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ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

REVIEW OF THE NIOSH SITE PROFILE FOR THE KANSAS CITY PLANT

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Record of Revisions

Revision Number	Effective Date	Description of Revision
0 (Draft)	09/06/2012	Initial issue
1 (Draft)	11/14/2013	Includes new information and revisions to the original report as a result of site visits, data capture and interviews. New findings related to potential internal exposures to magnesium thorium alloy particulates, uranium, and perhaps high-fired uranium particulates associated with machining uranium and exposure to Th-230 and metal tritides are also included.

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ABBREVIATIONS AND ACRONYMS

Advisory Board or Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AHU	air handling units
ALARA	As Low As Reasonably Achievable
AMAD	activity median aerodynamic diameter
AP	anterior-posterior
AWE	Atomic Weapons Employer
BNL	Brookhaven National Laboratory
cc	cubic centimeter
CFR	*Code of Federal Regulations*
cm^2	square centimeter
D-T	deuterium-tritium
DCF	dose conversion factor
DOE	(U.S.) Department of Energy
DOELAP	DOE Laboratory Accreditation Program
dpm	disintegrations per minute
DU	depleted uranium
EDM	Electrical Discharge Machining
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
ES&H	Environmental Safety and Health
FRC	Federal Records Center
g/cm^3	gram per cubic centimeter
GM	Geiger-Muller
GSA	General Services Administration
GSD	geometric standard deviation
HEPA	High Efficiency Particulate Air
Hp	personal dose equivalent at tissue depth d (d = 10 mm or 0.07 mm)
HR	Human Resources
HVAC	Heating, Ventilation, and Air Conditioning
ICRP	International Commission on Radiological Protection
IH	Industrial Hygiene
KCP	Kansas City Plant

LASL	Los Alamos Scientific Laboratory
m^3	cubic meter
$\mu Ci/m^3$	microcurie per cubic meter
$\mu g/cm^3$	microgram per cubic centimeter
µg/L	microgram per liter
µm	micron
MDL	minimum detectable level
MeV	million electron volt
mg/cm^2	milligram per square centimeter
MOU	Memorandum of Understanding
mrem	millirem
MSDS	Material Safety Data Sheet
MTs	metal tritides
NARA	National Archives and Records Administration
NCRP	National Council on Radiation Protection and Measurements
NDT	Non-Destructive Testing
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
n/p	neutron-to-photon ratio
NOCTS	NIOSH OCAS Claims Tracking System
NTA	Nuclear Track A (film)
NYOO	New York Operations Office
OBT	organically bound tritium
ORAUT	Oak Ridge Associated Universities Team
PBS	Public Building Services
pCi	picocuries
PDF	Portable Document Format
PPE	Personal Protective Equipment
PuBe	plutonium beryllium
QA	Quality Assurance
QC	Quality Control
R&D	research and development
RadCon	Radiological Control
RADEC	Radiation Detection Capability

RCRA	Resource Conservation and Recovery Act
rem	Roentgen equivalent man
RGD	radiation generating device
RTV	Room Temperature Vulcanization
RWA	Radiation Work Authorization
SC&A	S. Cohen and Associates (SC&A, Inc.)
SRDB	Site Research Database
SRS	Savannah River Site
STCs	special tritium compounds
TBD	Technical Basis Document
TEM	Tooling and Equipment Maintenance
TLD	thermoluminescent dosimeter
TMA	Thermo Analytical, Inc.
TQM	Total Quality Management
U_3O_8	an impure mixture of uranium oxides obtained during the processing of uranium ore
UO_2	uranium oxide
VOC	Volatile Organic Compound

PREFACE

This report presents Revision 1 to the original Kansas City Plant (KCP) Site Profile Review dated September 2012. This revision is necessary because at the time of preparation of the original review, it was not possible to perform the site visits, records review and interviews as is normally done for most site profile reviews. This situation arose as a result of a worker strike and reduction in staff at KCP at the time. This revision specifically includes new information and revisions to the original report as a result of site visits, data captures, and interviews performed subsequent to the issuance of the original site profile review. This revision contains notations that reveal the changes transitioning from the original to the current version. Noteworthy are new findings related to potential internal exposures to magnesium thorium alloy particulates, uranium and perhaps high-fired uranium particulates associated with machining uranium, and exposure to Th-230 and metal tritides. Also, our research identified a number of questions that might warrant additional worker interviews.

EXECUTIVE SUMMARY

This report presents Revision 1 to the original review of ORAUT-TKBS-0031, *Site Profile for the Kansas City Plant* (ORAUT 2006), which provides data and guidance for dose reconstruction of workers at the Kansas City Plant (KCP) located in Kansas City, Missouri. This review was conducted in accordance with SC&A's Board-approved *Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). Under these guidelines, 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 (2004).

The following presents our findings.

Finding 1: Without specific information regarding the chemical form and particle size distribution of uranium exposure experienced by a worker, dose reconstructors should use default assumptions regarding particle size and chemical form of uranium that result in the highest dose to the organ of concern.

Finding 2: It appears that high-fired uranium oxide (UO_2) was handled at KCP and this subject needs to be explicitly addressed in the site profile and information provided to dose reconstructors in terms of solubility factors.

Finding 3: The bioassay data summarized in Table 12 of the site profile appear to be incomplete, which raises concerns regarding their use in developing a coworker model.

Finding 4: SC&A believes that the default chronic pattern of intake used in the uranium coworker model, which apparently is being applied to all workers, may not apply to many workers. Our review of actual cases reveals that many workers have legible bioassay records and show patterns of excretion rates that indicate that the coworker model may not be claimant favorable for all workers.

Finding 5: The system used to categorize workers by administrative code for the purpose of implementing the coworker model might result in misassignments that result in underestimates of reconstructed doses.

Finding 6: The site profile should address the degree to which uranium exposures may have occurred pre-1959 (i.e., prior to the date bioassay data are available) and the method used to reconstruct the doses.

Finding 7: The Site Profile should address issues associated with inhalation exposures during uranium fires in both the pre- and post-1958 periods. The nature and number of incidents in these periods remains to be established.

Finding 8: The nature and extent of work with depleted uranium during and after 1997 as well as any intakes that may have resulted remain to be established.

Finding 9: Further evaluation is warranted in regard to the processes and isotopes contributing to liquid radioactive waste shipments from the Kansas City Plant, the time period during which these activities and shipments occurred, and the potential for unmonitored internal exposures from spills, leaks, cleanup, and routine handling/storage of contaminated drums. An investigation into whether thallium liquid waste was present is also needed.

Finding 10: The site profile needs to address internal exposures to magnesium-thorium alloy.

Finding 11: The site profile needs to address the potential internal exposure to thorium-230 at the KCP site.

Finding 12: The site profile needs to discuss the degree to which metal tritides were present and how doses would be reconstructed to account for this potential source of exposure, with particular attention to any incidents that may have occurred.

Finding 13: There appears to be limited information available to the dose reconstructor with respect to the nature of the work performed by the workers. This issue warrants further investigation, along with the investigation of the legibility/accuracy/completeness of the database(s) used for dose reconstruction, in order to assess the ability to reconstruct worker doses, as supplemented with the coworker model. Subsequent to the original site profile review, interviews revealed that worker training records do exist that indicate the qualifications required to work in specific areas and perform tasks specific to potential exposure to radioactivity. These records should be more thoroughly researched in the site profile.

Finding 14: It appears that there are large time periods where beta exposure records are lacking, making it difficult to reconstruct beta doses for workers during those time periods and for developing a coworker model that can cover those time periods. In addition, the details of beta exposures are lacking.

Finding 15: The scarcity of positive neutron doses might be explained, in part, by the limited ability of NTA film to detect neutron energies below ~1 MeV. Additionally, neutron exposures may have been missed during neutron area surveys, because the only neutron survey instrument listed in Table 5 (ORAUT 2006, p. 13) is a Nuclear Chicago Model #2715, and this instrument may not have correctly responded to the pulsed neutron fields with the generator(s) being operated in the microsecond pulse mode, which was typical at KCP, as indicated in Table 4 (ORAUT 2006, p. 12). An analysis of the workplace shielding and other parameters is needed to develop an adjustment factor for badge readings to take missed neutron dose into account.

Finding 16: The fading of the NTA film as a function of time, temperature, and humidity was not addressed in the site profile, nor were there any correction factors provided. Lower-energy moderated neutrons would show even more fading as compared to the higher-energy neutrons. Additionally, the angular response of NTA film and polycarbonate neutron dosimeters was not addressed, which generally requires a 30% correction factor.

Finding 17: During the data capture, we determined that neutron detection instrumentation was checked and may have been calibrated at KCP using some types of neutron sources. The site profile should investigate this situation further as a potential source of exposure to workers.

Finding 18: Neutron-to-Photon (n/p) ratios require additional investigation in order to develop a recommended approach for dose reconstructors.

Finding 19: It may not always be correct to assume that unmonitored workers experienced exposures that were generally lower than those experienced by monitored workers, because monitoring in the early years may not have been as thorough as would be desired. In addition, as discussed in previous findings, coworker categories are ambiguous and might result in inappropriate coworker dose assignments.

Finding 20: A correction factor for exposures to photon radiation might be needed, due to the differences between the actual photon energy distributions created largely by x-ray machines, and the relatively high-energy photons associated with Co-60, which was used for calibration of dosimeters. This issue is especially of concern regarding exposures to skin and shallow organs.

Finding 21: The status of accident records needs to be determined. Specifically, NIOSH needs to establish whether accidents (internal and external) are included in the records in NIOSH's possession or whether they need to be obtained and included. Further, NIOSH needs to establish rather than assume that the doses relating to fragile radioactive source incidents were insignificant from a compensation point of view.

An SC&A site visit was performed during the preparation of the original site profile review in order to supplement the information provided in the Site Research Database (SRDB). At that time, it was clear that there was a need for additional data capture activities, including worker interviews, in order to complete our investigations. These additional data capture activities were performed and establish the bases for this revision. However, there is a need for even further data capture for two reasons:

(1) One interviewee stated there were former employees that held the same troubled concerns that KCP operations resulted in health impacts that should be more thoroughly investigated and that these workers did not have the opportunity to tell their story.

(2) At the completion of certain campaigns, areas and departments were demobilized, converted to other uses, and records expunged. A site map of building activities and how they changed over time would be important for dose reconstruction and interpretation of records and interviewee explanations.

1.0 INTRODUCTION

On January 1, 2006, the National Institute for Occupational Safety and Health (NIOSH) issued ORAUT-TKBS-0031, *Site Profile for the Kansas City Plant* (ORAUT 2006), which provides data and guidance for dose reconstruction of workers at the Kansas City Plant (KCP) located in Kansas City, Missouri. This report presents a review of the site profile, as requested by the Advisory Board on Radiation and Worker Health (the Board) during the full board meeting held in Manhattan Beach, California, in February 2010.

1.1 SCOPE OF THE REVIEW

SC&A reviewed the KCP Site Profile for the following attributes, in accordance with SC&A's Board-approved *Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004):

- Objective 1: Completeness of Data Sources
- Objective 2: Technical Accuracy
- Objective 3: Adequacy of Data
- Objective 4: Consistency among Site Profiles
- Objective 5: Regulatory Compliance and Quality Assurance

SC&A's draft report and preliminary findings will subsequently undergo a multi-step resolution process. Resolution includes a transparent review and discussion of draft findings with members of the Advisory Board Work Group, petitioners, claimants, and interested members of the public. Prior to and during the resolution process, the draft report is reviewed by the U.S. Department of Energy (DOE), Office of Health, Safety, and Security, to confirm that no classified information has been incorporated into the report.

The NIOSH KCP site profile contained information and references that led to the discovery of additional information that was not addressed in the site profile. SC&A's review efforts included a data capture plan and a keyword data search of DOE records. Analysis of the search results identified approximately 50 boxes of unclassified site records of potential interest at the National Archives and Records Administration (NARA) Federal Records Center (FRC) in Lenexa, Kansas, and approximately 70 additional boxes of indeterminate classification status at the KCP National Nuclear Security Administration (NNSA) site. A scanning level review of the unclassified records revealed a significant number of dose reconstruction-related records that were subsequently added to the SRDB. Subsequent to the original site profile review, SC&A and the Work Group reviewed the remaining boxes at the site. A number of former workers from the Bannister Complex (including NNSA and non-NNSA workers) were interviewed. The onsite interviews of NNSA workers were completed after the original site profile review was issued. This revision to SC&A's original site profile review reflects the new information obtained from additional data captures, records reviews, and worker interviews.

