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Remediation Workers Exposure Assessment Feasibility Study At The Department of Energy's Hanford Site Phase I: Report

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Submitted to **National Institute for Occupational Safety and Health (NIOSH) Division of Surveillance Hazard Evaluation and Field Studies (DSHEFS), Health-related Energy Research Branch (HERB)**

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PREFACE

The Department of Health and Human Services (DHHS), subsequent to the implementation of a Memorandum of Understanding (MOU) between the Departments of Energy (DOE) and Health and Human Services, conducts a program of independent occupational and environmental research studies with funding from DOE. Research conducted under this MOU focuses on the examination of health effects that may have resulted from past or current DOE operations. The National Institute for Occupational Safety and Health (NIOSH) within the Centers for Disease Control and Prevention (CDC), DHHS is charged with the conduct of the occupational health research component of this MOU. This document on the DOE Hanford site represents the sixth background site document prepared for the development of the NIOSH project entitled: Exposure Assessment of Hazardous Waste (HW), Decontamination and Decommissioning and Cleanup workers at Department of Energy sites.

The purpose of this document is to assemble information relevant to remediation workers performing Hazardous Waste (HW), Deactivation (De), Dismantlement (Di), and Clean Up (CW) task activities at the DOE Hanford site addressing four primary objectives. The objectives are: identification of remediation workers performing HW, De, Di, and CW task activities anticipated or in progress from the recent past through the next five to 10 years; demographic definition of the workforce performing these activities; identification of the technologies in use or proposed to be used (including considerations regarding health and safety impact upon the workforce); and assembly of summary information for potential chemical, mixed, and radiological contaminant exposures that may be encountered during these processes. The information is drawn predominantly from existing DOE and contractor documents or reports. Other source documents may include those assembled for compliance purposes or to define activities dictated by site Decontamination & Decommissioning, restoration, transition, and cleanup agreements with local, state, and federal authorities or as mandated by DOE. This assembly of information is to support research hypothesis development in the next phase of this project. It will also provide insight and initial data for study feasibility and planning considerations.

The depth and scope of the information assembled provides a midrange presentation of data. Grappling with the needs for substantive information while avoiding premature detail and acknowledging changes in data relevance as time elapses influenced both the character and decisions that went into the assembly of this document. The data collection process limited the need for intensive site involvement. This document is descriptive in nature. The resource documents used to assemble the information are referenced. Information that could not be obtained or which did not exist in an accessible form is also identified.

The intended application of this document is to provide an overview of remediation workers performing HW, De, Di, and CW task activities at the DOE Hanford site. The information is presented in two ways, a text assembly of information with references and a tabular presentation. The intent of this approach is to permit disassembly of the document to facilitate combining similar information for different sites, ideally facilitating an assessment of the feasibility of involving multiple sites in a research study.

The limitations of this document should be recognized. The rate of change in organizational structure, workforce composition, and site activities at the DOE sites involving remediation workers preforming HW, De, Di, and CW tasks appears to be increasing in frequency and complexity. This coincides with a compression of the time frame committed to cleaning up sites by DOE, resource reductions, and an increase in the use of autonomous multi tiered subcontracting. Numerical data is presented as found in the cited references. No verification of summary data provided by the sites or obtained from pre-existing documents has been performed. Obstacles that may become substantial regarding exposure characterization of workforces on site include cessation of centralized data collection systems; introduction of "just in time" contaminant characterization on an as-justified basis; modification of site programs documenting worker exposures; shifts away from a stable, long-term workforce; and changes in the structure of site management. The information presented may also constitute tangential information related to the objectives specified for this phase of the project.

Note: Company names, products or innovative technology does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH).

TABLE OF CONTENTS

Section **Page #**

Acronym List

ACE	(U.S.) Army Corp of Engineers
ACES	Access Control Entry System
ACM	Asbestos Containing Material
ACS	Asbestos Conversion System
ADA	Americans with Disabilities Act
AEC	Atomic Energy Commission
AEDE	Annual Effective Dose Equivalent
AGV	Automated Guided Vehicle
AHCAT	Advanced Hot Cell Analytical Technology
AJHA	Automated Job Hazard Analysis
ALARA	As Low As Reasonably Achievable
AMW	Alkali Metal Waste
ARHCO	Atlantic Richfield Hanford Company
AS/RS	Automated Stacker/Retrieval System
AWF	Aging Waste Facility
BEMR	Baseline Environmental Management Report
BHI	Bechtel Hanford, Incorporated
BMI	Battelle Memorial Institute
BNFL	British Nuclear Fuels, Ltd.
B&W	Babcock &Wilcox Hanford Company Hanford
CAA	Clean Air Act
CAIRS	Computerized Accident / Incident Reporting System
CAP	Craft Alignment Program
CDC	Centers for Disease Control and Prevention
CEDE	Committed Effective Dose Equivalent
CEDR	Comprehensive Epidemiologic Data Resource
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHC	Chlorinated Hydrocarbons
Ci	Curie, unit of quantity of radioactivity
COC	Contaminants of Concern
Cs	Cesium
CSB	Canister Storage Building
CVDF	Cold Vacuum Drying Facility
CW	Cleanup Worker
CWA	Clean Water Act
CWC	Central Waste Complex

D&D	Decontamination & Decommissioning
DDE	Deep Dose Equivalent
De	Deactivation, Decommissioning, Decontamination, and Small Scale Dismantlement Worker Task
DE&S	Duke Engineering & Services Hanford, Inc.
DHHS	Department of Health and Human Services
Di	Dismantlement Worker Task
DIS	Document Information System
DOE	United States Department of Energy
DOE-HQ	United States Department of Energy - Headquarters
DOE-REMS	Department of Energy-Radiological Exposure Monitoring System
DOE-RL	United States Department of Energy - Richland Operations Office
DSITMS	Direct Sampling Ion Trap Mass Spectrometer System
DSM	Division Safety Monitor
DSTs	Double-Shell Tanks
DUN	Douglas United Nuclear
EAFS	Exposure Assessment Feasibility Study
EIS	Environmental Impact Statement
EJTA	Employee Job Task Analysis
ENCO	Enterprise Company
EPA	Environmental Protection Agency
ER	Environmental Restoration
ERC	Environmental Restoration Contractor
ERDA	Energy Research and Development Administration
ERDF	Environmental Restoration and Disposal Facility
EREE	Extended Reach End Effector
ESA	Endangered Species Act
ESAR	End State of Ash Residues (Plutonium Technology Focus Area)
ES&H	Environmental, Safety, and Health
ESPC	Energy Savings Performance Contract
ESS	Epidemiologic Surveillance System
ESW	Enhanced Sludge Washing
ETF	Effluent Treatment Facility
FDH	Fluor Daniel Hanford, Inc.
FDL	Fuels Development Laboratory
FERTF	Fuel Element Rupture Test Facility
FFCA	Federal Facility Compliance Act
FFTF	Fast Flux Test Facility
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FMEF	Fuels and Materials Examination Facility
FPIMS	Facility Profile Information Management System
FRA	Federal Railroad Administration

FS	Facility Stabilization
FY	Fiscal Year
HAMMER	Hazardous Materials Management and Emergency Response Training Center
HAMTC	Hanford Atomic Metal Trades Council
HAPO	Hanford Atomic Products Operation
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCC	Health Care Centers
HCR	Horizontal Control Rod
HEHF	Hanford Environmental Health Foundation
HEPA	High Effeciency Particulate Air Filtration
HERB	Health-related Energy Research Branch
HEW	Hanford Engineering Works
HF	Hanford Facility
HGU	Hanford Guards Union
HIH2	Hanford Industrial Hygiene System (IH Exposure Database)
HLW	High-Level Waste
HMU	Hazardous Material Unit
HOHP	Hanford Occupational Health Process
HOM	HEHF Occupational Medical System
HPC	Hanford People Core
HPT	Health Physics Technician
HRA	Hanford Remedial Action
HRD	Human Resources Services Division
HSC	Health Services Center
HSPR	Hanford Site Performance Report
HSRCM	Hanford Site Radiation Control Manual
HSS	Health Services System
HTLTR	High Temperature Lattice Test Reactor
HTWOS	Hanford Tank Waste Operations Simulator
HW	Hazardous Waste
HWOP	Hazardous Waste Operating Permit
HYDOX	Hydride/Oxidation Process
IAQ	Indoor Air Quality
IBEW	International Brotherhood of Electrical Workers
ICP/MS	Inductively Coupled Plasma / Mass Spectrometer
IH	Industrial Hygiene
IHLW	Immobilized High-Level Waste
IHT	Industrial Hygiene Technician
ILAW	Immobilized Low-Activity Waste
INEEL	Idaho National Environmental and Engineering Laboratory
ISMS	Integrated Environment, Safety and Health Management System
ISS	Interim Safe Storage

JC	Johnson Controls
LAMP	Labor Assets Management Program
LA/MS	Laser Ablation / Mass Spectroscopy
LARADS	Lasar Assisted Ranging and Data Systems
LAW	Low-Activity Waste
LDMM	Leak Detection, Monitoring, and Mitigation
LDR	Land Disposal Restriction
LDUA	Light Duty Utility Arm
LERF	Liquid Effluent Retention Facility
LLBG	Low-Level Burial Grounds
LLMW	Low-Level Mixed Waste
LLRW	Low-Level Radiological Waste
LLW	Low-Level Waste
LMHC	Lockheed Martin Hanford Corporation
MCO	Multi-Canister Overpack
M&I	Management and Integration
MITUS	Mobile Integrated Temporary Utility System
M&O	Management & Operations
MOU	Memorandum of Understanding
MOX	Mixed Oxide
MSDS	Material Safety Data Sheet
MWSP	Mixed Waste Staging Pad
NA	Not Available
NDA	Nondestructive Assay
NDE	Nondestructive Examination
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NIR	Near Infrared
NPL	National Priorities List
OCAW	Oil, Chemical, & Atomic Workers
OIPDS	Occupational Injury and Property Damage Summary
OMSC	Occupational Medical Services Contractor
ORE	Occupational Radiation Exposure Database
ORN	Occurrence Report Number
ORP	Office of River Protection
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers International Union
PAM	Packet Assay Monitor

PAWS	Portable Acoustic Wave Sensor
PCB	Polychlorinated Biphenyl
PCTR	Physical Constants Test Reactor
PFP	Plutonium Finishing Plant
pH	logarithm scale of hydrogen ions, measures acids-bases
PHFO	Plutonium High Fired Oxide
PHMC	Project Hanford Management Contract
PIP	Plutonium Immobilization Plant
PNNL	Pacific Northwest National Laboratory
PPE	Personal Protective Equipment
PRCF	Plutonium Recycle Critical Facility
PTL	Post-Irradiation Testing Laboratory
PUREX	Plutonium-Uranium Extraction
RA	Removal Action
RCRA	Resource Conservation and Recovery Act
RCT	Radiation Control Technician
R&D	Research & Development
REDOX	Reduction-Oxidation
REM1	Radiological Exposure Monitoring Data (Internal Dose Data)
REM2	Radiological Exposure Monitoring Data (Radiation Exposure Monitoring)
REMS	Radiological Exposure Monitoring Data
REX	Radiological Exposure Records
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation / Feasibility Study
RLID	Richland Operations Implementing Directive
RLIP	Richland Operations Implementing Procedure
RMMS	Risk Management Medical Surveillance System
RPE	Respiratory Protective Equipment
RTW	Return to Work
RUTI	Remote Ultrasonic Tank Inspection
RWP	Radiological Work Permit
SAIC	Science Applications International Corporation
SAM	South Alkali Metals
SAW	Surface Acoustic Wave
SCM/SIMS	Surface Contamination Monitor / Survey Information Management System
SDE	Shallow Dose Equivalent
SDE-ME	Shallow Dose Equivalent-Extremity
SDE-WB	Shallow Dose Equivalent-Whole Body (Skin)
SDWA	Safe Drinking Water Act
S&M	Surveillance and Maintenance
SNF	Spent Nuclear Fuel

SNM	Special Nuclear Material
SOW	Statement of Work
Sr	Strontium
SSE	Safe Storage Enclosure
SSO	Site Safety Officer
SSTs	Single-Shell Tank
STCG	(Hanford) Site Technology Coordination Group
STP	Site Treatment Plan
STREAM	System for Tracking Remediation, Exposure, Activities, and Materials
SVOC	Semi-volatile Organic Compound
SW	Solid Waste
SWMU	Solid Waste Management Unit
TEDE	Total Effective Dose Equivalent
TEDF	Treated Effluent Disposal Facility
Th	Thorium
THI	ThermoNutec Hanford, Inc.
TLD	Thermoluminescence Dosimeter
TMS/LRF	Topographical Mapping System / Laser Range Finder
TPA	Tri-Party Agreement
TRI	Training Records Information System
TRU	Transuranic
TRU Mixed	Transuranic Mixed Waste
TRUPACT	Transuranic Package Transporter
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage, and/or Disposal
TTR	Thermal Test Reactor
TWINS2	Tank Waste Information Network System 2
TWRS	Tank Waste Remediation System
U	Uranium
UNH	Uranium Nitrate Hexahydrate
UO_2	Enriched Uranium Oxide
UO_3	(Hanford) Uranium Trioxide Plant
UPR	Unplanned Release
USACE	U.S. Army Corp of Engineers
USTs	Underground Storage Tank
UV	Ultraviolet
VOCs	Volatile Organic Compounds

WAC	Washington Administration Code
WERF	Waste Experimental Reduction Facility
WESF	Waste Encapsulation and Storage Facility
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WM	Waste Management
WMFS	Waste Management Federal Services of Hanford, Inc.
WRAP	Waste Receiving and Processing Facility
WSCF	Waste Sampling and Characterization Facility
ZPPR	Zero Power Physics Reactor

1.0 Abstract

This document entitled **Remediation Workers Exposure Assessment Feasibility Study (EAFS) at the United States Department of Energy's (DOE) Hanford Site** addresses and identifies historic (November 1989 to June 1998), present (June 1998 - June 1999), and proposed (June 1999 and beyond) remediation worker demographics, available radiological and chemical exposure data, worker activities, and demonstrated/deployed Hanford remediation technologies.

