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September 15, 2006

Mr. David Staudt
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Subject: Contract No. 200-2004-03805, Task Order 1: *Review of the NIOSH Site Profile for the Pinellas Plant Site*, SCA-TR-TASK1-0015

Dear Mr. Staudt:

SC&A is pleased to submit to NIOSH and the Advisory Board our draft *Review of the NIOSH Site Profile for the Pinellas Plant Site.*

If you have any questions or comments on this report, please contact John Mauro at 732-530-0104. We look forward to discussing this draft report with NIOSH and the Advisory Board.

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 of Occupational Safety and Health

Review of the NIOSH Site Profile for the Pinellas Plant Site

Contract No. 200-2004-03805
Task Order No. 1
SCA-TR-TASK1-0015

Prepared by

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Disclaimer

S. Cohen & Associates: ***Technical Support for the Advisory Board on Radiation and Worker Health Review of NIOSH Dose Reconstruction Program***	Document No. SCA-TR-TASK1-0015 Effective Date: Draft – September 15, 2006 Revision No. 0 – Draft
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Project Manager: _____ Date: _____ John Mauro, PhD, CHP	

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ACRONYMS AND ABBREVIATIONS

Advisory Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AWE	Atomic Weapons Employer
CFR	*Code of Federal Regulations*
Ci	Curie
D&D	Decontamination and Decommissioning
DCF	Dose correction factor
DOE	Department of Energy
DOL	Department of Labor
DU	Depleted uranium
dpm	Disintegrations per Minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ES&H	Environmental, Safety, and Health Group
GE	General Electric Corporation
GEND	General Electric Aerospace, Neutron Devices
HHS	Health and Human Services
HTO	Tritium Oxide or Tritiated Water
HVL	Half value layer
ICRP	International Commission on Radiological Protection
KUB	Kidney, Ureter, Bladder
LANL	Los Alamos National Laboratory
LAT	Lateral
LLNL	Lawrence Livermore National Laboratory
LOD	Limit of Detection
µCi	Microcurie
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detectable Level
mL	milliliter
mm	millimeter
MeV	Million electron volts
MMSC	Martin Marietta Specialty Components, Inc.

mrem	Millirem
NCRP	National Council on Radiation Protection and Measurements
NIOSH	National Institute for Occupational Safety and Health
NTA	Eastman Kodak Nuclear Track Film Type A
NTS	Nevada Test Site
OCAS	Office of Compensation Analysis and Support
ORAU	Oak Ridge Associated Universities
OTIB	ORAU Technical Information Bulletin
PA	Posterior-Anterior
PFG	Photofluorography
PoBe	Polonium-beryllium
POC	Probability of Causation
RadCon	Radiological Control
rem	Roentgen equivalent man
RTG	Radioisotope Thermoelectric Generator
SC&A	S. Cohen and Associates
SMT	Stable Metal Tritide
SNL	Sandia National Laboratory
SRS	Savannah River Site
SSD	Skin to Surface Distance
TBD	Technical Basis Document
TIB	NIOSH Technical Information Bulletin
TLD	Thermoluminescent Dosimeter
TTA	Tube Transformer Assembly

1.0 EXECUTIVE SUMMARY

This report provides the results of an independent audit of the Pinellas technical basis documents (TBDs) conducted by S. Cohen and Associates (SC&A, Inc.). The TBDs reviewed make up the site profile developed by the National Institutes for Occupational Safety and Health (NIOSH) for the Pinellas Plant. This audit was conducted during the period May 2006–August 10, 2006, in support of the Advisory Board on Radiation and Worker Health (Advisory Board) in its statutory responsibility under the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA). This authority includes the conduct of such reviews and advising the Secretary of Health and Human Services (HHS) on the "completeness and adequacy" of the EEOICPA program.

The Pinellas Plant was located in central Pinellas County, Florida. The initial mission of the Pinellas Plant was to manufacture neutron generators and other components for nuclear weapons. Because of its success in the manufacture of neutron generators and the possession of the required equipment, facilities, and expertise that could be applied to a variety of specialty components, the Department of Energy (DOE) expanded the Pinellas Plant mission to produce multiple electronic and support components for other DOE programs. These components included thermal and long-life ambient temperature batteries, specialized shock-absorbing foam supports, ferroelectric- and glass-ceramic encapsulation materials, and Radioisotope Thermoelectric Generators (RTGs). This expansion included relocation of a similar production facility from Milwaukee, Wisconsin, to Pinellas during the 1966–1967 timeframe.

The plant was constructed in 1956 by the General Electric Corporation (GE) for the development and production of neutron generators for the nation's nuclear weapons programs. The Atomic Energy Commission (AEC) (predecessor of DOE) purchased the Pinellas Plant from GE in 1957, and contracted them to operate the site from its startup in 1957 until May 31, 1992. In June 1992, Martin Marietta Specialty Components, Inc. (MMSC), took over operation of the facility, and served as the managing and operating contractor until the site was shut down in September of 1994. As part of the DOE program to promote commercial uses of the site, DOE sold most of the Pinellas Plant to the Pinellas County Industry Council on March 17, 1995.

Questions have been submitted to NIOSH and its technical support contractor, Oak Ridge Associated Universities (ORAU), regarding issues developed during the course of this review. As of the date of this draft, no response to those questions has been received by SC&A. Once the responses have been received, a conference call will be conducted with NIOSH to clarify and resolve any standing issues. The response to the questions and a summary of the conference call will be included in the final report for the Pinellas Plant audit. At the current time, it appears that it will not be possible to hold a conference call with NIOSH regarding our questions. Hence, this draft report is being delivered to NIOSH and the Advisory Board without the benefit of the conference call.

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). As "living" documents, TBDs are constantly being revised as new information, experience, or issues arise. The complete list of the Pinellas TBDs, as well as supporting documents, that were reviewed by SC&A is provided in Attachment 1.

This review found that the site profile provides an excellent overview of the Plant operations and characterizes the primary radiological exposure sources and conditions. The presentation and analyses of the available data were generally technically sound. However, the TBDs failed to fully address the exposure implications of these and other radiation sources, as well as the potential impact of identified deficiencies in historic dosimetry program implementation. A particular concern is the lack of material describing the activities at the facility prior to 1980, bringing into question the ability to adequately assign appropriate radiation doses during the early years at Pinellas. Even though the tritium and plutonium exposures and dosimetry are characterized, the implications to dose reconstruction of metal tritides are not adequately addressed. Likewise, the "established" radiation dosimetry program is discussed in terms of what limits of detection (LOD), minimum detectable activity (MDA), monitoring frequencies, and badging policies were the policy and site practice at the time, without qualifying this information with past and current information regarding how effectively the dosimetry program was actually carried out.

With respect to sources of radiological exposure, the site profile provides dose characterization data for tritium, krypton-85, metal tritides, and plutonium, but does not fully address the uncertainties involved with conducting dose estimation.

It is not clear from the Internal Dosimetry TBD (ORAU-TKBS-0029-5) how dose estimation would be performed for maintenance and support workers who were not classified as radiation workers and who had access to Pinellas radiological operations. No guidance is provided in this TBD with respect to missed dose calculations for unmonitored workers, such as support personnel whose actual jobs (contamination spill cleanup, equipment maintenance, janitorial functions) could have led to exposures comparable to those of radiation workers, and whose access to various Pinellas buildings may have led to a variety of radionuclide exposures over their job history. In addition, the TBD gives values for use by dose reconstructors for adjusting bioassay data for missed dose, but fails to provide a succinct summary of all the factors.

The Occupational Medical Dose TBD (ORAUT-TKBS-0029-3) does little to reasonably document the variety of medical occupational exposures, and the lack of documentation on the type of equipment and the maintenance records does little to assure that a conservative and claimant-favorable estimation of dose is possible. This circumstance would suggest the need to reconsider a worst-case approach to establishing dose. NIOSH should revisit and update, as needed, Sections 3.2 and 3.3 of the TBD.

Since the primary radionuclide employed at Pinellas was tritium, external dose issues are minimized because of the extremely small occupational external doses evolving from plant operations. However, there were some minor concerns relative to the treatment of external doses, as described in ORAU-TKBS-0029-4. These concerns are detailed later in this report.

An overall comment on ORAU-TKBS-0029-4 is that some of the topics covered in the TBD are treated in an almost cavalier fashion. An example is the treatment of uncertainty in this document. This lack of attention to detail could have been a result of the extremely small external doses projected for plant operations. While SC&A would agree with the concept of keeping effort and resources for TBD development consistent with the magnitude of the impact involved, the effort should be technically sound and reasonably comprehensive.

Decontamination and decommissioning (D&D) activities at Pinellas are not addressed from the standpoint of historic radiation exposure history and dose estimations. While this experience is relatively recent (1994–1997) and founded on contemporary radiation protection standards and technology, it is also clear that a fundamental shift occurred with this transition regarding potential radiation hazards and radiological control philosophy. The site profile is essentially silent on any treatment of radiation exposure experience during this period, and for dosimetric techniques applied for the bulk of D&D and waste management activities.

Interviews were conducted with 10 former Pinellas Plant workers whose employment spanned the years 1956 to 1995. The purpose of these interviews was to receive first-hand accounts of past radiological control and personnel monitoring practices at Pinellas in order to better understand how operations were conducted. Interviews were conducted in small groups and one-on-one in St. Petersburg, Florida, on May 27–29, 2006. The interviews sought to solicit only unclassified information, as there were a number of operations conducted at Pinellas related to weapons components that are considered classified and could not be discussed.

Interviewees were initially identified from NIOSH's Worker Outreach meeting minutes. NIOSH could not disclose contact information for the workers because of Privacy Act issues; thus SC&A identified these former workers via the local telephone directory and contacted them by telephone. Through the first few telephone calls, SC&A was able to make contact with the leader of the Quarter Century Club, a former employee association that assisted SC&A in identifying additional workers. This method of identification of site experts was time-consuming and delayed completion of the employee interview portion of the site profile review.

Workers were briefed on the purpose of the interviews and the Pinellas Plant Site Profile. Participants were cautioned to avoid providing classified information during the interviews, and were given the opportunity to review the summary interview for accuracy and completeness as a safeguard against missing key issues or misinterpreting provided information. Some disagreement between site experts arose related to documented policies for radiation protection versus actual practice, and for the sake of completeness, both views are presented in the summary.

All interviews have been compiled and summarized in Attachment 2. The information provided is not a verbatim documentation, but a summary of information from multiple interviews. Individuals have provided this information based on their personal experience, and it is possible that these former workers' recollections and statements may need to be further substantiated. However, they stand as critical feedback on the operation of the Pinellas Plant over its operating lifetime. The interview notes are provided in that context, and former worker input is similarly

reflected in our discussion and, with the preceding qualifications in mind, has contributed to our findings and observations.

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 TBDs, 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 findings, because they represent deficiencies in the TBDs that need to be corrected, and which have the potential to materially impact at least some dose reconstructions.

Finding 1: Reconstruction of Doses in the Absence of Early Health Physics, Industrial Hygiene, and Environmental Records

The absence of pre-1980s records brings into question the ability to adequately assign radiation doses during the early years at Pinellas. The improvements in radiological monitoring and bioassay methodology, instrumentation, and in health physics, industrial hygiene, and environmental control programs, contraindicate the use of 1980s documentation for determining radiation doses for the early years of plant operations. The assumptions incorporated into ORAU-TKBS-0029-4 and ORAU-TKBS-0029-5, given the absence of firm information, appear to be claimant favorable. However, the uncertainties associated with projections without documentary evidence may result in missing doses that may not be accounted for by the claimant-favorable assumptions indicated in the documents.

Finding 2: Potential Doses from Insoluble Metal Tritides Not Sufficiently Addressed

The neutron tube manufacturing process required spray coating the inside of a glass tube with a thin metal film, resulting in the formation of insoluble stable metal tritides (SMTs), namely ScT_2, ErT_2, and TiT_2. There is no internal documentation indicating that there were adequate means of detecting exposures or monitoring SMTs. No guidance is provided for estimating the exposure to metal tritides; in fact, Section 5.9.2, Metal Tritide Exposures, is reserved for later entry. The practice of destructive testing of neutron generators and the methodology for performing the testing make it possible that exposures to metal tritides occurred. Further discussion of the potential exposure pathway and doses should be included in ORAUT-TKBS-0029-5 when Section 5.9.2 is completed.

Finding 3: MDCs and Uncertainties for Plutonium and Bioassay Measurements are Inadequately Addressed (ORAU-TKBS-0029-5)

ORAU-TKBS-0029-5 should provide more information about how bioassay sample activity concentrations were calculated and the uncertainties associated with these values. NIOSH should provide information on the use of the values in Table 5.1 to calculate internal doses.

The TBD should specifically address the uncertainties and the minimum detectable concentration (MDC) of the bioassay measurements, including the parameters of the MDC equation 5-1 on page 6, assigned as TREVA (*T = count time, R = recovery fraction, E = average detector efficiency, V = sample volume (L), and A = the alpha abundance for the radionuclide in question.*

Finding 4: Assessment of Personnel Badging Policy during Early Years Needs Further Review

ORAUT-TKBS-0029-6 states the following:

> *From 1960 to 1973, U.S. Atomic Energy Commission (AEC) annual exposure summary reports indicate that Pinellas had 27.5% of its labor force wearing dosimetry (377 of an average yearly labor force of 1,372). During the 1980s, while the data are not completely available, from 370 to approximately 400 of 1,650 to 1,975 workers (approximately 20%) were monitored for radiation dose. No documentation was found to show that all employees were monitored at some time during Pinellas operations.*

It is important to know who was considered a "radiation worker" and how they were selected for badging, as this has dose consequence. The TBD does not clearly address these issues by clarifying the basis for how monitoring was conducted, nor which worker categories were badged. These issues need to be reviewed and substantiation provided that the maximally exposed workers were badged, and that there is a means to estimate radiation dose to unmonitored support workers with access to production areas.

