ORAU Team **Dose Reconstruction Project for NIOSH** Technical Basis Document for Los Alamos National Laboratory - Introduction	Document Number: ORAUT-TKBS-0010-1 Effective Date: 01/25/2005 Revision No.: 00 Controlled Copy No.:________ Page 1 of 8
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ACRONYMS

EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
DOE	U. S. Department of Energy
LAMPF	Los Alamos Meson Physics Facility
LANL	Los Alamos National Laboratory (as of January 1981)
LANSCE	Los Alamos Neutron Science Center
LAPRE	Los Alamos Power Reactor Experiment
LASL	Los Alamos Scientific Laboratory (1943 to 1981)
ORAU	Oak Ridge Associated Universities
OWR	Omega West Reactor
IREP	Interactive RadioEpidemiological Program
IMBA	Integrated Modules for Bioassay Analysis
TBD	Technical Basis Document
MDA	minimum detectable activity

1.0 INTRODUCTION

Technical Basis Documents and Site Profile Documents are general working documents that provide guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy facility" as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 (42 U.S.C. § 7384l (5) and (12)).

Oak Ridge Associated Universities (ORAU) leads a team, the ORAU Team, to support NIOSH in conducting this major program. This Site Profile represents a specific support mechanism to the ORAU Team concerning documentation of historical practices at the LANL Site. This Site Profile can be used to evaluate both internal and external dosimetry data for unmonitored and monitored workers and serve as a supplement to, or substitute for, individual monitoring data. This document provides a site profile of LANL that contains technical basis information to be used by the ORAU Team to evaluate the total occupational radiation dose for EEOICPA claimants.

This document also provides supporting technical data to evaluate, with claimant-favorable assumptions, the total Los Alamos National Laboratory (LANL) occupational radiation dose that may reasonably be associated with a worker's radiation exposure. The total dose to a worker is determined from his or her exposures to external and internal radiation sources in LANL facilities; to LANL occupationally-required diagnostic x-ray examinations, and to on-site environmental releases. Also included is the dose that may have occurred while the worker was not monitored or the dose may have been missed. Over the years new and more reliable scientific methods and protection measures have been developed. The methods needed to account for these changes are also identified in this document.

The doses are evaluated using the NIOSH Interactive RadioEpidemiological Program (IREP) and the Integrated Modules for Bioassay Analysis (IMBA) computer codes. Information on measurement uncertainties is an integral component of the NIOSH approach. This document describes how the uncertainty for LANL exposure and dose records is evaluated.

2.0 SCOPE

The Site Profile consists of this Introduction and five Technical Basis Documents (TBDs) with supporting tables and attachments. This Introduction provides a summary description of the five TBD sections: Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dosimetry.

The Site Description TBD (ORAUT-TKBS-0010-2) presents a brief description of the facilities and processes that have been used in the development of nuclear weapons since the early 1940s.

The U.S. Department of Energy owns the Los Alamos National Laboratory (LANL) in northern New Mexico. From 1943 to 1981, the site was known as the Los Alamos Scientific Laboratory (LASL). The University of California has managed the laboratory since its establishment in 1943 as part of the Manhattan Project to create the first atomic weapons. LANL's responsibilities have expanded since then to include thermonuclear weapons design, high explosives and ordnance development and testing, weapons safety, nuclear reactor research, waste disposal, waste incineration, chemistry, criticality experimentation, tritium handling, biophysics, and radiobiology.

From time to time, Los Alamos also performed special functions in its backup role to Hanford and Rocky Flats Plant. For example, because of an accident at the Hanford Plutonium Finishing Plant in 1984, plutonium was sent in oxide form to Los Alamos for conversion to metal. In addition, Los Alamos served in a backup for limited periods after major fires in plutonium facilities at Rocky Flats in 1957 and 1969. Today, LANL is the only remaining U.S. pit production facility.

Operations at Los Alamos have taken place in land divisions called technical areas (TAs). The current convention for describing locations at LANL is TA 3 66, where 3 is the area number and 66 is the building number. For TA 3, buildings are identified by letters (for example, TA 3-29 Building 29). Some buildings in TA 3 are identified as SM 66 for South Mesa Site.