In many cases, accelerated clean up schedules are planned for DOE sites across the country with the intention of site remediation within the scope of a ten year period. This worker population, which might encounter hazards that it's predecessors (i.e., production workers) were not exposed to, may vanish upon completion of these tasks. The first phase of this study will address, identify, and summarize documentation regarding this work force for use as a foundation upon which further studies will be built.

For the purpose of this study, only workers with "hands-on" or full involvement/ participation in site remediation activities will be addressed; no administrative support (i.e., office managers, clerical support, etc.), or security support (i.e guards) will be included in the defined remediation worker population. Site remediation efforts undertaken prior to November 1989, when Hanford was not yet included on the National Priorities List (NPL), are not addressed in this study. Workers that utilize buildings or structures which have been "free released" for public or private industry will also not be addressed in this study.

2.0 Purpose

This study involves the assembly of background information necessary to address health hazards to remediation workers involved with waste streams at the Hanford site. The objectives of this study are:

1. Define and characterize the remediation workforce demographically.

2. Determine if exposure characterization data exists and categorize the available exposure information into the following groups: chemical, mixed, and radiological.

3. Identify and catalog historic, in progress, and anticipated remediation worker activities at the site.

4. Identify past, present, and proposed future technologies DOE will use for the work categories.

Information assembled as a result of this study will serve as a catalyst for subsequent exposure assessment and epidemiological studies of this work force.

3.0 Research Approach

3.1 Information Resources

Information utilized to fulfill the objectives of this study was collected from publicly available documents and Hanford site contacts. Publicly available documents were obtained from Internet sites, the National Institute for Occupational Safety and Health (NIOSH), Health-related Energy Research Branch (HERB) Library located at 5555 Ridge Road in Cincinnati, Ohio, and from DOE Public Reading Rooms. (1) Hanford site contacts were identified prior to the research phase of this project.

The External Hanford Home page (2) was the most comprehensive publicly available source of information for the Hanford Site via the Internet. Links to web-site documentation on a variety of topics were also available through this site, however these and other sites constantly changed throughout the research phases of this study presenting new information and deleting old. For purposes of this study, a hard copy of each on-line document was obtained and filed within a reference tracking system. This system is described prior to Section 14.0: Works Cited on page 258.

Other web-sites were also used as references in this document. They included: 1) the Facility Profile Information Management System (FPIMS) (3), 2) Lessons Learned Information Services (4), 3) Office of Environmental Policy and Assistance (5), 4) Technical Information Services (6), 5) Environmental Safety and Health Validated Site Profiles (7), 6) Defense Nuclear Facilities Safety Board (8), 7) Office of Oversight: Environment, Safety and Health Evaluations (9), 8) DOE Environmental Management (10). Other Internet sites not mentioned above were cited in applicable sections of this document.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) driven DOE Public Reading Room at the Hanford site served as a repository for the Administrative Record established under Section 113 (k) of CERCLA. The documents involved in creating the Hanford Administrative Record form the basis for the selection of a particular response (remedial response action) at the site. Section 113 (k) requires that the Administrative Record act as a vehicle for public participation in selecting a remedial response action. The Administrative Record and other DOE Hanford site documents located at the DOE Hanford Public Reading Room were used as references in this report.

NIOSH identified DOE site contacts acted as a liaison between NIOSH contracted study personnel, DOE and Hanford site contractors. These site contacts provided information not available from public information sources, i.e., documents and data sources pertaining to past, present, and proposed remediation worker demographics and exposures which have been historically difficult to obtain through publicly available documents. Specifics pertaining to activities and technologies were also obtained through Hanford site contacts. All information obtained from these resources excluded worker personal identifiers and focused on group or summary data only.

3.2 Exposure Assessment Feasibility Study (EAFS) Format

Information gathered to fulfill the objectives stated previously in Section 2.0 on page 2 is presented using two complimentary approaches. These are descriptive "text / information sections" and "exhibits / tables / figures" which present in an overview fashion the categories and type of information necessary to address each objective identified in the Statement of Work (SOW) for this EAFS.

Text / Information Sections include:

Hanford History and General Site Information (Section 4.0)

A general ecological description of the site is presented to include pertinent site facts, years of operation, site activity during production, a brief description of key facilities, current mission, future disposition of the site, and stakeholder / public involvement.

Hanford Site Regulatory Drivers (Section 5.0)

An overview of legal driving forces behind Hanford clean up is presented in this section. It includes the regulatory agencies and applicable legislation governing Hanford site remediation.

Hanford Waste Stream and Remediation Worker Task Definitions / Task-Based Classification Approach (Section 6.0)

This section is the basis for classification and decision logic in this EAFS. Waste types are described in detail. Remediation worker demographics, activities, potential exposures, and technologies are categorized according to the task definitions defined in this section.

Hanford Site Past, Present, and Proposed Remediation Worker Demographics, Site Safety Management, Remediation Worker Training and Demographic Data Systems (Section 7.0)

This section provides a demographic description of the remediation worker group at the Hanford site and includes, but is not limited to: overall numbers of remediation workers, union information, numbers of workers per contractor, turnover rates, job titles, tasks or categories, number of workers per job task or category, indication of where workers came from [e.g., former site workers, young unskilled laborers, etc.], industry profiles, construction trades, equipment operators, health and safety support / management, and remediation worker training. This section also identifies Hanford databases containing demographic information available for future epidemiology studies.

Hanford Remediation Worker Exposure Information (Section 8.0)

This section presents an overview of Hanford data systems providing information on radiological, industrial hygiene, and occupational medical data and the availability of past, present, and proposed information on the remediation worker population. Names of systems, data fields of interest, company locations, contacts, and database formats are available in this section.

Summary exposure data on the remediation worker population is also discussed in this section along with the use of DOE-HQ (Headquarter) databases accessible on the Internet.

Overview of Integrated Environmental Waste Management at the Hanford Site (Section 9.0)

This section provides an overview of Hanford integrated environmental waste management. The treatment, storage and disposition of each Hanford waste stream is also explained in this section with the use of waste stream disposition flow charts.

Hanford Past, Present, and Future Remediation Worker Activities (Section 10.0)

This section presents 35 independent past, present, and future remediation worker activities by Hanford project. They are described and defined relative to remediation worker task definitions and the physical location of those activities. While each of the 35 independent activities presented identify the major contaminant of concern expected to be encountered at each operation, it is likely that additional, unrecognized contaminants of concern may be encountered with some of these activities. Historic and current remediation worker exposure data was accessed, defined, and delineated into the following groups: chemical (i.e. hazardous), radiological, and mixed (i.e. radiological and hazardous material). Regulatory drivers specific to remediation worker group activities, activity duration, and number of workers per activity are also presented.

Identification of Past, Present, and Future Remediation Worker Task Technologies at the Hanford Site (Section 11.0)

Provided is a listing of 33 independent past, present and proposed future technologies for remediation workers. The list was indexed according to worker task and includes a brief description of technologies used, the number of workers required/proposed to use the technology, exposure risks (remote versus hands-on, Personal Protective Equipment (PPE) requirements, etc.), and perceived advantages and disadvantages of each technology.

Exhibits (Section 12.0)

This section presents, in a variety of formats (i.e. tables, charts), information relative to worker group activities, demographics, technologies, and exposures.

Tables (Section 13.0)

The required tabular format presentation of the data accompanies and summarizes in an overview fashion the material presented in the written text which is given with greater detail, explanatory information, sources, limitations, etc.

Works Cited/References (14.0)

Section 14.0 presents a listing of sources of information from points of contact and publicly available documents. An overview provides an explanation of reference tracking.

Note: Italics script within this document indicates direct quotes from the information resource.

Points of Contact (15.0)

Section 15.0 presents names, addresses, and phone numbers of Hanford site DOE representatives and site contractor personnel that were contacted for information necessary to fulfill the objectives of this study.

4.0 Hanford History and General Site Information

4.1 Site History

[Note: Hanford Site areas and major facilities are in bold type.]

In January 1943, the U.S. Army Corps of Engineers (ACE) selected the Columbia River Basin and the city of Richland, a 640 square mile area in the southeastern part of Washington state, as the location for the nation's first full-sized plutonium production operation.[11: P.1, 12: P.4] The Manhattan District of the Army Corps of Engineers along with the DuPont Corporation developed plans to build production reactors along the Columbia River (**100 Area**); processing plants and associated facilities on a plateau near the center of the site (**200 Area**); and the fuel fabrication buildings, laboratories, and other support facilities near the site's southern boundary (**300 Area**). (The site's southern boundary is also collectively referred to as the South 600 Area.)

The production of plutonium at the Hanford Engineering Works (HEW) involved three steps: *1) fuel fabrication, in which uranium was fabricated into fuel elements in the **300 Area** of the site; 2) fuel irradiation, in which fuel elements were irradiated in nuclear reactors in the **100 Area**, converting small amounts of the uranium fuel to plutonium; and 3) chemical processing, in which the irradiated fuel elements or "slugs" were chemically processed to extract the plutonium in the **200 Area** facilities.* [12: P. 5]

Uranium fuel fabrication processes took place in the **313 Metal Fabrication Building** and the **314 Press Building**. The 313 Building was used to machine uranium rods to desired dimensions for use in Hanford's reactors, 'jacket' the sized fuel elements, and test the jackets for proper bonding and sealing. The 314 Building contained equipment to extrude raw uranium billets into rods and perform final tests on the jacketed elements.[12: P. 5]

In the 1940s and 1950s, eight reactors (**Reactors F, H, D, DR, K-East, K-West, B and C**) were built in the Hanford **100 Area** for increased fuel irradiation purposes. **N Reactor**, which became operational in 1963, was used for both plutonium production and power production. In addition to the production reactors, two major test reactors were built: the **Plutonium Research Test Reactor** located in the **300 Area** (**Building 309**), and the much larger **Fast Flux Test Facility (FFTF)** located in the **400 Area**. These test reactors were used in fuel materials production, isotope production, and power research.[12: Pp. 5-6] Other **300 Area** test reactors were also constructed during Hanford production periods. They included the **Physical Constants Test Reactor (PCTR)** and **Thermal Test Reactor (TTR)** located in the **305 B Building**, the **High Temperature Lattice Test Reactor (HTLTR)** in **Building 318**, the **Fast Reactor Thermal Engineering Facility** in the 335 **Building**, the **Core Segment Development Facility** located in the **336 Building**, the **Plutonium Recycle Critical Facility** (PRCF) and the **Fuel Element Rupture Test Facility (FERTF)** located near the **309 Building**.[13: P.9]

After fabricated fuel had been irradiated in the production reactors, fuel slugs (spent fuel) were chemically separated in the ***200 Area****. The 200 Area processing buildings included the* ***Plutonium-Uranium Extraction Plant (PUREX)****, where spent fuel was processed to extract plutonium and unused uranium; the* ***Uranium Oxide Plant****, where uranium nitrate was converted to uranium oxide powder for recycling; and the* ***Plutonium Finishing Plant (PFP)****, where plutonium metal was fashioned. In addition, Hanford used the* ***B Plant*** *for bismuth phosphate processing and separation and purification of cesium and strontium for encapsulation,* ***C Plant*** *(Hot or Strontium Semiworks) for separation and process development;* ***S Plant*** *(or* ***Reduction-Oxidation Plant (REDOX)****), for separation through solvent extraction;* ***T Plant*** *for bismuth phosphate process separation and subsequent use as a decontamination and repair facility; and* ***U Plant*** *for chemical separation and processing.*[12: P. 6]

Beginning in 1964, the Department sharply curtailed plutonium production in response to the nation's changing defense needs. By 1971, eight of the nine production reactors had been shut down and by 1972, all related fuel separation facilities, including ***PUREX****, had ceased operations. In the early 1980s the Department briefly restarted* ***PUREX*** *and the* ***Uranium Oxide Plant****; however, these plants are now permanently shut down.*[12: P. 6]

The chemical processes required to extract the plutonium from irradiated uranium fuel generated millions of gallons of radioactive chemical waste. About 60 million gallons of this waste is stored at Hanford's **200 East** and **200 West** areas in **177 large underground storage tanks (USTs)**. The tanks are grouped into 18 tank farms containing either **single shell tanks (SSTs)** or **double shell tanks (DSTs)**. The 149 SSTs were constructed of a single carbon-steel wall (shell) encased in concrete. *The SST design was discontinued after 1964 with the discovery that 66 of these tanks had leaked a total of one million gallons of contaminated liquid into the ground.* Leaks have not been detected in the 28 DSTs constructed between 1968 and 1986. [13: P.7]

As a result of the reduction of plutonium production activities, the resources and capabilities of the Hanford Site were refocused toward developing nonmilitary applications of nuclear energy. In the 1970s, the Energy Research and Development Administration (ERDA), a predecessor to the Department of Energy (DOE), emphasized energy research programs, including solar, geothermal, and advanced systems; fossil energy; national security; conservation; energy policy analysis; and resource assessment. During this period, a full-size advanced test reactor (located at the Idaho National Engineering and Environmental Laboratory (INEEL)), *and the* ***Fast Flux Test Facility (FFTF)*** *were used for large-scale nuclear fuels testing in support of nuclear energy research.*[12: P. 6]

In 1989, the defense-related plutonium production mission at Hanford was replaced by the environmental management mission. The site's maintenance and operations contractor, Westinghouse Hanford, was also forced to switch company missions and planning goals. *The Hanford Site was placed on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund).* [12: P. 6] The Tri-Party agreement was also established in efforts of clean up. (Note: regulations governing the environmental mission at the site are described in Section 5.0 on page 16.)