1.2 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:

- Preface
- Executive Summary
- Introduction
- Background Information
- Occupational Medical Dose
- Occupational Environmental Dose
- Internal Dose
- External Dose during Operations
- Attachment 1: Site Expert Interview Summary

2.0 BACKGROUND INFORMATION

2.1 SUMMARY OF THE HISTORY OF KANSAS CITY PLANT (KCP) OPERATIONS

As described in Section 2 of the site profile, the KCP has its origins as a World War II facility to assemble engines for navy planes, and continues to operate today in the fabrication of non-nuclear components for the nuclear weapons programs. Many aspects of KCP's testing and manufacturing programs in support of the fabrication of weapons involved the use of uranium, radiation sources, and x-ray facilities, and the plant has maintained a formal radiation protection program since 1958. Tables 2, 3, and 4 of the site profile present categories of KCP activities and descriptions of radiation sources and electronic devices that could have resulted in internal and external exposures. These activities involve handling of uranium oxide powders, industrial x-ray units, x-ray devices for the measurement of the density and thickness of components, neutron generators and neutron sources, Cs-137 and Co-60 for radiography and testing of components, and beta-emitting sources for gauges. Other types of electronic equipment, such as electron beam welders, also had the potential to cause external exposures to x-rays. Our more recent data capture efforts and site visits uncovered information indicating other potential sources of exposures, such as magnesium-thorium alloy, Th-230, and metal tritides, which are addressed in this revision of our review of the site profile

2.2 DESCRIPTION OF KCP'S RADIATION PROTECTION PROGRAM

Sections 2.5 and 2.6 of the site profile describe the radiation protection program at KCP. This program was first described in 1964, although it began operations 20 years earlier. Table 5 presents a listing of radiation detection equipment, and Section 2.6 summarizes the radiological records maintained for about 4,400 workers. The following summary of the records was extracted directly from page 13 of the site profile.

- *Positive deep, shallow, and extremity doses were first recorded in 1950.*
- *Positive neutron doses were first recorded in 1966.*
- *Before about 1959, the recorded deep and shallow doses were essentially equal.*
- *Recorded extremity dose was higher in 1951 and 1952 than in any other year.*
- *Relatively high shallow dose (in comparison with deep dose) was recorded from 1959 to 1964 and during 1973.*
- *Recorded neutron dose is typically equal to recorded deep dose and to recorded shallow dose. The shallow dose is typically equal to the deep dose.*
- *There are comparatively few records with positive neutron dose.*
- *The only years with recorded positive uranium bioassay results are 1959 to 1971.*

3.0 OCCUPATIONAL MEDICAL DOSE

Section 3.0 of the site profile describes the occupational medical exposures experienced by workers, which apparently has a long history beginning with routine chest x-rays in 1949. Detailed instructions are provided for reconstructing occupational medical exposures, drawing heavily from ORAUT-OTIB-0006 (ORAUT 2005) and making use of historical records that provide the type of frequency of medical x-ray examinations for different categories of workers. SC&A has previously reviewed OTIB-0006, and we have no comments on this section of the site profile.

4.0 OCCUPATIONAL ENVIRONMENTAL DOSE

Section 4 and Appendix A of the site profile address the reconstruction of occupational environmental dose. In order to place an upper bound on potential occupational environmental exposures experienced by unmonitored workers, the site profile uses the simplifying assumption that the average annual airborne concentration of uranium outdoors is equal to 1% of the median indoor concentration, as provided in Table 11 of the TBD (i.e., 5.49E-13 $\mu g/cm^3$). As described in Attachment A to the TBD, this rule of thumb is a screening methodology recommended in NCRP Report No. 123, *Screening Models for Releases of Radionuclides to Atmosphere, Surface water, and Ground* (NCRP 1996). SC&A agrees with this basic strategy for bounding the average annual outdoor airborne concentrations of uranium and their associated doses.

Attachment A of the site profile also addresses the airborne concentration of depleted uranium (DU) that might have been experienced by workers on the roof working near the airborne effluent release point. The site profile concludes that the 1% rule of thumb also works for these workers. When one considers building wake effects, along with the fact that such workers would not have been involved in maintenance work close to the effluent release point for extended periods of time, and the fact that the wind direction varies, it seems unlikely that even these workers would experience protracted exposures in excess of 0.01 of the indoor airborne concentrations of uranium.

Based on the above discussion, we concur with the approach used in the site profile to derive occupational environmental doses.

5.0 INTERNAL DOSE

This section presents a brief description of the material provided in the site profile with respect to the type of operations that took place at KCP and the type of data that are available for reconstructing internal exposures at the facility. This is followed by a description of the instructions provided in the site profile for reconstructing internal exposures, and a critical review of those instructions and the data upon which they are based.

5.1 INTRODUCTION AND OVERVIEW

Section 5.0 of the site profile describes the data available and the methods for performing internal dose reconstructions at KCP. As described in Section 5, from 1958 through about 1971, the primary source of internal exposure was machining items containing DU oxide. The site profile also explains that, after 1971, operations changed and the potential for internal exposure to uranium became minimal because the process did not result in airborne uranium. In addition, the site profile explains that the potential for internal exposure to other sources of radionuclides is also considered minimal because the other sources, such as Cs-137 and Co-60, were sealed.

5.2 URANIUM

Uranium oxide (UO_2) was ordered by KCP in 10,000-lb lots and had the mass and radiological characteristics described in Table 9 of the site profile. One of the more important parameters describing the uranium is that the powder used to make the uranium had an activity median aerodynamic diameter (AMAD) of 1.175 microns and a geometric standard deviation (GSD) of 2.48. However, the site profile explains that there is uncertainty regarding the particle size distribution of the aerosols of uranium produced during machining.

Table 10 of the site profile provides information on the gross alpha contamination levels on surfaces in various locations at the KCP, as measured from 1962 to 1969. Both average and maximum contamination levels are presented in units of dpm/100 cm^2; presumably the values refer to removable contamination. Table 11 of the site profile presents statistical data characterizing the airborne DU concentration in units of $\mu Ci/m^3$ from 1958 through 1970. These data are all useful for the purpose of deriving internal doses from uranium.

Most importantly, the site profile indicates that there are bioassay records for individual workers written on cards, but the site profile states that these are nearly illegible. The implications are that it might not be possible to reconstruct uranium intakes for individual workers based on their personal bioassay records. However, electronic data in the form of statistical summaries of the individual records are available in the Site Research Database (SRDB), which can be used to build a coworker model. The following describes the coworker model developed in the site profile to support dose reconstruction for workers that were not monitored or whose records are illegible.

Section 5.1.3 of the site profile presents statistical data in electronic bioassay records characterizing the concentrations of uranium in urine samples collected from workers from 1959 through 1971 expressed in units of $\mu g/L$, and the associated derived inhalation rates expressed in units of pCi/day. The site profile explains that NIOSH assumed that the minimum detectable level (MDL) was 10 μg/L, which is presumably used to derive missed dose. The site profile also explains that the frequency of bioassay sampling varied for different individuals and time periods. These data are provided in Table 12 of the site profile, which is reproduced here as Table 1 because of its importance to dose reconstruction.

Table 1: Statistical Parameters of Recorded DU in Urine[a]

Year	Recorded Annual Urine Concentration[b]			Lognormal Fit		Chronic Intakes (pCi/d)[c]		
	No. of Workers Reported	Concentration (μg/L)		Concentration (μg/L)				
		Mean	Maximum	Median	GSD	5th	Median	95th
1959	214	4.125	52.60	2.642	2.675	1.05E+02	6.42E+02	3.92E+03
1960	281	36.58	140.	19.53	3.813	7.79E+02	4.75E+03	2.89E+04
1961	123	51.40	192.1	37.44	2.402	1.49E+03	9.10E+03	5.55E+04
1962	148	4.327	15.75	3.162	2.508	1.26E+02	7.69E+02	4.69E+03
1963	211	10.96	72.00	7.564	2.532	3.02E+02	1.84E+03	1.12E+04
1964	219	5.627	78.38	3.888	2.431	1.55E+02	9.46E+02	5.76E+03
1965	175	9.572	38.00	5.583	3.422	2.23E+02	1.36E+03	8.27E+03
1966	223	6.432	45.05	4.214	2.640	1.68E+02	1.02E+03	6.24E+03
1967	159	5.438	21.50	3.574	2.713	1.43E+02	8.69E+02	5.30E+03
1968	11	6.055	6.600	6.052	1.029	2.42E+02	1.47E+03	8.97E+03
1969	[redacted]	0.15	0.150	0.150	1.000	5.99E+00	3.65E+01	2.22E+02
1970	59	11.64	45.00	7.576	2.686	3.02E+02	1.84E+03	1.12E+04
1971	47	0.03596	0.1000	0.02993	1.903	1.19E+00	7.28E+00	4.44E+01
ALL	[redacted]	14.1	192.1	5.5	4.7			

a. All bioassay measurements.

b. The recorded annual sum of urine concentration is the sum of all bioassay results for the year. There is one sum for each person-year record. The listed statistics are based on the analysis of the data, which are the sums of all bioassay data for every person for that year.

c. Chronic intakes that produce the urinary excretion per day on the 365th day of intakes corresponding to the median excretion from the lognormal fit, and 5th and 95th percentile intakes using a GSD of 3. Assumes 5-micron (μm) AMAD particle size; intakes for 1-μm AMAD particle size, 10.97 g/cm^3 density, and absorption Type S are smaller.

Source: ORAUT-TKBS-0031, Table 12 (ORAUT 2006)

The footnotes provide important information. Specifically, footnote b indicates that the tabulated concentrations are based on the sums of all bioassay results for a given year. Presumably this means that in 1959, there were 214 workers with reported bioassay samples and, if you added up the uranium concentrations observed in urine samples for each worker and divided by the number of samples collected in that year for that worker, you would get the average annual uranium concentrations in the urine of 214 workers for 1959. Then you would simply report the maximum, average, median, and GSD of this population of 214 values. Using these values, chronic intake rates are derived by estimating the chronic intake rate that would give you the indicated concentration of uranium in urine on the last day of that year.

Footnote b and the accompanying text state that the intake rates were based on an assumed 5-micron AMAD and Type S uranium, because these assumptions result in higher intake rates than if 1-micron AMAD or other than Type S is assumed when calculating intake rates based on measured uranium concentrations in urine. We agree with this strategy. However, as discussed below, we have some concerns regarding the assumption that the intakes were chronic.

Table 13 of the site profile provides the number of bioassay measurements and the total and average uranium concentrations in urine sorted by occupational description over the years 1959 to 1971. If a dose reconstruction is being performed for a worker with a known job category, this table could help in assigning intakes to unmonitored workers or for workers whose bioassay records are illegible.

Given this information, Section 5.1.4 of the site profile provides guidance on deriving internal doses to uranium using the above-described tables. The site profile instructs the dose reconstructor to try to assign each worker undergoing dose reconstruction to one of the following four categories (ORAUT 2006, p. 22):

> *(1) workers routinely exposed to airborne or loose material, (2) workers occasionally exposed, (3) workers rarely exposed or exposed only to very low workplace airborne or contamination levels, and (4) workers with little or no potential for radiological exposure. Unmonitored workers in category 1 should be assigned the 95th percentile intakes; category 2 to the median intakes; category 3 to the 5th percentile intakes; and category 4 workers should be assigned internal exposures per the environmental section of this document.*

Given the above description of the coworker model, which apparently is intended to be used for most, if not all, workers due to the illegibility of the individual worker records, the following presents SC&A's review of the coworker model and the data upon which it is based.

5.2.1 Powder Activity Median Aerodynamic Diameter

The KCP had substantial quantities (10,000-lb lots) of UO_2 onsite at various times. Machining and grinding of DU metal creates fine dust available for intake by workers, and NIOSH states that (ORAUT 2006, p. 18):

> *In fitting bioassay data, dose reconstructors may wish to start with a 1-µm AMAD, a GSD of 2.5, a density of 10.97 g/cm^3, a lung solubility Type S, and f1 of 0.002 (ICRP 1995). However, it is not known what impact processes at KCP had on the particle size of uranium. Use of the* ***default 5-µm AMAD*** *particle size is also acceptable unless it is known that the intake was of unaltered UO_2 powder.* (Emphasis added.)

SC&A evaluated internal doses associated with inhaling uranium and determined that, since the Atomic Weapons Employer (AWE) activities at KCP involved handling substantial quantities of UO_2 powder, it does not appear to be appropriate to use the default option of 5-µm AMAD. Detailed information regarding processes, chemical forms, and handling conditions has not been available for evaluation. Since program(s) utilizing UO_2 powder were most likely classified, and workers in general were strongly discouraged from discussing work activities, it is likely that claimants (particularly survivors) would not be aware of an energy employee's exposure to powdered material. Without specific information regarding the chemical form and particle size distribution experienced by a worker, dose reconstructors should use combinations of 1- and

5-µm AMAD and Types M and S uranium, and use those assumptions that result in the highest dose to the organ of concern.

During review of records located at KCP and worker interviews, SC&A determined that the UO_2 powder procured by KCP was to be "…made by high firing U_3O_8 at 1800°C…" (Ulitchny et al. no date, PDF [Portable Document Format] p. 5). The site profile does not clearly indicate that NIOSH is taking into account high-fired uranium in its assumptions regarding solubilities and in reconstructing dose from uranium intakes at KCP. SC&A recommends modification of the site profile to include adequate information on this matter.

Finding 1: Without specific information regarding the chemical form and particle size distribution of uranium exposure experienced by a worker, dose reconstructors should use default assumptions regarding particle size and chemical form of uranium that result in the highest dose to the organ of concern.

Finding 2: It appears that high-fired UO_2 was handled at KCP and this subject needs to be explicitly addressed in the site profile.