The original main technical area (TA-1) processed plutonium and uranium for the World War II devices. TA-1 continued to build and test nuclear weapon critical assemblies on a limited scale until the late 1950s. Other radionuclides handled on a smaller scale compared with plutonium and uranium included americium, polonium, lanthanum, and barium. Starting in 1946, TA-21 (aka DP West and DP East) which was built over several years became the primary plutonium and uranium processing facilities. In 1978, plutonium and uranium operations were moved to TA-55 and the DP sites during the next several years underwent decontamination and decommissioning. The Chemistry and Metallurgy Research (CMR) at TA-3 processed primarily plutonium, uranium, and americium.

Omega Site (TA-2) was used for critical assembly experiments and was the site of the water boilers, Pu Fast Reactor, a.k.a. Clementine (1946-1950), Omega West Reactor (1956-1992), and other reactors for critical experiments that were later moved to TA-18 in 1947. Early reactors, built to confirm critical masses for fissionable materials and to study properties of fission and the behavior of the resultant neutrons, were the forerunners of a variety of reactors designed, and in some cases built and operated, at Los Alamos. While some of these reactors served as sources of neutrons for various nuclear research or for materials testing, other designs related to potential applications in power generation and propulsion of nuclear rockets into deep space. Some of the first significant steps towards controlled nuclear fusion as a power source were taken at Los Alamos, and the plasma thermocouple program explored methods for direct conversion of fission energy to electricity for potential application in spacecraft.

The Los Alamos Neutron Source Center (LANSCE), formerly known as LAMPF located at TA-53 is the largest accelerator at LANL. This unit became operational in 1972 and still operates today. It has been used for a variety of purposes including production of medical isotopes and weapons research. For some periods of time, radioactive airborne emissions have accounted for the largest boundary doses from all of LANL operations. For example, 117,000 Ci of air activation products were released to the environment from LAMPF in 1978. Principal radionuclides released to the air are ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O.

The Occupational Medical Dose TBD (ORAUT-TKBS-0010-3) provides information about the dose that individual workers received from X-rays that were required as a condition of employment. These X-rays included pre-employment and annual chest X-rays during their annual physical exams. The frequency of required X-rays varied over time and also as a function of the worker’s age.

Both the X-ray equipment and the techniques used for taking X-rays have changed over the years covered by this TBD. These factors have been taken into account in determining the dose that a worker would have received from the X-ray. When there was a doubt about the technique used, claimant favorable assumptions have been made to ensure the worker's dose has not been underestimated. The parameters that have been investigated include the tube current and voltage, exposure time, filtration, source to skin distance, the view (posterior-anterior or lateral), and any other factor that could affect the dose received by the worker.

The doses to other exposed organs from the chest X-ray have also been calculated. The calculated dose also takes into account the uncertainty associated with each of the parameters mentioned above. The doses received by the various organs in the body are presented in the tables for convenient reference by the dose reconstructors.

The Occupational Environmental Dose TBD (ORAUT-TKBS-0010-4) applies to workers who were not monitored for external or internal radiation exposure. The environmental dose is the dose workers receive when working outside the buildings on the site from inhalation of radioactive materials in the air, direct radiation from plumes (immersion dose from radioactivity in the air), contact with radioactive particles on the skin, and from direct exposure to radionuclides that were incorporated in the soil.

Exposure to these sources can result in an internal dose to the whole body or body organs from inhaling the radioactive materials or could result in a whole- or partial-body external dose from deposited radionuclides or submersion in the cloud of radioactive material.

The radionuclide concentrations within the Technical Areas at LANL are based on the source terms developed from air monitoring stations and release estimates. Screening studies have demonstrated that the radionuclides ^{3}H, ^{131}I, ^{41}Ar, ^{238}Pu, ^{239}Pu, ^{232}Th, ^{235}U, ^{238}U, and ^{90}Sr contributed the greatest dose to site workers. Other radionuclides evaluated include ^{241}Am ^{11}C, ^{13}N, ^{15}O, ^{137}Cs. The solubility of several of these radionuclides is also presented in this section.

Intakes of radionuclides by workers were assumed to occur near the air monitoring stations from which sampling data was used for estimating air concentrations. These data can be found in Section 4.2 tables (i.e., Tables 4-1, 4-2, etc.). Source emissions, screening results, and air concentrations are presented in Attachment 4A, 4B, 4C, and 4D of this section of the TBD along with source term data and submersion doses.

