.2.

Q. 3 SC&A: The response is fine. We do understand that the calculations as performed are OK - no problem.

Q.4 SC&A: The only reason that I brought up the administrative area was because, in the section where it was written about, there is reference to it, but it wasn't shown on the map. That was the only reason. Other than that, it is OK.

Q.5 SC&A: In the TBD, it identified upwind and downwind locations, and the response identified the downwind location as the primary consideration. The response is OK and, if it will be revised, that's fine.

Q.6 SC&A: OK – no problems.

Q.7 SC&A: We noted a typo, in that 75 mrem/200 hours should be 75 mrem/2,000 hours. In the Annual Environmental Reports for 2003 and 2004, we found the report that was previous to those that, let's say a 2000 report, that has some different information. Would it be reasonable to assume that if a report written in 2000 made recommendations, and within 3 years those recommendations had been instituted, that this could lower the doses? And if that is the case, is this previous document important to look at?

ORAU: Our response is if we had one document that is the 2003 report, and there are other documents that we could review for information, the purpose of the site profile is to summarize those documents as they exist. Do you know of any additional documents? Are you saying that the 2000 report does have a section on this?

SC&A: There is a 2000 report written by Bechtel Jacobs, actually a Bechtel Jacobs document, that is an investigation done by SAIC that has to do with the doses around the cylinder yards. The maximum value that they found is a little bit higher than the 75 mrem/2,000 hours, and it does estimate a gamma-to-neutron ratio for determination of neutron dose.

ORAU: I think it might be pertinent to provide that information. There is nothing that has come to light that would show what actions were taken within those 3 years that might have reduced the dose. We think it is important to get that document. Is that document on the Site Query Research Database?

SC&A: I believe that is a document we found during our site visit at the DOE reading room or the K-25 library. We will send it to them. We will need to identify which one you are referring to. We will see if we can get NIOSH/ORAU a copy.

ORAU: So, we would want to summarize the data that exists and provide multiple data points.

Q.8 SC&A: The reason we brought this information up was that we looked at the Portsmouth Gaseous Diffusion report where it identified the 200 mrem per 2000 hours. The K-25 TBD also made reference to that, but used a different value. To some extent, it leads to confusion. We guess it's pertinent to show that there are similar dose rates, but by putting the higher value in there, we don't know if this doesn't cause confusion or gives the impression that we are using a lower dose, when in fact, there are higher doses available. The response is definitely acceptable.

ORAU: So the observation here is that in Chapter 4, these kinds of results are consistent?

SC&A: Right.

Q.9 to Q.15 SC&A: We are fine with the rest of your responses. However, on Q.11, I would like to ascertain some additional things. We would like to better understand, in the TBD, in regard to environmental dose, are these planned releases always from the stacks and exhaust points? Is that correct?

ORAU: Yes.

SC&A: Then the question that we have is, Are there any releases or even unplanned releases that have been documented that we can show would have provided exposure to unmonitored workers?

ORAU: Are you saying are we aware of any?

SC&A: Yes.

ORAU: We are not, but if we see any of those records, we can certainly add them in. To my knowledge, none of those were included or were available when the TBD was prepared.

SC&A: We noted that the TBD does say that if additional information is found, it will be revised. We understand this is a very dynamic process and we appreciate that.

ORAU: You have had a chance to review it. Is there a particular incident that you came across that you were looking for that was not characterized that we should add?

SC&A: We recovered some information and reports that they had numerous releases that we think occurred primarily between 1980 and 1985, and we recognized that they were in buildings where they were breaking into process lines, but not released directly to the environment.

OCCUPATIONAL INTERNAL DOSE (ORAUT-TKBS-0016-5)

Q.1 SC&A asked, "Has NIOSH made any progress on analyzing the accuracy of the K-25 data in the database? We are talking here about the accuracy of the bioassay data. Is there any work on the analysis that is pending?"

