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ADVISORY BOARD ON

RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

REVIEW OF THE SITE PROFILE FOR THE CLARKSVILLE AND MEDINA PLANTS

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Review of the Site Profile for the Clarksville and Medina Plants	Page 2 of 32
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TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

Advisory Board or ABRWH	Advisory Board on Radiation and Worker Health
AEC	U.S. Atomic Energy Commission
CATI	Computer-Assisted Telephone Interview
CFR	*Code of Federal Regulations*
Ci	curie
cm^3	cubic centimeter
d	day
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DU	Depleted Uranium
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
g	gram
HE	High Explosive
HEPA	High Efficiency Particulate Air
HHS	Department of Health and Human Services
hr	hour
IAAP	Iowa Army Ammunition Plant
ICRP	International Commission on Radiological Protection
INRAD	Intrinsic Radiation measurements
IREP	Interactive RadioEpidemiological Program
MCNP	Monte Carlo N-Particle Transport Code
MDL	minimum detectable level
MeV	million electron volts
MHSMC	Mason and Hanger-Silas Mason Company
mrem	millirem
n/p	neutron-photon ratio
NIOSH	National Institute for Occupational Safety and Health
NTA	Nuclear Track Film Type A
ORAUT	Oak Ridge Associated Universities Team
OTIB	Oak Ridge Associated Universities Team Technical Information Bulletin
pCi	picocurie
RST	Radiological Safety Technician
RTG	Radioisotope Thermoelectric Generator
SC&A	S. Cohen & Associates (SC&A, Inc.)
SEC	Special Exposure Cohort
SNL	Sandia National Laboratory
SRDB	Site Research Database

TBD	Technical Basis Document
TIB	Technical Information Bulletin
W28	Nuclear weapons system
yr	Year

1.0 EXECUTIVE SUMMARY

This draft report presents the results of an independent review conducted by S. Cohen and Associates (SC&A) of ORAUT-TKBS-0039, *Site Profile for Clarksville Base Weapons Storage Area and Modification Center with Supplementary Guidance for Medina Base* (ORAUT 2006a), or Clarksville/Medina technical basis document (TBD), which was issued by the National Institute for Occupational Safety and Health (NIOSH) as a summary site profile document. SC&A conducted this review during the period August 2010 through November 2011.

This review was conducted in accordance with the Advisory Board on Radiation and Worker Health's *Data Access and Interview Procedures* (ABRWH 2009a) and SC&A's Board-approved *Standard Operating Procedure for Performing Site Profile Reviews* (SC&A 2004). SC&A evaluated the site profile for completeness, technical accuracy, adequacy of data, compliance with regulatory objectives, and consistency with other site profiles. Review criteria and methods are described in greater detail in Section 2.0 of this report.

The Clarksville and Medina Plants were 2 of 13 weapons storage areas (or "modification" centers) established in the 1940s under the Armed Forces Special Weapons Project. The Clarksville Base was constructed on a site adjacent to Fort Campbell, Kentucky, in the mid- to late-1940s, with the first weapons components arriving in July 1949. The Medina Base was constructed on 3,700 acres of Lackland Air Force Base near San Antonio, Texas, by the Air Force and the Atomic Energy Commission (AEC) between 1953 and 1955, with the first weapons components arriving in 1955.

For Clarksville, maintenance and quality assurance was performed by Sandia Corporation (later Sandia National Laboratory) in conjunction with the U.S. Navy; from 1958 to 1965, this function was supported by Mason and Hanger-Silas Mason Company (MHSMC). In 1965, the Clarksville mission was transferred to Pantex and other facilities, but the facility was not officially transferred to the Army until 1969 (the AEC continued to manage the site until 1967, with uncertainty regarding its status in 1967–1969, although there were no weapon components handled during that period) (ORAUT 2006a).

For Medina, corresponding activities were likewise performed by Sandia, AEC, and the Air Force from 1955 until MHSMC assumed responsibilities in 1959 (MHSMC was contracted in 1958).[1] In January 1966, the Medina mission was transferred to Pantex and the complex transferred to the Air Force.

Storage of nuclear systems at Clarksville was in an underground tunnel and bunker complex at the site, with additional above-ground structures, such as gravel gerties, igloos, and conventional brick structures used variously for maintenance and storage. At Medina, similar storage facilities, bunkers, igloos, and gravel gerties were constructed to support weapons modification, maintenance, and later, disassembly. As noted in the site profile, Medina's mission included performing "stockpile surveillance, modifications, retrofits, and weapon retirements," as well as "inspections for corrosion and replacement of tritium reservoirs" (ORAUT 2006a).

[1] However, the Department of Labor has only approved the site's applicability under Energy Employee Occupational Illness Compensation Program Act (EEIOCPA) for 1958–1966.

Radiological source terms at both modification centers primarily consisted of potential exposure pathways for plutonium, uranium (enriched and depleted), tritium, polonium, and radon. Internal dose would be due to surface particulate contamination from uranium, plutonium, or polonium present on weapons components being handled; depleted uranium (DU) contamination at the burning grounds (from burning of high explosives); airborne tritium from component leaks; and elevated natural radon levels in structures. External dose would primarily consist of the beta, gamma, and neutron fields associated with direct handling of nuclear weapons components, with the nature of these fields varying by weapon type and work activity involved. Additional exposure source terms consisted of occupational medical dose from routine medical x-rays and onsite occupational environmental dose due primarily to tritium emissions.

SC&A conducted data capture visits at Pantex and at Sandia National Laboratory for purposes of locating both classified and unclassified documents pertaining to Clarksville and Medina in August 2010, August 2011, and November 2011. Interviews were also conducted with former workers for both sites. The purpose of these interviews was to obtain first-hand accounts about past radiological controls, personnel monitoring programs, and site operations.

This draft report was prepared at the request of the Advisory Board and covers ORAUT-TKBS-0039, *Site Profile for Clarksville Base Weapons Storage Area and Modification Center with Supplementary Guidance for Medina Base* (ORAUT 2006a). As part of its evaluation, SC&A also reviewed other documents that were considered relevant, including the following:

- Relevant technical information bulletins (TIBs)
- Select documents that were referenced in the Clarksville/Medina Site Profile, particularly the Pantex Site Profile
- Documents contained in the NIOSH Site Research Database (SRDB)
- Documents retrieved from data capture at Pantex and Sandia National Laboratory
- Documented interviews conducted with former Clarksville and Medina workers

This review found that the NIOSH site profile for Clarksville/Medina, while acknowledging the lack of personnel monitoring data and useable site characterization information, did not adequately address the implications and shortcomings of applying what is effectively "surrogate" data from both the Iowa Army Ammunition Plant (IAAP) and the Pantex Plant as bounding dose estimates for operations at the two modification centers. Some of these implications include differing operations, varying time periods, and uncertain dosimetry and work procedures. While it is understood that such comparisons offer the only relevant characterization information available in lieu of actual site-specific data, more substantiation is necessary to justify the broad application of such data (albeit guidance on such substantiation was not available at the time of the initial site profile in 2006; it has since been codified into both NIOSH (OCAS 2008) and Advisory Board (ABRWH 2010) policy statements. Another implication is the carryover of deficiencies and dose reconstructability issues for IAAP and Pantex, as identified during their respective Special Exposure Cohort (SEC) evaluation reviews by NIOSH and the Advisory Board. Findings such as the inability to reconstruct dose with sufficient accuracy for DU at Pantex for 1958–1983, and corresponding Pantex Work Group findings governing dose

reconstructability of thorium exposures, will have clear implications for Clarksville and Medina dose reconstructions that will need to be addressed in the site profile. In terms of scope, SC&A also finds that the site profile fails to include any characterization of potential exposures that may have been associated with "broken arrow" systems that were handled at the two sites, as well as other non-routine handling of damaged systems received from the military.