Finding 5: Problems with Personnel Dosimetry

Section 6.2.2 of ORAUT-TKBS-0029-6 states the following:

> *This analysis was unable to locate specific designs of the film dosimeters used for approximately the first 20 years (1957 to 1974) at the Pinellas Plant, and there is limited documentation that indicates there was an early relationship with Nuclear-Chicago (GEND 2004a).*

Table 6-5 on page 16 of ORAUT-TKBS-0029-6 assigns a missed dose of 0.24 rem for beta-photons (monthly) for badges used during this time period. This assignment of missing dose evidently assumes that the badges used during this time period were equivalent to those provided

by Nuclear-Chicago. Additional discussion is needed on the uncertainty associated with the assumed missing dose, given that the origin of the dosimetry is not clearly established.

Finding 6: The Decontamination and Decommission Era of Pinellas Operations is not Sufficiently Addressed

Monitoring practices, particularly internal dosimetry, are not specified in the TBD for the D&D period (1995–1997) at the Pinellas Plant. A number of questions present themselves that are not addressed by the existing Pinellas Plant Site Profile. What specific external and internal monitoring program was established for D&D operations, and how effectively was it implemented? With the use of first-, second-, and third-tier subcontractors, to what extent were these workers "captured" in the site's dosimetry program, and were their records maintained? How would the co-worker dose model be applied for unmonitored workers located adjacent to D&D operations; was resuspension of radioactive particulates an onsite issue during D&D?

Finding 7: Missing Internal Dose Estimation Methods for Unmonitored Workers, such as Maintenance and Support Personnel, Not Provided

It is not clear from the Internal Dosimetry TBD (ORAUT-TKBS-0029-5) how dose estimation would be performed for maintenance and support workers who were not classified as radiation workers, and who had access to Pinellas Plant radiological operations. Section 5.9.1 of ORAUT-TKBS-0029-5 contains the statement, "All HTO and Plutonium potentially exposed workers have likely been monitored." The basis for this statement needs justification, particularly in light of the fact that tritium use and contamination was common in many Pinellas areas that may have been accessable to maintenance and, possibly, administrative personnel. However, no guidance is provided in this TBD with respect to missed dose calculations for unmonitored workers in the category of support personnel, whose actual jobs (contamination spill cleanup, equipment maintenance, and janitorial functions) and access to various Pinellas buildings may have led to radionuclide exposures over their job history. It is also not clear how the designation of "radiological worker" was historically defined at Pinellas, and how workers were selected on this basis for bioassay for various operations.

Finding 8: Potential for Missed Dose for Depleted Uranium

ORAUT-TKBS-0029-2**,** Section 2.3.2 contains a discussion of depleted uranium (DU), including the following statement:

> *The depleted uranium metal was fully contained inside the storage flask, and no information could be found to indicate that depleted uranium metal was released during plant operations (Ward, p. 12).*

Interviews with a former employee raised the possibility of loose DU contamination in an area of Building 100. There were no bioassay programs in place to determine internal dose from exposure to DU, thus DU internal exposure could represent a significant source of unmonitored exposure. There is minimal information in ORAUT-TKBS-0029-2 on the production of the

tritium beds, so it is not possible to discern if the process involves operations that could lead to internal exposures. Further discussion of the DU-related process is in order.

Finding 9: **The TBD Fails to Adequately Define and Assess Occupational Medical Exposure**

The current guidelines, as presented in Kathren and Shockley (2005), go a long way in assuring 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 (Demopoulos 2006) assumes an interpretation that also has been considered and applied at other sites, such as the Mound Plant and Los Alamos National Laboratory (LANL), and Paducah. To this extent, the assumption that medical procedures are limited to only one pre-employment chest x-ray and chest x-rays that are part of routine physical exams may substantially underestimate worker medical exposure when evaluating occupational medical exposure.

Finding 10: Techniques and Protocols Increase Uncertainty of Dose Correction Factors Listed in the TBD

Section 3.2 of the Occupational Medical Dose TBD fails to adequately describe all the information upon which to establish beam quality for x-ray units in use from 1957–1997.

The TBD is also deficient in that little documentation exists to validate x-ray protocols, equipment maintenance, and upkeep records prior to 1972.

Finding 11: Frequency and Type of X-ray Exposure is Uncertain

The Occupational Medical Dose TBD relies on a very limited review of archived medical records to establish frequency assumptions. The assumption of one chest radiograph (Posterior-Anterior view) every 3 to 5 years is not reasonably conservative, in that workers could essentially request an x-ray, or be subject to special screening exams. In addition, Section 3.2 of the Occupational Medical Dose TBD does not provide documentation or references to support the assumption that only a limited group of workers received x-ray exams more frequently than every 5 years after 1974.

In addition, Section 3.2 of the TBD states that photofluorography (PFG) units, although generally available up to the late 1950s at most DOE sites, were not documented as being used at the Pinellas Plant. The undocumented absence of PFG units at Pinellas clearly has significant dose implications to workers who may have been given much higher doses from PFG units.

2.0 SCOPE AND INTRODUCTION

Under the Energy Employees Occupational Illness Compensation Program Act of 2000 (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 82), the Advisory Board on Radiation and Worker Health (Advisory Board) is mandated to conduct an independent review of the methods and procedures used by the National Institute for Occupational Safety and Health (NIOSH) and its contractors for dose reconstruction. As a contractor to the Advisory Board, S. Cohen and Associates (SC&A, Inc.) 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 technical basis documents (TBDs) related to historical occupational exposures at Pinellas Site:

- ORAUT-TKBS-0029-1, *Technical Basis Document for Pinellas Plant – Introduction, Rev. 00* (Notich 2005)
- ORAUT-TKBS-0029-2, *Technical Basis Document for Pinellas Plant – Site Description, Rev. 00* (Orr 2005)
- ORAUT-TKBS-0029-3, *Technical Basis Document for Pinellas Plant – Occupational Medical Dose, Rev. 00 PC-1* (Demopoulos 2006)
- ORAUT-TKBS-0029-4, *Technical Basis Document for Pinellas Plant – Occupational Environmental Dose, Rev. 00* (Gorden and Mobasheran 2005)
- ORAUT-TKBS-0029-5, *Technical Basis Document for Pinellas Plant – Occupational Internal Dose, Rev 00* (Demopoulos 2005)
- ORAUT-TKBS-0029-6, *Technical Basis Document for Pinellas Plant – Occupational External Dosimetry, Rev. 00* (Palmrose et al. 2005)

A complete list of documents reviewed for this audit, including the above, is provided in Attachment 1.

SC&A, in support of the Advisory Board, has critically evaluated the Pinellas Plant 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 characterize 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.

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 the degree to which the TBDs can support dose reconstruction decisions. The criteria for evaluation include whether the TBDs provide a basis for scientifically supportable dose reconstructions in a manner that is adequate, complete, efficient, and claimant favorable. Specifically, these criteria were viewed from the position 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 a worker received in that environment through time. The hierarchy of data used for developing dose reconstruction methodologies is dosimeter readings and bioassay data, co-worker data and workplace monitoring data, and process description information or source-term data.

2.1 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 Pinellas personnel and environmental monitoring data, and the evaluation of key dose reconstruction assumptions.

2.2 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 Pinellas 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 is found 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 material 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.

In many ways, the TBDs were successful in addressing a series of technical challenges. In other areas, the TBDs exhibit shortcomings that may influence some dose reconstructions in a substantial manner.

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 Pinellas Plant Site Profile, supporting technical information bulletins (TIBs), and dose reconstruction workbooks; 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 Pinellas Plant 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 the Pinellas Plant. 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 Pinellas Plant TBD was compared with the Mound and Savannah River Site (SRS) site profiles. In particular, this dealt with how each site handled and is handling dose reconstruction for workers exposed to plutonium, stable metal tritides, and tritium.

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 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 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 assignments. Similarly, in order to maximize internal exposures, the 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 by 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 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 and their supplemental attachments giving due consideration to the three categories of dose reconstructions that the site profiles are intended to support. The six Pinellas Plant TBDs generally provide well-organized and user-friendly information for the dose reconstructor when adequate data were available to do that comprehensively.

ORAUT-TKBS-0029-1, Rev. 00, *Technical Basis Document for Pinellas Plant – Introduction* (Notich 2005), 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 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 that are revised, refined, and supplemented with TIBs as required to help dose reconstructors. Site profiles are not intended to be prescriptive or 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-0029-2, Rev. 00, *Technical Basis Document for Pinellas Plant – Site Description* (Orr 2005), is an extremely important document, because it provides a description of the facilities, processes, and historical information that serve as the underpinning for subsequent Pinellas Plant TBDs.

ORAUT-TKBS-0029-3, Rev. 00, *Technical Basis Document for Pinellas Plant – Occupational Medical Dose* (Demopoulos 2006), provides an overview of the sources, types of exposure, and the frequency of exams that workers potentially received.

ORAUT-TKBS-0029-4, Rev. 00, *Technical Basis Document for Pinellas Plant – Occupational Environmental Dose* (Gorden and Mobasheran 2005), 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-0029-5, Rev. 00, *Technical Basis Document for Pinellas Plant – Occupational Internal Dose* (Demopoulos 2005), presents background information and guidance to dose reconstructors for deriving occupational internal doses to workers.

ORAUT-TKBS-0029-6, Rev. 00, *Technical Basis Document for Pinellas Plant – Occupational External Dose* (Palmrose et al. 2005), 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 and their supporting documentation. SC&A then submitted questions to NIOSH with regard to assumptions and methodologies used in the site profile. These questions are provided in Attachment 3. Responses to those questions have not been received at the time of writing of this draft review.

After the Advisory Board and NIOSH have an opportunity to review this draft, SC&A plans to meet with representatives of the Advisory Board and NIOSH to discuss our findings. Following these meetings, the draft may be revised, depending on direction we receive from the Advisory Board. We anticipate that, in accordance with the procedures followed during previous site profile reviews, the draft report and any subsequent revisions will be published on the NIOSH Web site. 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 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.

3.2 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 Pinellas Plant TBDs. These strengths are described in the following sections.

(1) The Site Description TBD, ORAUT-TKBS-0029-2 (Orr 2005), effectively summarizes the radionuclides handled and room locations where work was done at the Pinellas Plant (Tables 2-1 and 2-2, page 9). Likewise, radiation-producing equipment is succinctly listed in Table 2-5, page 22. The listing of unusual events with the quantities of radionuclides released (Table 2-4, page 18) was useful in the review process and for dose reconstructors.

(2) The TBDs' use of personnel monitoring data and environmental monitoring data to determine dose is consistent with the requirements outlined in 42 CFR 82, as follows:

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

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

- Where environmental measurements are available, these data are used as the basis for environmental dose.

NIOSH has effectively complied with the hierarchy of data required under 42 CFR Part 82 and its implementation guides for monitored workers.

(3) There are several useful summary tables in ORAUT-TKBS-0029-6 (Palmrose et al. 2005). Table 6-11 provides a helpful summary of photon dosimetry over the operating period, and the recommended missed dose by facility and location. Table 6-12 gives the same information for missed neutron dose.

(4) In general, the TBDs describe in sufficient detail the historical site operations, sources of radiation dose, potential missing and unmonitored dose, and dose reconstruction guidance. The level of information provided appears to be consistent with the supporting documents reviewed and the magnitude of the potential doses associated with plant operations. There are omissions from each of the six TBDs and additional information and considerations that should be included in revisions of the documents. These shortcomings are detailed in Section 4.0.

4.0 VERTICAL ISSUES

SC&A has developed a list of key issues regarding the Pinellas Plant Profile. These issues relate to each of the five objectives defined in 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 Department of Energy (DOE) and Atomic Weapons Employer (AWE) sites, and should be considered in the preparation and revision of other site profiles.

4.1 FINDING 1: RECONSTRUCTION OF DOSES IN THE ABSENCE OF EARLY HEALTH PHYSICS, INDUSTRIAL HYGIENE, AND ENVIRONMENTAL RECORDS

The absence of pre-1980s records brings into question the ability to adequately assign radiation doses during the early years at Pinellas. The improvements in radiological monitoring and bioassay methodology, instrumentation, and in health physics, industrial hygiene, and environmental control programs contraindicate the use of 1980s documentation for determining radiation doses for the early years of plant operations. The assumptions incorporated into ORAU-TKBS-0029-4 and ORAU-TKBS-0029-5, given the absence of firm information, appear to be claimant favorable. However, the uncertainties associated with projections without documentary evidence may result in missing doses that may not be accounted for by the claimant-favorable assumptions indicated in the documents.

It appears that only documents available at Atlanta National Archives were considered in development of the Pinellas Plant TBDs. SC&A has some evidence that some of the more important early documents may be located at other DOE sites, and is currently working with NIOSH and the relevant sites to obtain them. Should we obtain these records and they present information significantly variant from that assumed in the TBDs, revision of some or all the TBDs might be in order.