ORAU: No, we did ask Mike Mchathy, because he did the review of the Y-12 data, which is in the same database. We found an e-mail message that said he was going to do that. We think he did tell me that he did check some of the K-25 data in the coworker database – but again, this is in the coworker database and we don't know if that would be the same. We believe that K-25 uses the same database that we have, but I don't think that has been pursued any further, and I don't know if he is the one that would be doing it.

ORAU: It's not being done by the group that Paul Szalinski is directing either. So, if you want us to come up with a schedule and find out the status, we can work with Liz and Mike to give you a more specific answer. It sounds like the schedule is still pending and has not been finalized yet.

ORAU: Actually, Mike Mchathy worked at K-25, so if he has a conflict of interest, he will not be the one to work this and I (Liz) can't either, so we will have to find someone else to do this.

Q.2 SC&A: Does NIOSH expect any difficulties in using the bioassay data appropriately, such as problems with labeling units on results with identified result units, units difficult to interpret, or typographical errors, etc.? It sounds like you had the Y-12 bioassay data looked at and maybe can infer some things.

ORAU: We did investigate this for K-25 – again, as far as coworker is concerned, we did investigate what units should actually be and did come to a conclusion of what they were supposed to be and documented that in the coworker OTIB-0035 in July 2006. This, however, did not make it into the Site Profile yet. But it was investigated. We did not put it into the TBD update, which came out (Chapter 5) in October 2006. There is some information there that we can glean from this for the next update.

SC&A: Has NIOSH identified any fecal sample data yet?

ORAU: We don't think there was any discussion of fecal samples or fecal sample MDAs in the TBD. The TBD focused mainly on urine. We would have to look and see if there is anything in the TBD on fecal sampling. We don't think we used fecal sampling results in the 2004 version and more recently the 2006 TBD version. There were none used in the coworker study. There was no fecal data found in the DOE files either and we have not run into any fecal samples at all at K-25.

SC&A: During the site visit, our team did find a document in 1964 or 1966 at the uranium recovery facility where they had very insoluble forms there, and they decided to have couple of years fecal monitoring—so there may be some fecal data out there, and these may have been combined with urine monitoring. But we don't know how well it's going to be retrieved. Looks like in-vivo sampling started up in 1964. They determined some lung retention half-times in that report. The report was going to be a presentation at the first IRPA Meeting in mid-1966. It was a fairly impressive report, discussing all the monitoring they were doing at that time at the uranium recovery facility at K-25.

ORAU: Is that a report that you say you have?

SC&A: Yes, I got the report from Kathy Robertson-DeMers.

ORAU: Can we get a copy of that, too, so that we can add it to our Site Research Query Database?

SC&A: Sure. It's on the list.

ORAU: Is it on the CD?

SC&A: It's on the list I have; I think it might be on the CD.

SC&A: I do remember it coming up. It was an IRPA conference presentation.

SC&A: It was more of a summary discussion of the whole program and it was obviously dealing with pretty insoluble forms. It was interesting to see that the in-vivo counters could provide information on lung retention half-times.

Q.3–Q.5 Okay

Q.6 SC&A: Has NIOSH found any centralized incident information systems for K-25 or databases listing incidents for K-25?

ORAU: We haven't seen such a box, but I would assume it exists.

SC&A: Is there any system in place to efficiently find incident report information if a claimant identifies incidents during the CATI that they were involved in some? Have you worked on a method to find them?

SC&A: Maybe a better question is, when they got their file from K-25, did it include any information about incidents?

ORAU: From what we have seen so far, we don't recall seeing information about incident reports for K-25 workers. If we run across a situation where an individual claimant tells us in his CATI that he was involved in an incident, and we do not have enough information provided in the record provided by the site, we can make a supplemental data request for more data to try to find more information. There does not seem to be incident documentation at K-25, but there is a system in place to pick it up. We have done that for various cases on some of these sites.

Q.9 SC&A: This relates to the last year of recycled uranium reprocessing of spent fuel, where you have opted to cover from 1952–1988 inclusive. We have a question as to how you are going to use that data. Will the default isotopic distribution that contains the transuranic and fission product contaminants (Table 5.6) be your default distribution? Will it be applied for all intakes of uranium assessed from 1952 to 1988?