5.2.2 Annual Sum of Bioassay Measurements

The KCP has developed and maintained a radiological records database that contains records for all monitored worker exposures at KCP for all years of record. According to NIOSH (ORAUT 2006), the database contains exposure data for about 4,400 workers. Page 19 of the site profile states the following:

> *The available data are shown on an annual basis and might be the sum of one or more bioassay measurements. If the individual case information does not yield additional information, dose reconstructors should make the claimant favorable assumption that the recorded bioassay quantities represent a single bioassay measurement taken at the end of the calendar year.*

SC&A reviewed the files of 528 claimants (see Table 2), and 50 of these workers had uranium results. Table 2 presents the results of that review. In each year, the reviewers noted some unreadable results, but the majority of the results, with the exception of 1970, were legible. The site profile leaves the reader with the impression that it is not plausible to perform dose reconstructions using the workers' bioassay data, but instead appears to recommend the use of the claimant-favorable assumption described above. SC&A found that it is possible to reconstruct the internal uranium exposures of many claimants using the workers' bioassay results. We suggest that the site profile make it clear that the workers' bioassay records should be used when available as opposed to the coworker model.

Observation: The site profile should state that the coworker model should be used when it is not possible to use the workers' bioassay records, presumably because they are illegible, incomplete, or lacking.

Table 2: Claimant File Review of Uranium Bioassay

Year	No. of Workers	Range of Annual Average Worker Excretion Rates (µg/L)	Max Individual Excretion Rate (µg/L)	Total No. Samples
1959	[redacted]	0–3.9	3.9	32
1960	11	0–10	72	28
1961	[redacted]	0–20	70	8
1962	[redacted]	0–1.5	4.3	5
1963	[redacted]	Not reported	16.5	11
1964	[redacted]	Not reported	5.3	12
1965	11	Not reported	16.5	16
1966	14	Not reported	13	21
1967	11	Not reported	20	16
1968	[redacted]	0	6	5
1969	[redacted]	0	0.6	7
1970	10	0–14	25	10
1971	[redacted]	0	0	3

Notes: Frequency of monitoring not related to results.
Frequency did not increase after high result.

5.2.3 Bioassay Coworker Model

Table 12 of the site profile (p. 20), which summarizes the electronic bioassay records, shows [redacted] with [redacted]. In contrast, SC&A's review of the records upon which Table 12 is based (refer to Table 2 above) reveals that [redacted] workers among the claimant group had bioassay records in 1969. Consequently, Table 12 appears to be incomplete, which raises questions regarding the use of the data in Table 12 as the basis for a coworker model. During the December 2012 site visit, SC&A and the Work Group identified records added to the SRDB that contain bioassay data specifically addressing uranium. These additional data should be reflected in the coworker model for dose reconstruction.

Finding 3: The bioassay data summarized in Table 12 of the site profile appear to be incomplete, which raises concerns regarding its use in developing a coworker model.

5.2.4 Chronic Uranium Intake

For the purpose of reconstructing internal exposures using the coworker model, the site profile presumes that intakes of uranium dust are chronic. The derivation of chronic intake rates based on the sums of individual results in a year may result in a less-than-favorable dose reconstruction for some workers. Our analysis of the claimant data has shown that some workers have high results in 1 month, followed by very low results in the following sampling period. For example, one worker had [redacted], on the order of [redacted]. The worker's results were below the MDL in 1960, [redacted] in January, below the MDL in February, [redacted] in May, and [redacted] in July and December. This pattern of excretion rate results is not characteristic of chronic intakes, and averaging concentrations in urine to obtain an average annual chronic intake rate would result in an underestimate of internal exposures.

The pattern of high results was not uniform among workers. In 1960, another worker presented the following excretion rate results: 0 in January, 14 µg/L in February, 10 µg/L in April, and 42 µg/L in December. This same worker in 1961 presented 20 µg/L in June and 70 µg/L in December. A third worker in 1961 had a result equal to 0 in August and a result equal to 20 µg/L in December.

In addition, Nasca (2005a) includes the following uranium bioassay results for an individual worker in 1960: 0 in January, 29 µg/L in February, 0 in April, 39 µg/L in May, and 66 µg/L in December. In the same document, a worker presented the following results in 1960: 35 µg/L in January; 0 in February, April and May; followed by 20 µg/L in September; and 0 in December. Those results are not characteristic of chronic intakes.

Finding 4: SC&A believes that the default chronic pattern of intake used in the uranium coworker model, which apparently is being applied to all workers, may not apply to many workers. Our review of actual cases reveals that many workers have legible bioassay records and show patterns of excretion rates that indicate that the coworker model may not be claimant favorable for all workers.

In addition to issues related to Table 12 of the site profile, we also have concerns regarding the way in which the site profile categorizes unmonitored workers for the purpose of implementing the coworker model. On page 22 of the NIOSH site profile, workers are grouped into the following four exposure categories: (1) workers routinely exposed to airborne or loose material, (2) workers occasionally exposed, (3) workers rarely exposed or exposed only to very low workplace airborne or contamination levels, and (4) workers with little or no potential for radiological exposure.

SC&A is concerned that the use of Table 13 of the site profile and this system to categorize workers might lead to less than claimant-favorable dose reconstructions. For example, our review of the SRDB revealed that administrative support/clerical/work planner Occupational Code Category 450 has a relatively high average bioassay measurement. In e-mail correspondence with Richard Traub (Battelle) regarding KCP Occupational Codes, Nasca explained that Category 450 includes not only secretaries with no expected exposures, but also work planners who are expected to show uranium uptakes (Nasca 2005b). Thus, workers with a high potential of exposures are classified in the same code as workers not expected to have any exposures to uranium.

Finding 5: The system used to categorize workers by administrative code for the purpose of implementing the coworker model might result in misassignments that result in underestimates of reconstructed doses.

5.2.5 Early Uranium Work

The NIOSH site profile states that uranium work started in 1958. However, the dates provided in Section 5.0 are primarily attributed to correspondence with a radiation safety staff member. An SC&A site expert interview indicates this individual was hired in 1989, and the correspondence cited in the site profile (Nasca 2005a) indicates that the staff member had limited data available regarding early uranium operations. Evidence from retrieved site documents suggests that uranium work started much earlier. For example:

- *History of Production Machining of Uranium*, written in 1952, includes a survey of uranium machining work in various areas (Mahaffey 1952). Starting on PDF page 17, a section titled "Slug machining in the Kansas City Area" states that KCP machined slugs for SRS and for Argonne Critical Experiment CP-6, which is indicative of earlier uranium work. Pages 57 and 58 of this file show a diagram of the uranium slug produced for the Argonne Critical Experiment.
- Production reports for Atomic Energy Commission (AEC) New York Operations Office (NYOO) Tonawanda Area from November 1951 refer to eight "scalped" uranium billets shipped from "Bendix Aviation Company" to Simonds Saw and Steel in October 1951 (NYOO 1951; Malone 1951a), 51 tons of "turned ingots" shipped to Simonds in November 1951 (NYOO 1951), two carloads of Bendix billets en route to Allegheny-Ludlum steel in January 1952 (NYOO 1952a), approximately 10 tons of DuPont rods scheduled for shipment to Kansas City in January 1952 (Malone 1952), and 355 ingots sent from Bendix to Lake Ontario Ordnance Works in April 1952 (NYOO 1952b).
- Correspondence from the Tonawanda Sub-Office in June 1951 states over 100 tons of uranium rods were to be held for shipment to KCP (Malone 1951b). Documentation of a 363-slug canning run at Argonne National Laboratory states, "the majority of the uranium slugs were turret lathed at Kansas City. . . " (Laing 1952, PDF p. 2).

This early uranium work raises two questions:

Question (1): How will reconstruction of routine uranium exposures during the early years be performed?

This remains an open question since the amount of work completed, the dates, and the similarities and differences between working conditions (e.g., work place ventilation) before 1959 and those after that date have not yet been established.

Finding 6: The site profile should address the degree to which uranium exposures may have occurred pre-1959 (i.e., prior to the date bioassay data are available) and the method used to reconstruct the doses.

Question (2): Is there a possibility of incidents such as uranium fires during that time period that needs to be addressed as a source of internal exposures during the early years before the availability of bioassay data?

With respect to Question 2, the machining of uranium at various sites during the early years was often associated with fires due to the pyrophoric nature of uranium metal. SC&A did not identify reported incidents of uranium fires in its initial review. However, one interviewee described involvement in follow-up after a fire in a radioactive machining area. SC&A suggests that NIOSH take advantage of recent work performed under the direction of TBD-6000 Work

Group, which addresses this specific issue. No treatment of this likelihood is presented in the site profile.

Finding 7: The Site Profile should address issues associated with inhalation exposures during uranium fires in both the pre- and post-1958 periods. The nature and number of incidents in these periods have not yet been established.

SC&A noted above that site expert correspondence is cited as a primary source of information regarding the start date of uranium handling. The site profile also references this correspondence (Nasca 2005a) in stating that the DU oxide project ended in 1972, there is no removable contamination with the process used to shape uranium metal since 1997, and intakes of DU after 1972 are not likely. SC&A notes that the site expert does not specifically identify start and end dates for the DU oxide work in this letter, nor does he mention the post-1997 process in this particular correspondence. SC&A also noted that the document describing product specifications for uranium dioxide (Ulitchny et al. 1998) was revised in 1997 and 1998; it is not clear why the product requirements would be updated in the late 1990s if the program that used DU oxide was discontinued in 1972. In any case, it would be desirable to substantiate the conclusions of the cited correspondence with documentation affirming DU oxide program start and end dates, the absence of uranium handling from 1972–1996, and the process and exposure potential (or lack thereof) for post-1996 uranium work.

SC&A is also aware of the potential for even DU to include recycled uranium once Hanford established its recycling program in the early 1950s. A cursory search of available documents did not reveal explicit mention of KCP as a recipient, but the potential for trace contaminants may exist.

Finding 8: The nature and extent of work with depleted uranium during and after 1997 as well as any intakes that may have resulted remain to be established.

5.3 OTHER RADIONUCLIDES

Section 5.2 of the site profile addresses internal exposures other than uranium, explaining that there were no significant worker intakes other than uranium. SC&A originally concurred with this position. However, subsequent data captures uncovered information indicating that workers might have been exposed to other radionuclides, including thorium, metal tritides, and magnesium-thorium alloy, all of which have the potential to cause internal exposures.

Records uncovered by SC&A contain correspondence regarding multiple liquid radwaste shipments from KCP to Los Alamos. This includes evidence of liquid radwaste spills, radiation levels, and clean-up costs at KCP and Los Alamos are described. According to a Los Alamos summary (LASL 1962), KCP shipped 585 drums, containing approximately 3,386 cubic feet of low-level waste for disposal during the first 6 months of 1962. Bendix Industrial Hygiene staff characterized the waste as “solids and water-soluble cutting oil” and “contaminated cutting oil” (Schiltz 1962), which may be consistent with “wet” machining of Mg-Th alloy (Bendix 1975) or other radioactive materials. Some correspondence (Clayton 1962; Schiltz 1962) describes vented containers that spilled during transit and/or unloading, which may not have significant implications for KCP workers. Other concerns noted by Los Alamos include barrels that were rusted and leaking from the bottom (Reichman 1962a; Reichman 1962b), which may imply potential exposures to KCP personnel.

The interview summary (Attachment 1) contains a mention of thallium liquid waste. The site profile only lists thallium as "beta scope, thickness gauges" (ORAUT 2006, Table 3, p. 11). The issue of thallium liquid waste also appears to warrant further investigation. Thallium metal dissolved in mercury was included in waste shipments circa early1970's to LASL (Porrovecchio 2013). SC&A notes that the SRDB shows no documents for the search term "thallium" or "Tl-204" or "^{204}Tl". However, site records not in the SRDB may contain such information.

Finding 9: Further evaluation is warranted in regard to the processes and isotopes contributing to liquid radioactive waste shipments from KCP, the time period during which these activities and shipments occurred, and the potential for unmonitored internal exposures from spills, leaks, cleanup, and routine handling/storage of contaminated drums. An investigation into whether thallium liquid waste was present is also needed.

SC&A reviewed several classified documents describing the origin and shipment of radioactive scrap, the handling of radioactive material, and operational accounts. Notes from this review are available on the SRDB (Porrovecchio 2013).

5.3.1 Magnesium-thorium Alloy

Records uncovered by SC&A include a compilation of multiple sub-documents on the topic of magnesium-thorium operations at KCP. Internal correspondence identifies the Mg-Th alloy program as RADEC (McKay 1970). Operations included "drilling, grinding, filing, sanding, buffing, welding, pickling, and chemical milling" (Bendix 1963). This program is not mentioned in the NIOSH site profile (ORAUT 2006). A memo written by C.S. Triplett of Health and Safety (Triplett 1970) states that the thorium-232 levels "approached" the permissible limit of 9×10^{-11} μCI/cc (with no health and safety concerns); however, the daily committed bone surface dose from this level of air concentration (assuming Type M) would be about 7 rem (assuming an inhalation rate of 1.2 m^3/hour and 8 hours per day). Accordingly, this program appears to have been a significant source of internal exposure and needs to be addressed in the site profile. Further evidence indicates machining of Th-Mg alloy seems to have been a long-term activity at KCP:

- McKay (1970) notes that over 200 hours of machining and sheet metal process work had been approved for the current fabrication request (September 1970).
- Health and Safety Guides issued and revised indicate operations with Mg-Th occurred in the 1960s and 1970s (Bendix 1963; Bendix 1970; Bendix 1975). These documents indicate machining operations in the Model Shop, Tool Room, and Department 851. Both solid and liquid wastes were generated.
- Documentation reflects consideration of health and fire hazards as far back as 1961 (Stewart 1961).