4.2 FINDING 2: POTENTIAL DOSES FROM INSOLUBLE METAL TRITIDES NOT SUFFICIENTLY ADDRESSED

The neutron tube manufacturing process required spray coating the inside of a glass tube with a thin metal film, resulting in the formation of insoluble stable metal tritides (SMTs), namely ScT_2, ErT_2, and TiT_2. There is no internal documentation indicating that there were adequate means of detecting exposures or monitoring SMTs. Powders were normally contained within vacuum systems and metal systems that generally remained intact; however, documented incidents involving some of these materials occurred. ORAUT-TKBS-0029-5 states, “Besides incidents, metal tritide intakes could have occurred from any of the process areas for HTO processing.” A review of the incidents listed in the above document (Table 5-10, page 24) clearly indicates the potential for metal tritide contamination and personnel exposure, even though no measurements were made. No guidance is provided for estimating the exposure to metal tritides; in fact, Section 5.9.2, Metal Tritide Exposures, is reserved for later entry. The practice of destructive testing of neutron generators and the methodology for performing the testing make it possible

that exposures to metal tritides occurred. Further discussion of the potential exposure pathway and doses should be included in ORAUT-TKBS-0029-5 when Section 5.9.2 is completed.

ORAUT-TKBS-0029-5 states that the dose reconstructor should consider TiT_2 as type M. With no National Council on Radiation Protection and Measurements (NCRP)- or International Commission on Radiological Protection (ICRP)-accepted dose model for metal tritides, NIOSH has not provided a sufficient technical basis for its assumed solubility designation. No recommendation for clearance class is provided for the other two possible metal tritides; ScT_2 and ErT_2.

4.3 FINDING 3: MDCS AND UNCERTAINTIES FOR PLUTONIUM AND BIOASSAY MEASUREMENTS ARE INADEQUATELY ADDRESSED

ORAU-TKBS-0029-5 should provide more information about how bioassay sample activity concentrations were calculated and the uncertainties associated with these values. NIOSH should provide information on the use of the values in Table 5.1 to calculate internal doses.

Page 17 of the TBD states the following:

> *Uncertainties or errors for plutonium bioassay measurements or the actual bioassay results themselves were usually not stated in the personnel records or database. MDCs were calculated based upon a 95% confidence level and samples were counted to a 2-sigma error as indicated in Pinellas procedures (Weaver). Note there were no verified positive bioassay results or known Pu contamination incidents.*

There are several factors that may influence the uncertainties and the minimum detectable concentration (MDC) of the bioassay measurements. The parameters of the MDC equation 5-1 on page 6, assigned as TREVA (*T = count time, R = recovery fraction, E = average detector efficiency, V = sample volume (L), and A = the alpha abundance for the radionuclide in question)*, have an important influence on the MDC value. The recovery is strongly dependent on the several factors related to the analysis of each sample, such as digestion of organic material of the sample, composition of the samples, reagents, and care in the preparation of the sample. The volume of the urine samples may not be correspondent to the 24-hour excretion rate.

The average MDC value is an important parameter for the calculation of the missed dose, mainly because for plutonium, the frequency of the routine bioassay program was annual. According to data presented on Table 5-1 (page 9), in 1980, the average MDC value for Pu-238 is 6.23E-11 uCi/mL and the maximum MDC value is 3.17E-10 uCi/mL; and the average MDC value for Pu-239 is 3.41E-11 uCi/mL and the maximum MDC value is 1.90E-10 uCi/mL. There is a factor of 5 between the average MDC value and the maximum value.

4.4 FINDING 4: ASSESSMENT OF PERSONNEL BADGING POLICY DURING EARLY YEARS NEEDS FURTHER REVIEW

ORAUT-TKBS-0029-6 states the following:

> *From 1960 to 1973, U.S. Atomic Energy Commission (AEC) annual exposure summary reports indicate that Pinellas had 27.5% of its labor force wearing dosimetry (377 of an average yearly labor force of 1,372). During the 1980s, while the data are not completely available, from 370 to approximately 400 of 1,650 to 1,975 workers (approximately 20%) were monitored for radiation dose. No documentation was found to show that all employees were monitored at some time during Pinellas operations.*

It is important to know who was considered a "radiation worker" and how they were selected for badging, as this has dose consequence. In that era, radiation hazards were not well recognized during that time period. This resulted in some workers not being monitored during a period when not all radiation hazards were recognized. The TBD does not clearly address these issues by clarifying the basis for how monitoring was conducted, nor which worker categories were badged. These issues need to be reviewed and substantiation provided that the maximally exposed workers were badged, and that there is a means to estimate radiation dose to unmonitored support workers with access to production areas. Additionally, since many Pinellas records on facility monitoring, safety evaluations, investigations, etc., prior to 1980 are not available, the determination of the adequacy of badging assignment and allocation of unmonitored dose will be complicated. The impact of this absence of early information should be addressed.

4.5 FINDING 5: PROBLEMS WITH PERSONNEL DOSIMETRY

Section 6.2.2 of ORAUT-TKBS-0029-6 states the following:

> *This analysis was unable to locate specific designs of the film dosimeters used for approximately the first 20 years (1957 to 1974) at the Pinellas Plant, and there is limited documentation that indicates there was an early relationship with Nuclear-Chicago (GEND 2004a).*

Table 6-5 on page 16 of ORAUT-TKBS-0029-6 assigns a missed dose of 0.24 rem for beta-photons (monthly) for badges used during this time period. This assignment of missing dose evidently assumes that the badges used during this time period were equivalent to those provided by Nuclear-Chicago. Additional discussion is needed on the uncertainty associated with the assumed missing dose, given that the origin of the dosimetry is not clearly established.

4.6 FINDING 6: THE DECONTAMINATION AND DECOMMISSION ERA OF PINELLAS OPERATIONS IS NOT SUFFICIENTLY ADDRESSED

Monitoring practices, particularly internal dosimetry, are not specified in the TBD for the D&D period (1995–1997) at the Pinellas Plant. A number of questions present themselves that are not addressed by the existing Pinellas Plant Site Profile. What specific external and internal monitoring program was established for D&D operations, and how effectively was it implemented? With the use of first-, second-, and third-tier subcontractors, to what extent were these workers "captured" in the site's dosimetry program, and were their records maintained? How would the co-worker dose model be applied for unmonitored workers located adjacent to D&D operations; was resuspension of radioactive particulates an onsite issue during D&D?

Buildings at Pinellas were designed and constructed to provide ventilation systems, fumehoods, and gloveboxes to minimize inhalation uptakes by workers. As demolition workers began to remove walls and dividers, and to remove these contaminated fumehoods, gloveboxes, and ventilation systems, these engineering controls were breached and no longer became effective in minimizing inhalation uptakes. Contamination within the ventilation ductwork would have been an additional source of uptakes. Not always being aware of the presence of radionuclides in specific demolition areas and/or researcher-handling areas made it difficult to adequately prevent, monitor, and detect uptakes of these radionuclides.

4.7 FINDING 7: MISSING INTERNAL DOSE ESTIMATION METHODS FOR UNMONITORED WORKERS, SUCH AS MAINTENANCE AND SUPPORT PERSONNEL, NOT PROVIDED

It is not clear from the Internal Dosimetry TBD (ORAUT-TKBS-0029-5) how dose estimation would be performed for maintenance and support workers who were not classified as radiation workers and who had access to Pinellas Plant radiological operations. Section 5.9.1 of ORAUT-TKBS-0029-5 contains the statement, "All HTO and Plutonium potentially exposed workers have likely been monitored." The basis for this statement needs justification, particularly in light of the fact that tritium use and contamination was common in many Pinellas Plant areas that may have been accessable to maintenance and, possibly, administrative personnel. However, no guidance is provided in this TBD with respect to missed dose calculations for unmonitored workers in the category of support personnel, whose actual jobs (contamination spill cleanup, equipment maintenance, and janitorial functions) and access to various Pinellas buildings may have led to radionuclide exposures over their job history. It is also not clear how the designation of "radiological worker" was historically defined at Pinellas, and how workers were selected on this basis for bioassay for various operations.

4.8 FINDING 8: POTENTIAL FOR MISSED DOSE FOR DEPLETED URANIUM

ORAUT-TKBS-0029-2**,** Section 2.3.2, contains a discussion of depleted uranium (DU), including the following statement:

The depleted uranium metal was fully contained inside the storage flask, and no information could be found to indicate that depleted uranium metal was released during plant operations (Ward, p. 12).

Interviews with a former employee raised the possibility of loose DU contamination in an area of Building 100. There were no bioassay programs in place to determine internal dose from exposure to DU, thus DU internal exposure could represent a significant source of unmonitored exposure. There is minimal information in ORAUT-TKBS-0029-2 on the production of the tritium beds, so it is not possible to discern if the process involves operations that could lead to internal exposures. Further discussion of the DU-related process is in order.

4.9 FINDING 9: THE TBD FAILS TO ADEQUATELY DEFINE AND ASSESS OCCUPATIONAL MEDICAL EXPOSURE

The current guidelines, as presented in Kathren and Shockley (2005), go a long way in assuring 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 (Demopoulos 2006) assumes an interpretation, which also has been considered and applied at other sites, such as the Mound Plant and Los Alamos National Laboratory (LANL), and Paducah. To this extent, the assumption that medical procedures are limited to only one pre-employment chest x-ray and chest x-rays that are part of routine physical exams, may substantially underestimate worker medical exposure when evaluating occupational medical exposure.

In more recent documentation (OTIB-0006, Revision 3 (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, etc.) and termination exams. The Occupational Medical Dose TBD does not recognize this change from the previous Revision 2 of the OTIB, and also assumes that special chest radiography for respirator certification, beryllium and asbestos workers, and food handlers are accomplished as part of the routine physicals. This is not documented in the 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.

The TBD (Demopoulos 2006) makes the conclusion that chest examinations are often quite limited after 1974, after which Kidney, Ureter, Bladder tests (KUBs) were no longer taken in addition to chest x-rays. It is suggested the policy was every 5 years before age 40, and every 3 years after age 40, but nothing is documented. 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. The majority of workers had chest x-rays as a routine at DOE sites until the mid-1980s, when Federal guidelines warning against routine screening were first being enforced.

After discussion with NIOSH personnel, it was their decision to limit occupational medical exposure to those chest exams described above, and to include all other exposure as part of

worker background. 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 with 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 of occupational medical dose, as provided in the most recent version of the OTIB (Kathren and Shockley 2005).

4.10 FINDING 10: TECHNIQUES AND PROTOCOLS INCREASE UNCERTAINTY OF DOSE CORRECTION FACTORS LISTED IN THE TBD

Section 3.2 of the TBD fails to adequately describe all the information upon which to establish beam quality for x-ray units in use from 1957–1997. In 1972, the site documented installation of a single phase GE 225 unit. There is only limited documentation to show that the GE 225 unit, in use from 1972 through 1997, had added filtration, approximately 3.5 mm of Al, as first measured by the Pinellas Health Department in 1972. In the absence of definitive tube output measurements, the TBD directs the use of default values and dose correction factors (DCFs) derived from ICRP Report No. 34 (ICRP 1982). These values are then applied to determine organ doses using Tables A.2 through A.8 of ICRP (1982). An issue of concern is that the DCFs are derived using a default half value layer (HVL) of 2.5 mm Al for Type 1 units in use from 1946–1980.

The Occupational Medical Dose TBD (Demopoulos 2006) provides little documentation to support the assumed techniques and protocols applied to calculate the dose, which is mainly derived from NCRP Report 102. The TBD states that a Posterior-Anterior (PA) chest x-ray was typically the only view. An undocumented assumption in the TBD is that exams required only a PA view. SC&A has inquired whether definitive protocol existed to validate that chest exams included PA views and Lateral (LAT) views only on a limited basis after 1974. 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 of records prior to 1972.

4.11 FINDING 11: FREQUENCY AND TYPE OF X-RAY EXPOSURE IS UNCERTAIN

The Occupational Medical Dose TBD relies on a very limited review of archived medical records to establish frequency assumptions. The assumption of one chest radiograph (PA) every 3–5 years is not reasonably conservative, in that workers could essentially request an x-ray, or be subject to special screening exams. The frequency of screenings and number and type of workers receiving x-rays does vary from site to site.

Section 3.2 of the Occupational Medical Dose TBD does not provide any documentation or references to support the assumption that only a limited group of workers received x-ray exams more frequently than every 5 years after 1974. To the contrary, up until about 1985, most DOE sites performed chest x-rays almost on a voluntary basis. DOE medical program reviews documented during the early 1990s showed many sites still used chest radiography as a general screening exam. Most workers accepted chest x-rays, even though the job did not require it. Also, the assumption that workers in special exposure categories, such as beryllium workers, were given chest x-rays only as part of their routine physical is not well documented and not consistent with special screening guidelines. The TBD applies no conservative assumption to cover such exams.

Section 3.2 of the Occupational Medical Dose TBD states that photofluorography (PFG) units, although generally available up to the late 1950s at most DOE sites, were not documented as being used at the Pinellas Plant. The undocumented absence of PFG units at Pinellas clearly has significant dose implications to workers who may have been given much higher doses from PFG units. The PFG unit provides a dose to the worker greater by a factor of 5–6 than that delivered by conventional radiography. The TBD does not provide documentation for the types of equipment in use at Pinellas prior to 1972. SC&A believes it is not claimant favorable to instruct dose assessors to assume only PFG-unit use from 1957–1960. To be fully claimant favorable, it would be appropriate to instruct dose assessors to use an annual dose of 3.0 rem per year for chest radiographs, in accordance with guidelines set forth (Kathren and Shockley 2005), until the review of medical records evidenced no further use of a PFG unit at Pinellas.

