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RECORD OF ISSUE/REVISIONS

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ACRONYMS

EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
DOE	U. S. Department of Energy
ORAU	Oak Ridge Associated Universities
IREP	Interactive RadioEpidemiological Program
IMBA	Integrated Modules for Bioassay Analysis
TBD	Technical Basis Document
PUREX	Plutonium-Uranium Extraction
REDOX	Reduction/Oxidation
MDA	minimum detectable activity

1.0 INTRODUCTION

In enacting the Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICPA), the U.S. Congress officially recognized the hazardous nature of producing and testing nuclear weapons. Under the Act workers, who have developed selected types of cancer or their survivors may be entitled to compensation and medical benefits. This program is administered by the Department of Labor (DOL) Office of Worker Compensation (OWCP). The Department of Health and Human Service's (HHS) National Institute for Occupational Safety and Health (NIOSH) is responsible for determining the individual worker's dose.

Specifically the Act requires the estimation of radiological doses from ionizing radiation received by workers in the nuclear weapons production programs of the various U. S. Department of Energy (DOE) and its predecessor agencies. Methods for implementing provisions of the Act have been promulgated in 42 Code of Federal Regulations Part 82 (42CFR Part 82), "Methods for Radiation Dose Reconstruction Under the Energy Employees Occupational Illness Compensation Program Act of 2000" (Federal Register, Vol. 67 No. 85, Thursday, May 2, 2002).

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 Hanford 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 Hanford 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 Hanford occupational radiation dose that may reasonably be associated with the worker's radiation exposure. This dose results from exposure to external and internal radiation sources in Hanford facilities; to Hanford 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 Hanford exposure and dose records is evaluated.

The Site Profile is divided into five major Technical Basis Documents (TBDs); Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dosimetry. Each TBD has an accompanying attachment that provides the critical data for the specialists reconstructing the doses.

The Site Description TBD (ORAUT-TKBS-0006-2) presents a brief description of the facilities and processes that have been used in the development of nuclear weapons since the early 1940s.

Beginning in 1944 nine reactors were operated to produce plutonium by the irradiation of metallic uranium fuel elements. In addition to the plutonium production, other defense-related radionuclides were experimented with, such as the irradiation of thorium to produce ^{233}U, irradiation of depleted uranium to produce ^{240}Pu, irradiation of neptunium targets to produce ^{238}Pu, and irradiation of americium to produce medical grade ^{238}Pu.

In addition to the production reactors, there were seven physical testing, research and demonstration reactors that were used for: testing fuel elements and fuel configurations; measuring changes due to various types of fuel elements; measuring the thermal impact on fission cross-sections; studying reactor physics technology; performing long-term testing of reactor materials; producing medical radioisotopes; and researching space power systems.

The reactor products had to be separated chemically to be used in the weapons program. These chemical separations were done in the T and B Separations Canyons. The complex chemical and physical processes that were performed in these canyons separated uranium, plutonium, and fission products. Specifically, plutonium was separated from the uranium and fission products by a bismuth phosphate precipitation batch process. Additional processing was done that resulted in the desired final plutonium product. The chemical separations processes changed over the years from the bismuth phosphate precipitation process to the reduction/oxidation (REDOX) process to the plutonium-uranium extraction (PUREX) process.

Both the REDOX and PUREX used organic solvent extraction processes. Each process improved the recovery of uranium, plutonium and other radionuclides such as neptunium.

The U plant was another facility that was used for the recovery of uranium from high level liquid waste from the B and T Plants. The U Plant operated from 1952 until January 1958.

Various other facilities were built to support the separations process for the uranium, plutonium, neptunium, and tritium.

In addition to the production and separations facilities, there were three facilities for fuel fabrication, i.e., the Uranium Metal Fuels Fabrication facility, the Uranium Metal Extrusion facility, and the Fuel Cladding facility. There were also two support facilities; the Uranium Storage and Oxide Burner facility and the Reactor Fuel Manufacturing Pilot Plant.

Overall there were more than 500 facilities on the 600 square mile Hanford site that contributed to the mission of producing plutonium, uranium, tritium, and other radionuclides that contributed not only to the weapons program but also to the space program and the medical profession. These facilities were used for radiation effects studies, nuclear physics research and development, criticality studies, calibrations, radiochemistry development, radiometallurgy, biochemistry, process equipment development, and many other applications.

Waste handling facilities were also present on the site to handle the high- and low-level radioactive wastes produced in the various processes mentioned above.

The Occupational Medical Dose TBD (ORAUT-TKBS-0006-3) 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. All workers received annual chest X-rays from before 1946 through 1959. From April 12, 1959 through January 28, 1983, workers over 50 years of age received annual X-rays, while workers in the 40-49 age group received X-rays biennially, and those under the age of 40 received an X-ray every 3 years. This frequency changed from January 28, 1983 to March 30, 1990, during which time employees over 50 years of age received an X-ray biennially, the 40-49 age group, every third year, and the under 40 age group every fifth year. From March 30, 1990 to April 22, 1997, all employees received an X-ray every fifth year. From April 22, 1997 to the present, X-rays were given only as required.

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, the most 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-0006-4) 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, contact with particles on the skin, and from direct exposure to radionuclides that may have become 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 in Hanford areas are based on the source terms developed by others. Screening studies have demonstrated that the radionuclides ^{131}I, ^{41}Ar, ^{144}Ce-^{144}Pr, ^{137}Cs, ^{239}Pu, ^{103}Ru-^{103}Rh, ^{106}Ru-^{106}Rh, ^{90}Sr, ^{90}Sr-^{90}Y contributed the greatest dose to site workers. The solubility of several of these radionuclides is also presented in this section.

Intakes of radionuclides by workers at specific locations on site were calculated using the RATCHET computer program and an Excel spreadsheet. These data are presented in the tables in Attachment A of this section 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-0006-5) discusses the internal dosimetry program that existed at the Hanford reservation. Initially (1943-1946) personnel monitoring was the responsibility of the Medical Department. At that time, there was no bioassay program in place to determine the internal dose workers may have received. Therefore 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. 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.

This TBD discusses the *in vitro* minimum detectable activities (MDAs), the analytical methods and the reporting protocols for the radionuclides encountered at Hanford. These parameters varied over the years for each of the radionuclides evaluated, i.e., plutonium, americium, curium, tritium, uranium, strontium, promethium, polonium, neptunium, and fission products. This is discussed in great detail in this TBD.

This TBD discusses the *in vivo* MDAs, the analytical methods, and the reporting protocols for the x and gamma ray emitting radionuclides. The *in vivo* measurement equipment and techniques were developed in the late 1950s and have been in routine use at Hanford since 1960. Detailed discussions are presented for the use of the whole body counter, the radionuclides for which it was used, the radionuclide-specific MDAs, and the reporting levels for the various periods during which these parameters changed. Similar discussions are presented for the *in vivo* chest counters, thyroid counters and head counters.

Detailed information is provided in the database to assist the dose reconstructors in interpreting data they may encounter in the worker's records.

Discussions are provided that provide 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, as a result of the detection capabilities available or the sampling techniques used, or because 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 Attachment D to aid the dose reconstructor in evaluating the potential doses received by workers under all circumstances.

The Occupational External Dosimetry TBD (ORAUT-TKBS-0006-6) 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, Hanford 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 potentially 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.