- SC&A notes from classified documents (Porrovecchio 2013) include the following observations: machining of polyurethane foam containing an alloy of metals was described in a document dated March 1972. A source document dated May 1974 indicates disposal of Mg-Th radioactive scrap—approximately 46 barrels (55-gal size) accumulated over time. The scrap material was accounted for as normal operation losses and shipped to LASL for disposal. A document dated June 1965 indicates that polyurethane foam machining occurred in D/22, D/217-22 and D25 areas.

It is clear Mg-Th alloy handling was a long-term activity at KCP and may have presented a chronic exposure potential to workers. SC&A was not able to confirm beginning and ending dates for these activities, but dates should be addressed in the site profile, along with an approach for dose reconstruction.

Finding 10: The site profile needs to address internal exposures to Mg-Th alloy.

5.3.2 Thorium-230 Exposures

Facilities Radioisotopes Data compiled by DOE Albuquerque Operations Office notes that 12 curies of thorium-230 were present at KCP in solid waste form (DOE-AL 1990). The document indicates the inventory data are from the 1980s; it does not indicate for what purpose, or during what period, Th-230 was used at KCP. Additional evidence (Porrovecchio 2013) indicates thorium-230 being used at KCP in documentation of normal operational losses and its transfer to LASL for burial in 55-gal drums as radioactive scrap (accumulated in approximately 46 barrels) through 1974.

Finding 11: The site profile needs to address the potential internal exposure to thorium-230 at the KCP site.

5.3.3 Metal Tritides

The Department of Energy (DOE) and its predecessor agencies have undertaken missions involving work with hazardous and/or exotic materials and agents, and byproducts of their production, storage, and use. Included in these exotic materials are metal tritides (MTs) and organically bound tritium (OBT), referred to collectively as special tritium compounds (STCs) (DOE 2004). KCP is not typically identified as a site involved in handling STCs, but KCP workers may have had contact with STCs as a byproduct of the work they conducted on components received from other facilities. One example of processes where STCs may create a potential for exposure include tritium targets for neutron generators (DOE 2004). There are any number of locations where these materials may be encountered, such as gloveboxes, fume hoods, ventilation systems, weapons components, and fuel storage basins (DOE 1997). STCs are categorized by physical form (e.g., liquid/vapor, particulate, or large solid form) and by solubility (e.g., insoluble, partially soluble, soluble). At some facilities, they refer to metal tritides as stable or unstable, which is a measure of how easily the tritium is released from the metal in air or aqueous material. Insoluble metal tritides (i.e., stable metal tritides) include hafnium, titanium, europium, and zirconium tritide. Soluble forms of MTs include uranium, lithium, and palladium tritide (DOE 1994; DOE 2004).

Krueger and Meunier (1987) investigated an employee concern regarding potential exposure to erbium tritide from particulate contamination of a data analyzer unit. This unit had been used in tests and returned to KCP. Tritium contamination was deposited in and on the unit, which was "cleaned" prior to shipment to KCP, but its interior not decontaminated, as was the practice. Bioassay resulted in no significant exposure, and the unit was returned to Sandia for cleaning.

The NIOSH site profile mentions 14.7 MeV neutron generators (Table 4). These were likely transferred from Pinellas, and were referred to as "controlatrons." According to Lutz (1995), Pinellas sent 52 controlatrons to KCP from 1980 to 1990 and 1 from 1991 to 1995. A Material Safety Data Sheet (MSDS), with reference to Pinellas but not to KCP, states the neutron generator contains a small quantity of erbium tritide in a vacuum tube. The MSDS also states there would be no exposure potential unless the tube was broken and the temperature was in excess of 500°C (GE 1976).

Finding 12: The site profile needs to discuss the degree to which metal tritides were present and how doses would be reconstructed to account for this potential source of exposure, with particular attention to any incidents that may have occurred.

6.0 EXTERNAL DOSE DURING OPERATIONS

This section presents a brief description of the material provided in the site profile with respect to the type of operations that took place at KCP and the type of data that are available for reconstructing occupational external exposures at the facility. This is followed by a description of the instructions provided in the site profile for reconstructing external exposures, and a critical review of those instructions and the data upon which they are based.

6.1 BACKGROUND

Section 6.0 of the site profile, which addresses external radiation exposures at KCP, explains that the sources of external exposure at KCP were primarily associated with fabrication and quality control testing of non-nuclear weapons components, and that clear descriptions of those activities are not readily available due to their classified nature. However, Table 3 of the site profile lists the external radiation sources at KCP, and Table 4 lists the radiation-generating devices (RGDs), which consisted of beta, gamma, x-ray, and neutron emitting/generating sources. Section 6.3 of the site profile describes the dosimeter technology that was used to record worker exposure to photon, beta, and neutron exposures associated with the variety of sources, and RGDs used at KCP over the years. This section reviews the data, models, and assumptions used in the site profile to reconstruct external exposures to KCP workers.

As explained in the site profile, because of its long history, a variety of personnel dosimetry devices were employed over the years, and an effort was made in the site profile to compare these different methods, so that dose reconstructions for different time periods can be performed in terms of a common metric, namely Hp(10) for penetrating dose and Hp(0.07) for non-penetrating dose.

Section 6.4 presents the methods recommended in the site profile to perform external dose reconstruction. Section 6.4.1 explains that external dosimetry exists for most workers, but some workers were not monitored. The site profile takes the position that workers who were not monitored experienced exposures that generally were lower than those experienced by monitored workers. This might be true in general, but it might not apply to all workers. Figure 2 of the site profile presents a statistical analysis of the annual penetrating dose experienced by all workers as compiled by NIOSH for 1950 through 2003. Also, Table 15 of the site profile presents a statistical analysis of the exposures for each year from 1950 through 1990. Because of its importance, Table 15 is reproduced here as Table 3:

Table 3: Statistical Parameters of Recorded Penetrating Annual Doses

Year	Arithmetic, All Recorded Dose			Lognormal, dose>0			
	No. of Workers	Dose, rem		No. of Workers	Dose, rem		GSD
		Mean	Maximum		Median	95%	
1950	46	7.09E-02	6.47E-01	29	5.01E-02	5.54E-01	4.31E+00
1951	227	2.78E-01	5.32E+00	158	4.97E-02	2.02E+00	9.52E+00
1952	233	1.91E-01	5.90E+00	220	2.45E-02	7.42E-01	7.96E+00
1953	103	1.37E-01	5.32E+00	72	2.13E-02	4.50E-01	6.38E+00
1954	65	1.61E-01	2.99E+00	21	1.19E-01	4.74E+00	9.39E+00
1955	41	9.18E-02	4.18E-01	25	1.10E-01	4.59E-01	2.39E+00

Table 3: Statistical Parameters of Recorded Penetrating Annual Doses

Year	Arithmetic, All Recorded Dose			Lognormal, dose>0			
	No. of Workers	Dose, rem		No. of Workers	Dose, rem		GSD
		Mean	Maximum		Median	95%	
1956	26	2.89E-01	1.75E+00	26	1.35E-01	1.07E+00	3.52E+00
1957	65	5.24E-01	7.89E+00	36	1.77E-01	6.33E+00	8.80E+00
1958	301	3.90E-02	8.43E-01	89	5.44E-02	4.84E-01	3.78E+00
1959	464	8.97E-03	2.30E-01	72	3.57E-02	1.78E-01	2.66E+00
1960	1,043	1.21E-02	1.35E+00	165	4.53E-02	2.31E-01	2.70E+00
1961	948	2.39E-02	5.90E-01	400	3.17E-02	1.64E-01	2.72E+00
1962	700	1.25E-02	1.65E+00	59	4.25E-02	4.53E-01	4.22E+00
1963	597	1.18E-02	1.63E+00	100	3.65E-02	2.02E-01	2.83E+00
1964	530	6.85E-03	6.90E-01	59	3.09E-02	1.97E-01	3.08E+00
1965	436	1.35E-03	8.00E-02	26	1.66E-02	5.59E-02	2.09E+00
1966	415	2.32E-03	2.00E-01	27	2.54E-02	8.95E-02	2.15E+00
1967	370	1.71E-03	2.50E-01	20	2.06E-02	7.14E-02	2.13E+00
1968	469	1.75E-03	3.50E-01	5	1.10E-01	6.84E-01	3.04E+00
1969	577	(a)	0.00E+00	0			
1970	580	1.60E-03	3.20E-01	29	1.61E-02	7.47E-02	2.54E+00
1971	575	9.39E-04	2.00E-01	16	2.02E-02	9.09E-02	2.50E+00
1972	195	1.19E-02	4.26E-01	68	2.04E-02	8.61E-02	2.40E+00
1973	199	9.86E-02	1.81E+01	69	1.87E-02	1.09E-01	2.91E+00
1974	169	1.30E-02	8.80E-02	67	2.86E-02	6.89E-02	1.71E+00
1975	150	5.72E-03	8.60E-02	44	1.25E-02	5.96E-02	2.58E+00
1976	126	9.65E-03	2.48E-01	53	1.37E-02	7.34E-02	2.77E+00
1977	123	5.45E-03	3.00E-01	12	2.76E-02	1.72E-01	3.04E+00
1978	152	7.53E-03	1.25E-01	18	4.55E-02	2.25E-01	2.64E+00
1979	162	2.69E-03	8.30E-02	17	2.12E-02	5.64E-02	1.81E+00
1980	185	4.19E-03	1.33E-01	22	2.74E-02	8.49E-02	1.99E+00
1981	210	4.12E-03	1.20E-01	24	2.72E-02	9.27E-02	2.11E+00
1982	209	2.00E-03	5.20E-02	22	1.67E-02	3.72E-02	1.63E+00
1983	226	2.98E-03	3.14E-01	12	2.76E-02	2.06E-01	3.39E+00
1984	216	1.89E-02	3.57E+00	18	2.44E-02	2.80E-01	4.41E+00
1985	201	4.67E-02	8.66E+00	49	1.41E-02	8.34E-02	2.95E+00
1986	194	3.22E-03	5.50E-02	27	2.05E-02	4.71E-02	1.66E+00
1987	196	1.65E-03	4.00E-02	20	1.18E-02	4.82E-02	2.35E+00
1988	188	3.52E-03	1.80E-01	11	4.62E-02	1.81E-01	2.29E+00
1989	233	8.03E-04	1.60E-02	17	1.09E-02	1.37E-02	1.15E+00
1990[b]	217	1.16E-03	4.10E-02	17	1.37E-02	2.50E-02	1.44E+00

a. Recommend using values for 1968. All 1969 recorded doses = zero.
b. Recommend using values for 1990 for all subsequent years.
Source: ORAUT-TKBS-0031, Table 15 (ORAUT 2006)

Given these data, the site profile makes the following recommendation:

> *Dose reconstructors should assign the ambient environmental dose to an unmonitored worker with minimal potential for radiation exposure from KCP operations, median coworker dose to an unmonitored worker with minimal likelihood of actual workplace exposure and the 95th percentile coworker dose to workers with a potential for workplace radiation exposure for each year of employment without a recorded dose. There should not, typically, be a significant*

> *neutron exposure of unmonitored workers because sources of neutron radiation were very limited.*

The following presents SC&A's review of the data and the instructions provided in the site profile.

6.1.1 Accuracy/Completeness of Dose Records

Page 13 of the site profile (ORAUT 2006) states that:

> *KCP has developed and maintained a radiological records database that contains records for all monitored worker exposures at KCP for all years of record. The database contains exposure data for about 4,400 workers.*
>
> *Dose reconstructors should use recorded doses from the KCP database to supplement the hard-copy original dosimeter processing information submitted by DOE because the respective claims are often difficult to read.*

SC&A's review of several KCP claimant files on the NIOSH OCAS Claims Tracking System (NOCTS) database indicates that some of the original dose records are indeed difficult to read, if not illegible. Apparently, there are hard copies and an electronic KCP database that contain the dose records for the workers; however, the accuracy and completeness of neither data source was addressed in the site profile. From the hardcopies examined of a limited number of claimant records, it would be difficult to decipher the correct recorded dose, and sometimes the dates, bringing into question the accuracy of the electronic database, if it was populated from the hardcopy records.

SC&A searched the 731 KCP claims on the NOCTS database using occupation descriptions that may indicate potential exposure, such as mechanics/repairers, machinists and engineers contained in Table 13 of the KCP site profile. SC&A scanned 61 of these cases for DOE external dose files and found that 14 cases contained external exposure records. It was found that for most of these 14 cases, the external dose records only had one sheet of data, generally listing dose for only 1, 2, or 3 years (maximum of 7 years). This information is summarized in Figure 1 below.

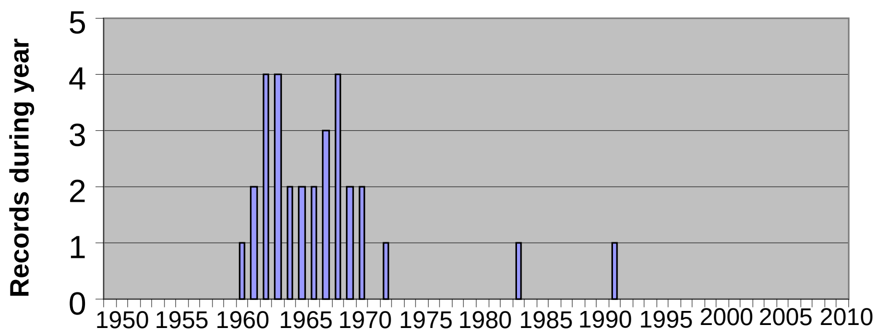

Figure 1: Number of External Exposure Records during a Given Year for 14 Cases with Records

Some workers had the same job title for many years, and the work period covered a wide range from 1951 to the present. It seems highly unlikely that workers (of those analyzed) would be monitored for only a year or two if they were performing the same task for many years. Additionally, as shown in Figure 1, the external dose records of these 14 cases seem to be centered around the mid-1960s, with very few outside that time period.