4.11.1 Secondary Issues

Secondary Issue 1: Additional Factors Contribute to Uncertainties Related to Occupational Medical Exposures

The Occupational Medical Dose TBD does not consider dose impacts due to less than optimal use of technology, such as using screens, grids, or bucky systems. The TBD does not consider these elements as potential contributions to uncertainty.

The TBD does consider the potential contribution to dose that may have resulted in less than optimal use of collimation at least prior to 1972, as stated in Section 3.3.2 of the TBD. 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 the unit in other TBDs in operation prior to 1997, little or no documentation exists. NIOSH has indicated in other TBDs that it will continue to search for other available records to better define equipment use and beam quality, and include it as appropriate in an updated version of the TBD.

Uncertainty is defined in the TBD as being due to measurement error and variation in kilovoltage, tube current, timers, and the skin-to-surface distance (SSD). This approach is quite similar to the uncertainty analyses documented in other DOE site profiles. The conclusion in this TBD and others is that dose reconstructors for exposure prior to 1997 should use an uncertainty

factor of +30%. SC&A believes the uncertainty correction factor of 2.0 being applied at other sites is more appropriate for use.

SC&A agrees that the TBD conservatively estimates these essential aspects of an uncertainty review. Unresolved is the contribution to uncertainty in dose, due to other errors introduced by lack of quality controls in processing equipment and lack of adherence to established Standard Operating Procedures. A reasonable estimate of these contributions to uncertainty would be an evaluation of retake rates per examination type. NIOSH should revisit the potential for significant retake rates and evaluate its potential effect on dose as part of future revisions of this TBD, especially as it relates to prior to 1972.

The Occupational Medical Dose TBD does not show that Pinellas applied dose minimization principles to reduce medical exposures. The document also does not assess or consider the likely exposure to workers who are referred to offsite medical facilities for follow-up. The TBD states that review of selected medical records and files did not reasonably show or match expected x-ray exam frequency and type of exam, as shown in Table 3.1.1. Little evidence exists to document the number of x-ray exams provided to the average worker, or for special exposure needs.

Secondary Issue 2: Inadequate Descriptions for Certain Plant Operations

The Site Description TBD, ORAUT-TKBS-0029-2, provides information on Plant operations as they relate to understanding the source and relative magnitude of radionuclide doses. The information is sufficiently complete in the case of operations involving tritium, krypton, and plutonium. The TBD inadequately describes operations involving Ni-63, C-14, and, particularly, DU and metal tritides. The TBD should be revised to provide the reader with a greater understanding of processes utilizing the indicated nuclides.

Secondary Issue 3: Perimeter Tritium Monitoring Stations

Tritium air monitoring stations were operated on the perimeter of the site for a major part of the plant operating history. Up to six samplers were continuously operated and collected samples for determining tritium gas and oxide airborne concentrations. The existence of these stations is not mentioned in ORAU-TKBS-0029-4. This is a missed opportunity to verify the modeling results by comparing them to measured values.

Secondary Issue 4: Inadequacy of ORAU-TKBS-0029-4, Section 4.4 – Uncertainty

This section is inadequate and needs to be reworked to more adequately address the topic it is intended to discuss, i.e., uncertainty. The discussion in this section centers on factors that affect the quantity of dose calculated, and not the uncertainty associated with estimates. While it may not be possible to quantify the uncertainty of estimated doses, a more relevant discussion on the relative magnitude and factors affecting uncertainty is needed.

Secondary Issue 5: Rejection of Plutonium Bioassay Results Based on Plutonium-238-to-Plutonium-239 Ratios, and Non-detectable Plutonium-239

In ORAU-TKBS-0029-5, two conditions for rejection of a positive Pu bioassay result as follows:

> *The ratio of ^{238}Pu to ^{239}Pu in a bioassay sample must be about 5:1 (±20%) or ^{238}Pu is detected while ^{239}Pu is not detectable.*

The meaning of "(±20%)" in this statement is not clear. Does it mean the range of ratios to be rejected is from 4 to 6? This inclusion needs further explanation.

The application of these criteria to Pu bioassay results for the 3 years discussed in the TBD (1988, 1989, and 1990) was responsible for approximately 30% of the samples being designated as non-positive. The high degree of uncertainty associated with alpha spectrometry results at the levels of Pu-238 expected in bioassay samples makes the use of such a ratio as a reason for rejecting a positive Pu-238 questionable.

These results should be reviewed on an individual basis in that the use of this criterion, because of the relatively large uncertainties associated with values near the detection limits for Pu, could result in the rejection of positive Pu-238 results. At a minimum, this would have prevented an investigation into the circumstances that could have led to the positive result.

Secondary Issue 6: Plutonium Solubility

In ORAUT-TKBS-0029-5, page 16, the following statement is made:

> *ICRP Publication 68 lists plutonium oxides as absorption type S (ICRP 1995, p. 83). A discussion of absorption type for plutonium oxides in ICRP 71 indicates that bioassay data from accidentally exposed workers to $^{238}PuO_2$ could have been closer to type M (ICRP 1996, p. 329).*

Page 329 of ICRP 71 (ICRP 1996) also states that plutonium can have different lung clearance characteristics when inhaled as mixed metal oxide. The extent of increased dissolution/clearance depends on the metal and the relative proportions of plutonium to metal. Since there is an uncertainty on the definition of the solubility rates for Pu-238, and there is no clear definition of the solubility of the handled compound, the selection of the type of compound for dose reconstruction should be the one that is more claimant favorable. For some scenarios, the selection of Type M compound is not the claimant-favorable approach**.**

Secondary Issue 7: Assumptions Relative to Unmonitored Workers

ORAUT-TKBS-0029-6, Section 6.4.1, contains the following statement:

> *The analysis assumed that unmonitored (i.e., nonradiation) workers did not receive a significant dose compared to monitored workers; therefore, assigning a photon*

> *dose distribution for each year based on the dose received by monitored workers would ensure a claimant-favorable estimate of any unmonitored worker dose. Based on the review of the available dosimetry data, employees with any significant potential for external dose exposure appear to have been routinely monitored, as evidenced by the large number of monitored individuals that routinely had doses below the reporting levels. Therefore, it is reasonable to assume that unmonitored workers received less dose than monitored workers at the Pinellas Plant.*

The fact that a large number of monitored individuals routinely had doses below reporting levels may give some level of comfort that workers with a significant potential for external dose were adequately monitored, but it is not proof. Neither does it lead to the automatic conclusion that unmonitored workers received less dose than monitored workers. These assumptions may be true, but can only be verified if there is reasonable certainty that unmonitored workers were not subjected to different exposure potential or conditions than monitored workers. For example, unmonitored maintenance and janitorial personnel could be exposed during routine maintenance, waste removal, and cleaning operations to levels that exceeded those of operational personnel.

Secondary Issue 8: Assumptions Relative to Minimum Detectable Level Adjustments to Dosimetry for Missed Dose

In Section 6.4.1.1, ORAUT-TKBS-0029-6, the following statement is made:

> *Missed dose is primarily estimated on dosimeter results n (the number of zero or < MDL values) multiplied by MDL/2. The MDL is particularly important during the early years of operation, when MDLs were probably higher and the dosimeter exchange rate was monthly rather than quarterly. One option to estimate a claimant-favorable maximum potential dose is to multiply the MDL by the number of zero dose results. This will provide an estimate of the maximum missed dose to the worker. The following sections consider missed photon dose for dosimeter results less than the MDL according to facility or location, dosimeter type, year, and energy range.*

It is not clear from this discussion which approach was taken to adjusting dosimeter results in the analyses and Table 6-11, following this statement. A definitive statement indicating the selected approach should be made in this TBD.

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

The SC&A procedures call for a "vertical" assessment of a site profile for purposes of evaluation of 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.

5.1 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 the Pinellas Plant represent an adequate accounting of the "core" tritium, krypton-85, and plutonium-handling operations, environmental dose, and dosimetry history of the Pinellas site, but falls short in fully characterizing a number of key underlying issues that are fundamental to guiding dose reconstruction. Section 6.0 summarizes the key issues. Detailed evaluation of these issues is provided elsewhere in the report.

5.1.1 Objective 1: Completeness of Data Sources

The breadth of data sources used as a basis for the Pinellas Plant Site Profile is evident in the number of reports available in the Site Profile Research Database, as well as the number of reports cited in the site profile references. The ORAU team's use of the available sources indicates an understanding of site operations, radionuclide usage, and personnel monitoring data. However, there are additional sources of data that have not been fully reviewed, because they were not available in the Atlanta National Archives, the apparent sole source of data used in the TBD developments. This missing information is from the pre-1980 era. There is a belief, based on employee interviews, that some of this early data may be available at other DOE sites. As of the date of this writing, SC&A's attempts to obtain early data have not met with success. Additionally, it is unclear to what depth the classified records have been reviewed.

When the Pinellas Plant closed, the records from the plant became the responsibility of the Department of Energy's Albuquerque Office. After reviewing the documents on the NIOSH's O-drive, SC&A began communications with DOE to determine whether additional documentation existed about the operations at Pinellas. DOE-Albuquerque indicated all Pinellas records were sent to the Federal Records Repository in Atlanta. Subsequently, a list of the records held in Atlanta was provided to SC&A for review. In general, our review of the records descriptions suggested an absence of early records, from site inception to the mid-1980s.

Furthermore, inquiries were made with regard to the early Pinellas records with DOE-Albuquerque. DOE-Albuquerque continued to refer SC&A back to Atlanta, although we indicated to them there was a lack of early records on their inventory.

In subsequent conversations, NIOSH indicated that all the records collected by the NIOSH/ORAU team were from Atlanta. There were 562 records available on the O-drive. There were 6 records from 1956–1960, 10 records from 1961–1970, and 53 records from 1971–1980. The inventory provided by DOE-Albuquerque indicated that there were significantly more early records in Atlanta. The number of records on the O-drive increased significantly after 1980 until plant shutdown. The records include health physics and environmental information; however, the completeness of the records is difficult to ascertain. Site expert interviewees indicated that they had generated reports on their activities routinely. Some of the site experts indicated that records were destroyed.

During the course of the interviews, SC&A became aware of the relationship between the Pinellas Plant and other DOE complex sites. Interviewees indicated that there was a flow of material and/or information between Pinellas and Sandia National Laboratory (SNL), the SRS, the Kansas City Plant, Lawrence Livermore National Laboratory (LLNL), Mound Laboratories, and Los Alamos National Laboratory (LANL). Each of the sites was asked to search their records database for relevant Pinellas documents. The Kansas City Plant and SRS had a limited amount of information; however, it was not relevant to dose reconstruction. SNL indicated that they found no relevant Pinellas records. LLNL referred SC&A to the SNL records group. A few technical reports were identified through the Argonne National Laboratory and have been provided. Based on conversations with DOE, the Department of Labor (DOL) is also having difficulty locating early Pinellas records.

SC&A had the opportunity to review two of claimants' radiation exposure files while in St. Petersburg. In at least one case, the individual's file was grossly incomplete, even though she worked in the Radioisotope Thermoelectric Generator (RTG) program. This leads to concern about the completeness of the claimant information provided in site records. Another employee was informed that there was no record of her employment at Pinellas. There should be some level of quality assurance check on the information received to ensure a complete dose reconstruction. This requires that NIOSH/ORAU not only evaluate what is received but also what is available at the site or records repository. The individual records appear to originate out of SNL.

The Occupational External Dosimetry TBD ORAUT-TKBS-0029-6 states:

> *…that most of the records concerning facility monitoring, safety evaluations, investigations, etc. were on operations after 1970. Records of radiation dose to individual workers from personnel dosimeters were generally available for 1957 to 1994 for the workers' time of employment.*

The TBD gives no quantitative indication of the completeness of personnel dosimetry data, thus there is no way, short of a complete review of all the dosimetry records, of determining the degree of completeness.

From 1960 to 1973, 27.5% of the Pinellas labor force wore dosimetry (377 of an average yearly labor force of 1,372). During the 1980s, approximately 20% were monitored for radiation dose. No documentation was found to show that all employees were monitored at any time during Pinellas operations. It is not clear what the policy was for assigning dosimetry to security, crafts, maintenance, janitorial, or administrative personnel with periodic duties related to radiation controlled areas.

Section 6.2.2 of ORAUT-TKBS-0029-6 states:

> *This analysis was unable to locate specific designs of the film dosimeters used for approximately the first 20 years (1957 to 1974) at the Pinellas Plant, and there is limited documentation that indicates there was an early relationship with Nuclear-Chicago (GEND 2004a).*

Table 6-5 on page 16 of ORAUT-TKBS-0029-6, assigns a missed dose of 0.24 beta-photons (monthly) for badges used during this time period. This assignment of missing dose evidently assumes that the badges used during this time period were equivalent to those provided by Nuclear-Chicago. Additional discussion is needed on the uncertainty associated with the assumed missing dose, given that the origin of the dosimetry is not clearly established.

Documentation of the nature and type of dosimetry in place for the time period 1957 to 1974 has not been located. This leaves a relatively high degree of uncertainty in the accuracy of doses recorded and the missing doses for that time period.

ORAUT-TKBS-0029-2 contains Table 2-4, Chronology of Unusual Events. The text indicates that the period covered by this table includes plant startup through 1982. The reason for not including years beyond 1982 should be offered. ORAUT-TKBS-0029-5 has a similar table (Table 5-10, page 23) that has information through 1989.

There is a lack of sufficient environmental monitoring data to fully characterize source terms to which workers were exposed during D&D operations at Pinellas, particularly as production began to cease. While the primary radionuclide remaining as contamination in buildings, production systems, and ventilation systems would have been tritium, it would be prudent to address the assignment of doses to workers involved in D&D operations during the closure of the Pinellas Plant.