Table 4.1 A summarizes the above information and presents Hanford primary contractors, responsible governmental agencies, site objectives, and milestones accomplished throughout Hanford's operational and environmental missions.

Table 4.1 A: Hanford History Identifying Primary Site Contractors, Responsible Governmental Agencies, Primary Objectives and Milestones Accomplished 1943 to June 1999

Date	Contractor	Contractor Objectives / Historic Milestones
1943	Manhattan District of the Army Corps of Engineers (ACE), DuPont Corporation Site Name: Hanford Engineering Works (HEW)	Construction (B,D,F Reactors, T,B,U Plants, and 64 USTs), Operations Worked to Produce Trinity Bomb Test at Alamogordo, NM and Bomb Dropped at Nagasaki, Japan.
1947	General Electric Company, ACE Site Name: Hanford Works (HW)	Second Post War Expansion (Construction of H, D and DR Reactors, PFP, C-Plant, REDOX, 42 USTs)
1950	General Electric Company, ACE Site Name: Hanford Works (HW)	Third Post War Expansion (Addition of Research Labs, C Reactor, 18 USTs, U Plant)
1953	General Electric Company, ACE Site Name: Hanford Atomic Products Operation (HAPO)	Construction of KE, KW Jumbo Reactors, PUREX, 21 USTs
1956	General Electric Company, ACE Site Name: Hanford Atomic Products Operation (HAPO)	Peak Production Period (1956-1964)
1965	Isochem, Douglas United Nuclear (DUN), ACE Site Name: Hanford Site	Chemical Processing Operations, Reactor Operations and Fuel Fabrication
1967	Atlantic Richfield Hanford Co. (ARHCO), Douglas United Nuclear (DUN), ACE Site Name: Hanford Site	Chemical Processing Operations, Reactor Operations and Fuel Fabrication
1977	Rockwell Hanford Operations, ERDA Site Name: Hanford Site	Chemical Processing and Reactor Operations
1987	Westinghouse Hanford Co., DOE Site Name: Hanford Site	Reactor Operations, Chemical Processing, and WM (N Reactor Stops in 1987)
1989	Westinghouse Hanford Co., DOE Site Name: Hanford Site	TriParty Agreement Implemented
1996	Fluor Daniel Hanford, Bechtel Hanford, DOE Site Name: Hanford Site	Management and Integration (M&I), Environmental Restoration (ER)

4.2 Current Hanford Environmental Status

The following excerpt describes the magnitude of Hanford's environmental contamination.

The DOE stores contaminated material, scrap, and liquid byproducts in **approximately 2,200** *locations at the site, including high-level and low-level liquid waste in storage tanks in the 200 Area. Environmental contamination is found in surface and subsurface soils. In addition, liquids (principally liquid low-level waste effluents) have been discharged into the soils and have contaminated about 520 square kilometers (200 square miles) of ground water. While much of this contamination is below drinking water standards, 11 contaminants (tritium, carbon tetrachloride, chromium, nitrates, cobalt, strontium, cesium, technetium, iodine, plutonium, and uranium) exist at levels that exceed these standards at various locations across the site.*[12: Pp. 6-7]

Prior to 1970, solid waste contaminated with hazardous chemicals, plutonium, or low-level waste was disposed in burial trenches. The burial trenches continued to be used for waste with hazardous chemicals from 1970 to 1986. After 1970, most of the plutonium-contaminated waste was placed into partially lined underground vaults or surface trenches designed for easier retrieval. Hanford also has sites in which packaged, low-level radioactive and hazardous waste is buried. These packages include drums, boxes, and bags.[12: P. 7]

The chemical processing of irradiated fuels generated the largest volume of Hanford's waste. The process waste waters were divided into high-level radioactive alkaline slurries containing heavy metals, organic and inorganic salts, uranium, plutonium, and mixed fission products stored in underground waste tanks, and low-level waste streams, such as cooling water, condensates, and other similar waste discharged to the ground.[12: P. 7]

Contaminated facilities located in the 100, 200, 300, 400, and 1100 areas consist of shutdown production and test reactors, chemical separation and processing plants, waste-handling facilities, and various support structures. These facilities are contaminated with radioactive and hazardous materials as a result of the various processes associated with fuel fabrication, fuel irradiation, and chemical processing, as described previously.[12: P. 7]

4.3 Current Facility Overview

The Hanford site currently covers 560 square miles of a shrub-steppe ecosystem and excludes the city of Richland which has a population of more than 35,000. Two cities nearby, Kennewick and Pasco, have approximately 70,000 people between them. Collectively the cities are known as the Tri-Cities. [11: P.1]

Nearby natural resource areas of interest include the Saddle Mountain National Slope, Gable Mountain, the Fitzner-Eberhardt Arid Lands Ecology Reserve, and the White Bluffs along the Columbia River.

For an understanding of Hanford areas, specific facilities and current Hanford waste site placement, refer to the maps located in the Appendix that accompanies this report. These maps present the entire Hanford site and also show detail of the **100 Areas**, the **200 Areas**, the **300 Area**, **400 Area**, and **1100 Area**.[14]

The 100 Areas

The 100 Areas are located at the north end of the site along the Columbia River and include nine former production reactors named reactors F (in the **100F Area**), H (in the **100H Area**), D and DR or D-Replacement (in the **100D-DR Area**), K-East and K-West (in the **100K Area**), B and C (in the **100BC Area**), and N (in the **100N Area**). All Reactors are scheduled for 'safe-storage' except the B Reactor which will be preserved as a museum. C-Reactor is the first reactor to under-go 'safe-storage' involving numerous technology and activity demonstrations. (These technologies and activities will be presented later in this document.) As of January 1999, C Reactor is near completion. F Reactor is scheduled to begin 'safe-storage' sometime in 1999 or early 2000. Other priorities the 100 Areas include clean-up of the K-Basins that currently contain about 2,300 tons of spent nuclear fuel from N Reactor operations. [11: Pp. 8-11]

The 200 Areas (200-East and 200-West)

As mentioned previously, the 200 East and West areas housed Hanford's processing facilities including **PUREX**, the **Uranium Oxide Plant**, the **Plutonium Finishing Plant (PFP)**, **B Plant**, **C Plant**, **S Plant** (or **Reduction-Oxidation Plant (REDOX)**), **T Plant**, and **U Plant**. The functions of these facilities have changed over time due to the site's environmental mission. Currently, the 200 areas also house a variety of facilities specifically established for the clean-up of the Hanford Site.

Table 4.3 A presents each 200 Area facility and current function or status as of May 1999. Some of these facilities will be described later in this document in greater detail. Waste types and regulation terminology in this table will also be described in greater detail in Sections 5.0 and 6.0.

Table 4.3 A: 200 Area Facility Names and Current Functions/Status as of May 1999 [11: Pp. 12-20]

Area	Name of Facility or Site within 200 Area	Functions and Primary Purpose
200-W	Facilities for Tank Waste Remediation System Project (TWRS) (This facility is just outside the 200-W area)	Office Buildings for the TWRS Project which is responsible for the management and eventual disposal of high level radioactive waste in 177 HLW USTs
200-W	Waste Sampling and Characterization Facility (WSCF)	Processes QA samples and routine process control samples that contain hazardous chemicals, paint, lead, asbestos, and low level radioactive waste. WSCF ensures that the liquid effluent plants are operating within the permit requirements.
200-W	T Plant and TRU Waste Storage and Assay Facility	Functions as a decontamination facility where radioactive and hazardous solid wastes are processed and packaged. Storage of TRU Waste.

Table 4.3 A (continued): 200 Area Facility Names and Current Functions/Status as of May 1999 (11: Pp. 12-20)

Area	Name of Facility or Site within 200 Area	Functions and Primary Purpose
200-W	Waste Receiving and Processing Facility (WRAP)	Major solid waste processing facility. Processes (inspects, treats, and repackages) low-level, mixed, and TRU waste for permanent disposal.
200-W	Low-Level Burial Ground (LLBG)	Low-level radioactive waste burial ground
200-W	Mixed Waste Disposal Landfills	Lined disposal trenches for mixed waste
200-W	Central Waste Complex (CWC)	Waste storage within 20 warehouses and 35 modules
200-W	Burial Trenches (Solid Waste Burial Grounds)	Interim storage for TRU waste. Storage of failed pieces of equipment, tools, laboratory waste, and dry waste contaminated with radioactivity.
200-W	Plutonium Finishing Plant (PFP)	Currently being deactivated. Plutonium will be placed in 'safe-storage' at PFP's shielded vault.
200-W	U Plant	Currently awaiting deactivation.
200-W	UO_3 Plant	Currently cleaned out. Will be decommissioned.
200-W	242-S Evaporator	Shut-down. Offices and change rooms are still in use.
200-W	REDOX	Currently awaiting deactivation.
200-W	222-S Laboratory (Hot Cells)	Characterizes high-level waste samples for the environmental and tank waste programs.
200-W	Environmental Restoration and Disposal Faciltiy (ERDF)	Receives wastes only cleaned up at CERCLA Sites.
200-W	Single Shell Tank Farms: T Tank Farm, U Tank Farm, S and SX Tank Farms	83 SSTs in the 200-West Area
200-W	Double-Shelled Tank Farm: SY Tank Farm: 101-SY, 102-SY, 103-SY	3 Double-shelled one-million gallon USTs for high level waste storage in the 200 West Area.
200-E	Chemical Engineering Laboratory (200-E)	Used to build prototypes for processing plants and waste-handling facilities. Non-radioactive.
200-E	Canister Storage Building	Long term storage of Spent Nuclear Fuel and interim storage of Immobilized High Level Waste.
200-E	Plutonium-Uranium Extraction Plant (PUREX) (200-E)	Canyon building currently deactivated. 41 ancillary building are awaiting deactivation.
200-E	242-A Evaporator (200-E)	Receives radioactive liquid wastes pumped through underground piping from DSTs and boils off the water. Concentrated waste returns to the tanks.
200-E	Liquid Effluent Retention Facility Basins (LERF) (200-E)	3 Storage basins or trenches for process condensate
200-E	200 Area Effluent Treatment Facility (200-E)	Receives coolant liquids, evaporator condensate, ERDF settled rainwater, contaminated groundwater, and other waste streams.

Note: Shaded areas indicate currently (May 1999) in development and construction phases.

Table 4.3 A (continued): 200 Area Facility Names and Current Functions/Status as of May 1999 (11: Pp. 12-20)

Area	Name of Facility or Site within 200 Area	Functions and Primary Purpose
200-E	Treated Effluent Disposal Facility	Disposal Area for treated effluent
200-E	Vitrified Low-Level Disposal Facility	Storage of vitrified low level waste
200-E	High-Level Waste/Low-Level Waste Vitrification Plants.	Proposed treatment of High Level and Low Activity Waste from the 200 East and West Tanks
200-E	Submarine Reactor Compartment Disposal Site (200-E)	Storage / disposal of reactor compartments from decommissioned, defueled Navy submarines
200-E	B Plant (200-E)	Undergoing deactivation. Accepts and stores low-level liquid waste from WESF.
200-E	Waste Encapsulation Storage Facility (WESF) (200-E)	Stores approximately 1,925 capsules containing salt forms of cesium and strontium in deep pools of water
200-E	DSTs (PUREX Tank Farms AX, AY, AZ, AP, AN, AW) (200-E)	25 Double Shelled USTs. Storage of high-level liquid waste.
200-E	SSTs (PUREX Tank Farm A, B-Plant Tank Farm)	66 SSTs

Note: Shaded areas indicate currently (May 1999) in development and construction phases.

The 300 Area (11: P.3)

The 300 Area is currently comprised for the most part of the Pacific Northwest National Laboratory (PNNL) operated by Battelle Memorial Institute. These privately owned buildings and equipment are run by government-owned resources. Battelle is an independent research and development institute. PNNL/ Battelle supports DOE missions and is a science and technology leader at the site. Activities at PNNL are directed at resolving environmental issues such as waste cleanup.

The 300 Area also contains several cleanup projects including: 1) deactivating the **313 and 333 Buildings**, 2) deactivating the **300 Area Fuel Supply Facilities** which contain special nuclear material primarily in the form of finished uranium fuel elements, and 3) deactivating the **324 and 327 Facilities** which were used to examine and test irradiated materials, primarily reactor fuel elements. These projects are currently in progress.

The 400 Area

The **Fast Flux Test Facility (FFTF)** and several other laboratory facilities are located in the 400 area.[12: Pp. 15-16] Currently, the FFTF is being maintained in a standby condition while it's future as a possible tritium producer is evaluated.[15]

The 1100 Area

Facilities offering services and support to the Hanford site are located in the 1100 Area and operated by Dyn Corp Tri Cities Services, a current subcontractor at the site. Facilities include the **Central Warehouse** and bus operations in the **1170 Building**.[11: P.2]

4.4 Current and Future Mission

The current and future mission of the Hanford Site is to manage the facilities and inventories of special materials, remedy the environmental contamination caused by decades of activities related to the production of plutonium, and support national research efforts in the areas of environmental and other sciences. The site has been under the direction of Office of Environmental Management since 1989, and its efforts are now specifically focused on minimizing, processing, and storing the backlog radioactive and hazardous waste generated from 1943 through 1993; managing spent nuclear fuels and special nuclear material; decontaminating and decommissioning facilities no longer required; and developing technologies to clean up Hanford and other environmentally contaminated sites. Efforts also include remediating the site, to the extent practical, to its former state, and managing the site as a national resource. The natural and cultural resources of the site will be managed in a manner consistent with Tribal rights. All existing facilities will be sold for salvage, decommissioned, or converted for commercial use.[12: P. 4]

4.5 Future Use [12 Pp. 7-8]

The DOE will develop a Comprehensive Land Use Plan for the Hanford Site to identify existing and planned land uses. The DOE will develop this plan with Hanford stakeholders. Decision of specific uses will not be complete for many years. Therefore, the programs described below reflect current assumptions about future uses for the major areas of the Hanford Site.