Finding 13: There appears to be limited information available to the dose reconstructor with respect to the nature of the work performed by the workers. This issue warrants further investigation, along with the investigation of the legibility/accuracy/completeness of the database(s) used for dose reconstruction, in order to assess the ability to reconstruct worker doses, as supplemented with the coworker model. Subsequent to the original site profile review, interviews revealed that worker training records do exist that indicate the qualifications required to work in specific areas and perform tasks specific to potential exposure to radioactivity. These records should be more thoroughly researched in the site profile.

6.1.2 Beta Dose

Page 25 of the site profile indicates that beta dose was measured from 1950–1964. However, prior to 1964, exposure record forms did not have a column to enter beta dose. Table 3 (ORAUT 2006, p. 11) covers 1964–1987 and not the entire period (1958–1972 and 1997) of DU operations, which could involve beta exposure.

The geometry of the worker's body parts with respect to the radiation source was not described. The use of gloveboxes/fume hoods was not mentioned; these fixtures would alter the dose received to the different organs in comparison to the badge worn on the chest. Sufficient details concerning the potential for beta exposure from the various electron-producing and beta-emitting sources, as a function of time and work location, are lacking in the TBD.

Finding 14: It appears that there are large time periods where beta exposure records are lacking, making it difficult to reconstruct beta doses for workers during those time periods and for developing a coworker model that can cover those time periods. In addition, the details of beta exposures are lacking.

6.1.3 Moderated Neutron Dose

The site profile states that neutron generators (D-T producing 14.7 MeV mono-energetic neutrons) and radioisotope neutron sources (PuBe producing an average energy of 4.5 MeV neutrons) were used at the KCP from the 1960s to 2004. These neutron sources are listed in Table 4 of the site profile (ORAUT 2006, p. 12). NTA film and polycarbonate neutron dosimeters can be calibrated to medium-energy neutron sources in the energy range of 1 MeV to 15 MeV. However, in any occupied working area, there will be neutron shielding in the form of moderating (hydrogenous) material between the neutron source and the workers, which degrades the neutron energy and creates gamma radiation from neutron-capture reactions. Some of these moderated neutrons will fall below the ~1 MeV thresholds of the NTA film and polycarbonate.

SC&A considers this a form of missed dose that would not be recorded on the workers' records. If a significant fraction of the dose is less than 1 MeV, a detectible neutron dose will not be recorded, even though an actual neutron dose was received.

This may partly account for the NIOSH statement (ORAUT 2006, p. 27):

> *Overall, the recorded neutron dose is a relatively insignificant component of the worker dose.*

During the onsite data capture activities, SC&A received documentation of phantom exposure studies conducted on an anthropomorphic phantom (Honeywell 2013; Nasca 2013a and 2013b). Continual exposure of the phantom to pulse neutron operations produced total neutron exposures of less than 1 mrem over several months. Workers involved in these particular operations may have been exposed to small neutron doses.

The site profile does not provide any information (as a function of time) concerning the physical setup, shielding, operating parameters (neutron output and usage fraction), and specific use of the generated neutron fields to allow for an evaluation of the potential neutron exposures to the workers. There are no neutron spectrum data for KCP (ORAUT 2006 p, 27). Rather, the site profile simply assumes a spectrum of 0.1 to 2 MeV. While this is claimant favorable for dose, it does not take into account the fact that neutrons below ~1 MeV would not be represented well in the badge readings. Hence an analysis of the workplace shielding and other parameters is needed to develop an adjustment factor for badge readings to take missed neutron dose into account. Additionally, job titles and/or training documentation associated with potential neutron exposures are necessary to evaluate the recorded neutron dose records and to assist the dose reconstructor in assigning neutron doses.

Finding 15: The scarcity of positive neutron doses might be explained, in part, by the limited ability of NTA film to detect neutron energies below ~1 MeV. Additionally, neutron exposures may have been missed during neutron area surveys, because the only neutron survey instrument listed in Table 5 (ORAUT 2006, p. 13) is a Nuclear Chicago Model #2715, and this instrument may not have correctly responded to the pulsed neutron fields with the generator(s) being operated in the microsecond pulse mode, which was typical at KCP, as indicated in Table 4 (ORAUT 2006, p. 12). An analysis of the workplace shielding and other parameters is needed to develop an adjustment factor for badge readings to take missed neutron dose into account.

<u>Neutron Dosimetry Correction Factors</u>

Section 6.3.2 of the site profile describes the personal neutron dosimetry systems employed at the KCP, including techniques and exchange frequencies provided in Table 14 (ORAUT 2006, p. 25). One of our concerns is that quarterly exchange of NTA film can result in complete loss of countable track and yield zero dose recordings for low-level and/or low-energy neutron exposures. This is illustrated in a 1974 article by L. Phillips (Phillips 1974, pdf p. 18), which describes tests run at Brookhaven National Laboratory (BNL) to determine NTA track fading. The results, using a relatively high-energy bare PuBe neutron source, are shown in Figure 2.

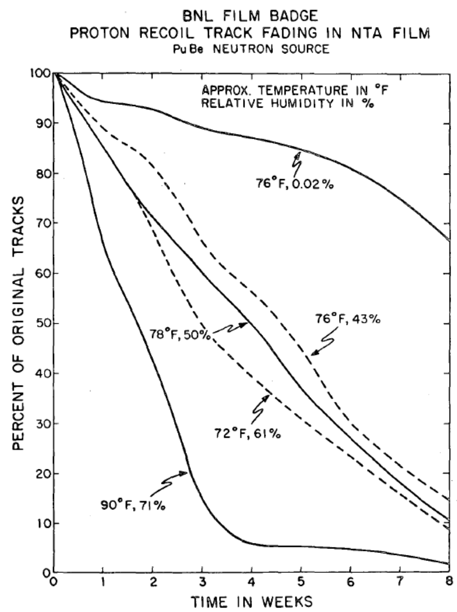

Figure 2: Percent of Original Tracks vs. Time

Finding 16: The fading of the NTA film as a function of time, temperature, and humidity, was not addressed in the site profile, nor were there any correction factors provided. Lower-energy moderated neutrons would show even more fading as compared to the higher-energy neutrons. Additionally, the angular response of NTA film and polycarbonate neutron dosimeters was not addressed, which generally requires a 30% correction factor.

Finding 17: During the data capture, we determined that neutron detection instrumentation was checked and may have been calibrated at KCP using some type of neutron sources. The site profile should investigate this situation further as a potential source of exposure to workers.

6.1.4 Neutron-to-Photon Ratios

Page 27 of the site profile (ORAUT 2006) states the following:

> *KCP worker recorded positive neutron dose was recorded a total of 35 times over a period from 1966 through 1996, with most instances occurring in the 1980s with good dosimetry capabilities, from a total of 14,758 annual dose records. In all cases, except for 2, the recorded annual deep dose is equal to the recorded annual neutron implying all recorded deep dose resulted from the neutron dose. ... As such, the recommended approach is to use a neutron to photon dose ratio of 1:1 as a conservative estimate of neutron dose to the few workers with any potential of neutron exposure.*

In light of concerns regarding the reliability of NTA film with respect to lower-energy neutrons, it is not apparent that there is a sound basis for assigning an n/p ratio of 1:1. In other site profile reviews, SC&A has stated that n/p ratios can be used to derive neutron doses if a reliable set of paired data of neutron and photon measurements are available and employed instruments that can detect the full range of neutron energies. It does not appear that this approach was used to derive the n/p ratio of 1:1.

Finding 18: Neutron-to-Photon (n/p) ratios require additional investigation in order to develop a recommended approach for dose reconstructors.

6.2 COWORKER DATA ISSUES

Page 26 of the site profile (ORAUT 2006) states the following:

> *…it is reasonable to assume that any unmonitored dose would be less than the dose received by monitored workers.*

Figure 2 of the site profile, which presents a lognormal probability plot of KCP recorded annual penetrating dose (ORAUT 2006, p. 27), shows the probability of occurrence versus the annual dose (mrem) for 1950–2003. This plot indicates a median dose of around 20 mrem/year and a 95th percentile of around 70 mrem/year. Table 15 (ORAUT 2006, p. 28) provides a list of coworker doses as a function of year for the period of 1950–1990. There appears to be a reasonable amount of data available for this coworker model. However, it would be useful to obtain a spreadsheet of the data in Table 15 to allow creation of a plot consisting of dose versus year to better visualize trends and abnormalities in the data.

Table 15 also shows that there were 577 workers monitored during 1969, with all zero recorded doses. This appears to be unusual, because the adjacent years had approximately the same number of workers monitored with the median and 95th percentile doses both positive. To use the information in Table 15 as coworker data, the reason for the 1969 abnormality needs to be investigated to determine if there were problems with the dosimetry system (which may have spilled over into other years) or if the lack of recorded positive dose was a result of other influences, such as changes in operations, lost records, etc.

Finding 19: It may not be always correct to assume that unmonitored workers experienced exposures that were generally lower than those experienced by monitored workers, because monitoring in the early years may not have been as thorough as would be desired. In addition, as discussed in previous findings, coworker categories are ambiguous and might result in inappropriate coworker dose assignments. Furthermore, Table 15 may reflect decreased average recorded doses, as the number of zero dose records included may not be a complete accounting of the actual dose to workers. Refer to Finding 11, which may have some applicability to this finding.

6.2.1 Dosimeter Response to Low-Energy Photons

Page 24 of the site profile (ORAUT 2006) states the following:

> *The photon energy spectra in KCP workplaces have not been measured. The spectra are related to the configuration of the X-ray machines, the process, and the extent of shielding. However, regardless of the precise spectra, significant*

> *photon radiation would have been readily measured at KCP by the available dosimeter technology during all years of operation.*

And on p. 28, it is stated:

> *The energy of prevalent photons based on the radiation sources is readily measured, so no adjustment of recorded dose would be likely based on the response characteristics of the different dosimeters.*

However, on p. 25, it is stated:

> *Eberline standard (three-chip, TLD-100) TLD – used from 1983 through 1990. This dosimeter employs one chip under a 10-mg/cm^2 filter to measure the shallow or skin dose and one or two chips under a 285-mg/cm^2 filter to measure the deep or whole-body dose (TMA 1990). The use of this dosimeter was terminated due to its inability to pass DOELAP lower energy photon performance testing categories…*

The dosimeters were apparently calibrated using Co-60 (ORAUT 2006, p. 24), which is a relatively energetic photon source (1.17 and 1.33 MeV). However, numerous x-ray-producing units were used at the KCP, as listed in Table 4 (ORAUT 2006, p. 12). These x-ray machines produced a wide spectrum of primary and scattered photons down to very low energies. The dosimeters calibrated using Co-60 may not have correctly responded to these lower-energy photons. Therefore, a correction factor may be needed, especially for determining the dose to skin and shallow organs.

Finding 20: A correction factor for exposures to photon radiation might be needed, due to the differences between the actual photon energy distributions created largely by x-ray machines, and the relatively high-energy photons associated with Co-60, which was used for calibration of dosimeters. This issue is especially of concern regarding exposures to skin and shallow organs.

6.2.2 KCP Site Profile Text Issues

The following areas need clarification/correction to provide more definitive information for the reader or dose reconstructor:

- **Radiation Sources** – Table 4 (p. 12.) provides a list of the typical radiation sources used at the KCP. The 230-curie Cesium Irradiator is listed as used for "Calibration of radiation detection instruments." However, this would be a very large source to use for calibration of instruments; most likely it was an irradiation source for parts or inspection, not for calibrating instruments.

- **Neutron Dosimeters –** The text in Section 6.3.2 (p. 25) discusses only the Lexan neutron detector, but lists other neutron detectors in Table 14. The text should provide information concerning all types of neutron detectors used at the KCP. Additionally, Table 14 is incomplete for the 1961–1967 and 1967–1973 time periods, because the type of neutron detector is not specified (1967–1973 only lists "film," not specifically NTA film).

- **Shallow Dose Uncertainty** – Section 6.5.4 (p. 31) discusses using Tables 19 and 20 for determining the uncertainty for shallow doses. However, Section 6.5.3 recommends an alternative approach for photon dose that is simpler; the KCP site profile should state whether this alternative approach also is applicable to shallow dose.

- **MDL Method not Applicable to Gaps in Records** – The last paragraph on page 26 reads:

> *Dose reconstructors should use Method 1 if there is sufficient information and only occasional missed doses, and Method 2 if significant doses are zero or missing. Use Method 2 for workers who were monitored with missing or zero recorded dose or who worked in an area or an occupation where positive dose would be expected but was not recorded.*

The term "missing" in this content refers to the lack of entry in the dose records, or the lack of dose records. Therefore, assigning dose based on Method 2 (MDL of the detector) is scientifically incorrect, because the worker did not wear a monitor, or the results were not recorded. Instead, coworker or adjacent recorded doses in the worker's records should be used to fill this gap.