5.1.2 Objective 2: Technical Accuracy

In general, the TBDs for Pinellas favorably reflect the depth of knowledge and technical understanding of the various authors and experts who developed the documents. The analyses and recommendations are generally consistent with NIOSH guidance and the available data from the site. Some exceptions are noted below.

Section 3.2 of the TBD (Demopoulos 2006) fails to describe adequately all the information upon which to establish beam quality for x-ray units in use from 1957–1997. In 1972, the site

documented installation of a single phase GE 225 unit. There is only limited documentation to show that the GE 225 unit, in use from 1972 through 1997, had added filtration, approximately 3.5 mm of Al, as first measured by the Pinellas Health Department in 1972. In the absence of definitive tube output measurements, the TBD directs the use of default values and DCFs derived from ICRP Report No. 34 (ICRP 1982). These values are then applied to determine organ doses using Tables A.2 through A.8 of ICRP (1982). An issue of concern is that the DCFs are derived using a default HVL of 2.5 mm Al for Type 1 units, in use from 1946–1980.

Section 3.2 of the Occupational Medical Dose TBD provides no documentation or references to support the assumption that only a limited group of workers received x-ray exams more frequently than every 5 years after 1974. To the contrary, up until about 1985, most DOE sites performed chest x-rays almost on a voluntary basis. DOE medical program reviews documented during the early 1990s showed many sites still used chest radiography as a general screening exam. Most workers accepted chest x-rays, even though the job did not require it. Also, the assumption that workers in special exposure categories, such as beryllium workers, were given chest x-rays only as part of their routine physical is not well documented and not consistent with special screening guidelines. The TBD applies no conservative assumption to cover such exams.

5.1.3 Objective 3: Adequacy of Data

On the whole, the TBDs address the data necessary for assignment of occupational dose, including missed and unmonitored dose, for the Pinellas Plant. The data critical for dose reconstructors are not always presented in a succinct and easily obtainable manner.

The Occupational Internal Dose TBD ORAUT-TKBS-0029-5 does not adequately cover the dose potential from D&D activities that have been ongoing since the end of the weapons component production period. The section on metal tritide exposure is reserved until additional exposure data can be researched and developed.

The Occupational External Dose TBD ORAU-TKBS-0029-6 lists DU as a radiation source, but fails to address any potential exposure to DU. Sufficient information should be presented to either dismiss DU as a potential dose contributor or provide dose constructors with guidance on the missed doses associated with its use at Pinellas.

5.1.4 Objective 4: Consistency among Site Profiles

SC&A compared and contrasted the methodologies to determine external, internal, medical, and environmental dose used in the Pinellas Plant Site Profile with other site profiles reviewed to date. These comparisons focused on the methodologies and assumptions associated with dose assessments and the derivation of values used to obtain a POC for individual claimants. Specifically, we compared the Pinellas Plant Site Profile to those for Mound and SRS, because of the similarity of radionuclides between the three sites. SC&A found a consistent application of NIOSH guidance and claimant-favorable assumptions at the sites compared.

All three TBDs fall short in providing specific guidance to the dose reconstructors on how best to do claimant-favorable dose reconstructions for metal tritides. NIOSH has yet to develop a consistent approach for the handling of stable metal tritide dose reconstructions.

5.1.5 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 82. In addition, SC&A evaluated the TBDs for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions. Section 6 addresses this topic.

6.0 USABILITY OF SITE PROFILE FOR INTENDED PURPOSE

SC&A has identified seven criteria that reflect the intent of the EEOICPA and the regulatory requirements of 42 CFR 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 defensible. SC&A used the following seven objectives to guide its review of the Pinellas Plant Site Profile TBDs to determine whether they meet 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 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.

6.1 AMBIGUOUS DOSE RECONSTRUCTION DIRECTION

ORAUT-TKBS-0029-5 states:

> *The dose reconstructor should consider TiT_2 as type M based upon ICRP 71 and the recent article in the Health Physics journal. Besides incidents, metal tritide intakes could have occurred from any of the process areas listed in Table 5-8 for HTO processing as presented in section 5.12.*

This recommendation is given while the section on metal tritide exposure is reserved. It would be prudent to reserve a recommendation on lung clearance type until more is known about the exposure conditions.

6.2 INCONSISTENCIES AND EDITORIAL ERRORS IN THE SITE PROFILES

Equation 5-2, page 8, of TBD ORAUT-TKBS-0029-5 lacks a description for the terms contained in the equation.

Section 5.2.5 of ORAUT-TKBS-0029-5 contains the following statement:

> *Radionuclides that were not included in the bioassay program at Pinellas but were used at unknown quantities are included in Table 5-3.*

The radionuclides included in Table 5-3 include only tritium and plutonium, which were included in the bioassay program.

6.3 UNRESOLVED POLICY OR GENERIC TECHNICAL ISSUES

A number of issues were identified that are common in the Pinellas 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, 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 has indicated that it may develop separate TIBs in order to address these more generic issues. The following represents those issues identified in the Pinellas 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) Resolution is required on the availability of early records from other DOE sites.

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

(3) Mobility of the workforce 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.

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

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

(6) Analysis needs to be performed regarding how "frequent or routine incidents" should be addressed, given the possibility that such "spike" exposures may often 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 D&D workers should be assessed. Many facilities have large-scale D&D operations, which extend back many years. Decontamination and decommissioning operations often require working in unknown situations, which may provide unique exposure situations.

(9) A consistent methodology for assessing exposure to metal tritides should be developed and applied to all sites where these chemical forms are identified.

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.

7.0 REFERENCES

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ATTACHMENT 1: TECHNICAL DOCUMENTS CONSIDERED DURING THE REVIEW

Technical Basis Documents

ORAUT-TKBS-0029-1, *Technical Basis Document for Pinellas Plant – Introduction, Rev. 00* (Notich 2005).

ORAUT-TKBS-0029-2, *Technical Basis Document for Pinellas Plant – Site Description, Rev. 00* (Orr 2005).

ORAUT-TKBS-0029-3, *Technical Basis Document for Pinellas Plant – Occupational Medical Dose, Rev. 00 PC-1* (Demopoulos 2006).

ORAUT-TKBS-0029-4, *Technical Basis Document for Pinellas Plant – Occupational Environmental Dose, Rev. 00* (Gorden and Mobasheran 2005).

ORAUT-TKBS-0029-5, *Technical Basis Document for Pinellas Plant – Occupational Internal Dose, Rev 00* (Demopoulos 2005).

ORAUT-TKBS-0029-6, *Technical Basis Document for Pinellas Plant – Occupational External Dosimetry, Rev. 00* (Palmrose et al. 2005).

Technical Support Documents

OCAS-TIB-002, Rev 00 (2003). Tritium Calculations with IMBA, Office of Compensation Analysis and Support, National Institute of Occupational Safety and Health, Cincinnati, Ohio. April 22, 2003.

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ORAUT-OTIB-0006, 2005. *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures* , Rev. 03, Oak Ridge Associated Universities, Oak Ridge, Tennessee. December 21, 2005. (Kathren and Shockley 2005).

ATTACHMENT 2: SITE EXPERT INTERVIEW SUMMARY

Interviews were conducted with 10 former Pinellas Plant workers. Years represented by those interviewed ranged from 1957–1995. The interviews were conducted by "Q"-cleared members of the SC&A Pinellas Plant review team. The purpose of these interviews was to receive first-hand accounts of past radiological control and personnel monitoring practices at Pinellas, and better understand how operations were conducted. Interviews were conducted in St. Petersburg, Florida, on May 27–29, 2006. Interviews were conducted in small groups or one-on-one to solicit unclassified information. There are a number of operations related to weapons components that are considered classified and could not be discussed in these interviews. As a result, further interviews might be necessary during the comment resolution process. A revision to this document would be issued, if necessary.

Interviewees were initially identified from NIOSH's Worker Outreach meeting minutes. SC&A independently identified these former workers via the telephone directory and internet searches, as NIOSH could not disclose the contact information of the workers from their Worker Outreach meetings because of Privacy Act issues. Through the first few contacts made, SC&A spoke with the leader of the Quarter Century Club, who assisted in identifying additional workers. This method of identification of interviewees was laborious and very time-consuming.

Workers were briefed on the purpose of the interviews and the Pinellas Plant Site Profile. They were asked to provide their names, in case there were follow-up questions. Participants were reminded that they would be provided the opportunity to review the interview summaries prior to inclusion into this report. Interviewees were cautioned not to provide classified information during the course of the interviews.

Pinellas facilities discussed during the interviews included Buildings 100, 300, 400, the accelerator facility, and outside areas. The job categories represented included the following:

- Environmental Protection Specialist
- Health Physicist
- Health Physics Inspector
- Development Engineering
- Quality Assurance Inspector
- Process Control Operator
- Material Handler
- Janitor
- Final Test Operator

Individuals interviewed were given the opportunity to review the interview summary for accuracy and completeness. This is an important safeguard against missing key issues or misinterpreting some vital piece of information. Some disagreement between site experts arose related to documented policies for radiation protection versus actual practice. Both views are presented in this summary.

All interviews have been compiled and summarized below. The information provided is not a verbatim discussion, but a summary of information from multiple interviews with multiple individuals. Individuals provided this information based on their personal experience. It is recognized that these former worker recollections and statements may need to be further substantiated before adoption in the TBD. Statements from the interviews are included here with minimal effort by SC&A to verify their accuracy; 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, have contributed to our findings and observations.

General Information

DOE had knowledge that General Electric (GE) Milwaukee (X-ray Department, Neutron Devices Department) had experience with the tritium-deuterium reaction and, as a result, they were asked to establish and operate the Pinellas Plant. GE established a temporary plant located in the downtown St. Petersburg area. Later a permanent facility was established in Largo, Florida, including the hiring of 600 people of diversified technical backgrounds and the building of a railroad. Initially, GE did not know the details of the work to be performed at Pinellas, but within 3 years, they made a workable product. The Pinellas Area Office of DOE provided oversight to the facility and reported to the DOE Albuquerque Operations Office.

There were connections between the Pinellas Plant and the Kansas City Plant, Los Alamos National Laboratory, Sandia National Laboratory (SNL), Lawrence Livermore National Laboratory (LLNL), and Mound Laboratories. These relationships mandated that Pinellas staff members visit the other facilities periodically. Pinellas employees were also involved in yield and effects testing of components at the Nevada Test Site (NTS). When the neutron generator work was terminated at Pinellas in September 1991, the responsibility went to SNL and the tritium operation went to the Savanna River Site (SRS). Pinellas gave one of the Radioflo Units to LLNL.

There was pressure on members of the non-exempt workforce and several members of the exempt work force to meet production goals and milestones. During the production period, it was not uncommon to work double shifts or work every day until the goal was met. This was especially true in the 1960s. On average, site experts indicated that they worked up to 40% overtime. For other exempt staff members, the overtime was occasional and typically occurred in response to a problem (e.g., radiation alarm).

A color-coding system was used to separate those with clearances from others. An area marked with green indicated a Q-cleared area. To enter these areas, one had to pass through Security. The information shared with the workers was on a need-to-know basis only. Area 400 was a high security portion of the plant, and was surrounded with razor wire.

A portion of the workforce was mobile, primarily those involved in Test Equipment Design and Test Equipment Fabrication.

Subcontractors were a part of the workforce at the Pinellas Plant. The Environmental, Safety and Health (ES&H) Group was notified when subcontractors worked onsite. They determined whether the subcontractors needed monitoring. This may have included bioassay and/or dosimetry. Pinellas provided other DOE contractors with personnel exposure results to their respective sites when they visited Pinellas.

Few of the upper management team visited the production areas on a frequent basis. As a result, upper management was not close to daily problems in various areas.

Operations

Building 100 was referred to as the Ferguson Building. There were a wide variety of operations conducted in Building 100. Some of these operations involved the use of radioactive material and others did not. A room within Building 100 was referred to by laboratory number, area, or process name (e.g., Area 108, Area 8, or Tube Exhaust and Test). The major operations including radioactive material are given in the table below.

Laboratory*	Function
104	Machine Shop
107	Tube Assembly/Tube Exhaust Area; Contained glass domes
108	Tritium Loading Area
109	Final Certification (x-ray, storage, vibrators) for Neutron Generators
111	Storage of Tubes containing Tritium
112	Core Winding Area/Resin Casing
118 Vicinity	Transitor Testing and Inspection prior to Assembly
126	Tube Assembly
128	Laboratory
130	Laboratory
131	Laboratory
182	Loading Facility
185	Systems Development

* The information in the table corresponds to the original floor plan of Building 100 unless otherwise noted.

The neutron generators manufactured by Pinellas were used to generate neutrons at a specific time within the weapons detonation scheme. The generators produced were of weapons reserve quality, and hence used in weapons systems (e.g., weapons used on the Trident Submarine). These worked on the principle of a tritium-deuterium reaction. A neutron generator has a vacuum tube for tritium and deuterium. Tritium is introduced into glass flasks of powdered uranium where it is held as uranium tritide. The powder was heated, driving the tritium gas into the tubes. The Neutron Tubes were loaded in Area 108 and then assembled into Tube Transformer Assemblies, and finally neutron generators in other areas. Room 18, Area 108, was used to turn DU slugs or pellets into uranium hydride. Titanium was used in place of uranium during some operations. Employees wore fresh air, a film badge, lab coat, shoe covers, and gloves during this process. In later years, the site transitioned from a glass tube system to a metal (stainless steel) system. When using glass tubes, there were periodic events where the

tubes would crack and result in contamination spread. This occurred about once every 1–2 months. Experimental Research Tests were conducted on components. If the engineers increased the voltage on the test generator too much, tubes could break. Scandium tritide was present at Pinellas; however, the exact use is not known.