1.1 SUMMARY OF FINDINGS

A summary of SC&A's primary findings for the Clarksville/Medina site profile is presented below. Detailed discussions of all findings and observations can be found in Section 3.0 of this report, "Vertical Issues."

1.1.1 Finding 1: Unsupported Assumptions for Modeling Depleted Uranium Exposures

The recent Pantex Work Group SEC deliberations and recommendation for the feasibility of dose reconstruction for DU at the Pantex Plant have direct relevance to the site profile for reconstructability of DU at Clarksville/Medina Plants. The systems dismantled there included the W28 and other systems containing oxidized DU. No routine bioassay or limited air monitoring were conducted during the scope and timeframe of operations. No respiratory protection was provided system handlers, and the contamination control program was limited to smearing components and a reported use of a "portable glovebox." A clear exposure potential existed for DU for all workers involved in surveillance and retrofit activities at the Clarksville and Medina plants. The cited dose reconstruction methods contained in the current site profile are not supportable based on more recent research and deliberations by both NIOSH and the Advisory Board.

Potential exposure would have been present when specific weapons systems were first received at Clarksville and Medina. To date, the only timeframe available for maintenance and quality assurance activities (i.e., in-service surveillance) is 1958 for the W28 system. This would encompass the designated EEOICPA period at Medina, but would exclude the earlier years at Clarksville (which received components as early as 1949). Research is continuing by both NIOSH and SC&A regarding the DU exposure potential for systems that predated the W28 that may have contained oxidized uranium components.

An exposure pathway for the burning grounds at Clarksville and Medina existed for DU, given the contamination that likely existed on the high explosives that were burned. The site profile states that air sampling measurements and intakes by the burning ground operators for similar operations at Pantex would be bounding for those at Clarksville (and by association, Medina). SC&A agrees that based on available documentation, the operations were similar and exposures likely representative, and that the recommended dose estimation approach, therefore, would be bounding.

1.1.2 Finding 2: Potential Thorium Exposure Pathway Not Addressed for Medina Plant

At the Medina Plant in the 1960s, weapon system casements containing thorium were handled during surveillance and maintenance resulting in an exposure potential from thorium oxide,

which is not addressed in the Clarksville/Medina site profile. No bioassay program was conducted for workers during these operations, and no air sampling results for thorium have been located.

A thorium contamination source term was acknowledged for Pantex weapons disassembly operations in that site profile [specifically, ORAUT-TKBS-0013-5 (ORAUT 2006c)]. During the Pantex Work Group review of the NIOSH Evaluation Report for Petition SEC-00068, a proposal was made by NIOSH "to determine a ratio of airborne thorium to DU in the workplace" as a means to bound potential airborne thorium exposure based on the 1989 "bounding" DU event (Ruhter et al. 2011). An activity ratio of thorium-232 to DU was calculated to be 0.018 to 1. However, with the subsequent HHS action to approve an SEC class based on the inability to use the 1989 event as a bounding exposure for DU at Pantex, there remains no clear approach to estimate thorium dose from weapons system surveillance, maintenance, and disassembly activities, either at Pantex or at the two modification centers in question.

SC&A does not agree that the NIOSH methodology presented in the Pantex TBD is bounding of potential exposures to thorium or can be supported by available technical information. The NIOSH "check of reasonableness" provided is based on 258 worker urinalysis samples from 1992–1996. However, neither the operational conditions nor samples taken could be representative of the 1960s–1980s era at Pantex, nor the early 1960s at Medina or Clarksville.

1.1.3 Finding 3: Use of Pantex Tritium Dose Experience as Surrogate for Upper Bound for Clarksville/Medina Plants is Questionable

In the absence of tritium monitoring records, NIOSH will apply a 122 mrem/year upper bound dose for production operators at Clarksville and Medina Plants based on the maximum annual dose recorded for similar operators at Pantex during the height of disassembly operations there in the 1970s–1980s timeframe. Similarly, a 1,200 mrem dose is assigned for any production operator, quality specialist, or quality control inspector at Clarksville in 1962, the year a major tritium leak was experienced, based on the 1989 leak at Pantex. These assumptions were made based on an assumption that "disassembly [at Pantex having been] similar to maintenance activities [at Clarksville/Medina]," without any confirmation or evaluation regarding the similarity of the operations involved (disassembly versus surveillance/maintenance). Another question is whether there were confounding differences in the conduct of operations and radiological controls between the mid-1950s at satellite "modification" centers (i.e., Clarksville and Medina) and the peak disassembly era at Pantex, which was later in the 1980s–1990s. While the use of surrogate data in this case is justifiable, a more objective rationale needs to be provided that the Pantex tritium dose data would be bounding for that at Clarksville and Medina.

1.1.4 Finding 4: N/P Ratio Method Cited has been Replaced with Correction Factor for NTA Film Coupled with MCNP-Based Estimate for Missed Doses below 0.5 MeV Energy Threshold; However, Questions Remain

NIOSH finds available neutron dose records "unreliable," and proceeds to apply neutron-to-photon dose (n/p) ratios, which were calculated from Pantex post-1993 dosimeter data "because the work performed at Clarksville Base and the Pantex Plant were similar" (ORAUT 2006a).

From an analysis of Pantex neutron data by Strom (Strom 2004), n/p ratios were determined and a 95th percentile ratio of 1:6 was calculated as an upper bound for direct weapons system handling. A maximum ratio of 1:4 was determined for the early era (1949–1956) when Po-Be initiators were handled. However, during an Advisory Board review of the same n/p ratio approach at another site, the limitations of relying on such ratios, particularly with respect to energy dependent NTA film, were recognized and alternatives were considered.

Accordingly, NIOSH has moved from its former n/p ratio approach to one of estimating neutron dose at Pantex for 1952 to 1977 by applying a correction factor. The correction factor consists of three elements, including (1) correction for the energy threshold of NTA film, (2) angular response of NTA film, and (3) NTA track fading. NIOSH proposes to apply the Monte Carlo N-Particle Transport Code (MCNP) program to determine the fraction of the neutron dose equivalent that would fall below a 0.5 MeV threshold. As noted in its May 18, 2011, memorandum to the Pantex Plant Work Group, SC&A had a number of questions related to the use of MCNP for this purpose, the most important of which was how MCNP would bound neutron dose for the range of systems assembled and disassembled for the period 1951–1991 at Pantex (Fitzgerald 2011a).

For Clarksville/Medina, an additional question is whether the activities at the modification centers would be sufficiently similar such that the Pantex correction factor would be bounding for neutron exposures at the two sites? This issue is particularly important recognizing that an n/p ratio of 1:4 (vs. 1:6 at Pantex) would have been applied for 1949–1956 at Clarksville, given the exchange of Po-Be initiators that was being performed during that early period of the weapons program. (This was not performed at Pantex.)