- **Incorrect Table Reference** – The last paragraph on page 33 of Section 6.6 states "…is to use the organ DCFs for an AP exposure geometry as indicated in Tables 6 and 7." However, Tables 6 and 7 are from Section 3 for occupational medical exposures. It appears that this statement should refer to **Tables 21 and 22** in this section.

7.0 INCIDENT RECORDS

A 1980 internal Bendix memorandum states that accident records were excluded from the data due to the Privacy Act:

> *The Bendix Kansas City Division records for personnel having Radiation Exposure' data includes 4,326 individuals. Data for Occupational and Industrial accident records are not included because these records are excluded from coverage by the Privacy Act as stipulated in our prime contract.* [Williams 1980]

This memorandum indicates that accidents may be systematically excluded from corporate records. It is unclear if accidents are reflected in individual worker records or in the data compilation that NIOSH is using. This applies to both internal and external dose data.

An interviewee was involved in the Pm-147 cleanup. They used protective equipment in doing this work, such as laboratory clothes and perhaps a hood. The worker had a film dosimeter. The worker [who was at KCP for over 30 years] did not remember any other incidents. The worker recalled using a respirator during the Pm-147 cleanup. The respirator was a full-face unit referred to as a "moon face." The site profile discusses the Pm-147 incident and notes that [less than 9] workers were found to have some contamination (ORAUT 2006, p. 23). The site profile also notes that other "fragile and relatively unsealed" sources were also used but dismisses the dosimetric implications as "comparatively insignificant":

> *KCP operations do include the use of several radioactive sources that can be fragile and relatively unsealed, as occurred with the ^{147}Pm source incident. However, any intakes from KCP use of various small sources would probably be comparatively insignificant.* [ORAUT 2006, p. 23]

The conclusion that exposures resulting from small sources would "probably be comparatively insignificant" does not have analytical support in the site profile. Moreover, in light of the 1980 memorandum quoted above (Williams 1980), it is important to establish whether there were small-source incidents and to show that the implications were "comparatively insignificant."

Finding 21: The status of accident records needs to be determined. Specifically, NIOSH needs to establish whether accidents (internal and external) are included in the records in NIOSH's possession or whether they need to be obtained and included. Further, NIOSH needs to establish rather than assume that the doses relating to fragile radioactive source incidents were insignificant from a compensation point of view.

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ATTACHMENT 1: SITE EXPERT INTERVIEW SUMMARY

INTRODUCTION

As technical support contractor for the Advisory Board on Radiation and Worker Health (Advisory Board), S. Cohen and Associates (SC&A) has been tasked with reviewing the site profile for the Kansas City Plant (KCP) that was prepared by the National Institute for Occupational Safety and Health (NIOSH). One component of SC&A's review is a series of interviews with site experts, including current and former site workers. The purpose of worker interviews is to hear first-hand accounts of past radiological control and personnel monitoring practices, and to better understand how operations and safety programs were implemented at the site over time.

Joe Porrovecchio (SC&A); Josie Beach, Brad Clawson and John Poston (Advisory Board KCP Work Group); Grady Calhoun (NIOSH); and Jack Fix (ORAUT) participated in a site tour and conducted onsite, secure interviews with nine current and former KCP employees during a site visit December 3–6, 2012. Participants were identified by SC&A, the site coordinator, site health physics, and advocates involved with site concerns, with selections based on availability and relevance to subject matter. Nine site experts were interviewed on this visit, including KCP personnel who led the tour.

Joseph Porrovecchio and Dr. Robert Bistline (SC&A) also conducted unclassified, offsite interviews with five former GSA employees at the Bannister Federal Complex (KCP) that were non-DOE employees in October 2011; these interviews were conducted in conjunction with review of unclassified records at the Federal Records Center in Lenexa, Kansas.

Interviewees were briefed on the background of the Energy Employee Occupational Illness Compensation Program Act (EEOICPA) and the purpose of the interviews. Workers were asked to supply names and contact information for follow-up. Participants in offsite interviews were directed not to disclose sensitive or classified information. Written notes and interview summaries were submitted to KCP for classification review.

Interviewees were given the opportunity to review their individual interview summaries for accuracy and completeness. This is an important safeguard against missing key issues or misinterpreting information.

- The offsite interviewees received written interview summaries by mail or e-mail after the interview notes and typed interview summaries had been cleared by KCP. Two of the individuals (40%) did not respond to SC&A's request for review of the written summary.
- For the onsite interviews, KCP provided a classified computer and a display monitor to facilitate real-time entry and review of interview notes/summaries. All of these interviewees reviewed and verbally approved the content of written summaries during the interviews.

- Responses were received from 60% of the offsite interviewees and 100% of the onsite interviewees (86% overall). Information obtained from non-responders has been withheld from this master summary.

The workers whose interviews are summarized below represent the time period from 1951 through the present (December 2012). Their employers at the Bannister Federal Complex included Bendix, Allied, Allied-Signal, Honeywell, Atomic Energy Commission, Energy Research and Development Administration, Department of Energy (DOE), General Services Administration (GSA), National Archives, and Department of Defense.

The work categories and programs collectively represented by the interviewees include the following:

- Administrative, clerical
- Chemical stores
- Electronics
- Engineering
- Facility management, maintenance, construction trades
- Inspection and testing
- Manufacturing, fabrication
- Production, operations, assembly
- Radiation Safety
- Transportation
- Telemetry
- Tool and equipment repair

The information provided by the workers and site experts is invaluable in helping SC&A to better understand the operations at KCP. This summary report is not a verbatim presentation of the material contained in the interview notes, nor is it a statement of SC&A findings or opinions—it is a consolidated summary of statements, opinions, observations, and comments that the interviewees communicated to SC&A. The sole intent of this summary is to communicate to the Work Group, the Advisory Board, and other interested parties information acquired by SC&A during these interviews.

Although an abundance of good information was provided during the tour and in interviews, this summary concentrates on areas that could potentially impact claimants' dose assignments in the dose reconstruction program under the EEOICPA. Comments are included in brackets where SC&A has provided clarification to the site expert's statement.

Information provided by the interviewees is based entirely on their personal experience at KCP. The site experts' recollections and statements may need to be further substantiated; however, they stand as critical operational feedback and reality reference checks. This interview summary is provided in that context. Key issues raised by site experts are similarly reflected in SC&A's review discussions, either directly or indirectly. Information from all interviewees who reviewed and approved their individual interview summaries has been consolidated into this summary document. Where conflicting observations and statements have been received, both perspectives are presented.

The information gathered has been categorized into topical areas:

- Facilities and Operations
- Maintenance and Construction Trades
- Radiological Control
- External Monitoring
- Internal Monitoring
- Incidents and Accidents
- Waste Management and Environmental Monitoring
- Medical X-ray Examinations
- Radiological Records
- Miscellaneous Comments

FACILITIES AND OPERATIONS

[The interviewees, collectively, provided their characterization of the facilities and operations at KCP, as follows.]

[KCP shared space in the Bannister Federal Complex with several other agencies, including Internal Revenue Service, National Archives, Department of Defense, U.S. Marine Corps, and GSA. GSA is responsible for some aspects of facility administration and maintenance.]

There was shared air between both sides of the complex. In the Building 1 basement, Corridor 16 goes north-south through the entire building. Q corridor went east to west to the wall demarking GSA/Honeywell side (column 26 demarks the moveable wall that separates GSA from DOE in the same 67-acre building).

[Some work areas previously utilized for DOE/NNSA (National Nuclear Security Administration) activities were later transferred to GSA.]

- Building 41 is a little building in the north parking lot. There was construction in Building 41 while an interviewee worked there. It was used for a farmers market after 2000. Building 41 was a very messy, filthy building before it was refurbished. When GSA took over the building (~1973–1975), the building was dusty, and they had to clean it up. [GSA workers] disposed of waste from Building 41. Whatever was there went to the landfill.

- About 1991–1992: A wall was taken down between GSA and DOE areas in Building 1. They moved the partition about 100–150 yards, with GSA taking over the CASAU area from Honeywell. [Acronym definition is not known.]

The workforce at KCP went from 2,000 to 9,000 employees during a build-up in the 1960s. Staffing level was reduced in 1974. There was another buildup in 1978 until the mid-1980s.

The following past and present activities at KCP involved radioactive materials and radiation-generating devices:

- Industrial radiography for NDT [Non-Destructive Testing]
- Telemetry
- Neutron radiation pulse operations
- Sealed-source handling (typically Health Physics lab and check sources)
- Analytical science lab boron analysis
- Formerly, beta backscatter analysis for measuring thickness of plating
- DU [depleted uranium] process etching (1997–2010)
- Machining parts (1960s)

[Interviewees were asked if they had experience or knowledge regarding (1) a project that used uranium oxide in a powder form and (2) a microelectronics facility operated by KCP at Sandia National Lab in Albuquerque, New Mexico (~1975–1991).]

- None of the individuals available for interviews had knowledge of the uranium oxide project, although one interviewee thought there may have been some material in the waste.
- Some interviewees knew about the microelectronics facility, but they never worked there. One worker had taken a tour of the microelectronics facility at Sandia.

Some interviewees indicate job titles are well-defined; several workers observed that the titles are not closely associated or correlated with radiological work. An interviewee said job titles changed over time; in the 1990s, for the first time, job descriptions were printed out and signed by employees.

Training records are likely the best evidence of locations where persons worked. Currently, an RWA [Radiation Work Authorization] provides evidence of radiation workers on a specific project. Medical screening records [may also be useful for identifying radiological workers]. An interviewee thought it would be difficult to associate job descriptions with potential for radiation exposure; the worker's employment records do not indicate anything like this until 1991. The previous Radiation Safety Coordinator for Telemetry maintained lists of radiation workers in the Telemetry area; these go back to about 1990.

An interviewee suggested that examples of radiological worker training, qualifications, etc., would be good sources of supplemental information.

A worker [1960s era] recalled that Department 22 was the only department that worked with radioactive material other than x-rays. The security badge had a '22' on the credential, and this was required for entry.

When asked about the use of thorium at KCP, a Radiation Safety worker was only aware of small check sources. The interviewee has no knowledge of any processed thorium at KCP. There may have been some [consideration of thorium projects], but the interviewee is not aware of any confirmed thorium. Often national projects are scoped at each site to review capabilities. There typically is no follow-up documentation to indicate that the project was not established or was conducted at other sites.

Manufacturing

[Fabrication and machining activities involved a number of skilled crafts.] A General Machinist manufactured, machined, and fabricated parts. As a production worker, an interviewee deburred and degreased manufactured parts. Tool and Die makers and model makers were involved in lead fabrication, processing and planning of tools/jigs, fixtures and molds. A Tool and Die Apprentice participated in a 6-year formal certified training program. There were model makers in the Model Shop and in the engineering shop. A Sheet Metal Fabricator participated in R&D [research and development] and engineering processes for process prove-in [development and implementation of a manufacturing production process].

Interviewees worked in the Model Shop, engineering shop, Helpers Paint Shop, RTV [Room Temperature Vulcanization] Shop, TEM (Tooling and Equipment Maintenance) shop, Sheet Metal Shop, vapor blast shop, plating shop, welding shop, Lab Shop, heat treat EDM (Electrical Discharge Machining), and Chemical Stores.

Other positions in machining areas included drill operator, lathe operator, machine operator, and (at the model shop) model maker.

A machine area worker recalls being loaned out to other organizations during the period of employment. [A machinist] worked in about all areas [over the worker's] career. Departments 22 (radioactive area), 24, 25, and 48 (plastics) were all within a common area. The worker was required to punch out each day from the home department.

An interviewee could not remember exactly the facility layout, but does remember the general activities. The interviewee milled uranium and also worked with uranium plugs that were shiny in appearance; the worker would inscribe a radius on the plugs.

[A machine area worker recalls work with uranium "chips."] This likely occurred in about 1961 or later. The worker could not recall what was done with the uranium chips. Within a couple of weeks, the chips would turn a golden color. A liquid solvent was used during the machining, but the worker could not remember what was done with the material after the work was done. The interviewee also worked on machining depleted uranium (DU) items, in oil bath and solvents, which the worker did not like because the material would splash on the worker. The scrap DU items were placed within 55-gallon barrels.

The worker was sure that they cleaned up the uranium chips at the end of each shift. [The chips were] placed into barrels, which the worker believes contained a liquid solvent—it may have been carbon tetrachloride. Workers may have placed concrete in the barrels on top of the liquid solvents and over the uranium chips. The barrels were then quite heavy. The interviewee was unaware of barrels being buried at KCP; the worker thought they were sent to New Mexico. A young worker used to swab the floor with carbon tetrachloride. The carbon tetrachloride was used for many purposes, such as cleaning the floor, washing the lathe tools, washing hands, etc. It would evaporate nearly instantly.

An interviewee remembered work in the model shop [prior to 1971] on material that came from the "gold room" that may have been radioactive. The worker recalled machining the part until a vacuum was released. The worker was not aware of the materials involved and was not required to wear a dosimeter. The part had to be mounted into a Plexiglas jig prior to machining. The piece was returned to the gold room after machining. Access to the gold room was secured. [Current Radiation Safety staff was not present at this time and is not familiar with this project.]

Telemetry

Telemetry was not active until about 1975. The Telemetry Department has basically stayed in the same location. There was a temporary relocation (a few months) in about 1989 for a renovation. Telemetry [activities are conducted] in the basement area.

An Inspector and Tester Electronics inspect all products prepared by telemetry technicians.