Neutron Generators were tested to see if they put out the correct number of 14 MeV neutrons. The energy and number of neutrons emitted from a generator or tube was a production specification. Both routine and experimental tubes were tested in Room 131 on trays designed for leak testing. The tubes were then sent to another department for the addition of components. The unit was then returned to Room 131, where it underwent functional testing to determine if it would withstand high voltages.

Operators were responsible for maintaining liquid nitrogen levels in Room 108 during the day. On the off-shift, Nitrogen Handlers completed this job. There was one maintenance person assigned to an area during the day (routine).

The Machine Shop (Building 100, Room 104) was involved in sandblasting neutron generators for painting. Sandblasting dust became airborne and subject to being inhaled. Site experts reported that the yellow powder, which they suspected may have been DU powder, would get on the workers' clothes in the Resin Casting area (Building 100, Room 112). The site was also involved in the development, building, and testing of equipment used for the operations and acceptance testing process.

Between 1975 and 1990, Building 400 became involved in producing Radioisotope Thermoelectric Generators (RTGs). The primary function of these sources was to generate heat and ultimately electrical power. Radioisotope Thermoelectric Generators were composed of Pu-238 on a thermal electric battery in insulation. The Pu-238-encapsulated discs arrived in blue cans and were shipped out in padded yellow containers. Armed guards accompanied the material, and remained with it until it was unloaded and put in storage. The Pu-238 used for RTGs was triply encapsulated. They were primarily a gamma exposure hazard. The heat sources were set up in a clean room. Two RTG heat sources were loaded into a fixture, and the fixture was then placed in a pass-through window. Up to six units could be processed at one time. The operator would exit the clean room and put the unit into a furnace for 5–6 hours to allow the heat to press the two heat sources together. The containers were manually transported to inspection. Site experts described Building 400 as "very hot" with respect to radioactive material.

The thermo-battery pellets required inspection periodically throughout the manufacturing process to determine if they were within tolerance (i.e., no dips, chips, water stains, etc.) Other plant inspections were conducted on metalized ceramics, glass tubes, and components used in the Magnetic Area.

The Radiflo Unit was used for leak testing, and contained a gas mixture of Kr-85 and nitrogen in known quantities. Glass containers used for tritium were brought to the Radiflo for leak testing. The unit was brought up to a pressure, which was maintained for a period of time. Tubes were placed in the unit then brought up to pressure for a certain length of time. The amount of leakage

was then calculated, based on the concentration of Kr-85. Following testing, Kr-85 was returned to the storage tank. Sometimes there would be leakage into the unit, thus requiring the use of a cold trap to capture Kr-85 from the diluted nitrogen/krypton mixture.

Radiological Health and Safety

Initially, Pinellas health physicists had difficulty obtaining information related to the monitoring of tritium. As a result, many of the techniques were developed in-house. Eventually, SNL and Mound laboratories provided some information. Prior to the Tiger Team Assessment in the early 1980s, there were five health physicists onsite to handle the plant's program.

Regulations in the 1950s, 1960s, and 1970s were minimal, so exposure measurements were not as rigorous as they were later. In general, members of the workforce disregarded radiological postings. Radiation tape was commonly used on the floors to mark radiological areas. Desks were placed inside radiological areas, and individuals typically drank their coffee at their desks. Employees were not allowed to eat in the assembly areas and Area 108; however, some individuals ignored the prohibitions. The Tiger Team audit at Pinellas initiated a dramatic change; for example, a more substantial use of radioactive material labeling began.

Area 108 was the "hot-spot" of the plant. This area monitor alarmed periodically because of elevated radiation levels. Decontamination of the areas and glass systems occurred often, and decontamination also occurred in other areas (e.g., Area 165), mostly at night when radiological control samples were taken. Spills were cleaned up, a smear survey conducted, and the area was either determined to be within acceptable limits or the decontamination process was repeated. A space above the ceiling of Area 108 periodically had to be vacuumed for contamination removal. Area 109 was among the several areas posted as a contamination area.

Personal Protective Equipment use was based on where an employee worked and the materials handled. For Area 108, staff working with radioactive material during the day wore white coveralls with booties. This was not always the case with the off-shift personnel. Company shoes were provided for those working with liquid nitrogen fillers. In Area 116, lab coats, shoe covers, and a hat were worn. Visitors to radiological areas wore yellow shoe covers.

The beta/gamma and neutron monitoring were dependent on the area and the job function. Health Physics reviewed each job description and determined what monitoring was required. It was the responsibility of the supervisor to sign individuals up for dosimetry and bioassay. The process was documented in the Radiological Instruction Manual.

The production workers or those working with radioactive material were provided with dosimetry. Support staff employees (e.g., Test Equipment Engineers, Process Control Engineers, Material Handlers, Nitrogen Handlers, and Expeditors) were not always monitored. Dosimetry was not provided to all personnel in the Tube Transformer Assembly (TTA) and the Resonator Area. Other employees were assigned dosimeters when they made entries into radiological areas of the plant. Administrative employees were generally not assigned dosimeters or asked to submit bioassay samples, although they did enter radiological areas to deliver paychecks and the plant newsletter. Extremity dosimetry in the form of finger rings was primarily assigned to those

working on the RTG program, as this work involved hands-on operations with Pu-238. Copper step wedges were used for calibration to determine the density versus dose for film badges. A procedure was eventually put in place for the calibration process. The site had some pocket ionization chambers for use as necessary.

If there was an unusual reading, the exposure on the badge was recorded as indicated during readout. For example, a woman intentionally overexposed her badge and RadCon assigned the dose that was indicated on the badge, knowing that her actual dose was less. There was an elevated background level at the badge storage racks in Building 300 due to aggregate and plaster in the walls. These racks had to be moved and the incident was documented.

In 1957, Pinellas health physics staff traveled to Albuquerque, New Mexico, to learn how to read Nuclear Track Emulsion Type A (NTA) film. To read NTA film, the proton recoil tracks were counted to determine the neutron exposure. If a neutron struck the NTA film head-on, it would shoot through the film leaving a dot, while others neutrons would scatter, creating a track. The tracks were counted; however, the dots were not. The main track and scatter were counted as one track. Neutron film was calibrated using a polonium-beryllium (PoBe) source. Each batch of film had a set of exposed neutron film to provide the dose curve. This calibration curve was used each time they developed NTA film at Pinellas.

For Area 108, employees submitted weekly urinalysis samples. Special urine samples were collected if area alarms went off. Urine was collected at the end of the shift. The recording levels for tritium bioassay started at 0.67 µCi/liter. The value was reduced to 0.3 µCi/liter, 0.1 µCi/liter, and finally 0.003 µCi/liter with the Beckman Liquid Scintillation counter. Bioassay samples were considered positive at 1 µCi/liter, and a work restriction was issued at 10 µCi/liter. Special bioassay samples were collected when there was any rise in the individual's routine bioassay sample, as required by the Radiation Work Permit, or after an incident involving tritium release. There was a Hand and Foot Monitor in Area 108, and "sniffers" were also used by some individuals to detect tritium in their breathing zone. One technique that was recommended to employees as a means to purge the system of radioactive material was to drink beer.

Documentation shared with SC&A indicated a relative biological effectiveness through 1974 of 1.7 for tritium and 10.0 for neutrons was used. The biological half-life for tritium was assumed to be 12 days. Recorded tritium results for 1975 and later use a quality factor of 1.0. Although urine was submitted, workers indicated that the results of the analysis were not shared with them.

Kanne Chambers were used for general area monitoring. Each hood had four systems and a drop monitor outside the hood in front of each system in TTA. A Kanne Chamber with a recorder and alarm capabilities was placed outside the room. They were periodically checked with an external source. Portable tritium air samplers were available in areas without a fixed Kanne Chamber. Neutron monitoring in the field was limited to area monitors at each station. Cesium-137 was used for calibrating Kanne Chambers. Cobalt-60 and PoBe sources were used to calibrate other instruments.

Prior to entering the clean room, personnel had to use a blower to blow the dust and other loose material off themselves. The clean room protective clothing included floor-length gowns with long sleeves, booties, beanie caps, and a mask similar to a painter's mask.

The accelerator built in Building 800 was well shielded with thick concrete walls; however, there was an issue identified with skyshine. The mission was related to tritium targets. Pinellas handled C-14 sources, but site experts interviewed were not aware of the use of Ni-63. Nickel transistor tubes were shipped to Pinellas in lead pigs and were surveyed with a Geiger- Mueller Counter to eliminate the possibility of receiving Co-60 by mistake.

There was heavy use of Electron Beam Welders in Building 300, which was originally a separate building from Building 100. Industrial x-ray units were used throughout the plant for various inspection tests. They were surveyed periodically by health physics with a Geiger- Mueller Counter. These surveys were documented and were stored with the health physics records.

Environmental Monitoring

Environmental monitoring had included soil sampling, water sampling (onsite and offsite), and air sampling. There was no direct radiation monitoring. There were perimeter and offsite (e.g., by the Clearwater/St. Petersburg airport, roof of the Clearwater County Building) air monitoring stations. The samples were exchanged monthly. Pinellas also conducted a Meteorological Study looking at wind conditions, temperature, and release rates. Any tritium released as an oxide was collected on Silica Gel. Gaseous tritium passed through heated copper oxide and converted to tritium oxide, so it could also be collected on the gel. The maximum airborne concentration of tritium recorded was 4×10^{-9} µCi at the boundary.

The tritium was not completely retrieved by the uranium beds from the systems. As a result, when the system was opened, there was a release to the environment. This was observed by the spikes on the stack monitor. The stack monitor was a 16.5 liter Kanne Chamber. Flaming the glass systems to rid them of impurities such as stopcock grease generated a lot of releases out the stack. If they broke, there was also a potential exposure to the work area. Any time the metal exhaust system was opened; there was a conversion of gas to HTO. There was an elephant truck over the area for ventilation. The Building 100 exhaust system included a method for recovering tritium, thus reducing the tritium released.

Tritium released in the liquid effluent stream had a limit of <3 µCi/liter. The tanks were sampled to determine the concentration, and water was added if the concentration was too high. Part of the offsite monitoring included sampling liquid down stream.

Chemical and radioactive waste was diverted to the northeast pond. There were some cases where neutron tubes were dumped in the northwest pond. It is not known if these tubes contained radioactive components or were tubes that were rejects and unloaded. At times, there may have been dumping in the ocean. The site also had a spray irrigation area. The pond has been well characterized and is specifically addressed in the 1972 environmental assessment. The U.S. Geological Survey was performing a Ground Penetrating Radar survey and located drums buried on the northeast section of the property. A follow-up survey located drums in the

northwest section of the property. Although the waste met the regulations at the time it was buried, it did not meet the more stringent criteria of the 1990s. The drums were removed during remediation and sent elsewhere for disposal.

During the decontamination and decommissioning (D&D) phase of the plant, workers were encouraged to close the plant down as fast as they could. The decision to close the plant came in the early 1990s. In 1995, all production for the DOE was halted. The cleanup was completed by 1997. Higher-risk activities conducted during D&D included dismantling the stack, removing gloves boxes and other laboratory equipment, and retrieving waste drums. There were smears taken of all the equipment, walls, glove boxes, etc., at this time.

Incidents or Unusual Occurrences

Few incidents were mentioned during the course of site expert interviews:

- There was one incident where contaminated materials were received from another DOE site.

- There was a release of 79.8 Ci of tritium out the stack on July 25, 1984. There was a problem associated with the sieve from the Tritium Recovery System.

- Kr-85 was released out the stack of Building 100. The exact date is documented in the health physics reports.

If incidents occurred, they were generally documented in monthly and quarterly health physics reports.

Records

Pinellas Plant personnel transferred an electronic database of radiation exposure records and hard copy files to Albuquerque after the plant shutdown. (Note: Nulls in records indicated individuals were not monitored.) Other documents generated by health physics included periodic (i.e., weekly, monthly, and/or quarterly) environmental and health physics reports. There were also incident reports generated. If personnel had to be decontaminated, there was a Personnel Contamination Report issued.

There is a disagreement among site interviewees as to whether records were destroyed. Some interviewees maintain that records from health physics were never destroyed. It was stated that one ES&H staff member accompanied an employee to the site library to access the employee's radiation records. The records had been converted from hardcopy to microfilm. The librarian located the microfilm, but the images were illegible and the original records had been destroyed after conversion. Another individual formerly working for ES&H indicated that files he kept while at Pinellas were destroyed after he retired. One record shown to SC&A during the interview indicated an incomplete record of an individual's work history. She began her employment in May 1968 as a Process Control Operator in Building 400. During her tenure at

Pinellas, she was married and changed her name in 1982. Although documentation indicated that she started in May 1968, monitoring records were only available for 1979 and 1980.

Daily operations logbooks were maintained by Security, foremen, and individuals. The logbooks typically included what occurred during a given day (i.e., routine work, non-routine work, experiment results, events). The foreman of a particular area was responsible for maintaining security logs, which required employees to sign in and out of sensitive areas.

Occupational Medicine

The Medical Department had procedures with the settings for the medical x-ray unit. Exams were conducted once per year; however, there was a subset of individuals that received semi-annual exams. At startup, some individuals were on a 5-year frequency. The exams included chest and lumbosacral x-rays. Some site experts indicated they received up to four views per chest x-ray exam (Anterior-Posterior, Posterior-Anterior, lateral on each side). Health Physics monitored the medical x-ray units using a calibrated integrated ion chamber (R-Chamber). In the 1970s and 1980s, the Pinellas County Health Department started to calibrate the medical x-ray unit at Pinellas.