The Columbia River corridor and the North Slope sections are currently classified as 'Recreational'. The surface, subsurface, and ground water associated with the North Slope have already been remediated.

The Fitzner-Eberhardt Arid Lands Ecology Reserve is classified as 'Open Space with Restricted Access'. The surface and subsurface of the Ecology Reserve, including Rattlesnake Mountain, have also been remediated.

The 100 Area is currently classified as 'Open Space with Restricted Access'. The area along the southern shoreline of the Columbia River will be restored to a condition compatible with uses such as recreation, wildlife preserves, and historical/cultural preservation. The Environmental Management program will remove contamination in surface and subsurface soils, as well as contamination that threatens the Columbia River.

The land encompassing the current 300, 400, 1100, and 3000 (the **3000 area** includes the old U.S. Army barracks) areas is assumed to be held for 'Industrial' use, as are the sites already reserved for commercial power generation plants, the **Laser Interferometer Gravitational-Wave Observatory**, and the **Hazardous Materials Management and Emergency Response Training Center (HAMMER)**. Remediation of the 1100 Area has been completed. The 300 and 400 Areas will be remediated to standards compatible with 'Industrial' use.

The Central Plateau (200 Area) will be designated as 'Controlled Access' and parts of this area will be held exclusively for the disposal, containment, and management of waste. The DOE will maintain this area in a stable, safe condition for the foreseeable future. Surface and subsurface contaminants will be contained in place, waste disposal areas will be contained and controlled, and major facilities will be entombed in place.

Use of the ground water all around the site will be classified as 'Restricted', and the DOE will maintain control because its use could affect the behavior of ground water in other parts of Richland.

4.6 Hanford Stakeholders and Public Involvement [16: Pp.1-7, 253,254]

The Department of Energy Richland Operations Office (DOE-RL) maintains relations with the community and stakeholders through the site's Office of External Affairs. The following is a list of local groups involved in the debate and conduct of Hanford issues. For a detailed list of the Citizens Advisory Committee on Public Health Service Activities and Research at DOE Sites: Hanford Health Effects Subcommittee as of July 1, 1999, refer to Exhibit 12.1 on page 166 through 169. [254]

1) Local and Regional Public Health
2) Hanford Work Force (Central Building and Construction Trades Council, Hanford Atomic Trades Council)
3) Non-Union, Non-Management Hanford Employees (Fluor Daniel Hanford, Pacific Northwest National Laboratory)
4) Local Government Interests (City of Richland (and West-Richland), Benton-Franklin County Regional Council, City of Pasco, City of Kennewick, Grant County)
5) Oregon Hanford Waste Board
6) Washington State University
7) Tribal Governments (i.e. Nez Perce Tribe)
8) Regional Citizen, Environmental and Public Interest Organizations (Columbia River United, Hanford Watch, Hanford Education Action League, Heart of America Northwest, Washington League of Women Voters)
9) State of Oregon
10) Public at Large (Washington State, Oregon State)
11) Local Business Interests (Tri-Cities Industrial Development Council)
12) Local Environmental Interests (Audubon Society, Columbia Conservation League) [16]
13) Hanford Health Effects Subcommittee
14) Hanford Downwinders
15) Hanford Health Information Network [253,254]

5.0 Hanford Site Regulatory Drivers

The DOE-RL operates the government-owned, contractor-managed Hanford facility. Most remaining operations are dedicated to stabilization, treatment, safe storage, and containment of waste streams at the site. All removal and remediation activities at Hanford must be in accordance with the following applicable agreements and acts:

5.1 Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement, TPA)

In 1989, the DOE, the EPA, and the Washington State Department of Ecology entered into the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement or TPA) which was an agreement established to reach compliance for major waste streams managed at the Hanford Site. The agreement currently provides a schedule (milestones) for site activities and focuses on backlog waste that must be addressed by the Hanford Integrated Waste Management (WM) program. (12: P. 6)

All DOE sites must develop a site treatment plan (STP) according to the Federal Facility Compliance Act (FFCA), however the TPA requires a report on land disposal of restricted mixed wastes (called the LDR Report). The LDR report meets the guidelines for a STP. [17, 18: P. 2]

5.2 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [19]

The CERCLA (42 U.S.C. 9601-9675, enacted in 1980 and amended in 1986) established a program to *ensure that sites contaminated by hazardous substances are cleaned up by responsible parties or the government. The Act primarily covers waste cleanup of inactive sites.* The Washington State Department of Ecology has also implemented the state's more stringent regulations through the Washington Administrative Code (WAC) 173-340: Model Toxics Control Act - Cleanup in coordination with the Tri-Party Agreement. [20: P.16]

Hanford Compliance:

Preliminary assessments conducted for the Hanford Site revealed ***approximately 2,200*** (this number is dynamic in nature) *known individual waste sites where hazardous substances may have been disposed of in a manner that requires further evaluation to determine impact to the environment.*

The DOE is actively pursuing the remedial investigation/feasibility study (RI/FS) process at some of the 72 operable units on the Hanford Site. The operable units currently being studied were selected as a result of Tri-Party Agreement negotiations.

5.3 Emergency Planning and Community Right-To-Know Act [19]

This Act requires that the public be provided with information about hazardous chemicals in the community and establishes emergency planning and notification procedures to protect the public from a release.

Hanford Compliance:

The 1996 Hanford Site's emergency and hazardous chemical inventory was issued to the State Emergency Response Commission, local county emergency management committees, and local fire departments in March 1997. The inventory report contained information on hazardous materials in storage across the site. A toxic chemical release inventory report [21, 22] was issued in August 1996, which provided details regarding releases, offsite transfers, and source reduction activities involving ethylene glycol, the sole toxic chemical used in excess of regulatory thresholds during 1995. No such reporting thresholds were exceeded in 1996. During 1996, the Hanford Site was in compliance with the reporting and notification requirements contained in this Act.

5.4 Resource Conservation and Recovery Act (RCRA) [19]

The Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901-6992) *establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous wastes. The Washington State Department of Ecology has been authorized by the EPA to implement its dangerous waste program in lieu of the EPA for Washington State, except for some provisions of the hazardous and solid waste amendments of 1984. The Washington State Department of Ecology has therefore implemented the state's more stringent regulations (Washington Administrative Code (WAC) 173-303). RCRA primarily covers ongoing waste management at active facilities.*

Subtitle I of the RCRA deals with regulation of underground storage tank systems. These regulations were added to the Act by the hazardous and solid waste amendments of 1984. The EPA has developed regulations implementing technical standards for tank performance and management, including standards governing the cleanup and closure of leaking tanks. These regulations do not apply to the single- and double-shell tanks (constructed prior to 1984), *which are regulated as treatment, storage, and disposal facilities.*

Hanford Compliance:

At the Hanford Site, over 60 treatment, storage, and disposal units (TSDs) have been identified that must be permitted or closed in accordance with RCRA and Washington State regulations.

To comply with the RCRA, the HF (Hanford Facility) RCRA Permit fulfilling federal and state regulations became effective in September 1994. The Permit is comprised of two portions, a Dangerous Waste Portion, issued by Ecology, and a Hazardous and Solid Waste Amendments Portion, issued by the EPA. The HF RCRA Permit has a significant impact on Hanford Site activities along with the TPA. Virtually all programs are impacted in some manner by HF RCRA Permit requirements. [23: Pp. 1-2]

5.5 Clean Air Act (CAA) [19]

The purpose of this Act is to protect public health and welfare by safeguarding air quality, bringing polluted air into compliance, and protecting clean air from degradation. In Washington State, the provisions of the Act are implemented by EPA, Washington State Department of Ecology, Washington State Department of Health, and local air authorities.

Hanford Compliance:

Washington State regulations require applicable controls and annual reporting of all radioactive air emissions. The Hanford Site operates under a license for such emissions.

Emissions from the Hanford Site are within the state and EPA offsite emissions standard of 10 millirem per year. Nearly all Hanford Site sources currently meet the procedural requirements for flow measurement, emissions measurement, quality assurance, and sampling documentation.

The local air authority (the Benton County Clean Air Authority) regulations pertain to detrimental effects, fugitive dust, open burning, odor, opacity, and asbestos handling. The Authority has also been delegated responsibility to enforce the EPA asbestos regulations under the revised Clean Air Act. The site remains in compliance with the regulations.

5.6 Clean Water Act (CWA) [19]

This Act applies to point discharges to waters of the United States. At the Hanford Site, the regulations are applied through National Pollutant Discharge Elimination System permits that govern effluent discharges to the Columbia River. The permits specify discharge points (called outfalls), effluent limitations, and monitoring requirements. Several permit exceedences occurred at the 300 Area Treated Effluent Disposal Facility in 1996 despite the use of the best available technology. Preparations for a modification to the facility's discharge permit are under way.

5.7 Safe Drinking Water Act (SDWA) [19]

The National Primary Drinking Water Regulations of the Safe Drinking Water Act apply to the drinking water supplies at the Hanford Site. These regulations are enforced by the Washington State Department of Health. In 1996, all Hanford Site water systems were in compliance with requirements and agreements.

5.8 Toxic Substances Control Act (TSCA) [19]

The application of TSCA requirements to the Hanford Site essentially involves regulation of polychlorinated biphenyls. The site is currently in compliance with regulations for nonradioactive polychlorinated biphenyls. All radioactive polychlorinated biphenyl wastes are being stored pending development of treatment and disposal technologies and capabilities.

5.9 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) [19]

The EPA is responsible for ensuring that a chemical, when used according to label instructions, will not present unreasonable risks to human health or the environment. This Act and specific chapters of the Revised Code of Washington apply to storage and use of pesticides. In 1996, the Hanford Site was in compliance with these requirements.

5.10 Endangered Species Act (ESA) [19]

Many rare species of native plants and animals are known to occur on the Hanford Site. Two of these (bald eagle and peregrine falcon) are listed by the U.S. Fish and Wildlife Service as endangered or threatened. Others are listed by the Washington State Department of Fish and Wildlife as endangered, threatened, or sensitive species. Hanford Site activities complied with the Endangered Species Act in 1996.

5.11 National Historic Preservation Act, Archaeological Resources Protection Act, Native American Graves Protection and Repatriation Act, and American Indian Religious Freedom Act [19]

Cultural resources on the Hanford Site are subject to the provisions of these Acts. In 1996, the Hanford Site was in compliance with these Acts.

5.12 National Environmental Policy Act (NEPA) [19]

This Act establishes environmental policy to prevent or eliminate damage to the environment. This Act requires that major federal projects with significant impacts be carefully reviewed and reported to the public in environmental impact statements (EIS). Other documents such as environmental assessments are also prepared in accordance with requirements of the Act. Several environmental impact statements related to programs or activities on the Hanford Site are in process or in the planning stage.

5.13 Environmental Occurrences [19]

Onsite and offsite environmental occurrences (spills, leaks, etc.) of radioactive and nonradioactive effluent materials from 1990 to 1998 at the Hanford Site were reported to DOE and other federal and state agencies as required by law (DOE Order 232.1A). *All emergency, unusual, and off-normal occurrence reports, including event descriptions and corrective actions, are available for review in the DOE Hanford Reading Room located on the campus of Washington State University at Tri-Cities, Richland, Washington.* They are also available through the DOE Occurrence Reporting and Processing System (ORPS) via the Internet [24]. (Note: Special access is required for ORPS use.)

5.14 Other Significant Regulatory Drivers at the Hanford Site

Laws and Regulations [20: P.16]

1) *Atomic Energy Act of 1954*, *Nuclear Waste Policy Act of 1982*
2) 42 USC 2286, *Enabling Statute of the Defense Nuclear Facilities Defense Board*
3) Occupational Safety and Health Administration, 10 CFR 835, 'Standards for Protection Against Radiation'; 10 CFR 830, 'Nuclear Safety Management'; WAC 246-220, 'Radiation Protection--General Provisions'; WAC 246-221, 'Radiation Protection Standards;' WAC 246-222, 'Radiation Protection Worker Rights'
4) 10 CFR 71, 'Packaging and Transportation of Radioactive Material;' DOE Order 5480.3, *Safety Requirements for the Packaging Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes*; 40 CFR 263, 'Standards Applicable to Transporters of Hazardous Wastes'
5) 10 CFR 1021, 'DOE NEPA Implementing Procedures'
6) 40 CFR 1500-1508, 'Council on Environmental Quality Regulations'

DOE Departmental [20: Pp. 16-17]

1) DOE Order 5630.12A, *Safeguards & Security Inspection & Assessment Program* (1992)
2) DOE Order 5500.1B, *Emergency Management System* (1991)
3) DOE Order 5480.23, *Nuclear Safety Analysis Reports* (1992)
4) DOE Order 5420.2A, *Radioactive Waste Management* (1988)
5) DOE Order 451.1A, *National Environmental Policy Act Compliance Program* (1997)

Richland Office Polices and Directives (20: P.17)

1) RLID 430.1, *Systems Engineering Criteria Document and Implementing Directive* (1996)
2) RLPD 430.1, *Hanford Site Systems Engineering Policy* (1996)

Environmental, Safety, and Health (ES&H) Requirements (20: P.17)

1) DOE/EA-0210, *Draft Environmental Assessment for Characterization of the Hanford Site Pursuant to the Nuclear Waste Policy Act of 1982* (Public Law 97-425)
2) ERDA-1538, *Waste Management Operations, Hanford Reservation, Richland Washington: Final Environmental Statement* (1975)
3) DOE/EIS-0046F, *Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste* (1980)
4) 46 FR 26677, 'Program of Research and Development for Management and Disposal of Commercially Generated Radioactive Wastes, Record of Decision.'