1.1.5 Finding 5: Inadequate Consideration of Potential Exposures Resulting from Handling of "Broken Arrows"

There are historic accounts of damaged weapon systems being received, examined, and handled at both Clarksville and Medina Plants during their respective operating periods. However, the site profile does not acknowledge these potential exposure sources, nor provide any guidance regarding characterizing and estimating potential personnel doses that may have been received by the workers involved. In terms of non-routine exposures, these sources may be important, in that potential contamination would likely have been greater for workers involved with disassembly, inspection, and handling of damaged components.

1.1.6 Finding 6: Use of Surrogate Pantex External Dose Distribution for Clarksville/Medina "Exposure Groups" Belies Lack of Dose Records in Earlier Years, Dosimeter Uncertainty, and Definitive Operational Information

As noted in the site profile, "external dosimetry records for Clarksville Base are sparse and the connection between the dose records and the worker may be missing..." and that "statistical analysis of doses received at Clarksville cannot be performed with the few records found to date" (ORAUT 2006a). The site profile indicates that a relatively small number of positive results were found after 1960 for Clarksville (a limited database for MHSMC workers was maintained by Pantex after that date). It also notes that "because Clarksville and Pantex were operated by

the same contractor, it is reasonable to assume that identical dosimetry service was provided for both sides."

While the similarity of the source terms involved is acknowledged, SC&A finds the back-extrapolation of surrogate data to unduly "stretch" the enabling criteria later defined by the Advisory Board for such an approach. There is no objective information provided to substantiate that the handling of components during surveillance and maintenance activities in 1949–1958 at Clarksville presented a comparable upper bound dose as the period 1952–1958 at Pantex (240 mrem/yr at 95th percentile for unmonitored workers). In the latter case, plant construction and startup activities dominated the early part of the period in question, which would have limited potential radiation exposure, whereas at the modification centers, actual systems and components were being directly handled from the beginning. Likewise, while very limited records exist for that period, one interviewee cited by NIOSH indicates that the "maximum reported radiation dose was as high as 1 rem/yr from 1949 to 1952 (ORAUT 2006a). While NIOSH has assigned the higher dose value of 1,040 mrem/yr from 1959–1960 at Pantex for Clarksville Group 1 workers, the basis for applying any Pantex annual dose as a surrogate bounding dose for Clarksville and Medina should be re-examined in the context of current surrogate data policies.

SC&A has another concern regarding the site profile's use of Pantex external dose data. In SC&A's 2007 site profile review for Pantex (SC&A 2007), a series of findings were made regarding the reliability of early recorded deep dose (Hp10), how calibration and dosimeter processing were performed by outside vendors, how the current dose estimation methodology assigned exposures from skin contamination, and how missed photon doses for monitored workers should be reflected in the derivation of photon and neutron doses for unmonitored workers. NIOSH agreed to review the external dose findings from SC&A's site profile review in that context and clarify its dose estimation approach keying on these SC&A findings.

1.1.7 Finding 7: Lack of Dose Records and Source Term Characterization Data for Clarksville/Medina leads to Use of Inadequately Justified Surrogate Data

The approach adopted for both Clarksville and Medina plants in the absence of almost all site-specific monitoring data and operational information, particularly for the pre-MHSMC contract period, is to use surrogate data from the Pantex Plant, given the assumed "similarity" of operations. However, no objective information is provided in the site profile as an evaluative basis for this wholesale application of data from another site. The only source of validation is essentially the interview of one former worker, who provides his recollections of operations and radiation exposure conditions for the 1950s and 1960s. While a legitimate case can be made for the similarity of maintenance activities at Clarksville/Medina and full disassembly in later years at Pantex, substantiation of a more objective and evaluative nature needs to be provided in the site profile to warrant such a sweeping use of surrogate data.

1.2 STRENGTHS

The TBD discusses the site, activities occurring at the site, and the characteristics of radiation exposure. It addresses the historic scope of operations, physical layout, job categories, and

various radiological source terms at the respective plant sites. The sections on Occupational Medical Dose, Occupational Environmental Dose, and "Assessing Occupational Internal Dose from Elevated Radon Concentrations" are particularly well done, with detailed tables containing site-specific information. While SC&A questions the basis for applying Pantex exposure data, the tabular display of dose calculation parameters and IREP input parameters, as in Table 5-5, is a clear and effective means to guide dose reconstructors. Given the scarcity of site-specific information (that is not classified) for the two sites, the authors have done a commendable job in presenting a well organized synopsis of dose reconstruction methods that leverage those in similar operations at Pantex (albeit, it is not always clear that Medina, which is only addressed in the appendices, mirrors Clarksville's operations and source terms as closely as inferred in the site profile). The site profile is also candid in its appraisal of the availability and value of dosimetry data for the two sites, making it clear that much of it is has not been located or is of little use in dose reconstruction.

1.3 OPPORTUNITIES FOR IMPROVEMENT

While the TBD provides detailed information concerning the history, scope of activities, and facilities at Clarksville, and to a lesser extent, Medina, there are bases and assumptions that can be strengthened and improved. Recommendations to support these bases and assumptions, as well as completeness of dose reconstruction efforts, include:

- Evaluation of the exposure potential related to early surveillance and maintenance activities at the "modification" facilities, such as Clarksville and Medina, as compared with disassembly operations at Pantex
- Identification of a possible thorium source term for potential exposure consideration at Medina
- Further searches for missing internal and external dose records for the two sites, which would strengthen the site-specific database and reduce the reliance on surrogate dose distributions from Pantex
- Linkage of external dosimetry information with actual personnel identifiers
- Review and inclusion of "broken arrows" and other non-routine sources of exposure

SC&A understands that site profiles are living documents, which are revised, refined, and supplemented with NIOSH technical information bulletins (TIBs) as required to help dose reconstructors. Site profiles are not intended to be prescriptive or necessarily complete in terms of addressing every possible issue that may be relevant to a given dose reconstruction. However, future revisions in the Medina and Clarksville site profiles would serve to mitigate some of the gaps and issues raised in this report.

2.0 SCOPE AND INTRODUCTION

The review of the site profiles for the Median and Clarksville Plants was authorized by the Advisory Board at its February 9–11, 2010, meeting in Manhattan Beach, California, and was conducted between August 2010 and November 2011 by SC&A's team of health physicists and technical personnel. The Pantex Work Group asked that these site profiles be linked to the ongoing Advisory Board SEC review of the Pantex Plant, given the similar operations conducted at these plants and at Pantex, and recognizing that source term information and exposure potential issues would be similar. Therefore, research being conducted within the Pantex SEC review was relevant to SC&A's parallel review of the site profiles for these two plants. The pertinent records reviewed were both classified and unclassified, and were located at various Department of Energy (DOE) record repositories. This review was performed in accordance with *Data Access and Interview Procedure* (ABRWH 2009a), which provides for appropriate onsite coordination and data access protocols in conjunction with the Advisory Board, NIOSH, and DOE, and with *Department of Energy Classification Review of Documents* (ABRWH 2009b), which provides for appropriate security clearance reviews.

2.1 REVIEW SCOPE

This report provides a review of the technical basis document related to historical occupational exposures at Medina and Clarksville, ORAUT-TKBS-0039, *Site Profile for Clarksville Base Weapons Storage Area and Modification Center with Supplementary Guidance for Medina Base* (ORAUT 2006a).