The external dose to workers from the ambient radiation levels on site and from submersion in a cloud of radioactive material are also presented along with the skin dose from the ^{41}Ar.

The Occupational Internal Dosimetry TBD (ORAUT-TKBS-0010-5) discusses the internal dosimetry program that existed at the Los Alamos National Laboratory. Initially, there was no bioassay program in place to determine the internal dose workers may have received. Blood tests were performed following potential exposures starting in 1944. However, these blood tests were performed for blood count levels related to external radiation exposure rather than the radioactive content of the blood. Therefore, any records of blood counts performed on an individual or mentioned in the claimant interviews will not be directly applicable to internal dose calculations. Many of the exposure histories and work records are not specific about the assigned work areas of individuals. However, when information concerning the work location is available, claimant favorable assumptions have been made to provide the dose reconstructors with the ability to determine a worker's dose in these early time periods. Section 5.2 discusses *in vitro* methods for specific radionuclides. Excreta bioassay methods for determining internal exposures were developed in late 1944 for plutonium (fully implemented in April 1945) and polonium, in 1949 for uranium, and in 1950 for tritium. Only workers with a significant potential for exposure were monitored. Although the number of individuals monitored has increased, not all individuals working at LANL are currently monitored. A survey taken in 1986 estimated that approximately 350 persons had known burdens of plutonium.

Air samples, identifiable with an individual's record, were performed beginning in 1944. These data along with coworker data can be used to estimate doses for unmonitored workers as deemed appropriate by the dose reconstructors.

As the state of the art of radiation detection progressed, whole-body counting for fission products was begun in 1955, chest counting was begun in 1970, and wound counting was performed beginning before 1967. Section 5.3 discusses *in vivo* bioassay methods used currently and historically at LANL.

Later the bioassay program was developed and constantly improved over the years as technology progressed. Electronic databases were developed to maintain urinalysis records. This is discussed along with the various codes used to identify the specific analysis performed. Much of the older monitoring data needed for LANL claims is not in a format that is easily retrieved. NIOSH and ORAU team members are currently developing a new bioassay database for all *in vitro* and *in vivo* results that will allow access to a complete set of records for all available data for a given claimant. Detailed information is provided in the database to assist the dose reconstructors in interpreting data they may encounter in the worker's records.

This TBD discusses the *in vitro* minimum detectable activities (MDAs), the analytical methods and the reporting protocols for the radionuclides encountered at LANL. These aspects of the bioassay program varied over the years for each of the radionuclides evaluated, i.e., plutonium, americium, tritium, uranium, polonium, and fission products. Details of the monitoring techniques and programs are presented in this TBD.

Discussions are provided that present information on the specific radionuclides that the workers in each of the various facilities may be exposed to. Information is also provided for the periods of time when processes changed as a result of improvements in the processing systems.

Interferences that may be encountered in the collection and analysis of bioassay samples are discussed, as are the uncertainties in the bioassay measurements. Information is also presented for workers with no confirmed intakes, but who may have been exposed in the early days when the detection capability and sampling techniques were poor or there were missed samples. Methods for evaluating potential doses that may fall in this category are presented. Additional data are provided for the evaluation of the worst case scenario and for unmonitored workers.

Many tables are provided in this TBD to aid the dose reconstructor in evaluating the potential doses received by workers under all circumstances.

The Occupational External Dosimetry TBD (ORAUT-TKBS-0010-6) discusses the program for measuring skin and whole body doses to the workers. The methods for evaluating external doses to workers have also evolved over the years as new techniques and equipment have been developed. Concepts in radiation protection have also changed. The dose reconstruction parameters, LANL practices and policies, and dosimeter types and technology for measuring the dose from the different types of radiation are discussed in this section. Attention is given to the evaluation of doses measured from exposure to beta, gamma, and neutron radiation. Test results are tabulated for various dosimeters exposed to different exposure geometries and radiation energies.

Sources of bias, workplace radiation field characteristics, responses of the different beta/gamma and neutron dosimeters in the workplace fields, and the adjustments to the recorded dose measured by these dosimeters during specific years are discussed in detail.

There are sources of potential dose that could be missed because of the limitations of dosimetry systems and the methods of reporting low doses. This missed dose is discussed as a function of facility location, dosimeter type, year, and energy range. Attachment E describes the use of the external dosimetry technical basis parameters to facilitate the efforts of the dose reconstructors.