Planning Assumptions (20: P.17)

1) HRA-EIS (*Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan*) (1996)

Other Requirements (20: P.17)

1) All other applicable federal, state, and local laws.

6.0 Hanford Waste Stream and Remediation Worker Task Definitions / Task-Based Classification Approach

6.1 Overview

Classification of remediation workers at the Hanford site is based on worker function and the types of waste streams handled during a particular remediation activity. For purposes of this study, an approach for categorizing these workers was developed in order to define the remediation worker population at the site and categorize Hanford remediation worker activities and technologies.

Remediation workers at the Hanford site are frequently moved from project to project and area to area. Due to the variety of activities and projects assigned to each Hanford employee and the tendency to work with different waste types, categorization of remediation workers can only be achieved by task.

Table 6.1 A provides definitions of **Hanford waste types.** Hanford waste treatment / storage / and final disposition paths are discussed in Section 9.0 on pages 74 through 86.

Remediation workers may perform tasks involved with one or more of the following wastes.

Table 6.1 A: Hanford Waste Type, Associated Acronym, and Description (12. Pp. 34-48, 25. Sec. 3/26 & 3/28, 26: Pp 4-7, 27, 28: Sec.IV-1)

Waste Type and Associated Acronym		**Waste Description**
Hazardous Waste	HW	...is waste that is regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA) and the Washington Administrative Code (WAC) 173-303 (termed as dangerous waste). It contains hazardous constituents but no radionuclides. Hazardous components may include lead and other heavy metals, solvents, paints, oils, other hazardous organic materials, or components that exhibit RCRA characteristics of toxicity, ignitability, corrosivity, or reactivity.
Sanitary Waste	SW	...is waste that is essentially non-hazardous and non-radioactive, however, waste termed Sanitary Waste in the 200 Areas is treated as mixed waste due to the potential of radiological and chemical contamination (200 Area SW is classified as LLMW).
Low-Level Radioactive Waste	LLRW	...is any radioactive waste that is not classified as HLW, TRU, SNF, byproduct tailings containing uranium or thorium from processed ore, or naturally occurring radioactive material. It is produced by every process at the site involving radioactive materials. LLRW contains small amounts of radioactivity in large volumes of materials and may be in solid or liquid form.
Low-Level Mixed Waste	LLMW	...is low level waste determined to contain both a hazardous component subject to RCRA and a radioactive component subject to the Atomic Energy Act. Low-level waste containing polychlorinated biphenyls, asbestos, or other regulated toxic components will be managed under the Toxic Substances Control Act (TSCA). Hazardous components may include lead and other heavy metals, solvents, paints, oils, other hazardous organic materials, or components that exhibit RCRA characteristics of toxicity, ignitability, corrosivity, or reactivity.

Table 6.1 A (continued): Hanford Waste Type, Associated Acronym, and Description (12: Pp. 34-48, 25: Sec. 3/26 & 3/28, 26 Pp.4-7, 27, 28: Sec.IV-1)

Waste Type and Associated Acronym		Waste Description
TRU (Transuranic) and TRU Mixed Waste	TRU / TRU MIxed	...is waste containing radioactive isotopes with atomic numbers greater than 92 and half-lives longer than 20 years at concentrations exceeding 100 nanocuries of alpha-emitting radionuclides per gram. TRU Mixed waste contains both radioactive and hazardous components similar to those described for LLMW.
Contaminated Media	-	...is LLMW and LLRW contaminated soil, debris, and groundwater. Contaminated media is managed by the Environmental Restoration Contractor (ERC) at the Hanford site. It also includes HW debris, Asbestos, TRU debris, leachate from the Environmental Restoration Disposal Facility, and contaminated basin water.
High Level Waste	HLW	...is highly radioactive material resulting from reprocessing SNF and irradiated targets, including liquid waste that contains fission products in sufficient concentrations. HLW came from the production of plutonium and recovering enriched uranium from reactor fuel. It typically contains highly radioactive, short lived fission products as well as long lived isotopes, hazardous chemicals, and heavy metals. Liquid high-level waste is typically stored in large tanks, while waste in powered form is stored in bins. All high level waste is managed as mixed waste, **but is RCRA exempt.**
Immobilized HLW	IHLW	...is HLW that has been separated and treated. IHLW at the Hanford site is vitrified HLW.
Low-activity Waste or Immobilized LAW	LAW / ILAW	...is liquid waste from the tanks (after separation of HLW components) and secondary waste from the HLW vitrification facility which consists of waste from canister decontamination, drying of feed material, and off-gas treatment.
Contaminated Equipment	-	...includes sampling equipment, augers, cranes, construction equipment, and stainless steel, lead-lined shielded receivers from tank farm operations. Contaminated equipment is essentially LLRW, but is noted separately in this document so that disposition may be presented and as well as it's association to HLW.
Spent Nuclear Fuel	SNF	...consists of nuclear materials or heavy metals such as uranium, plutonium, or thorium withdrawn from a nuclear reactor or another neutron irradiation facility. SNF exists primarily in solid form as metal-clad rods.
Special Nuclear Material	SNM	...is plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Nuclear Regulatory Commission, pursuant to the provisions of section 51 of the Atomic Energy Act of 1954, determines to be special nuclear material, but does not include source material; or any material artificially enriched by any of the foregoing, but does not include source material.

6.2 Remediation Worker Task Definitions

The following remediation worker task definitions were developed using a combination of process knowledge, information gleaned from Hanford publicly available documents, and Hanford site contacts. These definitions will vary between Department of Energy (DOE) sites due to site specific functions and missions.

There are four types of remediation worker tasks performed at the Hanford site. An individual remediation worker may perform one or more of the following tasks. They include:

Hazardous Waste Tasks (HW Tasks)

Hazardous waste (HW) tasks include sampling, surveying, containerization, treatment, transportation, storage, and disposal of **Hazardous Waste (HW)** (i.e. regulated chemical waste or chemically contaminated wood, metal, concrete, asphalt, debris, process residues, discarded product, contact waste, etc.), **Low-level Mixed Waste (LLMW),** and **Transuranic Mixed Waste (TRU Mixed)** associated with solid waste management units (SWMUs), hazardous material units (HMUs), unplanned release sites (UPRs) or any other facility that requires HW, LLMW, or TRU Mixed waste remediation. HW tasks are also involved in removal, excavation, packaging, and/or transport of mixed waste portions (i.e. LLMW, TRU Mixed) of **Contaminated Media** (i.e. mixed waste contaminated soil and/or groundwater).

HW tasks are regulated by either the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) depending on whether the waste is located at an inactive waste site (CERCLA) or an active waste site (RCRA). Hazard waste tasks can also include the duties of an Industrial Hygienist Technician (IHT) who surveys, samples, or containerizes chemical non-radiological substances to determine employee exposure potential. Laboratory workers who sample, survey, transport, treat (bench-scale), and dispose of non-radiological hazardous waste or mixed waste are also classified as HW task workers.

Deactivation, Decontamination, and Decommissioning Tasks (De Tasks)

Deactivation tasks involve placing a facility in a safe and stable condition to minimize the long-term cost of a surveillance and maintenance (S&M) program that is protective of workers, the public, and the environment until facility decommissioning is complete. Tasks include the removal of non-irradiated fuel (**Special Nuclear Material (SNM)**), draining and/or de-energizing non-essential systems, removal of stored radioactive (**Low Level Radioactive Waste (LLRW)** and **Transuranic Waste (TRU)**), mixed (**LLMW** and **TRU Mixed Waste**), and **HW** materials, and related actions. As a bridge between operations and decommissioning, based on facility-specific conditions and final disposition plans, deactivation can accomplish operations such as final process runs and decontamination activities aimed at placing the facility in a safe and stable condition.

Decommissioning takes place after deactivation and includes the S&M, decontamination, and/or small-scale dismantlement of process lines, tanks, and equipment within the facility or structure. These De tasks are conducted at the end life of the facility to retire it from service with adequate regard for the health and safety of the workers, the public, and protection of the environment. The ultimate goal of decommissioning is the unrestricted release or restricted use of the site. **Asbestos** abatement (i.e. removal and packaging prior to transoprt) is also conducted by workers performing De tasks. De tasks are usually CERCLA driven.

Demolition and Large Scale Dismantlement Tasks (Di Tasks)

Dismantlement tasks involve the disassembly, demolition and removal of any structure, system, or component, and the satisfactory interim or long-term disposal of the residue from all portions of the facility. Dismantlement tasks also involve final large-scale (superstructure) dismantlement, disassembly and/or demolition of the facility subsequent to facility deactivation. **Low-level Radiological Waste (LLRW)** is the primary waste stream involved with Di Tasks.

Unlike hazardous waste, deactivation and cleanup tasks, which are performed by major and sub-tiered contractors at the site, dismantlement tasks are usually performed by workers who are pulled from and are dedicated exclusively to dismantlement tasks. Di tasks are usually CERCLA driven.

Cleanup Worker Tasks (CW Tasks)

Cleanup worker tasks (CW tasks) involve systems operation and maintenance including treatment, transportation, storage, and disposal of **LLRW**, **High Level Waste (HLW)**, **Spent Nuclear Fuel (SNF)**, **TRU Waste**, **SNM**, **Sanitary Waste (SW)**, **Low-activity Waste (LAW)**, **Contaminated Equipment** (associated with HLW), and **Contaminated Media** (radiological components only) generated or handled during day-to-day remediation activities at the Hanford site. Workers involved with CW tasks will also survey, monitor, and analyze **LLRW, HLW, TRU, SNF, SNM, SW, LAW, and Contaminated Equipment and Media**. Laboratory workers as well as Radiological Control Technicians (RCTs) are considered to perform CW tasks. Like HW tasks CW tasks are either RCRA or CERCLA driven but are more likely to handle RCRA-exempt materials such as HLW.

Examples of Tasks performed by Remediation Workers

Under a removal action (RA) or closure action, remediation workers performing HW tasks will remediate any hazardous waste site within an area (soils and groundwater) prior to facility deactivation (if applicable). RAs, authorized by *CERCLA Section 104d (2)*, are designed to address immediate threats to human health and the environment associated with abandoned or inactive sites. A removal action may be conducted during any point in the CERCLA response process. Typical removal actions include preventing migration of hazardous substances through excavation or placing barriers and removing barrels, drums, tanks, or other contaminated materials from facilities or past operations disposal areas.

Upon completion and disposition of the removed hazardous waste, remediation workers performing De Tasks will enter the building to be deactivated and remove any salvageable equipment, loose radiological gross contamination, or 'holdup material' (material left in process lines, machinery, equipment etc.). At this point, the facility may placed in a 'safe' mode requiring surveillance, maintenance and monitoring or the internal structure of the building will be decommissioned and made ready for large-scale dismantlement (if applicable). A contract is then let to a dismantlement company for the final phase of the process. Remediation workers performing Di tasks will use brute force activities with heavy equipment (i.e. cranes) to completely demolish the structure.

Remediation workers performing CW tasks will provide maintenance and support to areas associated with the treatment, storage, and disposal of LLRW, HLW, TRU, SNF, SNM, SW, LAW, and Contaminated Equipment and Media. They will also transport, treat and dispose of those wastes (usually higher in contamination) not handled by the worker performing HW or De Tasks. CW task workers could be in a laboratory performing bench scale treatment/technology research or working to retrieve or characterize HLW slurry or sludge from Hanford tank farms. Workers performing CW tasks can experience the greatest radiological exposure potential at the site.

Classification of 'Below' and 'Above' Grade Remediation Worker Tasks

In terms of 'below-grade' (below ground level) (i.e. trenches, burial grounds, cribs, french drains, gravel pits, etc.) remediation, tasks are either classified as HW or CW depending upon the waste types removed from the area. De and Di tasks are usually performed 'above-grade' or above ground within or on structures or facilities. The exception to this includes the decontamination or dismantlement of 'below-grade' pipes or tanks.

The following table summarizes the basis for remediation worker task classification and also presents example remediation worker tasks and associated waste streams at the Hanford site.

Table 6.2 A: Classification Basis for Hanford Remediation Worker Tasks

Remediation Worker Task	Associated Wastes	Example of Task Activities
Hazardous Waste Task (HW Task)	LLMW, TRU Mixed, HW, and Contaminated Media.	Sampling, surveying, containerization, excavation, treatment, transportation, storage, and disposal of hazardous and mixed waste. Task can be 'below-grade'.
Deactivation, Decommissioning, Decontamination, Small-Scale Dismantlement Task (De Task)	LLMW, LLRW, TRU Mixed, TRU, HW, SNM, and Asbestos Waste.	Deactivation, Decommissioning, Decontamination, Small-scale Dismantlement of facilities. Task is usually 'above-grade'. The exception includes De tasks with 'below-grade' piping or tanks.
Dismantlement, Demolishing Task (Di Task)	LLRW	Demolishing, Large-scale Dismantlement of facilities. Involved with radiological waste only. Task is usually 'above-grade'. The exception includes Di tasks with 'below-grade' piping or tanks.
Clean-up Worker Task (CW Task)	LLRW, TRU, HLW, SNF, SNM, Contaminated Equipment, Contaminated Media, and LAW.	Systems operations and maintenance. CW workers will identify, weigh, sample, survey, containerize, store, and prepare radiological waste. Treatment, transportation, storage, and disposal of HLW, TRU, LLRW, SNF, SNM, LAW, and Contaminated Equipment and Media. Task can be 'below-grade'.