To date, the site profile has not been supplemented by site-specific TIBs, but there are two generic TIBs that provide additional guidance to the dose reconstructor:

- ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures*, Rev. 03-D, December 21, 2005 (ORAUT 2005)

- ORAUT-TIB-0055, *Technical Basis for Conversion from NCRP Report 38 Neutron Quality Factors to ICRP Publication 60 Radiation Weighting Factors for Respective IREP Input Neutron Energy Ranges*, June 5, 2006 (ORAUT 2006b)

SC&A also reviewed other pertinent documents, including those cited on the NIOSH SRDB. SC&A has critically reviewed the Medina/Clarksville TBD, as well as supplementary and supporting documents, against the following three evaluation criteria:

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

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

The review is directed at "sampling" the site profile analyses and data for validation purposes. The review does not provide a rigorous quality control process, whereby actual analyses and calculations are duplicated or verified. The scope and depth of the review are focused on aspects or parameters of the site profile that would be particularly influential in dose reconstructions, bridging uncertainties, or correcting technical inaccuracies.

The Clarksville/Medina site profile document serves as site-specific guidance to support dose reconstructions for EEOICPA claimants. It provides the health physicists who conduct dose reconstructions on behalf of NIOSH with consistent general information and specifications to support their individual dose reconstructions. This report was prepared by SC&A to provide the Advisory Board with an evaluation of whether and how the TBD can support dose reconstruction decisions.

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

2.2 ASSESSMENT CRITERIA AND METHODS

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

2.2.1 Objective 1: Completeness of Data Sources

SC&A reviewed the site profile with respect to Objective 1, which requires SC&A to identify principal sources of data and information that are applicable to the development of the site profile. The three elements examined under this objective are (1) determining if the site profile made use of available data considered relevant and significant to the dose reconstruction, (2) investigating whether other relevant/significant sources are available, but were not used in the development of the site profile, and (3) determining if worker input was considered in the development of the site profile.

2.2.2 Objective 2: Technical Accuracy

Objective 2 requires SC&A to perform a critical assessment of the methods used in the site profile to develop technically defensible guidance or instructions, including evaluating field characterization data, source term data, technical reports, standards and guidance documents, and literature related to processes that occurred at both Clarksville and Medina plants. The goal of this objective is to analyze the data according to sound scientific principles, and then evaluate this information in the context of dose reconstruction.

2.2.3 Objective 3: Adequacy of Data

Objective 3 requires SC&A to determine whether the data and guidance presented in the site profile are sufficiently detailed and complete to conduct dose reconstruction, and whether a defensible approach has been developed in the absence of data. In addition, this objective requires SC&A to assess the credibility of the data used for dose reconstruction. The adequacy of the data identifies gaps in the facility data that may influence the outcome of the dose reconstruction process. For example, if a site did not monitor all workers exposed to neutrons who should have been monitored, this would be considered a gap and thus an inadequacy in the data. An important consideration in this aspect of our review of the site profile is the scientific validity and claimant favorability of the data, methods, and assumptions employed in the site profile to fill in data gaps.

2.2.4 Objective 4: Consistency among Site Profiles

Objective 4 requires SC&A to identify common elements within site profiles completed or reviewed to date, as appropriate. In order to accomplish this objective, the Clarksville/Medina TBD was compared to other TBDs, particularly those referenced in the site profile and those related to frequently visited facilities. This assessment was conducted to identify areas of inconsistencies and determine the potential significance of any inconsistencies with regard to the dose reconstruction process.

2.2.5 Objective 5: Regulatory Compliance and Quality Assurance

Objective 5 requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in 42 CFR Part 82. In addition, SC&A evaluated the TBD for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions.

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 Working Group, petitioners, claimants, and interested members of the public. Prior to and during the resolution process, the draft report is reviewed by the DOE Office of Health, Safety, and Security to confirm that no classified information has been incorporated into the report.

All review comments apply to Rev. 00 of the Clarksville/Medina site profile document, which is the most recently published version. Site expert interviews were conducted with former and

current Clarksville/Medina site workers to assist SC&A in obtaining a comprehensive understanding of the radiation protection program, site operations, and historic exposure experience. The Attachment to this report contains a summary of the collective interviews conducted by SC&A during the course of this review and approved by interviewees.

2.3 REPORT ORGANIZATION

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

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

Based on the issues raised, SC&A prepared a summary list of findings, which is presented in the Executive Summary. Issues are designated as primary findings if SC&A believes they represent deficiencies that need to be corrected and pose the potential for substantial impact on at least some dose reconstructions. Issues can be designated as secondary findings if they simply raise questions, which, if addressed, would further improve the site profile and may possibly reveal deficiencies that will need to be addressed in future revisions of the site profile. Detailed analyses of the primary and secondary findings are provided in Section 3.0 of this report. Section 4.0 summarizes the evaluation of the TBD with respect to the stated objectives.

3.0 VERTICAL ISSUES

3.1 FINDING 1: UNSUPPORTED ASSUMPTIONS FOR MODELING DEPLETED URANIUM EXPOSURES

The Clarksville/Medina site profile cites the Pantex Occupational Internal Dose TBD (ORAUT 2006c, pg. 26) for its source term assumptions for calculating a claimant-favorable dose estimate for disassembly and maintenance workers for which no bioassay monitoring was performed. It assumes that "about half a cup (118 cm^3) of oxidized DU was available for resuspension." By assuming a "density of UO_2 of 11 g/cm^3," an "estimated mass of UO_2 of 1,300 grams of which about 1,140 grams is DU" would be available for resuspension (ORAUT 2006a). It then applies an assumed airborne release fraction and respirable fraction, coupled with other assumptions for ventilation, work day, and breathing rate to derive an assumed "upper bound" intake value of 3.99×10^{-3} grams or 1,600 pCi per weapon disassembled. With an assumed average of "50 surveillance/disassembly operations" conducted by a Clarksville/Medina worker per year (doubled for the "MHSMC years"), a chronic annual inhalation of 80,000 pCi of DU (219 pCi/d) is projected as a "constant upper bound for 1949 through 1957, and twice that rate for 1958 through 1965" (ORAUT 2006c).

The source term of "about a half cup" of oxidized DU being available for resuspension is not apparent in the referenced 2006 Pantex Occupational Internal Dose TBD, nor is any reference to the dose estimation approach cited above. That TBD notes that "from 1961 to 1965, most disassemblies were performed at the Medina and Clarksville plants" and that "before about 1980 nuclear weapon disassembly operations were generally free of contamination" (ORAUT 2006c, pg. 24). It assumes that "it is claimant-favorable to assign unmonitored workers an intake that is the same as that from 1980 to 1993, "because documentation on the number of disassemblies and partial disassemblies and the contamination levels are not specifically available." For that period, the 2006 Pantex Occupational Internal Dose TBD assigns to Production Technicians, RSTs, and Quality Assurance Technicians either 1.3 pCi/day for Type M inhalation or 19 pCi/day for Type S inhalation.

In the updated version of the Internal Dose TBD (ORAUT 2007), it is likewise recommended that the intake values for 1980 to 1993 be used for earlier intakes, observing that the median excretion rate of 0.375 dpm/day of the (then) 34 available DU bioassay samples taken in 1963–1967 compared favorably with the median excretion rate of 0.188 dpm/day, assuming chronic intake for the samples collected in 1990 following the contamination incident that occurred in 1989. As has been noted in SC&A's site profile review for Pantex (SC&A 2007) and in its reviews of the Pantex SEC Evaluation Report (NIOSH 2008), there are a number of concerns with the dose estimation approaches for DU in both the Clarksville/Medina site profile and the referenced methods in the Pantex site profile.