A Telemetry worker has some association with DU items; the worker did inventory on product control numbers as part of the receipt verification. The worker did not actually handle the uranium and is not aware of the use of the depleted uranium bars.

Interviewees worked with low-level radiation sources. [They identified the following radioactive items that are received, handled, and shipped:]

- Barium bolts used to calibrate the lead probe in the neutron tester
- Tritium target assemblies in the neutron generators
- X-ray source
- Sealed sources (e.g., Cs-137 and Am-241) used for calibration

There is hands-on work with the barium bolts. The barium bolts, tritium [assemblies in the neutron generator], and Cs-137 check source are described as sealed or encapsulated sources. The neutron generators [tritium target assemblies] are not opened at KCP, but are returned to Sandia.

Test Equipment staff designs and maintains the test equipment that uses the electronic neutron generator. One interviewee was responsible for maintaining health physics records and provided phantom exposure records indicating extremely low worker doses associated with neutron generator operations.

A radiological worker with Rad Worker I training has worked on portable neutron detectors. The worker procured a gamma source (perhaps Cs-137) to calibrate the detectors. The source was kept in a locked cabinet.

MAINTENANCE AND CONSTRUCTION TRADES

[The interviewees involved with construction and maintenance, collectively, provided a description of construction and maintenance activities at KCP, as follows.]

[GSA workers responsible for facility maintenance entered parts of the facility where work was conducted for DOE/NNSA.] There was roof access to both sides for maintenance. [Workers noted controls, including] guard post and escort for access into [NNSA] areas.

Workers occasionally went over on the Honeywell side of the roof to do maintenance of ventilation systems. GSA maintained 16 building air handling units (AHU) on the roof with 60-horsepower motors; the 8 AHUs on the west side handled heat. Exhaust air went out of roof "dog houses" and there was a possibility for air exchange between exhaust and intake. There was shared air on the one ventilation unit that was split between GSA and NNSA, and there was an unlocked door between that they could go through anytime. [To the best of the worker's knowledge], there was no lockout/tagout for HVAC [Heating, Ventilation, and Air Conditioning] repair or maintenance. When they worked on the roof [flat roof surface and dome shaped concrete 18 inches thick at the columns and about 6 inches thick at the center], the radiation generating equipment was below them. [GSA workers] maintained all HVAC systems on roofs, but did not work on HEPA [High Efficiency Particulate Air] filter systems. That may have been done on the DOE/NNSA side.

[GSA workers] also went on the east side of the main Honeywell building to work on condensate pumps. The pumps were in a pit with orange slime and they pumped into a lagoon located east of the pit. A barrel wash (skid wash) area was located by the pit. Barrels were washed when they came in, and the water went into the lagoon.

[A GSA worker] did not handle radioactive material and is not aware of surveys for radioactive contamination in the work area. The worker did not have a dosimeter, submit samples for bioassay, sign an access log, or wear personal protective equipment (PPE). The worker does not recall working around other people who were monitored or wearing PPE.

MOU stands for "Memorandum of Understanding." These were agreements between DOE and GSA. [There were] MOUs [between the agencies] from 1974 through 1993. In the event of a spill or incident on the DOE side, GSA would send its maintenance crew, and DOE would pay from its fund. The interviewee does not know how often the MOUs were used.

RADIOLOGICAL CONTROL

[The interviewees, collectively, provided their characterization of the radiation protection organization and practices at KCP, as follows.]

Interviewees generally stated that KCP is supportive of all DOE orders [DOE 1988 was specifically discussed] and is continually improving to strive for excellence. [Relevant standards have been] the DOE Radiological Control (RadCon) Manual,[1] then 10 CFR [*Code of Federal Regulations*] 835.[2]

One interviewee indicated that KCP did not share information [for national security reasons] with workers that were not involved with handling radioactive materials about what activities took place.

Access to Site and Work Areas

Access controls for the facility involve a gated entry to the complex requiring DOE clearance. Access to the NNSA facility is controlled by badge controls and guard posts at entry points.

[Interviewees describe the evolution of access controls as follows:] [In the 1970s], workers handed their badges to a guard at each entrance. Badge readers were installed about 1990, and turnstiles were installed about 10 years ago [early 2000s].

[When asked about access controls and measures to prevent non-rad workers from entering radiation areas], an interviewee remembered it was difficult to gain access to the plant. The security credential had a number which indicated the area authorized for entry. A worker vaguely recalled signing in when entering an area—possibly to receive a dosimeter to be used while machining.

In the past, lists were used to identify workers who could enter an area. Training records may provide evidence of work area access. The access is not associated with job title. RWA documentation may also provide evidence of worker access to specific work areas. Security records may indicate worker access approval.

For some positions, such as messenger, a worker had access to many areas. The worker does not recall being in the immediate area with radiation, but may have had access to the area. The worker has no recall of being monitored and was not aware of whether there was any radiation.

An interviewee went to x-ray, medical, and worked in Department 45. The worker was uninformed as to whether or not the work areas contained radioactive material. The worker observed barrels marked radioactive, but there were none in the interviewee's shop.

An interviewee said that security badges were marked with a designation (i.e., 1, 2, 3, etc.) which controlled which areas could be entered. Another interviewee explained that a blue security badge was required for general plant access. For Department 22, the security badge was marked with a "22," which was required for access. An interviewee noted that [security ID] badges were changed only after they became old and unrecognizable. ID badges would turn color and not be recognizable and then would be changed.

[1] This statement references a prior version of *U.S. Department of Energy Radiological Control Manual* (DOE/EH-0256T), which was revised in April, 1994.

[2] This statement references a prior version of 10 CFR 835, *Occupational Radiation Protection*, which has subsequently been revised.

An interviewee signed an access log when entering certain areas, but that practice was not instituted until the 1990s.

The Telemetry Department involves a Badge reader, which approves personnel on an access list. [Workers on the access list] do not need to sign an access log. [An unmonitored individual] can come in as a visitor, but must be escorted. They cannot be working the equipment and they cannot be alone. This is specified in the RWA. An access log [showing entry to the department] does not mean the person entered the radiation area. The radiation area of the Telemetry Department involves requirements for dosimetry and staff are trained radiological workers. Anyone in the radiation area must have a dosimeter.

There are technicians who are not allowed to enter certain areas because of mandatory training requirements.

Control of Sealed Sources

There was a KCP initiative to reduce the number of [radioactive] sources following the 1989 Pm-147 incident. The tracking of sources has become much more stringent following the release of a DOE RadCon Manual.

Certainly in earlier days, the requirements were much less demanding. These varied over the years. There are documents of KCP periodic inventories of precious metals and radioactive sources. A specific issue was noted pertaining to Co-60 sources used historically; there is significant information that was collected in the KCP Site Profile.

Sources are distributed throughout the plant in various work areas according to where the source is used. The radiation safety representative has a key to the locked sources storage. At each department, since 1989, there is an authorized list.

A 24/7 source log is kept for each source and location, indicating removal, location, and return. The interviewee does not know the history of the log books, but this information should be available from document control. Telemetry workers definitely had these log books in the 1980s. The emphasis has been on knowing the location of the source.

Other Administrative Controls

KCP uses RWAs for workplace reviews. The Health and Safety group determines appropriate controls and PPE for each project.

[In response to a query regarding training and records at KCP], an interviewee said that the RWA is relatively recent with the associated training and protective equipment requirements for workers. During earlier years, there was greater emphasis on “need to know” requirements.

A worker [who machined uranium] does not remember receiving any radiation training. The worker was aware of radioactive material, but does not remember being informed of the specific material with which he was working. Information regarding the material being worked was typically not known or discussed. Workers were strongly discouraged from discussing the work being done.

An interviewee said employees were not told what was potentially contaminated and what hazards were present, if any. The worker is suspicious of KCP management because they did not did not inform [the worker] about hazards. This worker is suspicious of activities that, for national security purposes, were not revealed to workers that may have been exposed to hazardous chemicals or radiation. The interviewee worked in many trades and crafts at KCP, was unaware of activities nearby, and was not informed. Even after the fact, the worker [still wants to know] what went on in the work areas.

A Telemetry worker noted that there was not a lot of data on neutron generators [in the late 1970s], but dosimeters were worn at all times. There was less understanding on low radiation level safety, but over time, improvements were made. The company made improvements over time, but was never lax in safety.

[When asked if work areas, machines, or sources were posted or labeled as radioactive], an interviewee recalled that doors on the secured area were marked, and the worker does remember seeing radiation signs in areas. [The worker was employed at KCP over 30 years.] Another interviewee recalls radioactive signs on the door of Department 22 and also on the barrels.

Telemetry work areas, machines, or sources are posted or labeled as radioactive. A barrier chain and the yellow/magenta stripe are used as work zone controls. Two interviewees [whose employment dates from the 1970s] said, in their experience, radioactive materials have always been labeled appropriately. An interviewee is not aware of any time when labeling was not used. There was always an exclusion area [posted] with the signs, perhaps marked with a chain. The worker would need to sign an RWA periodically.

Workers [from radiological machining areas] recalled that clothing was provided, including shoes. Shoes were painted red or orange on the toes to clearly designate shoes not to be worn outside the work areas. The KCP-issued clothes were to be worn within the plant. There was a clothes change room with a shower. Workers showered before going home. There were low-level positive GM [Geiger-Muller] readings on clothing [in Department 22], but these clothes were changed prior to leaving; workers changed coveralls before they went to lunch. Showers were taken at the end of each shift.

An interviewee said that eating was done in the clothes change area and not in the work area. The worker remembers going to a cafeteria for meals. The worker's hat and marked shoes were most likely left in the change area upon egress. The worker smoked at that time, but believes this was done in the change area only. Another worker recalled there was no drinking, eating or smoking in the Department 22 work area. For example, you could go out to get a cup of coffee, but you could not return to the work area with the coffee.

[When asked if eating/drinking was allowed in the work area where radioactive materials were handled, a Telemetry worker said], "Absolutely not." Another worker [with experience in Telemetry and Testing areas] indicated that it was acceptable to smoke in the radiation area in the earlier years. The interviewee said they were allowed to drink, eat, and smoke until a few years ago (i.e., such as with the barium bolt). Another Telemetry worker recalled that there may have been a time when food was allowed; however, there is concern that food/drink could affect the devices, so this is discouraged. The interviewee does not know when changes were made.

[A worker who was not assigned to radiological areas] said there were vending machines in the work area with snacks and drinks. The general consensus was that you could eat, drink, and smoke. Another worker [who is not aware of handling radioactive materials] also recalls workers smoked and ate at the work place so as to continue production and not have time to congregate.

Although [an unmonitored] worker observed that other workers changed clothes down to underwear, the worker personally did not shower or change clothes before going home.

Honeywell employees had their own cafeteria; Department of Defense and U.S. Marine Corps employees shared a different facility. An interviewee saw other workers who came to the cafeteria in their work coveralls. There were two cafeterias on the DOE side, one in GSA area, and one in IRS area.

Personal Protective Equipment (PPE)

A worker from the machine area remembers wearing canvas shoe covers. The worker also remembered using respirators on occasion, but does not recall the time period or the work activity. The worker was checked out to use a respirator, but it was hard to breathe while using one.

There were about five workers per shift in Department 22. Some workers, such as engineers, could enter the area, but they were required to wear the shoe booties so they did not track residue outside the area.

Respirators, gloves, and other PPE are often used for chemical safety purposes rather than for radiation work. For example, workers involved in the potting shop (handling a two-part chemical mixture) wear respirators.

An interviewee has used safety glasses. Another interviewee recalls using safety glasses and "paper lab coats that were not very good."

Surveillances

An interviewee recalls cleaning up black powder residue in the machining area, but there was little support. The worker recalls using a Geiger counter to check general radiation levels. Cleaning was done primarily using a brush and a dust pan. The residue was primarily a black dust-like material. The dust was disposed into a bag inside a barrel. The barrels were sealed and removed when full. The material was U-235 for the machined parts. Interviewees were not aware of air sampling in the work area.

A machine area worker remembers using a GM counter to check that tools were cleaned before turning them into the tool crib. The worker does not recall using the GM to self-check for personal contamination. Another worker recalls [self-survey] only at the end of a shift following removal of the outer clothing; the interviewee does not recall detecting any remaining contamination on skin.

A worker [who did not have a dosimetry badge] was never evaluated for skin contamination. The worker never used survey equipment to check for contamination on skin or clothing. The worker [does not believe skin rashes were handled appropriately]. The onsite medical officer issued [cortisone] cream to apply to the rash [rather than investigating potential causes].

Radiation Safety is responsible for any radiological shipments coming or going. [A worker involved with incoming and outgoing shipments] did not conduct surveys; the worker recalls occasions when health and safety did a survey.

Neutron probe testers are used to check the neutron generator output. Health Physics swipes neutron probe test units for contamination. Swipes are done when any generator is changed—upon entry into the plant and also prior to shipment. Maintenance technicians receive these shipments; shipping containers are not opened until health physics is present.

[When asked about practices related to decontaminating, decommissioning, or surveying areas where radioactive materials had been handled in the past], an interviewee does not know and is "waiting to get this information from the company today." [KCP personnel indicated] swiping and frisking surveys are performed. DOE 5400.5, and currently a new order number with the same criteria table, [establishes release criteria] for unrestricted use.