7.0 Hanford Site Past, Present, and Proposed Remediation Worker Demographics, Site Safety Management, Remediation Worker Training and Demographic Data Systems

7.1 Overview of Hanford Site Personnel

Current staffing for the entire Hanford Site represents a site-wide mix of federal and tiered contractor personnel.[12: P.54] The Department of Energy (DOE) Richland Operations Office (RL) manages prime contractor activities. Prime operating contractors at Hanford include: 1) **Fluor Daniel Hanford (FDH),** the management and integration contractor responsible for the Project Hanford Management Contract (PHMC), 2) **Bechtel Hanford, Inc. (BHI),** the environmental restoration (ER) contractor, 3) **Hanford Environmental Health Foundation (HEHF)**, the occupational medical services contractor (OMSC), 4) **Johnston Controls, Inc.,** the energy savings performance contractor (ESPC), and 5) **Battelle Memorial Institute**, the contractor responsible for operating Pacific Northwest National Laboratory (PNNL). All lower-tiered sub-contractors at the site fall under a prime with the exception of Hanford enterprise companies (ENCOs) and British Nuclear Fuels Limited (BNFL, the privatization contractor). ENCOs at the site are considered independent entities and are able to pursue non-Hanford work[29] and in June of 1998 BNFL agreed with DOE-RL to treat and immobilize Hanford high level waste. BNFL will design and construct the facility for on-site tank waste treatment.[30] BNFL will not take part in the overall environmental management and operation of the site. Refer to Section 10.3 on page 106 for a more detailed explanation of BNFL responsibilities and missions.

The following tables present organizational charts showing contractor involvement post 1989. The first table (Table 7.1 A on page 29) presents operating contractors from 1989 to 1996 and the second table (Table 7.1 B on page 30) shows the current (as of November 1998) contractor organization. Approximately 76 lower tiered sub-contractors are not presented in the current organizational chart. [31: P.1-4]

Table 7.1 A: The Management and Operations (M&O) Contract from 1989 to 1996 at the DOE-RL Hanford Site

Prime Contractors	Sub-Contractors	Function
Westinghouse Hanford Services (M&O Contractor)	Westinghouse Service Sub-Contractors	The management and operations contractor (M&O).
Bechtel Hanford, Inc. (Effective 1994)	No Major Sub-contractors	The environmental restoration contractor (ERC).
Kaiser Engineers Hanford	No Major Sub-contractors	Engineering services.
U.S. Army Corps. of Engineers	No Major Sub-contractors	Engineering services.
Pacific Northwest National Laboratory (PNNL)	Battelle Memorial Institute	The on-site national laboratory supporting environmental management programs.
Hanford Environmental Health Foundation (OMSC Contractor)	No Major Sub-contractors	The health and services contractor providing occupational health and medical services.
MACTEC-ERS	No Major Sub-contractors	Provided vadose zone and groundwater monitoring.

Table 7.1 B: The Integrated Management Contract (IMAC) from 1996 to the Present at the DOE-RL Hanford Site as of November 1998 (32: P.3, 33: P.3)

Prime / Operating Contractors at the Hanford Site				
Fluor Daniel Hanford (PHMC)	Bechtel Hanford Inc. (ERC)	Johnson Controls, Inc. (ESPC) (1998)	Battelle Memorial Institute (PNNL)	Hanford Env. Health Foundation (OMSC)

Major Sub-Contractors FDH	Function / Responsibility	Major Sub-Contractors BHI
Lockheed Martin Hanford	Tank Waste Remediation Systems Project	CH2 Hill
Waste Managment Federal Service of Hanford	Waste Management	ThermoNutech
DE&S Hanford	Spent Nuclear Fuel Project	
B&W Hanford	Facility Stabilization	
Numatec Hanford	Technology Implementation and Nuclear Engineering	
Dyn Corp Tri Cities Services	Infrastructure Support Services	

Enterprise Companies (ENCO)	Function / Responsibility
B&W Protection (Protection Technology as of 3/1999)	Security and Safeguards
COGMEA Engineering	Process Engineering and Technical Services
Lockheed Martin Services	Information Resource Management
Fluor Daniel Northwest	Architect, Engineering, and Other Services
DE&S Northwest	Quality Assurance
Waste Management Federal Services Northwest, Inc.	Waste Management and Environmental Services

DOE-RL Privitization Contractor	Teaming Partners	Function / Responsibility
British Nuclear Fuels Ltd. (BNFL) (1998)	Bechtel National, Inc.	Project for the treatment and immobilization of high-level waste: Environmental remediation project for the treatment and stabilization of radioactive waste.
	GTS Duratek	
	Science Applications International Corp. (SAIC)	

*Approximately **10,610** people work at the site as of November 1998.*[33: P. 2] This number will vary according to reference and is most likely due to the inclusion or exclusion of enterprise companies (ENCOs) or small lower-tiered contractors. For example, the Hanford Phone Directory lists approximately 13,000 site employees (as of June 1998) [34] and the Hanford Environmental Health Foundation (HEHF) reported 12,000 employees in June 1998 [35].

The following table is representative of the total number of Hanford employees per year since 1989. Note that in 1996 average employment was 11,415, down considerably from the peak of 19,176 in 1994. The drop reflects not only employment declines, but also reorganization of the contractors under the PHMC. Under the PHMC, almost 2,200 employees of the former M&O contractor were moved into ENCOs and ceased to be counted as 'inside the fence'. Only about 100 employees out of the 2,200 pursue non-Hanford work.

Table 7.1 C: Total Number of Employees ('inside the fence') at the Hanford Site from Fiscal Year 1989 through FY 1998

FY Year	Total Number of Employees
1998	*10,610 [33: P.2]
1997	*11,140 [36: P.6]
1996	*11,415
1995	15,244
1994	19,176
1993	17,255
1992	16,096
1991	15,043
1990	14,045
1989	12,695

* Does not include ENCOs.

Out of the 10,610 employees currently at the site, approximately 500 are DOE-RL employees, 875 are BHI, CH2 Hill, ThermoNutec, employees [37: Sec.16] and 3,500 are PNNL/Battelle employees.[33: P. 2]

7.2 Historical (1989 through 1998) Overview of the Remediation Worker Population at the Hanford Site

Remediation workers performing Clean-up (CW), Hazardous Waste (HW), Decontamination / Decommissioning (De), and Dismantlement (Di) tasks have been at the Hanford site since 1989. The workers are primarily represented by the **Hanford Atomic Metal Trades Council (HAMTC)**, the site's largest union council representing 14 local unions including occupations such as crafts, firefighters, Radiological Control / Industrial Hygiene Technicians, and data / clerical personnel. Other groups also comprise the remediation worker population and will be discussed later in the section. For a detailed look at the HAMTC, including job classifications and local union information, refer to Table 7.3 C: HAMTC Local Union Contacts and Number of Members as of June 23, 1998, on page 39.

Prior to 1989, HAMTC worked with site production prime contractors (Refer to Table 4.1 A on page 9 for production period contractors) and performed tasks relating to site operations. Today, most remediation workers are former site production workers, however young un-skilled laborers have entered to workforce over the last 10 years.

From 1989 through October 1996, Westinghouse Hanford Company (WHC) and PNNL operated by Battelle Memorial Institute held labor agreements with the HAMTC. [38] Beginning in October 1996, Fluor Daniel Hanford, Inc. (FDH) took over the WHC labor agreement along with securing the Project Hanford Management Contract (PHMC) from DOE-RL. Few changes were made in the new labor agreement, however some job classifications were eliminated, added or redefined. For example, Laundry Workers were eliminated from the agreement and Industrial Hygiene Technicians (IHT) were added. [39: P. 207]

Table 7.2 A on pages 33 and 34 presents numbers of hourly paid remediation employees affected by the FDH / HAMTC agreement from 1990 through 1998.[40, 41] Data for the end of 1989 was not made available for this study. Note that Nuclear Chemical Operator and Health Physics Technician classifications have the highest numbers of HAMTC workers.

In July of 1994, Bechtel Hanford, Inc. (BHI) became the Environmental Restoration Contractor (ERC) at the site and consequently entered a labor agreement with the HAMTC. [42] At this time, many HAMTC employees changed contractors, leaving WHC for BHI. Table 7.2 B on page 35 presents numbers of hourly paid employees (remediation workers) affected by the BHI/HAMTC agreement from 1994 to 1998. [43, 44] Note that D&D and Radiological Control Technician classifications have the highest numbers of HAMTC employees. Also note that the Health Physics Technician classification changed to Radiological Control Technician in 1996.

PNNL/HAMTC total workers are also presented in Table 7.2 C (on page 36) from 1993 to 1998. For this table, the top nine classifications as identified by the PNNL Human Resources Department are presented. [45] Information prior to 1993 is available through archived PNNL data only. [46]

Table 7.2 A: Hourly Paid Employees Affected by the Hanford Atomic Metal Trades Council (HAMTC) and the Westinghouse / Fluor Daniel Hanford (FDH) Labor Agreement 1990 - 1998 [40]

Classification	Number of FDH/HAMTC Workers / year: 1990-1998 (1989 not available)								
	90	91	92	93	94	95	96	97	98
Storekeepers	56	58	58	63	65	49	28	29	30
Nuclear Chemical Operator	442	405	381	437	495	450	429	368	355
D&D Workers	23	24	26	39	57	66	79	94	84
Reactor Fuels Operator	41	36	31	34	31	27	50	50	40
Metal Fuels Operator	4	4	4	4	4	4	8	0	0
Stationary Operating Engineer	159	148	155	162	163	141	135	126	115
Chlorinators	1	1	1	1	1	1	0	1	1
Sheetmetal Workers	16	15	14	14	14	10	15	10	10
Crane Operators	14	14	13	14	14	19	17	13	13
Heavy Equipment Operators	14	14	12	13	15	12	13	12	11
Heavy Truck Drivers	198	187	192	214	222	180	156	161	157
Lube and Tiremen	5	6	7	9	8	6	2	5	6
Servicemen	4	8	15	5	3	0	0	0	0
Carpenters	29	27	27	26	31	24	26	22	23
Linemen	6	8	8	8	8	8	5	6	5
Electrician	143	140	142	151	155	136	138	132	132
Substation Electrician	12	10	14	13	12	11	7	7	7
Substation Operator	4	5	5	5	2	2	1	1	0
Meter Relay Technician	3	2	3	3	3	3	2	2	2
Millwright	80	74	68	68	89	58	59	53	49
Welders	27	23	22	22	20	16	11	11	9
Plumber Steamfitter	118	108	103	116	117	103	95	91	83
Painter/Carpet Installer	32	30	29	29	33	26	24	20	16

Table 7.2 A (Continued): Hourly Paid Employees Affected by the Hanford Atomic Metal Trades Council (HAMTC) and the Westinghouse / Fluor Daniel Hanford (FDH) Labor Agreement 1990-1998 [40]

Classification	Number of FDH/HAMTC Workers / year: 1990-1998 (1989 not available)								
	90	91	92	93	94	95	96	97	98
Cement Finisher-Plaster	1	1	1	1	1	1	0	1	1
Boilermaker	17	15	14	16	13	10	4	7	3
Glazier / Glassworker	1	1	1	1	1	1	1	1	1
Ironworker / Rigger	47	47	45	47	50	60	59	51	50
Insulators	28	30	30	27	30	29	22	12	12
Machinists	32	30	30	30	34	28	25	18	20
Shop Material Take-Off / Coordinator	37	36	38	37	44	41	35	35	34
Chemical Technologists	142	132	122	130	125	113	107	95	87
Hot Cell Technicians	0	0	0	0	0	0	0	29	29
Industrial Hygiene Technicians	0	0	0	0	0	0	0	12	20
Health Physics Technicians	277	275	292	340	372	355	410	408	401
Totals	2025	1926	1909	2084	2237	1993	1950	1872	1800

Table 7.2 B: Hourly Paid Employees Affected by the HAMTC and Bechtel Hanford, Inc. Labor Agreement [43]

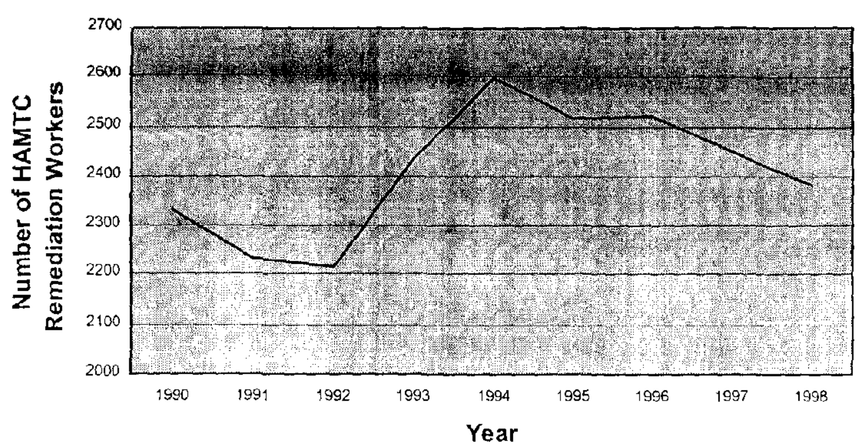
Classification	Number of BHI/HAMTC Workers per Year 1995-1998*			
	1995	1996	1997	1998
Boilermaker	2	0	2	0
Carpenter	6	6	5	4
Crane Operator	5	3	4	4
Decontamination-Decommissioning	65	90	88	84
Electrician	8	9	12	13
Health Physics Technician	51	0	0	0
Heavy Equipment Operator	5	4	3	4
Industrial Hygiene Technician	0	0	0	8
Instrument Specialist	4	6	7	8
Insulator	6	1	0	2
Ironworker Rigger	9	10	7	9
Lube & Tireman	0	1	1	2
Machinist, Research and Development	0	0	1	1
Material Coordinator	2	2	2	2
Millwright	0	1	2	4
N Control Power Operator	2	2	2	2
Nuclear Power Operator	2	2	2	2
Nuclear Process Operator	4	5	6	6
Nuclear Operator	4	2	1	1
Painter-Carpet Installer	1	1	1	1
Plumber Steamfitter	5	5	5	5
Power Operator	6	0	0	0
Radiological Control Tech	0	72	95	95
Reactor Fuels Operator	2	0	0	0
Reproduction Operator	0	1	1	1
Stationary Operating Engineer	0	7	5	5
Storekeeper	3	2	2	2
Truck Driver - Heavy	30	38	53	59
Welder-Plumber-Fitter	1	1	2	1
Totals	223	271	309	325