First, the assertion contained in the referenced Pantex TBD that disassembly operations before 1980 were relatively contamination free is apparently based on the assumption that oxidation of the DU in certain systems would take some years before becoming a significant contamination issue during disassembly. As discussed in the Pantex Work Group, interviews with knowledgeable site experts indicate that such corrosion began almost immediately at the time of

fabrication, and would be exacerbated by environmental conditions, such as high humidity. Therefore, the earlier assembly and disassembly activities, such as those at Clarksville and Medina during their operating periods, cannot be assumed to involve minimal contamination. Therefore, the source-term assumption in the Clarksville/Medina site profile of "one-half cup" or 118 cm^3 of DU does not have any clear basis as derived from the Pantex TBD (assuming such a referenced estimate is, in fact, provided in that TBD).

Second, assuming that the current Pantex TBD (ORAUT 2007) approach is substituted for that cited above in the Clarksville/Medina site profile, SC&A has already found, and the Pantex Work Group has accepted, that the back-extrapolation of the Pantex 1989 DU contamination incident bioassay data is not adequate as a means to bound annual DU intakes and doses during disassembly of the W28 system (considered having the highest exposure potential for DU) beginning in 1958. As noted in SC&A's memorandum to the Pantex Work Group on October 11, 2011 (Fitzgerald 2011b), the basis for this conclusion included:

- *NIOSH's finding that the 1984–1989 W28 campaign represents greater exposure potential than prior years is based largely on interviews with several managers who were asked whether they believed that particular event presented a higher exposure potential than for other systems and events from earlier years. However, these were subjective recollections that were not backed up by reliable, comparative data or facts. SC&A's interviews with another like knowledgeable Pantex manager found a different recollection: that the 1989 depleted uranium (DU) contamination incident was not the worst one experienced at Pantex, just the one that finally garnered management's attention; that at least two others may have been worse. No analytic comparisons with earlier reliable bioassay results, air sampling results, or contamination results are available or have been presented by NIOSH to make an objective case, in this regard.*
- *In the Site Profile and Petition Evaluation Reports, the original bases provided by NIOSH for reliance on the 1990 bioassay data set was, variously: because it was the "oldest set of data that provides isotopic determination of uranium alpha activity in urine samples and has significant data to perform statistical analysis;" and because it was the "most comprehensive set of depleted uranium intake data found in the Pantex records," and it represented "large, known high quality, intakes from exposures expected to be above normal operational exposures." SC&A agrees with these earlier NIOSH rationales that the 1990 set is the "best" DU data set available from the standpoint of quality and quantity, just not necessarily the bounding one required for dose reconstruction with sufficient accuracy.*
- *NIOSH's use of relatively contemporary data (1990) to bound potential exposures from 1958–1989 necessitates at least some corroboration that essential attributes of operations can be normalized during this lengthy time period, e.g., number of units handled at one time, personnel handling practices, extent of uranium corrosion, contamination control practices, etc. This has not been accomplished and invalidates the assumed representativeness of exposure pathways in 1990 as compared with those from as much as thirty years earlier.*

While it is noted in the Clarksville/Medina site profile that "portable gloveboxes with HEPA-filtered exhausts" were used to contain oxidized DU when weapons underwent inspections, maintenance, and refurbishment during the Sandia years, it is not known how regularly and effectively such controls were applied, how much contamination was removed and resuspended from cleaning rags that were used to wipe down oxidized and contaminated components, and how much of the DU contamination was in the respirable range. (On this last point, substantial uptake by workers in the 1989 contamination event renders this question less important – the exposure potential via inhalation of DU particles proved significant.)

An exposure pathway for the burning grounds at Clarksville and Medina existed for DU, given the contamination that likely existed on the high explosives that were burned. The site profile states that air sampling measurements and intakes by the burning ground operators for similar operations at Pantex would be bounding for those at Clarksville (and by association, Medina). As noted in the Clarksville/Medina site profile:

> *The estimated intake at Pantex was 130 pCi/d of DU based on the 95th percentile air concentration for the cleanup activities. It is assumed this intake rate applies as well to Clarksville workers involved in burning high explosives. The intake is an upper-bound estimate so the distribution is a constant.* (ORAUT 2006a)

SC&A agrees that the operations were similar and exposures representative; the recommended dose estimation approach using the 95th percentile distribution should be bounding.

In conclusion, the recent Work Group SEC deliberations and recommendation for the feasibility of dose reconstruction for DU at Pantex have direct relevance to the site profile for reconstructability of DU at Clarksville/Medina Plants. The systems dismantled there included the W28 and other systems containing oxidized DU. No routine bioassay and limited air monitoring were conducted during the scope and timeframe of operations. No respiratory protection was provided system handlers, and the contamination control program was limited to smearing components and the reported "portable glovebox." A clear exposure potential exists to DU for all workers involved in surveillance and retrofit, as well as assembly and disassembly activities at Clarksville and Medina Plants, and the proposed dose reconstruction methods contained in the current site profile are not supportable.

3.2 FINDING 2: POTENTIAL THORIUM EXPOSURE PATHWAY NOT ADDRESSED FOR MEDINA PLANT

Thorium was known to figure in historic weapons systems and was a contamination concern in at least four systems dating back to the 1960s (SC&A 2007). While it is stated in ORAUT-TKBS-0013-5 (pg. 35) that "there is no record of disassembly of thorium weapons before 1980, it is clear that there were early modifications of one of the aforementioned systems that was retired in 1966.

At the Medina Plant in the 1960s, weapons system casements containing thorium were handled during surveillance and maintenance resulting in an exposure potential from thorium oxide, which is not addressed in the Clarksville/Medina site profile. No bioassay program was

conducted for workers during these operations and no air sampling results for thorium have been located. As noted in the Pantex site profile, "…information on source terms of weapons containing thorium is classified, as is the number or percentages of weapons that contain thorium." Therefore, source term characterization in lieu of personnel monitoring data or air sampling measurements is problematic.

During the Pantex Work Group review of the NIOSH Evaluation Report for Petition SEC-00068 (NIOSH 2008), a proposal was made by NIOSH "to determine a ratio of airborne thorium to DU in the workplace" as a means to bound potential airborne thorium exposure based on the 1989 "bounding" DU event (Ruhter et al. 2011). An activity ratio of thorium-232 to DU was calculated to be 0.018 to 1. However, with the subsequent HHS action to approve an SEC class based on the inability to use the 1989 event as a bounding exposure for DU at Pantex, there remains no clear approach to estimate thorium dose from weapons system surveillance, maintenance, and disassembly activities, either at Pantex or at the two modification centers in question.

SC&A does not agree that the NIOSH methodology presented in the Pantex TBD is bounding of potential exposures to thorium or can be supported by available technical information. The NIOSH "check of reasonableness" provided is based on 258 worker urinalysis samples from 1992–1996. However, neither the operational conditions nor samples taken could be representative of the 1960s–1980s era at Pantex or the early 1960s at Medina or Clarksville.