Miscellaneous

- Pinellas did not have in-vivo count capabilities.
- The Pinellas County and Florida State Health Physicists worked closely with the plant to monitor environmental releases. Howard Moreland authored an article entitled *Tritium the New Genie* in 1979. He referenced Ulray Clark (Florida Public Health Physicist), who was quite critical about how tritium exposures were under-rated in the federal government.
- There were numerous chemical hazards associated with operations at Pinellas. Chemicals that site experts worked with included toluene, turpentine, beryllium resins, acetone, asbestos, xylene, ethyl alcohol, sewage, methylene chloride, and liquid nitrogen, as well as other toxic chemicals.
- Pinellas was known for its high-quality products. In about the 1980s, they took over the magnetic work previously done by the Kansas City Plant, due to their quality product reputation.
- The Ferro Electric Devices were sent to Pinellas from Mound. These were used in the explosive generator.
- Area 16 was responsible for building various timer subassemblies.

- A site expert attended a classified meeting during the Cold War; the year of 1980. The director of the meeting told employees that they could become ill with thrombocytosis working with radiation, radioactive materials, and toxic chemicals at Pinellas. Workers have noted a cluster of cancers in individuals who worked in a particular area of the facility.

- There was a community concern related to the involvement of Pinellas in the nuclear weapons program. Picketing occurred on a weekly basis in front of the plant.

- The glass tubes would be cracked, releasing material. There were occasional breaks of tubes.

NIOSH TBD Comments

The former head of Health Physics reviewed the NIOSH TBD and thought it was relatively comprehensive and reflective. This individual was interviewed by NIOSH regarding the Health Physics program. Concerns were raised that those individuals who were not monitored by the site are being compensated.

There is concern among former Pinellas workers that Pinellas is being lost in the shuffle of the compensation program. An employee received a letter from NIOSH denying her employment record for Pinellas.

ATTACHMENT 3: KEY QUESTIONS FOR NIOSH/ORAU REGARDING SITE PROFILE DOCUMENTS

ORAUT-TKBS-0029-3 through ORAUT-TKBS-0029-6

Absence of Early Health Physics, Industrial Hygiene, and Environmental Records

The absence of pre-1980s records brings into question the ability to adequately assign radiation doses during the early years at Pinellas. Improvements in radiological monitoring and bioassay methodology, instrumentation, and in health physics, industrial hygiene, and environmental control programs, contraindicate the use of 1980s documentation for determining radiation doses for the early years of Plant operations. The assumptions incorporated into ORAU-TKBS-0029-4 and ORAU-TKBS-0029-5, in most instances, given the absence of firm information, appear to be claimant favorable. However, there can be a high degree of uncertainty in using later years information and data to assign doses for early years' operations. This uncertainty is not adequately addressed in the TKBS to the degree that it should be to ensure that dose reconstructors would consider its relevance.

Question: How can NIOSH be confident that all assumptions regarding early occupational doses are claimant favorable, given the absence of records and information?

It appears that only documents available at Atlanta National Archives were considered in development of the Pinellas TKBSs. SC&A has evidence that some of the more important early documents may, in part, be located at other DOE sites, and is currently working with NIOSH and the relevant sites to obtain them. Should we obtain these records and they present information significantly variant from that assumed in the TKBS, revision of some or all the TKBSs may be in order.

Question: Will NIOSH revise the TKBSs to accommodate information obtained by SC&A from other DOE sites and sources?

ORAUT-TKBS-0029-2

Changing Plant Operations

Figure 2-3 is apparently a recently developed site map. It does not reflect changes made to the site over the operating lifetime. Likewise, the discussion in Section 2.2 appears to reflect the condition of the site late in its operating history.

Question: Would it not be beneficial to discuss some of the major modifications to the operating facility during its lifetime?

Depleted Uranium (DU)

Section 2.3.2 contains a discussion of depleted uranium, including the statement:

> *The depleted uranium metal was fully contained inside the storage flask, and no information could be found to indicate that depleted uranium metal was released during plant operations (Ward, p. 12).*

Interviews with a former employee raised the possibility of loose depleted uranium contamination in an area of Building 100. There were no bioassay programs in place to determine internal dose from exposure to DU, thus DU internal exposure could represent a significant source of unmonitored exposure. There is minimal information in ORAUT-TKBS-0029-2 on the production of the tritium beds, so it is not possible to discern if the process involves operations that could lead to internal exposures. Further discussion of the DU-related process may be in order.

Question: How certain is NIOSH that depleted uranium does not represent an unmonitored source of radiation exposure? Were there any operations within the Pinellas Plant that could have led to internal exposure to DU? Will NIOSH consider revising ORAUT-TKBS-0029-2 to describe the treatment of DU at Pinellas, including further documentation that it does not represent a source of unmonitored dose?

Solid Radioactive Waste

Section 2.3.3 contains the statement:

> *The majority of radioactive waste from the site consisted of tritium-contaminated classified components. These components were packaged and shipped to a DOE-controlled site for disposal.*

Interviews with former employees raised the possibility of onsite burial of radioactive wastes. If onsite burial occurred, it could have been an additional source of exposure for unmonitored site workers.

Question: Does NIOSH have any information to indicate or dismiss the possibility of onsite burial of radioactive materials?

ORAUT-TKBS-0029-3

Frequency of Medical Chest X-rays

In Section 3.1, the statement is made:

> *The policy for chest x-ray frequency may have been (no written policy has been located) every 5 years before age 40 and every 3 years > 40 years of age.*

Question: What is the basis for this statement? What frequency will NIOSH have the dose reconstructor assume?

Medical X-rays other than Chest X-rays

In Section 3.1, the statement is made:

> *Other x-rays that were offered to employees included KUB, lumbar spine, cervical spine, hand, ankle, foot, sinuses, and wrist. As far as it is known, these x-rays were not given in conjunction with employment and are not included in doses under EEOICPA.*

Question: Without documentation, what is the basis of determining that these x-rays were not related to employment?

ORAU-TKBS-0029-4

Detection Limit for Tritium/Krypton Gases

Section 4.1.2.1 contains the statement:

> *Air samples were drawn through Kanne type ionization chambers connected to pico ammeters to analyze tritium gas and krypton gas (minimum detection limit of 6.4E-6 µCi/ml) (IT/Radiological Sciences Laboratory, 1986).*

Question: To which of the radionuclides does the minimum detection limit refer?

Description of Emissions Monitoring Sampling

In Section 4.1.2.1, emission monitoring sample collection techniques are described for tritium and krypton, while radioanlaytical methods are discussed for plutonium and C-14.

Question: Should monitoring sample collection techniques be described for plutonium and C-14?

Aeration of Industrial Effluent as Exposure Source

Section 4.1.2.2 contains the statement:

> *From 1974 to December 1, 1982, the industrial effluent was combined with the sanitary waste effluent in the 2,600,000 gallon west lake where the waste water was aerated and pumped to a nine-acre spray irrigation field.*

Aeration of these effluents is not considered as a source of airborne tritium exposure in the document.

Question: Should aeration and spray field operations be considered as a source of airborne tritium exposure?

Source of Early Plant Emissions Data

Section 4.1.4 contains the statement:

> *By 1992, approximately 82% of the total releases had occurred during the first 4 yr of operation, 1957 through 1960. Table 4.1.4-2 lists the radionuclide releases from Pinellas Plant exhaust stacks (AEC, 1972; 1973; 1974; ERDA, 1975; 1976; 1977; DOE, 1978; 1979; 1980; 1981; 1982; 1983b; 1984; 1985; 1986; 1987; 1988; 1989; 1990; 1991; 1992; 1993; 1994; 1995b).*

The source citations are for the years 1972 through 1995, with none for the period before 1972.

Question: What is the source(s) of the emissions data for 1957 through 1971? What is the basis for the assertion that 82% of the total releases occurred from 1957 through 1960?

Perimeter Tritium Monitoring Stations

Tritium air monitoring stations were operated on the perimeter of the site for a major part of the plant operating history. Up to six samplers were continuously operated and collecting samples for determining tritium gas and oxide airborne concentrations. The existence of these stations is not mentioned in ORAU-TKBS-0029-5. This is a major omission and a missed opportunity to verify the modeling results by comparing them to measured values.

Question: Does NIOSH plan to revise the TKBS to include a comparison of modeled airborne concentrations to measured values for tritium?

Inadequacy of Section 4.4 – Uncertainty

This entire section is inadequate and needs to be rewritten to address the topic it presumes to discuss, i.e., uncertainty. The discussion in this section centers on factors that affect the quantity of dose calculated and not the uncertainty associated with estimates. While it may not be possible to quantify the uncertainty of estimated doses, a more relevant discussion on the relative magnitude and factors affecting uncertainty is needed.

Question: Does NIOSH plan to revise the TKBS to include a more relevant discussion of uncertainty?

ORAU-TKBS-0029-5

MDCs and Uncertainties for Plutonium and Bioassay Measurements are Inadequately Addressed

ORAU-TKBS-0029-5 should provide more information about the uncertainties and how the activity concentrations were calculated. The information in ORAU-TKBS-0029-5 is not sufficient to verify the adequacy of this information.

Question: Can NIOSH provide more information on the use of the values in Table 5.1 to calculate internal doses?

Following an explanation of the usage of Equation 5-1 for calculating the MDC for Pu, the equation and statement below are given:

> *Plutonium MDCs for either ^{238}Pu or ^{239}Pu was calculated with the following formula:*

$$A_{Pu} = \frac{\{Net\ ROI_{CTS}(^{238}Pu \text{ or } ^{239}Pu) \times CF\}}{\{Net\ ROI_{CTS}(^{242}Pu) \times sample\ size\}} \qquad (5\text{-}1)$$

Question: Can SC&A be provided an explanation on the origin and purpose of this equation and definitions of the symbols?

The average MDC value is an important parameter for the calculation of the missed dose, mainly because for plutonium, the frequency of the routine bioassay program was annual. According to data presented in Table 5-1 (page 9/31), in 1980, the average MDC value for Pu-238 is 6.23E-11 uCi/mL and the maximum MDC value is 3.17E-10 uCi/mL; and the average MDC value for Pu-239 is 3.41E-11 uCi/mL and the maximum MDC value is 1.90E-10 uCi/mL. There is a factor of 5 between the average MDC value and the maximum value.

Question: Can NIOSH provide information to explain the wide range of individual MDC values for bioassay samples for plutonium?

The following statement is included in this section:

> *No confirmatory evidence of a positive plutonium bioassay or a dose calculation and investigation was found in the Pinellas Plant documentation.*

Question: Is this statement true for the entire plant operational period, for 1988, or for the period after 1988 when a positive result had to meet a five-criterion test?

Two conditions for rejection of a positive Pu bioassay result are:

> *The ratio of ^{238}Pu to ^{239}Pu in a bioassay sample must be about 5:1 (±20%) or ^{238}Pu is detected while ^{239}Pu is not detectable.*

The application of these criteria to Pu bioassay results for the three years (1988, 1989, and 1990) discussed in the TBD was responsible for approximately 30% of the samples being designated as non-positive. These results should be reviewed on an individual basis, in that the use of this criterion, because of the relative large uncertainties associated with values near the detection limits for Pu, could result in the rejection of positive Pu-238 results. At a minimum, this would have prevented an investigation into the circumstances that could have led to the positive result.

Question: Does "*(±20%)*" mean the range of ratios to be rejected is from 4 to 6? Is NIOSH confident that the use of this criterion did not cause the rejection of positive Pu-238 bioassay results?

Plutonium Contamination

The ORAUT-TKBS-0029-5 on page 13/31, item 5.3.1.2, *Plutonium Contamination Monitoring*, states that one source had a contamination level greater than the detection limit, as stated below:

> *Upon receipt of plutonium sources directly to Building 400, there were leak checks in the receiving area in the containment hood, and the sources were repackaged into 2R storage and transport containers and placed into the storage vault. A 6-dpm/swipe release limit was the control level for the source contamination release limit at the 95% confidence level [an Eberline SAC-4, ESP-1/Ludlum 43-10 or Baird accu-count was used (Burkhart 1989)]. A maximum of 1 of 70 plutonium sources received during the course of one month had a contamination level greater than the detection limit of 6 dpm. All were decontaminated before RTG processing. Plutonium sources greater than 200 dpm contamination levels were sent back to the vendor (Huffman 1979). There was no documentation found indicating that any units had to be sent back.*

Question: Since the contamination was detected, can SC&A be provided more information about it? What was the result of finding this contamination? What follow-up actions resulted?

Nickel-63 and Carbon-14

The ORAUT-TKBS-0029-5 states that Ni-63 and C-14 were also part of the processes in Pinellas, but no internal monitoring was conducted.

Question: What guidance will NIOSH present for dose reconstruction associated with exposures from Ni-63 and C-14?

Plutonium Solubility

In the ORAUT-TKBS-0029-5 on page 16/31, it stated that:

> *ICRP Publication 68 lists plutonium oxides as absorption type S (ICRP 1995, p. 83). A discussion of absorption type for plutonium oxides in ICRP 71 indicates that bioassay data from accidentally exposed workers to ^{238}PuO2 could have been closer to type M (ICRP 1996, p. 329).*

ICRP 71, on page 329, also states that plutonium can have different lung clearance characteristics when inhaled as mixed metal oxide. The extent of increased dissolution/clearance depends on the metal and the relative proportions of plutonium to metal.