Table 7.2 C: Total Number of PNNL / HAMTC employees from 1993 though 1998 [47]

Top Classifications	Number of PNNL/HAMTC Workers per Year 1993-1998					
	1993	1994	1995	1996	1997	1998
Carpenter	14	15	10	10	10	9
Electrician	32	33	29	27	22	22
Instrument Specialist	32	37	35	36	35	31
Power Operator	23	25	24	27	25	24
Millwright	19	19	17	16	11	11
Pipefitter	22	24	21	20	21	21
Radiation Protection Technologist	41	43	43	42	24	26
Truck Driver	18	20	17	19	18	16
Total Number of PNNL/HAMTC Workers (All HAMTC Classifications)	353	361	300	299	268	255

The following figure (Figure 7.2 D: Changes in the Total Number of HAMTC / Remediation Workers by Year 1990 to 1998) was calculated by adding worker numbers from the above tables. It shows that total number of remediation workers increased from 1990 through 1994. This may have been due to the new environmental clean-up mission at the site and the addition of BHI as the environmental restoration contractor. The table also demonstrates that total numbers of remediation workers have decreased by approximately 3 percent since 1994. [44, 41]

Figure 7.2 D: Changes in the Total Number of HAMTC/Remediation Workers by Year



7.3 Current Remediation Worker Population at the Hanford Site Defined

For the purpose of this Exposure Assessment Feasibilty Study (EAFS), Hanford remediation workers are defined as HAMTC represented employees working for FDH, BHI, PNNL, and Johnson Controls, Inc [48, 49]. The population also consists of approximately 204 Building Trade workers represented by the Central Washington Building and Construction Trades Council [50, 51] and non-union laboratory technician workers performing bench scale remediation treatment technologies, including the packaging, storage and disposal of contaminated materials. Non-union workers performing remediation oriented laboratory duties are employed by FDH and PNNL. These workers are presented in Table 7.3 A: FDH non-union remediation workers at the Hanford site and Table 7.3 B: Non-union PNNL remediation workers at the Hanford site on page 38. BHI, Inc. indicated that all laboratory workers are represented by the HAMTC. [52]

Contacts and demographic descriptions of prime, subcontractor, and union remediation workers at Hanford are presented in Table 13.1, pages 229 through 236. This table combines contractor and labor union information. Note that the total remediation worker population at the Hanford site is approximately 4720 Hanford employees. Remediation workers comprise approximately 44% of the total Hanford employee population of 10,610. The total number of remediation workers at the site does not include lower-tiered subcontractors that are contracted for specific short-term projects such as small demolition or construction projects.

It should be noted that during the summer months at the site the remediation worker population may increase as much as ten percent. For July 1999, the Building Trades workers increased their population from 204 to 244 workers.[51, 50]

The Table 7.3 C on page 39 presents a detailed description of the HAMTC including contacts for all local unions and numbers of members by local union. [53]

In Table 13.1 on pages 229 through 236, Tasks Categories (CW, HW, De, and Di) are listed with associated contractor and project responsibility. The organization of the Hanford site gives this EAFS a basis for grouping tasks according to project, however in the activities section of this document (Section 10.0 on page 87), other task categories not listed in Table 13.1 may fall within the contractor or project responsibility due to the nature of the specific activity. In Table 13.1 pages 229 through 236, remediation worker tasks were assumed according to the general activities of the specific contractor. For example it was assumed that remediation workers associated with the K Basins (Duke Engineering and Services Hanford, Inc.) perform primarily CW tasks.

Table 7.3 A: FDH Non-union Remediation Workers at the Hanford Site as of June 1999 [54, 55]

PHMC Job Classification	December 1996	December 1997	December 1998	June 1999
Director Industrial Hygiene	0	0	1	1
Engineering Tech	0	35	33	31
Industrial Hygiene Tech	0	14	3	2
Industrial Hygienist	0	21	23	24
Mgr Industrial Hygiene	0	3	3	5
Scientific Tech	0	11	10	12
Supervisor Industrial	0	2	1	0
Tech - Engineering	298	250	249	248
Tech - Scientific	125	110	109	109
Total	423	446	432	432

Table 7.3 B: PNNL Non-union Remediation Workers at the Hanford Site as of End FY 1998 [47, 45]

Year	Number of Non-union Research/Laboratory PNNL Employees
1993	1258
1994	2176
1995	1830
1996	1731
1997	1639
1998	1689

Table 7.3 C: HAMTC Local Union Contacts and Number of Members as of June 23, 1998 [53]

Local Union	Contacts, Address, Telephone Number	Number of Employees as of 6/23/98
IRON WORKERS LOCAL NO. 14	BILL BURNES, BUSINESS MANAGER 824 WEST LEWIS STREET, SUITE 101 PASCO, WASHINGTON 99301 547-2911 Fred McClure, Chief Steward 373-2724	51
SHEET METAL WORKERS LOCAL 66	DICK MARBERG, BUSINESS REPRESENTATIVE 2638 W. BRUNEAU KENNEWICK, WASHINGTON 99336 735-3542 Gary Muth, Chief Steward 373-6093	16
I.B.E.W. LOCAL NO. 77	TOM MCMAHON, BUSINESS REPRESENTATIVE 77 ANGUS SQUARE KENNEWICK, WASHINGTON 99336 783-9453 Armando Trenti (Sonny), Chief Steward 373-5102	338
ASBESTOS WORKERS LOCAL 120	RICHARD LAYMAN, BUSINESS AGENT 303 GAUGE BLVD, APT 319 RICHLAND, WASHINGTON 99352 373-2681 Richard Layman, Chief Steward 373-2681	10
BOILERMAKERS LOCAL 242	LYNN RAWLINS, SECRETARY TREASURER NORTH 6404 PITTSBURGH SPOKANE, WA 99207 1-489-1891 Juan Castenada, Chief Steward 373-2791	5
OPERATING ENGINEERS LOCAL 280	DON BUSHEY, BUSINESS MANAGER 1305 KNIGHT STREET RICHLAND, WASHINGTON 99352 946-5101 Rick Barrickman, Chief Steward 521-3145 (Cell #)	322
O.C.A.W. LOCAL 1-369 (P.A.C.E. as of Jan. 1999)	JAMES L. WATTS, BUSINESS MANAGER 1305 KNIGHT STREET RICHLAND, WASHINGTON 99352 943-8441	692

Table 7.3 C (continued): HAMTC Local Union Contacts and Number of Members as of June 23, 1998 [53]

Local Union	Contacts, Address, Telephone Number	Number of Employees as of 6/23/98
PLUMBERS & STEAMFITTERS LOCAL 598	GARY BARCOM, BUSINESS MANAGER RICK BERGLUND, BUSINESS REPRESENTATIVE 1328 ROAD 28 PASCO, WASHINGTON 99301 545-1446 Jim Bateman, Chief Steward 946-0326, Pager #85-3052	117
TEAMSTERS LOCAL 839	MARY FARAGHER/BOB HAWKS, BUSINESS REP. 2508 W. SYLVESTER P.O. BOX 4090 PASCO, WASHINGTON 99302-4090 547-7514 Dave Molnaa, Chief Steward Pager #85-7646	221
I.B.E.W. LOCAL 984 (HEALTH PHYSICS TECHS)	MAT VAN UNEN, BUSINESS MANAGER 1305 KNIGHT STREET RICHLAND, WASHINGTON 99352 943-4646	450
RICHLAND PAINTERS LOCAL 1789	MIKE FITZSIMMONS, BUSINESS AGENT 1305 KNIGHT STREET RICHLAND, WASHINGTON 99352 946-8242	48
MACHINISTS LOCAL 1951	ROGER ELBER, DISTRICT MANAGER 1766 FOWLER, SUITE B RICHLAND, WASHINGTON 99352 735-1951 Ed Rittenburg, Chief Steward 373-9180	76
CARPENTERS & MIILLWRIGHTS 2403	H. A. PARKER, JR., BUSINESS REPRESENTATIVE 102 E. FIRST AVENUE KENNEWICK, WASHINGTON 99336 376-9417 H.A. Parker (Butch), Chief Steward Pager 985-2599	96
	HAMTC Total Members (3-month Average)	**2530**

7.3.1 Decision Logic in Defining the Remediation Worker Population at the Hanford Site

During a Hanford site visit in June of 1998, the authors of this exposure assessment feasibility study were encouraged by Hanford employees to examine the following groups of workers: 1) HAMTC represented employees working for FDH, PNNL, and BHI, 2) laborers represented by the Central Washington Building and Construction Trades Council (Building Trades, BT), 3) DOE Facility Representatives, 4) Federal Union Workers, 5) Security Guards, and 6) Johnson Controls personnel. After discussion and examination of each group, the following was determined.

1) All FDH, BHI, and PNNL HAMTC represented employees (except those performing non-remediation work) should be included in the remediation worker population as well as non-union laboratory / technician occupations within the PHMC/FDH. All laboratory / technician workers at BHI are represented by the HAMTC.

2) DOE Facility Representatives and Federal Union Workers [56] should be excluded from the remediation worker population due to the nature of their work at the site. It is assumed that the DOE Facility Rep. and some Federal Union Workers function as overseers and do not perform hands on CW, HW, De and Di tasks on a regular basis.

3) Security Guards represented under the FDH/Hanford Guards Union (HGU), Local 21 labor agreement [57] are also excluded the remediation worker population. Even though these workers are on the site for long periods of time often in contaminated areas they do not perform CW, HW, De and Di tasks and are assumed to have limited exposure to radiological or chemical contaminants when compared to full time hands on workers.

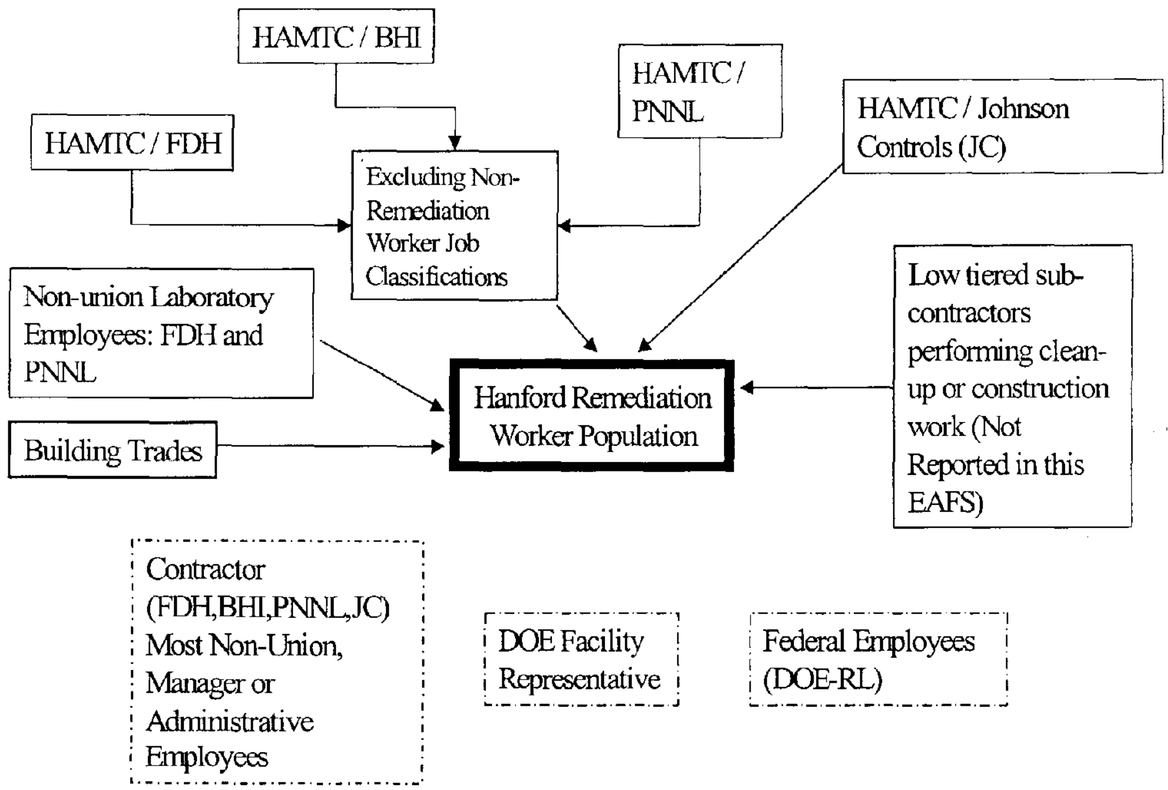
4) Johnson Controls, Inc. the new Energy Savings Performance Contractor (ESPC) at the Hanford site began working in March of 1997. Johnson Controls has a hand full of HAMTC workers who are Electricians and RCTs. Building Trade workers are also working with new construction projects under Johnson Controls. It was noted that this small HAMTC group should be placed in the remediation worker EAFS population since some of the activities involve the stabilization of facilities. Since the contract is fairly new, Johnson Controls has yet to establish a labor agreement between themselves and HAMTC, but seem to follow guidelines similar to FDH/HAMTC, BHI/HAMTC, and PNNL/HAMTC. [58, 59]

5) PNNL/HAMTC workers involved in laboratory work from 1989 to 1998 and remediation activities in the 324/327 Facilities from 1989 through 1995 should also be included in the remediation worker population. Workers performing special D&D activities in the 324/327 Facilities are described in Section 10.5 Activity 32 on page 141.[60]

6) Building Trade Workers performing construction activities within potentially radioactive areas should also be included within the remediation worker population. Workers involved in construction activities that require work in a radioactive area maybe exposed to the same contaminants as a worker performing treatment, storage, disposal, clean-up, and decontamination /decommissioning activities.