3.3 FINDING 3: USE OF PANTEX TRITIUM DOSE EXPERIENCE AS SURROGATE UPPER BOUND FOR CLARKSVILLE/MEDINA PLANTS IS QUESTIONABLE

As noted in the site profile, routine tritium intakes likely occurred at both Clarksville and Medina Plants beginning with the arrival of reservoirs in the mid-1950s. While it is clear that this exposure source was recognized at both locations, and air monitoring and personnel bioassay monitoring performed, limited records have been found. In the absence of such records, NIOSH will apply a 122 mrem/year upper bound dose for production operators at Clarksville and Medina Plants based on the maximum annual dose recorded for similar operators at Pantex during the height of disassembly operations there in the 1970s–1980s timeframe. Similarly, a 1,200 mrem dose is assigned for any production operator, quality specialist, or quality control inspector at Clarksville in 1962, the year a major tritium leak was experienced, based on the 1989 leak at Pantex.

These assumptions were made based on an assumption that "disassembly [at Pantex, having been] similar to maintenance activities [at Clarksville/Medina]," without any confirmation or evaluation regarding the similarity of the operations involved (disassembly versus surveillance/maintenance). One option would be interview information from a worker involved with both types of activities at both Clarksville/Medina and Pantex (a number of workers from the former plant finished their careers at the latter plant). Another question is whether there were differences in the conduct of operations and radiological controls between the mid-1950s at satellite "modification" centers (i.e., Clarksville and Medina) and the peak disassembly era at Pantex, which was later. There is also no consideration given by NIOSH of potential exposures

to chemical forms of tritium other than the gaseous from reactivity over time. While the use of surrogate data in this case is justifiable, a more objective rationale needs to be provided that the Pantex tritium dose data would be bounding for that at Clarksville and Medina.

3.4 FINDING 4: N/P RATIO METHOD CITED HAS BEEN REPLACED WITH CORRECTION FACTOR FOR NTA FILM COUPLED WITH MCNP-BASED ESTIMATE FOR MISSED DOSES BELOW 0.5 MEV ENERGY THRESHOLD; HOWEVER, QUESTIONS REMAIN

In the site profile, NIOSH finds available neutron dose records "unreliable," and proceeds to apply n/p ratios, which were calculated from Pantex post-1993 dosimeter data, "because the work performed at Clarksville and the Pantex Plant were similar" (ORAUT 2006a). From an analysis of Pantex neutron data by Strom (2004), n/p ratios were determined and a 95th percentile ratio of 1:6 was calculated as an upper bound for direct weapons systems handling. A maximum ratio of 1:4 was determined for the early era (1949–1956), when Po-Be initiators were handled. However, during an Advisory Board review of the same n/p ratio approach at another site, the limitations of relying on such ratios, particularly with respect to energy-dependent NTA film, were recognized and alternatives were considered.

Accordingly, NIOSH has moved from its former n/p ratio approach to one of estimating neutron dose at Pantex for 1952 to 1977 by applying a correction factor. The correction factor consists of three elements, including (1) correction for the energy threshold of NTA film, (2) angular response of NTA film, and (3) NTA track fading. NIOSH proposes to apply the MCNP program to determine the fraction of the neutron dose equivalent that would fall below a 0.5 MeV threshold. The input parameters for the MCNP run include:

- Weapons-grade plutonium metal with a spontaneous fission neutron spectrum (average energy of 1.934 MeV)
- RDX Moderator with a thickness of 0, 1, 2, and 4 inches
- A symmetrical 3-meter tall concrete silo with 12-inch thick walls and a 12-inch thick ceiling and floor
- Point source located 1 meter above the floor
- Operator and observer distances of 60 cm and 240 cm, respectively

As noted in SC&A's draft memorandum of May 18, 2011, to the Pantex Work Group (Fitzgerald 2011a), SC&A has a number of questions regarding how MCNP will be applied under the following circumstances:

(1) What happens when the moderator is thicker than 4 inches? Is 4 inches an appropriate thickness for very large weapons? The assumed thickness of the moderator should reflect the range of thickness of actual weapon systems. A sensitivity analysis of HE thickness in its actual range should be conducted.

(2) How is "direct" or "close contact" by workers addressed? The position of the source term in relation to the worker was assumed to be 60 cm (~2 feet) and 240

cm (~8 feet). Interviewed workers indicated the source term was handled directly. In particular, pits were held in workers' laps for cleaning. As observed during the tour, workers now handle pits on stands and on trolleys. With the advancement of time, these stands and transports facilitated less direct contact with the radioactive constituents as compared with direct handling in the earlier years of Pantex assembly and disassembly operations.

(3) How is dosimetry geometry addressed? Work with multiple radiological sources increases the likelihood of posterior-anterior exposure.

(4) How is the presence of multiple units (including those in storage) addressed? Within a cell or bay and RTG storage vaults, shipping and receiving areas, and magazines, the workers (including Material Handlers and security) could be in the proximity of multiple weapons at one time including multiple pits. This could include the same or different units. During worker interviews, it was indicated that 10 components could be worked on at the same time while 10 components were in staging. This situation was more common historically than in more modern times.

(5) What consideration is given to the light elements present in the weapons system and their impact on neutron energy?

(6) What consideration is given to the joint presence of pits and RTGs in the weapon?

(7) How is unit specific angular dependence demonstrated and bounded?

(8) The source term quantity used in MCNP modeling is not specified making validation of the resulting neutron fluence difficult.

(9) The MCNP model focuses on only assembly/disassembly scenarios, and excludes workers handling, storing, inventorying, transporting and receiving, and guarding accountable materials.

Most importantly, NIOSH needs to demonstrate how its proposed parameters for MCNP will result in a bounding neutron dose estimate for the range of systems assembled and disassembled for the period of 1951–1991 at Pantex, as well as the years of operations at Clarksville and Medina. The INRAD reports reviewed by SC&A for different weapons systems show large variability in the neutron dose rate, depending on the distance from the source, the angle of exposure, and the configuration of the particular unit. Where neutron spectral measurements are available in the INRAD reports, the data can be used for benchmarking the results obtained by MCNP for a single component or weapon. It is also of note by SC&A that documents dated 1962 and 1963 discuss new assembly of weapons systems was taking place at Clarksville and Medina, which has not been addressed by NIOSH in the site profile for these sites. This factor raises additional external dose concerns from both photon and neutron doses to workers in the early years of these sites.

For Clarksville/Medina, an additional question is the one raised earlier, i.e., would the activities at the modification centers be sufficiently similar such that the Pantex correction factor would be bounding for neutron exposures at the two sites? This issue is particularly important,

recognizing that an n/p ratio of 1:4 (vs. 1:6 at Pantex) would have been applied for 1949–1956 at Clarksville, given the exchange of Po-Be initiators that was being performed during that early period of the weapons program (this was not conducted at Pantex).

3.5 FINDING 5: INADEQUATE CONSIDERATION OF POTENTIAL EXPOSURES RESULTING FROM HANDLING OF "BROKEN ARROWS"

There are historic accounts of damaged weapons systems being received, examined, and handled at both Clarksville and Medina during their respective operating periods. However, the site profile does not acknowledge these potential exposure sources, or provide any guidance regarding characterizing and estimating potential personnel doses that may have been received by the workers involved. In terms of non-routine exposures, these sources may be important, in that potential contamination would likely have been greater for workers involved with disassembly, inspection, and handling of damaged components.