ORAU: Yes, we are applying the recycled uranium component from Table 5-6 to each of the dose reconstructions, based on our uranium information that we have for all years. Our assumption is that once it gets there, it is still going to be there. Just because they stopped receiving it, doesn't mean that it is all gone

ORAU: Moreover, we can't really tell when it stopped and started, so we believe it's claimant favorable to do just that.

SC&A: What about from 1988 to the present – will you assume the same isotopic distribution?

ORAU: That's what we have been doing, yes.

Q.12   SC&A: Regarding the default distribution being claimant favorable, has any additional source term information been found in the last couple of months that would change your defaults? The site interviews and document searches indicate that there may have been other radionuclides involved with some work at the site and higher enrichments, than the default, which were used at the site.

ORAU: We don't have any additional information as it pertains to the existing site profile. We think it behooves us to look at the coworker study that was issued in July, and see if there have been any changes that would be needed there.

ORAU: The coworker study would refer back to the TBD for the contaminants.

SC&A: If we are depending on the TBD, we don't have any new information today that would revise Table 6 in regards to any changes to those default distributions?

ORAU: There is an OTIB on recycled uranium that hasn't been looked at in relation to K-25, in particular. They did address larger DOE facilities, so there may be more information in there. We don't think that this OTIB has been published yet. It's close to being released. It is supposed to address recycled uranium across the complex.

NIOSH: So that would be one document that we could look at for the K-25 site profile and verify that. We can follow the publication of OTIB-0053 on recycled uranium, and once issued, we could re-look at Table 5-6.

ORAU: I believe OTIB-0053 is at OCAS now, because we had it for internal review already.

ORAU: We could look at the new OTIB document and see how it applies. This particular topic has been of a lot of interest. I remember when we first started working on the document for K-25, as we looked at distributions at Paducah, and at Portsmouth, we actually had a subcommittee we formed called the harmonization committee to try to come up with some consistent assumptions, because at each site we had headed off in different directions and Cindy Bloom tried to help us harmonize the three gaseous diffusion plants.

SC&A: Good, it looks like you are making sure we get all the radionuclides involved with all the default distributions.

Q.17   SC&A: This question is about which enrichment. Is NIOSH going to assume 3% enrichment for all U intakes identified with mass concentration bioassay data, and will not consider a higher enrichment? Site documents indicate enrichments higher than 3% at certain buildings during certain periods – higher enrichments generally in the earlier periods.

ORAU: We can't speak to that question, but we can tell that most of the bioassay results are in terms of activity, so the enrichment doesn't affect the outcome of the dose assessment. For the coworker OTIB, we only used the results that were in activity. There were some mass measurements done at the same time, but there were activity measurements also.

ORAU: Yes, we are using activity.

ORAU: And, not that we don't have to mention enrichment, but it will have little affect on the dose determination.

SC&A: At least you are aware that when you are interpreting mass concentration, that you are not always sure how much is there. If you just changed 3% to 4%, the dose would go up significantly. There were a lot of areas during different periods, especially in the early years, where enrichment went up to 5% or 10% or 12%. We know what you are saying, and that most of that period was covered by the gross alphas data – the activity measurement should be associated with the higher enrichment.

ORAU: Most of the data in the early days is gross alpha. They were doing gross alpha even when they were doing the mass measurements, so most people have both, and we use just the activity measurements.

INTERNAL DOSIMETRY COWORKER DATA FOR K-25

Q.2 SC&A: Has NIOSH found any information on early radiological controls during the pre-1948 period, or that any doses would have been significantly higher before the beginning of the bioassay sampling? Site document searches found some documents that describe these earlier years that could be interpreted as showing controls were not as advanced as in the years that followed this period.