Since there is an uncertainty on the definition of the solubility rates for Pu-238, and also there is not a clear definition of the solubility of the handled compound, the selection of the type of compound for dose reconstruction should be more claimant favorable. For some scenarios, the selection of Type M compound is not the claimant-favorable approach**.**

Question: Does NIOSH intend to provide further guidance to dose reconstructors regarding plutonium solubility?

Insoluble Metal Tritides

The neutron tube manufacturing process required spray coating the inside of a glass tube with a thin metal film, resulting in the formation of insoluble stable metal tritides (SMTs), namely ScT_2, ErT_2, and TiT_2. There is no internal documentation indicating that there were adequate means of detecting exposures or monitoring SMTs. Powders were normally contained within vacuum systems and metal systems that generally remained intact; however, documented incidents involving some of these materials occurred.

ORAUT-TKBS-0029-5 states:

> *Besides incidents, metal tritide intakes could have occurred from any of the process areas for HTO processing.*

A review of the incidents listed in the above document (Table 5-10, page 24) clearly indicates the potential for metal tritide contamination and personnel exposure, even though no measurements were made. The practice of destructive testing of neutron generators and the methodology for performing the testing make it possible those exposures to metal tritides existed. Further discussion of the potential exposure pathway and doses should be included in ORAUT-TKBS-0029-5. Insufficient guidance is provided for estimating the exposure to metal tritides.

Question: Does NIOSH intend to provide additional guidance for assessing doses for metal tritides at Pinellas?

The Decontamination and Decommission (D&D) Era of Pinellas Operations is Not Sufficiently Addressed

Monitoring practices, particularly internal dosimetry, are not specified in the TBD for the D&D period (1995–1997) at the Pinellas Plant. A number of questions present themselves that are not addressed by the existing Pinellas Site Profile.

Question: What specific external and internal monitoring program was established for D&D operations, and how effectively was it implemented? With the use of first-, second-, and third-tier subcontractors, to what extent were these workers "captured" in the site's dosimetry program, and were their records maintained? How would the co-worker dose model be applied for unmonitored workers located adjacent to D&D operations; was resuspension of radioactive particulates an onsite issue during D&D?

Decontamination and decommissioning is not addressed in any detail in the documents reviewed to date on the "O" drive concerning external doses. In revisions to the TBDs, NIOSH should devote a section to D&D operations, and find ways to quantify dose for workers involved in D&D and demolition operations. No external dose monitoring, precautions, unusual conditions, or incident tracking during D&D are mentioned. All D&D workers in the radioactive areas should have been badged for photons, beta, and possibly neutrons. It is not clear if this was done, or if workers always wore respiratory protection during D&D operations.

The period from the end of operations to complete closure of the site appears to be missing from the TBDs reviewed to date. It is not possible to evaluate the external dose issues during this period without additional information on the D&D operations, health physics and monitoring procedures, and dose data results.

Question: Will NIOSH address D&D operations in subsequent revisions to the TBDs?

Natural Uranium in Glass Concerns

A document entitled, *Natural Uranium in Glass Concerns,* by A. S. Weaver (Document No. 2401370) taken from the "O" drive was reviewed by SC&A. The following is excerpted from the document:

> *An existing operation at the Pinellas Plant uses glass containing (1.5% by weight) naturally occurring uranium oxide ($U_1 0_0$). This operation has been conducted for many years. Processes with this glass have been reviewed to assess worker radiation exposures and potential environmental impact.*
>
> *Personnel exposures during handling have been assessed using conservative work periods and measured dose rates. Estimated worse case exposure to whole body and extremities are well below DOE annual limits (5000 mrem/yr whole body (WB) and 50,000 mrem/yr extremities). Highest doses would be 15 mrem/yr to WB and 75 mrem/yr extremities, DOE requires monitoring if exposures may exceed 10% of annual limits.*

Later in the document, the following statement is made:

> *Dosimetry devices will be issued to workers as a means of verifying the estimated doses.*

The usage of the glass containing uranium oxide was apparently widespread and occurred over a number of years. The statement relative to issuing dosimetry devices implies that the workers handling the glass were, prior to the date of this document, 1992, unmonitored. There is no reference to this source of potential unmonitored dose in ORAUT-TKBS-0029-5.

Question: Does NIOSH consider the potential unmonitored dose to be sufficient to revise the TBKS to reflect it?

ORAUT-TKBS-0029-6

Assessment of Personnel Badging Policy

ORAUT-TKBS-0029-6 states:

> *From 1960 to 1973, U.S. Atomic Energy Commission (AEC) annual exposure summary reports indicate that Pinellas had 27.5% of its labor force wearing dosimetry (377 of an average yearly labor force of 1,372). During the 1980s, while the data are not completely available, from 370 to approximately 400 of 1,650 to 1,975 workers (approximately 20%) were monitored for radiation dose. No documentation was found to show that all employees were monitored at some time during Pinellas operations.*

It is important to know who was considered a "radiation worker" and how they were selected for badging, as this has dose consequence. The TBD does not clearly address these issues by clarifying the basis for how monitoring was conducted, nor which worker categories were badged. These issues need to be reviewed and substantiation provided that the maximally exposed workers were badged, and that there is a means to estimate radiation dose to unmonitored support workers with access to production areas. Additionally, since many Pinellas records on facility monitoring, safety evaluations, investigations, etc., prior to 1980 are not available, the determination of the adequacy of badging assignment and allocation of unmonitored dose will be complicated.

Question: Will NIOSH revise the TKBS to more adequately address the impact and potential unmonitored dose to unmonitored personnel?

Problems with Personnel Dosimetry

Section 6.2.2 of ORAUT-TKBS-0029-6 states,

> *This analysis was unable to locate specific designs of the film dosimeters used for approximately the first 20 years (1957 to 1974) at the Pinellas Plant, and there is limited documentation that indicates there was an early relationship with Nuclear-Chicago (GEND 2004a).*

Table 6-5 on page 16 of ORAUT-TKBS-0029-6 assigns a missed dose of 0.24 beta-photons (monthly) for badges used during this time period. This assignment of missing dose evidently assumes that the badges used during this time period were equivalent to those provided by Nuclear-Chicago. Additional discussion is needed on the uncertainty associated with the assumed missing dose, given that the origin of the dosimetry is not clearly established.

Question: Will NIOSH revise the TKBS to more adequately address the impact and potential missed dose to Pinellas workers?

NTA Film Fading

Section 6.2.1.1 of ORAUT-TKBS-0029-6 recognizes the problematic fading characteristics of the NTA neutron badges. On page 13, ORAUT-TKBS-0029-6 states:

> *GEND established a factor of 3 to correct for track fading beginning in January 1970, based on a track fading study (GEND 1969).*

Following this declaration, there is a discussion of the potential errors related to applying this factor based on the time of exposure relative to the reading of the dosimeter. However, no "missed dose" is listed in Table 6-5 to account for dosimeter fading. In addition, it is not clear that correction for fading was applied to recorded doses prior to 1970.

Question: Can NIOSH provide more definitive guidance on assigning the missed dose for NTA film fading?

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ATTACHMENT 4: NIOSH RESPONSES TO SC&A KEY QUESTIONS

To be provided when received.

ATTACHMENT 5: SUMMARY OF CONFERENCE CALL ON SC&A QUESTIONS PROVIDED TO NIOSH

To be provided after Conference Call takes place.

ATTACHMENT 6: OVERVIEW OF NIOSH RECOMMENDED DOSE RECONSTRUCTION PROCEDURES FOR THE PINELLAS PLANT

The following is a brief summary, with some notes, of how it appears that NIOSH presently plans to perform dose reconstruction for **monitored** and **unmonitored** workers at the Pinellas Plant for 1957–1994. This was derived from studying the Occupational External Dosimetry TBD ORAUT-TKBS-0029-6 (Palmrose et al. 2005) and other Pinellas-related documents.

Monitored workers with dose records available

Beta and Photon

1957–1974: (All *radiation* workers badged with photon film of undocumented type.)

- Beta - Photons– Dose of record + 240 mrem/yr possible missed dose due to MDL (Nuclear Chicago or Pinellas – whole body).
- Beta - Photons– Dose of record + 240 mrem/yr possible missed dose due to MDL (Film badge - wrist).
- Beta - Photons– Dose of record + 240 mrem/yr possible missed dose due to MDL (Film badge - finger).

1974–1990: (All *radiation* workers badged with photon and neutron NTA film.)

- Photon – ~1974–April 1990: Dose of record + 60 mrem/yr possible missed dose due to MDL (Landauer G1 badge with Monthly changeout).
- Photon – ~1974–April 1990: Dose of record + 20 mrem/yr possible missed dose due to MDL (Landauer G1 badge with Quarterly changeout).
- Beta – ~1974–April 1990: Dose of record + 240 mrem/yr possible missed dose due to MDL (Landauer G1 badge with Monthly changeout).
- Beta – ~1974–April 1990: Dose of record + 80 mrem/yr possible missed dose due to MDL (Landauer G1badge with Monthly changeout).
- Photon – July 1974–~1983: Dose of record + 120 mrem/yr possible missed dose due to MDL (Landauer K badge with Monthly changeout).
- Beta – July 1974–~1983: Dose of record + 240 mrem/yr possible missed dose due to MDL (Landauer K badge with Monthly changeout).
- Photon – July 1974–~1983: Dose of record + 120 mrem/yr possible missed dose due to MDL (Landauer J badge with Monthly changeout).
- Beta – July 1974–1983: Dose of record + 240 mrem/yr possible missed dose due to MDL (Landauer J badge with Monthly changeout).
- Beta – July 1974–~1983: Dose of record + 240 mrem/yr possible missed dose due to MDL (Landauer M-wrist badge with Monthly changeout).
- Photon – July 1974–~1983: Dose of record + 120 mrem/yr possible missed dose due to MDL (Landauer M-wrist badge with Monthly changeout).
- Photon – ~1983–1990: Dose of record + 120 mrem/yr possible missed dose due to MDL (G5-wrist badge with Monthly changeout).
- Photon – ~1983–1990: Dose of record + 40 mrem/yr possible missed dose due to MDL (G5-wrist badge with Quarterly changeout).
- Beta – ~1983–1990: Dose of record + 240 mrem/yr possible missed dose due to MDL (G5-wrist badge with Monthly changeout).
- Beta – ~1983–1990: Dose of record + 80 mrem/yr possible missed dose due to MDL (G5-wrist badge with Quarterly changeout).

1990–1997: (All *radiation* workers badged with photon and neutron NTA film.)

- Photon – 1990–1997: Dose of record + 60 mrem/yr possible missed dose due to MDL (Landauer Z1dosimeter with Monthly changeout).

Neutron

1957–1978: NTA track film

- Neutron – Dose of record + 402 mrem/yr possible missed dose; corrected for fading, MDL threshold, and poor energy response for RTG (1975–1990)

July 1974– ~1983: Landauer Type K

- Neutron: Dose of record + 402 mrem/yr possible missed dose due to track fading.
- Neutron: Dose of record + 240 mrem/yr possible missed dose due to MDL.
- Neutron: Dose of record + 360 mrem/yr possible missed dose due to poor energy response for RTG

October 1979–October 1987: Mound albedo dosimeter

- Neutron: Dose of record + 120 mrem/yr possible missed dose due to MDL
- Neutron: Dose of record + 132 mrem/yr possible missed dose due to signal fading
- Neutron: Dose of record + 40 mrem/yr possible missed dose due to poor energy response for RTG

~1978–1997: Landauer Neutrak E1 dosimeter

- Neutron : Dose of record + 240 mrem/yr possible missed dose for MDL – Monthly changeout (until Jan. 1990)
- Neutron : Dose of record + 80 mrem/yr possible missed dose for MDL – Quarterly changeout
- Neutron : Dose of record + 79 mrem/yr possible missed dose for poor energy response for RTG – Monthly changeout

October 1987–1997: Landauer 18 Neutrak Extended Range dosimeter

- Neutron : Dose of record + 240 mrem/yr possible missed dose for MDL – Monthly changeout (until Jan. 1990)
- Neutron : Dose of record + 80 mrem/yr possible missed dose for MDL – Quarterly changeout
- Neutron: Dose of record + 79 mrem/yr possible missed dose due to poor energy response for RTG – Monthly changeout (until Jan. 1990)
- Neutron: Dose of record + 20 mrem/yr possible missed dose due to poor energy response for RTG – Quarterly changeout.(after Jan. 1990)

<u>Unmonitored/Undermonitored Workers</u>

External

From ORAUT-TKBS-0029-6, Section 6.4.1.1:

> *Unmonitored dose should be assigned to account for external dose that may have been received that was not measured. Summarized dosimetry data available for the period 1983–1993 indicates that the highest annual external dose for an individual at the Pinellas Plant was 0.550 rem. Typical annual dosimetry results for personnel monitored between 1957 and 1979 indicated few individuals received doses greater than 0.500 rem. Even though doses at the Pinellas Plant were expected to be lower than the maximum individual dose, the maximum doses may be assigned based on an assumption of 0.550 rem to each full or partial year. However, typically over 95% of monitored workers received annual doses below 0.100 rem. The only exceptions found to this were for the years 1958 and 1960, when only 80% and 84% of the monitored population were below 0.100 rem. The data indicates that an annual dose of 0.100 rem is representative of the upper 95th percentile dose for the Pinellas Plant. The unmonitored photon doses would be adjusted by DCF and other applicable factors.*

Internal

ORAUT-TKBS-0029-5 offers no specific guidance for unmonitored workers.