For Clarksville, interviewees mention a "unit that came from North Carolina" that had been in an accident, which they had subsequently disassembled (SC&A 2010). It was also mentioned that they had handled several damaged systems in transit to Pantex for dismantlement, including those involved in the Palomares accident (SC&A 2010). Apparently, Clarksville received a number of other systems damaged while in the military inventory during its operating period. The history at Medina is less clear from interviews, but should be researched in this regard to ensure appropriate guidance to dose reconstructors when this activity is cited in Computer-Assisted Telephone Interview (CATI) accounts.

3.6 FINDING 6: USE OF SURROGATE PANTEX EXTERNAL DOSE DISTRIBUTION FOR CLARKSVILLE/MEDINA "EXPOSURE GROUPS" BELIES LACK OF DOSE RECORDS IN EARLIER YEARS, DOSIMETER UNCERTAINTY INFORMATION, AND DEFINITIVE OPERATIONAL INFORMATION

As noted in the site profile, "external dosimetry records for Clarksville Base are sparse and the connection between the dose records and the worker may be missing..." and that "statistical analysis of doses received at Clarksville cannot be performed with the few records found to date" (ORAUT 2006a). The site profile indicates that a relatively small number of positive results were found after 1960 for Clarksville (a limited database for MHSMC workers was maintained by Pantex after that date). It also notes that, "because Clarksville and Pantex were operated by the same contractor, it is reasonable to assume that identical dosimetry service was provided for both sides."

For unmonitored workers and those whose records have not been located, NIOSH has categorized them into four groups, as provided in Table 6-4 of the site profile. These groups, defined by exposure potential (extensive work with pits/full-time exposure; entered radiation areas, but did not handle pits; exposure equivalent to 500 hr/yr; infrequent entry into radiation areas; exposure equivalent to 200 hr/yr; and did not enter radiation areas; exposure from environmental sources only), included operators, inspectors, material handlers, and various support workers. The site profile finds that, "operations at Clarksville Base between 1959 and

1965 were similar to those at the Pantex Plant, and MHSMC operated both facilities," and therefore, "statistical information from the Pantex External Dosimetry TBD (ORAUT 2006d) was used to provide guidance for unmonitored workers at Clarksville for the MHSMC years." Accordingly, NIOSH applied the Pantex dose distribution, with an adjustment to replace zero dose readings by MDL/2 for the monthly reporting period. The unmonitored dose value for 1949–1958 is estimated as much lower than that for later years, but is seen as valid for that period of time (the "Sandia years"), because "workers handled components rather than performing intimate handling of pits, so doses would be expected to be smaller than those for MHSMC operations" (ORAUT 2006a). The site profile goes on to state:

> *This is mostly consistent with* [Interviewee]*'s recollections in that* [the Interviewee] *indicated that maximum doses of 1 rem occurred up to 1952 and that all doses were less than 100 mrem after that* [ORAUT 2006a]. *A small number of external dose data have been found for 1949 through 1957. Of those dose records, 28 worker-years of data have been found for nine Sandia workers who did surveillance on nuclear capsules. There were no results for 1949, only two for 1950, and only one each for 1956 and 1957.* (ORAUT 2006a)

The circumstances for the Medina Plant are similar, in that a Pantex external dose database exists for MHSHC workers at Medina for the period April 1959 through 1966, but does not include dose records for Sandia workers at the site before that time (it is noted that none have been located). The database for MHSHC workers has been corrected and recompiled in "Medina Dose Records, 1959–1966" (Martin 2006), with the Pantex dose distribution being applied for Medina as it is for Clarksville, given the similarities of their respective, albeit limited, badge data and similar operations (ORAUT 2006a).

While the similarity of the source terms involved is acknowledged, SC&A finds the back-extrapolation of surrogate data to stretch the enabling criteria defined by the Advisory Board for such an approach. There is no objective information provided to substantiate that the handling of components during surveillance and maintenance activities in 1949–1958 at Clarksville presented as low an upper bound dose as the period 1952–1958 at Pantex (240 mrem/yr at 95th percentile for unmonitored workers). In the latter case, plant construction and startup activities dominated the early part of the period in question, which would have limited potential radiation exposure, whereas at the modification centers, actual systems and components were directly handled. Likewise, while very limited records exist for that period, one interviewee cited by NIOSH indicates that the "maximum reported radiation dose was as high as 1 rem/yr from 1949 to 1952 (ORAUT 2006a). While NIOSH has assigned the higher dose value of 1,040 mrem/yr from 1959–1960 at Pantex for Clarksville Group 1 workers, the basis for applying any Pantex annual dose as a surrogate bounding dose for Clarksville and Medina should be re-examined in the context of current surrogate data policies.

SC&A has another concern regarding the site profile's use of Pantex external dose data. In SC&A's 2007 site profile review for Pantex, a series of findings were made regarding the reliability of early recorded deep dose (Hp10), how calibration and dosimeter processing were performed by outside vendors, how the current dose estimation methodology assigned exposures from skin contamination, and how missed photon doses for monitored workers should be

reflected in the derivation of photon and neutron doses for unmonitored workers. SC&A noted during the May 2, 2011, Pantex Work Group meeting that while these were site profile issues in nature, some of them involved incorrect adjustment factors or values that would affect the accuracy of dose estimates if used as stated. NIOSH agreed to review the external dose findings from SC&A's site profile review in that context. It was agreed in the Pantex Work Group that the SC&A site profile review lays out these concerns in detail, including the implications of a 1980 DOE investigation report that cited deficiencies in how the dosimetry program was administered and with the credentials of the Pantex personnel responsible for that program. NIOSH's response during the May 4, 2010, meeting confirmed that these concerns were not likely of SEC significance and accordingly, NIOSH agreed at that time to follow-up and clarify its dose estimation approach keying on the SC&A site profile review findings.

3.7 FINDING 7. LACK OF ADEQUATE AND COMPLETE SOURCE TERM CHARACTERIZATION AND DOSE RECORDS PRECLUDE USE OF CLARKSVILLE/MEDINA SITE DATA

The site profile acknowledges that "no records were found indicating bioassays were performed or internal dose was assessed for workers at Clarksville Base." It adds that, likewise, "no data were found for air samples or urinalyses." For tritium, it is noted that "no air sample or tritium bioassay results for Clarksville Base were found." For a major accident involving a tritium release, the site profile verifies that "no documentation of the accident or any information about the amount of tritium that might have leaked has been found." For uranium exposure, it is noted that "no records were found indicating that bioassay was performed on workers to determine uptake of DU." For potential DU exposures from the Burning Grounds at Clarksville, "there is no information concerning the amount of high explosives or DU contamination burned at Clarksville…" For external monitoring, the site profile acknowledges that "statistical analysis of doses received at Clarksville cannot be performed with the few records found to date," and that "few dosimetry records have been found for Clarksville; those that have been found do not always identify the person receiving the radiation dose." With respect to the dosimeter badges, themselves, it is noted that "results from film badges were reported on 'cardex' dosimetry records…however, records from these dosimeters have not been found in the SNL archives" (ORAUT 2006a). Finally, the neutron doses of record at Clarksville are unreliable, and dose reconstructors should not use them" (ORAUT 2006a).