Interviewees were generally not aware of air sampling for radioactive material in their work areas. Some interviewees indicated air monitoring is not done for radiation, but chemical air sampling is used for certain projects. Air sampling was done after 2002 for a beryllium study.

One interviewee indicated that an area of 230,000 square feet of GSA space occupied by NNSA was contaminated [possibly with beryllium] and not cleaned for 8 years. GSA PBS [Public Buildings Service] Region 6 was prevented [by red tape] from ridding itself of this contamination. [SC&A is not certain if the interviewee was referring to beryllium contamination or radiological contamination.]

EXTERNAL MONITORING

[The interviewees, collectively, provided their characterization of how external monitoring was performed at KCP, as follows.]

Workers were aware that Department 22 involved radiation, and they were issued film dosimeters while working in Department 22. An interviewee had a security badge that stayed with the worker all the time. There were dosimeters on a board that were taken upon entry into the Department 22 area. An interviewee does not recall anyone receiving a positive dosimeter reading.

[A worker] remembered wearing a pencil dosimeter, [and seeing other workers wearing them] sometimes. The worker does not remember wearing a film badge.

An interviewee entered areas where other workers wore dosimeter badges and/or special safety equipment. No one assigned to work in an interviewee's shop had dosimeter badges.

There have been changes in monitoring practices over the years, primarily in consideration of the technology that is currently available. Dosimeters have changed over time, as well as the exchange period. Telemetry workers said dosimeters are currently exchanged every 6 months. An interviewee recalls the exchange period changing from monthly to every 6 months. There are lists of neutron workers who are issued a neutron dosimeter. An interviewee is aware of ring dosimeters used at one time for handling the barium bolts, but this is not the worker's area of responsibility.

NIOSH mentioned a letter discovered in 1995 describing personal neutron monitors in Telemetry in which the phantom neutron dosimeters showed an unexpected increase in the neutron dose. The increase was such that assignment of personal dosimeters was reinstated. [Radiation Safety staff] thought this may have been attributed to transfer of work from Pinellas that resulted in greater neutron doses. These workers still have assigned neutron dosimeters. There was a time in which there was emphasis on reducing the number of assigned dosimeters to workers who do not exceed 100 mrem per year.

[Interviewees who worked in Telemetry] do not recall any time in which neutron dosimeters were not used in the Telemetry radiation area. An interviewee was not familiar with a situation in 1995 regarding re-assigning neutron dosimeters to workers based on readings from the ambient phantom dosimeters.

An interviewee [who is monitored for neutrons] has not witnessed anyone in a radiation area who was not wearing a dosimeter. If this situation had occurred, the worker would stop [the person without appropriate dosimetry] from entering the area.

ALARA [As Low As Reasonably Achievable] is emphasized at the plant. A Telemetry worker's reported doses are generally zero. The interviewee recalled one unusual incident in which the storage location of the sealed sources was moved near where the dosimeters were stored, and this was detected by the dosimeters.

The question of potential exposure of GSA employees on the roof was raised. An interviewee stated that neutron radiation from the neutron testers would have to pass through the first floor and then the second floor prior to arriving at the roof where GSA employees may be present. KCP has monitoring data for workers within about 3 feet from these sources. The dose to any workers on the roof would be exceedingly small.

INTERNAL MONITORING

[The interviewees, collectively, provided their characterization of how internal monitoring was performed at KCP, as follows.]

Workers from Department 22 received periodic urinalysis [estimated 30–90 day intervals]. One interviewee did not have knowledge of participation in a urine bioassay program, recalling that urinalysis was part of a routine physical. Another worker was aware of urine bioassay, but does not recall receiving any urinalysis results; the worker does not recall if urinalysis was done upon completing work in Department 22.

INCIDENTS AND ACCIDENTS

[The interviewees, collectively, provided their recollection and understanding of what incidents occurred at KCP, and how they were handled and documented, as follows.]

An interviewee recalls hearing of fires in the machining area, but did not personally witness any fires. The worker remembers a follow-up to a fire in Department 22 in which the ceiling piping was highly rusted or corroded. Even the tops of the cabinets were "rusty." Another interviewee does not recall any fires in the Department 22 machining area.

An interviewee was involved in the Pm-147 cleanup. They used protective equipment in doing this work, such as laboratory clothes and perhaps a hood. The worker had a film dosimeter. The worker [who was at KCP for over 30 years] did not remember any other incidents. The worker recalled using a respirator during the Pm-147 cleanup. The respirator was a full face unit referred to as a "moon face."

[On one occasion], contamination (unusual black powder) was discovered on the surface of product returned to KCP [after] a flight test. Bioassay was performed; results were negative. There should be documentation available from Health Physics for this incident.[3] The interviewee is not aware of another problem of this type [having occurred]. There was an investigation of a potentially leaking generator, but no contamination was found.

An interviewee heard there was detection of contamination on a swipe sample [from neutron generator surveillance] many years ago. The interviewee was not personally involved and did not know details of the event.

On one occasion, [non-rad workers] at the model shop received and opened a box [apparently delivered to their area in error]. After removing the packaging and "a small unit," they found a red label at the bottom of the box saying "RADIOACTIVE MATERIAL INSIDE." The interviewee took the box to the ES&H [Environmental Safety and Health] Director. The worker never heard anything more about the incident.

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[3] A safety department investigation report (Krueger and Meunier 1987) independently documents the occurrence described by the interviewee.

A [redacted] was assigned to a job outside the Model Shop. It was a special job: the Model Shop supervisor [interviewee] was involved in setting up the work area in an outside department, clearing the set-up through safety, getting the set-up functioning, and setting up screening to close in the machining process. Shortly after the job was completed, the [redacted] it [redacted]. Soon after that, Industrial Hygiene (IH) staff came to the Model Shop and wanted to speak with [redacted] about possible contamination of the machined parts. When [redacted] returned to work, the IH staff member came to the shop with [redacted] other people to question [redacted]. The supervisor asked about the source of the suspected contamination but was not told. The supervisor was not observed or monitored for the substances that may have affected the [redacted]. The supervisor wrote a memo about the incident, but the [KCP management] person who received it was not interested in following up.

There was a glovebox explosion that apparently involved lead, but not radiation. An interviewee recalls this incident was documented.

[Nearby but offsite] explosions in the 1990s shook the building, dropping all sorts of debris and dust that was cleaned up by workers in respective work areas.

The KCP interviewees were not aware of any building evacuations other than for tests.

WASTE MANAGEMENT & ENVIRONMENTAL MONITORING

[The interviewees, collectively, provided their characterization of waste management and environmental monitoring practices at KCP, as follows.]

[A worker in Department 22] was not responsible for handling waste. Someone else would remove the material from the work areas.

About 1982, they were digging up the parking lot East of Building 41. [An interviewee recalls] dump trucks were removing soil all night for 4–5 weeks.

An interviewee [who had responsibility for incoming and outgoing] shipments initially did not recall shipping any waste offsite. The worker subsequently mentioned a vague recollection of classified waste shipments to Los Alamos. The worker remembers there being little waste. There was one barrel in a secured, controlled access area near the upstairs test cells. The worker handled incoming radioactive shipments by placing the material into a secured container. [When asked about direct handling of radioactive material, the worker said], probably not, but there may have been some in the waste, such as the tritiated exit signs. [Typically], everything was packaged, and the worker placed the packages into drums. The worker does recall thallium liquid and solid waste being stored. [When asked about a project that used uranium oxide in a powder form], the worker thought there may have been some material in the waste.

The current waste management group (3 years ago) handles shipments and RCRA [Resource Conservation and Recovery Act]. ES&H record keeping is archived.

[When asked about field and environmental characterization data, Radiation Safety staff recalled] an incident involving the recovery of radioactive waste on the north side of KCP. Since

KCP does not have any routine emissions or waste production, there is limited characterization activity that the interviewee can recall.

[Workers in several areas were involved in chemical waste disposal.] These areas include the Plating Shop, Paint Shop, RTV, and Chemical Stores. An interviewee kept a log of source materials, such as paint, used in the work area. In the 1990s, an interviewee was involved in collection of VOC [volatile organic compound] data. [An individual] was in charge of VOC records for the plant. Another interviewee was involved in cleaning up spills of materials such as sealants and glue. They used vermiculite. Waste from the cleanup was taken to the landfill. The interviewee does not recall specific incidents, but everything was a big deal after 2002. Sometimes NNSA would evacuate the building because of odors.

[An advocate] has documents regarding the chemical inventory and environmental test results for Building 41.

MEDICAL X-RAY EXAMINATIONS

[The interviewees, collectively, provided their recollections of the x-ray examinations at KCP, as follows.]

[An interviewee whose employment dated back to the late 1950s] recalled receiving a physical about every 90 days from an in-house medical organization. The interviewee thought this was a full physical to include an x-ray and urinalysis.

RADIOLOGICAL RECORDS

[The interviewees, collectively, provided knowledge of their understanding of the completeness and adequacy of radiological and medical records, as follows.]

A Microsoft Access® database contains KCP dose history since 1949. Radiation Safety personnel hired sub-contractors through a temp agency to enter the internal and external dosimetry data for each worker who had hard copy records. Some work was performed by a KCP administrative staff member. Since the employee dose history database entry was contracted out, Radiation Safety staff set up a QA [Quality Assurance]/QC [Quality Control] system and documented audits performed on the database entries.

An annual rems report is sent to DOE each year. Radiation Safety staff also maintains a whole-body dose history report that could be useful. There are also the area dosimeter data for Telemetry and other areas that may be of interest. The data are primarily for x-ray departments.

The following supplemental documents received from interviewees have been added to the SRDB:

- Memorandum regarding internal monitoring for personnel working with DU (Runkle 1997)
- Radiation data for neutron area – phantom badge dose at neutron tube (Nasca 2013a)

- Radiation data for neutron area – phantom badge dose at x-ray tube (Nasca 2013b)
- KCP personnel dosimetry history – annual whole body external dose (Honeywell 2013)

MISCELLANEOUS COMMENTS

[The interviewees, collectively, provided additional comments they wished to include in the summary for consideration, as follows.]

Interviewee(s) concerns regarding non-radiological and non-DOE worker occupational health:

[A 1960s-era worker] recalled some activity involving carbon tetrachloride at KCP. The worker recalls that beryllium was their favorite metal with which to machine. [An interviewee who was employed into the 1990s] remembered some industrial type accidents and has participated in the 5-year testing cycle for berylliosis. Another interviewee and a coworker machined 99% pure beryllium in the lab-model building. When the lab-model shop was shut down, they cleaned it up.

[An interviewee raised concerns regarding the general safety culture at the site. The interviewee recalled a 1996–1997 memo from Karen Clegg, President of Allied Signal that said] the attitude on safety was "Cavileer" [sic].[4] President Bill Clinton stated that safety was lax; production was the goal. Employees' participation in matters of safety was resisted, as seen when TQM (Total Quality Management) was introduced—about 1986. Some TQM efforts were suspended (model shop, tool room) when employees insisted on aiding with workplace safety suggestions. The interviewee indicated personnel records in HR [Human Resources] [as sources to support this statement].

NBC Action News investigated conditions at KCP. They reported that falsehoods as to conditions at the plant were made to five federal agencies by the plant. Meeting minutes of the Community Advisory Panel indicate employees are afraid to report anything that occurred related to accidents, incidents, and injuries. The St. Louis Post-Dispatch last month revealed a 1950s release of a "smoke screen" of contamination over populated areas.[5]

Other interviewees stated the organization has a high focus on safety that has improved over time. An interviewee noted there was definite improvement [in the overall safety program] over the years. With a Department of Health & Safety [in the early 1990s], the improvement was tremendous. The worker was not aware of any deficiencies. Another interviewee stated safety has always been a prime area of concern; [the approach included] more proactive activities with the arrival of the Voluntary Protection Program.

[4] Interviewee did not have a copy of the memo available. The date was estimated based on interviewee's recollection.

[5] SC&A located an article online that appears to be consistent with interviewee's description (Mann 2012). This article is not directly related to KCP or Kansas City; it appears to illustrate the worker's concern regarding government failure to disclose hazards associated with weapons development to affected individuals.

An interviewee observed, “It is human nature to anticipate there may be unknown issues; however, I have never experienced that the company has kept anything from me that would be potentially harmful.”

[In regard to non-radiological but general safety culture, a GSA worker expressed significant concern regarding beryllium exposure, protections, and medical surveillance.] The GSA PBS Region 6 occupational focus centered on asbestos ingestion, and GSA did not furnish safety equipment until the Federal Labor Relations Authority’s 1991 decision forced GSA to pay for Hazardous Duty Risk. [GSA initiated a medical surveillance program in 1985.] In 1988, 1989, and 1990, several maintenance workers had positive findings, including [redacted]. In 1991, a different pulmonary specialist assessed the [redacted] x-rays as negative. Since x-ray readings and disease symptoms are essentially the same for beryllium and asbestos [exposure], PBS chose to accept the 1991 readings to be negative. They did complete physicals and chest x-rays that identified medical issues and then killed the program. The interviewee has not been satisfied with GSA’s response to requests to resolve the conflicting medical opinions. The interviewee provided supplemental documentation regarding the medical surveillance program and [redacted] efforts to obtain resolution of conflicting medical opinions.] GSA Inspector General investigated from 1999 on and found GSA without credibility regarding its Safety and Health federal requirements. These earlier years of improper Safety and Health should also be exposed for the GSA employees, especially those who provided maintenance in contaminated areas.