ORAU: We don't know if anything has been found on radiological controls, but what we did with the coworker OTIB was to take people who started in the days before monitoring, and we looked at their results later on. With the slow excretion of uranium, you can take samples several years later, and still get a relatively reasonable picture of what their exposure has been. The people who started in 1945, their results in 1948 and later were no different than the other people who had started in 1948, and later. So it looks like the exposures were still similar over the whole time frame. The workers in 1945 seemed to be excreting uranium at the same level as those in 1948 and later. It looks like we could assume the same intake rate for each period. In the coworker document, it is a single intake rate for this entire early period. The urine results are pretty steady. It only varied up and down by a factor of 3 or so. For the whole period of 50 years, it's still within a factor of 3 or 4 for every year.

Actions for Follow-up for NIOSH/ORAU from the Conference Call

K-25 Medical Dose TBD Follow-up

(1) Q.2 – When the Medical TBD is updated, ensure that it includes a discussion of PROC-0061 and OTIB-0006 (Kathren and Shockley 2005) and how it related to the dose reconstruction process on occupational medical dose.

(2) Q.9 – Clarify in a future update of the Medical TBD that the OTIB-0006 procedures were available, pre-issuance, and have been considered in the (Turner 2006 update). Clarify that the Table 3-2 documentation of skin entrance kerma of 2.488 cGy for these early PFG x-rays was used, and that it was used in lieu of the generic default value of 3.0 cGy from OTIB-0006.

(3) Q.14 – Ensure that the below information, included in the NIOSH response to Q.14, is added to any new updates of the K-25 Medical TBD.

The K-25 TBD and OTIB-0006 both assume a poorly collimated beam prior to 1970, and use substitute DCFs to account for this. The substitute dose conversion factors are chosen (and documented in ORAUT-OTIB 0006, Rev. 2, 2003 and Rev. 3, 2005) to include more organs in the primary beam than would be the case for a properly collimated beam.

K-25 Environmental Dose TBD Follow-up

(4) Q.1 – Investigate further the possible dose potential from noble gases.

(5) Q.4 – Review/resolve inconsistencies in the down-wind maximum ground level concentrations mentioned in the text vs. those shown in the map in Figure 4-1, pg. 8.

(6) Q.7 – Correct the typographical error. 75 mrem per 200 hours should be 75 mrem/2,000 hours.

(7) Q.7 – SC&A to provide NIOSH with Bechtel Jacobs document regarding the investigation dose around the cylinder yards in regard to gamma-to-neutron ratios that is on the CD-ROM sent out to SC&A Team Members.

(8) Q.8 – Make sure assumptions for potential external exposure at the Portsmouth Gaseous Diffusion Plant are applicable to the potential exposures at K-25.

K-25 Internal Dose TBD Follow-up

(9) Q.2 – SC&A to provide NIOSH with a copy of the 1966 IRPA conference presentation summarizing whole-body counting programs and in-vivo bioassay on insoluble uranium.

(10) NIOSH is to ensure that the default isotopic distribution contained in the recycled transuranic and fission product contaminants (Table 5.6) for intakes of uranium assessed from 1952 to 1988 are consistent with OTIB-0053 when it is released.

(11) SC&A to provide NIOSH with the overview documents CD-ROM that was developed from scanned documents found at K-25 during the K-25 Site visit for interviews and document searches.

(12) SC&A and NIOSH to explore a way to get a copy of the hardcopy documents found during the document search effort at K-25 to NIOSH for scanning into PDF files and added to the OCAS O Drive. John Burn at NIOSH would be a point of contact to facilitate this. SC&A is to provide a list of the hard-copy documents that were sent the SC&A site visit team members at the conclusion of the site visit, so that NIOSH can determine the importance of capturing in PDF files what was found.

NIOSH – In responses where we need to modify those, should we do that at this point, or is this all going to feed into the SC&A audit report?

SC&A: There won't need to be individual responses back; this will just be overviews in the summary of our SC&A report. SC&A will leave it to NIOSH/ORAU to resolve the intended actions and update the appropriate K-25 TBDs. The good news is that this has all been recorded in a conference call recording tape and in the next few hours, it will be available if anyone wants to review it. If no one has anything else, we appreciate your attendance and involvement and we will get back as soon as we can on it.