The approach adopted for both Clarksville and Medina Plants in the absence of almost any site-specific monitoring data and operational information, particularly for the pre-MHSMC contract period, is to use surrogate data from the Pantex Plant, given the assumed "similarity" of operations. However, no objective information is provided in the site profile as an evaluative basis for this wholesale application of data from another site. The only source of validation is essentially the interview of one individual, who provides recollections of operations and radiation exposure conditions for the 1950s and 1960s. While a legitimate case can be made for the similarity of maintenance activities at Clarksville/Medina and full disassembly in later years at Pantex, substantiation of a more objective and evaluative nature needs to be provided in the site profile to warrant such a sweeping use of surrogate data.

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

The SC&A procedures call for both a "vertical" assessment of a site profile, for evaluating specific issues of adequacy and completeness and a "horizontal" assessment, considering how effectively the profile satisfies its intended purpose and scope. This section addresses the latter objective in a summary manner by assessing:

(1) How, and to what extent, does the site profile satisfy the five objectives defined by the Advisory Board?

(2) How usable is the site profile as a generalized technical resource for the dose reconstructor when individual dose records are unavailable?

(3) Have generic technical or policy issues been identified that transcend any single site profile and need to be addressed by the Advisory Board and NIOSH?

4.1 OBJECTIVE 1: COMPLETENESS OF DATA SOURCES

As noted in Finding 7 above, site-specific data are largely lacking or incomplete. Even for occupational medical x-ray exams, no records were found and no information regarding "x-ray equipment manufacturers, models, examination techniques, and exposure rates for those techniques has been found" (ORAUT 2006a). For the environmental source term characterization, "no records on environmental releases from Clarksville Base have been discovered."

4.2 OBJECTIVE 2: TECHNICAL ACCURACY

As noted above, given that the key dose parameters are founded on upper bound surrogate values from the Pantex Plant (or in the case of occupational environmental doses from tritium, from IAAP), there is little intrinsic accuracy for the dose estimates made for Clarksville and Medina. Arguably, the most accurate source term estimations are radon daughter levels at Clarksville, for which actual building measurements were made in later years. The environmental tritium source term would likely be accurate, given the identical components being handled and similar circumstances of handling at Clarksville and Medina. The uranium and plutonium source terms due to component contamination are largely surmised, based on experience at Pantex and interview accounts, but without comparative analysis of operations or actual systems handled. As noted previously, the use of n/p ratios from Pantex operational experience does not necessarily account for earlier neutron sources at Clarksville, nor does it account for the technical shortcomings of relying on NTA film readings.

4.3 OBJECTIVE 3: ADEQUACY OF DATA

As noted under Finding 7 above, pertinent data sources for internal and external dose are largely lacking for Clarksville and Medina Plants, particularly for the early years of operation before MHSMC assumed operational management of the two sites. NIOSH compensates for the lack of

site-specific source term characterization information and monitoring data by applying that of Pantex, given the similarity of operations. While it is clear that no alternative approach may be possible under the circumstances, it is also clear that the extensive use of surrogate data in this manner entails justification through a comparative analysis of operations, dosimetry, and radiological controls to demonstrate the feasibility of applying surrogate data. This comparison has only been done on a qualitative basis, with an assumption of "similarity" based on the nature of activities and interview accounts. Unless additional monitoring data have been found since the issuance of this site profile, NIOSH needs to provide this additional validation.

Data sources for occupational medical, environmental, and radon sources, while not necessarily available, have more bearing in site-specific conditions and source term characterization, as provided in the site profile. For example, the frequency and type of medical x-ray examinations are based on worker interviews and practices at the time, as normalized at various other sites. Occupational environmental releases are based on identical tritium-containing components and release experience at IAAP. Radon source terms are based on actual measurements inside containments at a later time period for Clarksville. However, even in these instances, the lack of site-specific data creates uncertainties:

- Were the exhaust and filtering characteristics at Clarksville and Medina similar to those at IAAP?
- Were the exposure pathways to workers present in the environs of the two facilities more or less exposed to environmental releases than those at IAAP?
- While radon measurements were made at Clarksville, inside levels were inferred for Medina, based on being "more like" Pantex than Clarksville given soil characteristics and geological concentrations of radium. However, were the physical characteristics of the various buildings at Medina sufficiently different than those at either Pantex or Clarksville to warrant a higher upper bound (e.g., more air-tight, less ventilated structures)?

4.4 OBJECTIVE 4: CONSISTENCY AMONG SITE PROFILES AND OTHER NIOSH DOCUMENTS

SC&A has conducted reviews of methodologies applied for weapons assembly/disassembly facilities at the IAAP and the Pantex Plant, which share operational similarities to the activities conducted at the Clarksville and Medina Plants. The Clarksville/Medina site profile adopts much of the dose distributions and methods from the Pantex TBD, with the exception of the occupational environmental source term for tritium, which comes from the IAAP site profile. The IAAP site profile (ORAUT 2004), in turn, adopted the bounding dose values and approach used in the Pantex TBD for uranium and radon. In these cases, it is not a question of consistency as opposed to adoption of surrogate data in lieu of site-specific information for Clarksville and Medina.

4.5 OBJECTIVE 5: REGULATORY COMPLIANCE AND QUALITY ASSURANCE

SC&A reviewed the site profile with respect to Objective 5, which requires SC&A to evaluate the degree to which the site profile complies with stated policy and directives contained in

42 CFR 82. In addition, SC&A evaluated the site profile for adherence to general quality assurance policies and procedures utilized for the performance of dose reconstructions.

The key issue in this context is what information is being substituted, given the lack of individual monitoring data at Clarksville and Medina, as noted repeatedly in this review. Where individual monitoring data are lacking, three types of "quantitative" information can be applied (42 CFR 82, 2002):

a) Monitoring data from co-workers, if NIOSH determines they had a common relationship to the radiation environment;

b) A quantitative characterization of the radiation environment in which the covered employee worked, based on an analysis of historical workplace monitoring information such as area dosimeter readings, general area radiation and radioactive contamination survey results, air sampling data; or

c) A quantitative characterization of the radiation environment in which the employee worked, based on analysis of data describing processes involving radioactive materials, occupational tasks and locations, and radiation safety practices.

This issue was addressed at the November 2010 Advisory Board meeting in Santa Fe, New Mexico, and this "quantitative" approach in lieu of site-specific data was reaffirmed. While radiological monitoring data are lacking for both Clarksville and Medina, a quantitative source term characterization based on site-specific information is not evident in the site profile. In lieu of this characterization, surrogate data from the Pantex Plant (and for environmental releases of tritium, IAAP) are used. However, where surrogate site data are to be applied, as is the case for Clarksville and Medina, it is incumbent on NIOSH to provide a clear basis for doing so, as prescribed by governing procedures for applying surrogate data. Given that the surrogate data policy was not in place at the time of TBD issuance in 2006, that review remains to be accomplished.

4.6 INCONSISTENCIES AND EDITORIAL ERRORS IN THE SITE PROFILE

Page 20 of 69 of the site profile (Section 4.0, 1st paragraph) states that "complete disassemblies were not performed at Clarksville Base," yet on page 15 of the same document, it points out that disassembly of the weapon pit was required to remove the initiator, which was at the pit center. It is assumed that this should be interpreted as a partial disassembly activity. This should be clarified.

5.0 REFERENCES

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ATTACHMENT 1: SUMMARY OF SITE EXPERT INTERVIEWS

[To be provided at a later date]