Decision logic for the inclusion and exclusion of groups in the Hanford remediation workers population is presented in Figure 7.3.1 A.

Figure 7.3.1 A: Hanford Remediation Worker Population Decision Logic



Note: Solid lines indicate Hanford groups included in the remediation worker population and dashed lines indicate groups excluded from the remediation worker population.

7.4 Hanford Labor Agreements

As mentioned previously, FDH, BHI, and PNNL/Battelle, Inc. hold agreements with the HAMTC. The labor agreements govern duties relating to environmental restoration, D&D work, maintenance and upkeep of facilities, treatment/storage/disposal of wastes whether defined hazardous or radioactive, emergency management (i.e. firefighting), monitoring (i.e. RCT, IHT, Chemical technicians and operators), and data/clerical operations. Exhibits 12.2 and 12.3 on pages 170 through 184 present Remediation Worker Local Unions and associated Job Titles / Descriptions all of which are represented by the HAMTC.

7.4.1 1997 FDH/HAMTC Labor Agreement (39)

The following union information was selected from the August 7, 1997 collective bargaining agreement between FDH and the HAMTC. The bargaining agreement defines a set of employment terms and conditions agreeable of the HAMTC, FDH, and DOE-RL. The Employer (FDH) and the Council (the HAMTC) work under the Project Hanford Management Contract (PHMC). Team members, including major (prime) subcontractors, subcontractors, and enterprise companies, will adhere to the agreement for work under the PHMC and the goals mandated by the DOE TriParty Agreement. Misunderstandings or disputes between these parties will be rectified by the Joint Labor Management Committee.

The bargaining unit includes 14 unions, 13 of which include remediation worker tasks. The agreement excludes all salaried personnel, guards, watchmen, and professional personnel.

FDH Site Management (39: Pp.1-17)

* *The Employer retains the exclusive right to manage its business including the right to determine the methods and means by which its operations are to be carried on, to direct the workforce, to conduct its operations in a safe and efficient manner, and the right to discipline or discharge employees for reasonable cause.*

* *The Employer must provide safety inspections, first aid service, and safety and radiation protection equipment to minimize accidents and health hazards to the employees at the plant during the hours of their employment. They must also establish a safety committee.*

* *The Employer intends to maintain a work force consistent with scheduled requirements and provide regular employment for its bargaining unit employees before work is contracted outside. The Employer will notify the Council President in writing of any work to be contracted out.*

FDH Hours of Work and Shifts (39: Pp. 23-34)

Employees under the 1997 FDH/HAMTC labor agreement are classified as either Straight-day workers, or Shift workers. For Straight-day workers, employees are scheduled to work Monday through Friday (this may vary) and will start work after 6:00 a.m. and before 6:00 p.m.

Shifts are classified as:

1) Days: 7:30 am to 4:00 pm with a 30 minute lunch

2) Swing: 3:30 pm to 12:00 Midnight with a 30 minute lunch

3) Graveyard: 11:30 pm to 8:00 am with a 30 minute lunch

Shift workers may work:

A) a Rotating Schedule (28 Day Rotation) Seven Days

B) a Rotating Schedule Five Days

C) a Modified Rotating Schedule Five Days (Day and Swing Shifts Only)

D) a Modified Rotating Shift (35 Day Rotation) Seven Days

E) a 4/10 Shift Schedule (4 days 10 hours)

F) a Twelve Hour Shift Schedule: (This shift will start after 5:30 a.m.)

Certain groups of employees are on special shifts not described in the agreement. Assignments within certain groups are negotiated with the Council as needed.

Employees are eligible for overtime pay, premium rates, time off with pay (includes vacation, personal time off, facility closure days, illness or injury, family emergencies and medical/dental appointments), workmen's compensation, leave of absence or military leave and pension. HAMTC represented employees accumulate seniority regardless of employer. Employees are listed in Seniority Groups (Refer Exhibit 12.2 on pages 170 through 182 for listings of seniority groups) as mutually agreed upon by the Council and the Employer. Seniority classifications will ultimately protect the employee. Employees in any seniority group who wish to be reassigned to another classification in a different seniority group may file their request with Industrial Relations. (39: Pp. 35-110)

Labor Assets Management Program (LAMP) (39: Pp. 112-118)

HAMTC represented employees are assigned to perform work in their regular job classification with one of the subcontractors of Fluor Daniel or its enterprise companies. Employees are subject to work assignments as necessary, but the Employer will be responsive to future work assignment preferences of the employee. Duration or changes in work assignments shall be administered as directed by the Labor Assets Management Program.

Craft Alignment Program (CAP) (39: Pp. 129-132)

The Craft Alignment Program (CAP) works to allow greater flexibility and therefore more effective and efficient use of the workforce. Labor agreement employees are assigned to augment the work effort so that provisions are consistent with the collective bargaining agreement. In making assignments, the following parameters will be followed:

* Safety is priority in the performance of work.

* The Employee must have the qualifications and ability to perform the work safely

* Job classifications, seniority and seniority rules will be unchanged.

* There will be no formal cross-training program into other classifications; however, incidental on-the-job training and mutual sharing of knowledge and skills, in order to accomplish the work in a more efficient manner, will be expected.

* There will be no change in layoff procedure. Employees will not be laid off as a result of implementation of this program.

* The Employee will be paid the wage of his classification regardless of the task.

7.4.2 1997 BHI/HAMTC Labor Agreement [61]

The Bechtel Hanford, Inc., Thermo Hanford, Inc. and HAMTC 1997 Labor Agreement is very similar to the FHD/HAMTC 1997 labor agreement described above. Management must provide safety inspection, first aid service, and safety / radiation protection equipment to minimize accidents and health hazards to the employees. Thus, BHI/THI has their own separate health and safety departments and management from other prime contractors at the site. BHI and FDH do not incorporate health and safety practices or tracking systems in field.

Standard hours of work consist of eight hours between 6:00 am and 6:00 pm with one-half hour unpaid lunch. The standard work week is five consecutive workdays beginning on Monday and ending on Friday. Workers under this agreement also follow shifts as stated in the FDH/HAMTC agreement. 4/10 shifts are also utilized. Overtime is to be distributed as fairly as possible and seniority rules apply the same as the FDH agreement. HAMTC represented employees accumulate seniority regardless of employer. So, those employees moving between FDH and BHI do not loose seniority at the site.

Due to extensive D&D work at the site, BHI recognizes D&D workers as a separate classification. Under FDH, D&D workers are classified with Nuclear Operators and Operator trainees. [61; P.101]

The Labor Management Committee instituted by the BHI agreement is established and conducted in the same manner as FDH's LAMP and Craft Alignment Program.

7.4.3 1992 Agreement between Pacific Northwest Laboratories of Battelle Memorial Institute and HAMTC [62]

The 1992 PNNL/HAMTC agreement has similar provisions as the two agreements described above. Differences include separate seniority classifications and minor changes in definitions of job classifications. (Refer to Exhibits 12.2 and 12.3 on pages 170 through 184 to compare FDH/BHI and PNNL job classifications.) Currently, 225 craftsmen are currently working under the agreement. (Refer to Table 7.2 C on page 36).

7.5 Remediation Worker Population Turnover Rates

BHI, Inc. turnover rate for the current remediation worker population (340 workers) was reported as 19.5% in calendar year 1997. For PHMC / FDH, Inc., site representatives were not able to report this information without consulting all sub-contractor and enterprise companies. [41] This information was not available in a centralized location. However, a site contact did mention that the turnover rate was low for this population.

7.6 Future Remediation Work Force at the Hanford Site

Site planning is nearly complete at Hanford. It is, therefore, expected there will be a downward trend in the number of managerial, administrative, engineering, research, and other professional positions and an upward trend in the number of technical, craft, laborer, and operator positions over the next 5 to 10 years. [12: P. 55]

The remediation worker population has previously followed this upward trend, but has decreased slightly (approximately 3%, See Figure 7.2D: Changes in the Total Number of HAMTC/Remediation Workers by Year on page 36) over the last three to four years. With recent near completions of technology demonstrations, i.e. the full scale demonstration of C Reactor (See Section 11.3 on page 147), it is expected that numbers of remediation workers will increase quickly to accomplish planned goals.

7.7 Health and Safety at the Hanford Site [63]

DOE-RL is required to provide a safe and healthy work environment for all Hanford site employees. DOE-RL works with the Environmental Safety and Health Division to see that adequate, effective safety programs covering all site work in their respective divisions are established. DOE-RL will take oversight, but allow the contractors to take responsibility for establishing and maintaining an organization that will assure safe and healthful work places for every employee. Historic operations (i.e. previous contractor) health and safety systems and sub-contractor activities / records are also under the responsibility of the prime contractor. Individual employees regardless of contractor are responsible for following safety requirements, however enforcement of safety and fire prevention regulations is a supervisory responsibility.

Employees may exercise ‘stop work’ at any time. The assigned Division Safety Monitor (DSM) is the initial point of contact for matters concerning the correction of routine safety and health issues. Requests for inspection or reports of unsafe or unhealthy working conditions are to be made to the DSM and Division Director of the affected work area, or to the Director of Quality, Safety, and Health Programs Division. Verbal complaints with the RL Employee Concerns Office may also be filed. DOE has a policy of "Zero Tolerance" against any employer who fails to disclose a health or safety issue.

7.7.1 Hanford Industrial Safety / PPE Guidelines

General safety and health requirements for various facilities on site are clearly posted as is the required personal protective equipment (PPE) (e.g., safety glasses, hard hats) and respiratory protective equipment (RPE) [64]. Standards meeting OSHA criteria govern PPE and RPE site guidelines [65, 66]. Information on required PPE and RPE is provided to individuals at job-specific orientation. [63]

Hanford has many industrial safety programs at the site including, 1) Drill Rig Safety, 2) Electrical Safety, 3) Excavation, Trenching, and Shoring Safety, 4) Fall Protection, 5) Hoisting and Rigging, 6) Ladder Safety, 7) the Lockout/Tagout Program, 8) Scaffolding Safety, and 9) Vehicle Safety. (67)

7.7.2 Occupational Medicine (63)

Employees preforming hazardous tasks or having special medical conditions are required to obtain medical evaluations from the Hanford Environmental Health Foundation (HEHF). HEHF, the occupational medical contractor at the site, determines health status and permits early detection of the effects of hazardous working conditions. Employees are scheduled for medical evaluations depending on their risk assessment and the potential exposure from work site hazards. Health appraisals are also available at no cost to the employee.

Employees requiring first aid medical services are encouraged to seek assistance at one of the Health Care Centers (HCC) or Health Service Center (HSC) located in most areas of the Hanford Site. Employees with on-the-job injuries or health issues believed to be work related must report to their supervisor following the incident. The HCCs are staffed by Occupational Health Nurses and provide wellness information and medical care. The 200 East Center is staffed by nurses and a physician who provide a broader range of services. The reports of job-related injuries or illnesses are initiated after each visit to a HSC, but are also forwarded to the supervisor. RL Operations, in areas where an employee is exposed, are consistent with procedures established to control exposures to harmful environmental contaminations or stresses. Claims for work-related injuries must also be reported to the Human Resources Services Division (HRD).

Occupational medical data is primarily tracked within the **Hanford Environmental Health Foundation Occupational Medical System** (HOM). This system is described in detail in Section 8.2.3 on page 64.

7.7.3 Hanford Site Industrial Hygiene (68, 69)

Coordination of industrial hygiene programs at the Hanford site is the dual responsibility of the Occupational Medical Services Contractor (OMSC) HEHF and the prime contractors on site (FDH, BHI, PNNL). Sub-contractors also staff their own industrial hygienists and are required to report data to their prime contractor. IH data for companies under the PHMC is kept within the Hanford Industrial Hygiene System (HIH2) (Please see Section 8.2.2 on page 63). PNNL and BHI data are kept in separate tracking systems.

HEHF currently provides 1) medical services, 2) technical IH support services and consulting, 3) IH analytical laboratories, 4) work environment surveys, 5) noise and hearing conservation programs, 6) maintenance of centralized personal exposure data and monitoring (1989 through 1995) (NOTE: Contractors were required to maintain adequate exposure records in addition to HEHF record keeping), and 7) maintenance of the Hanford Site Material Safety Data Sheet (MSDS) system. In the past, HEHF played a larger role in the areas of site-specific IH monitoring, assessment, and record keeping. The change became largely due to the establishment of the Project Hanford Management Contract in 1996, but started phasing out of this responsibility in 1995. Prime contractors at the site now provide for their own IH monitoring and record keeping needs.

Prime contractors at the site must 1) conduct effective programs to educate employees of potential health hazards, control measures and necessary protection to reduce risks, 2) inform employees of health hazards and the results from monitoring, 3) ensure resources are available for training, 4) evaluate the effectiveness of proposed environmental control equipment, 5) perform evaluations of the impact on the work environment of modifications or process changes on new facilities, and 6) provide judgement and experience where no code or standard exists regarding hazardous materials or physical agents.

The Hanford site wide IH program addresses the following major IH topics through all contractors and DOE-RL: 1) use of respiratory equipment, 2) asbestos material, 3) regulated carcinogen or suspect carcinogenic materials, 4) blood borne pathogens, 5) cross-connection (i.e. any physical arrangement whereby a potable water supply is connected) control standards for Hanford water systems, 6) control of hazardous materials, 7) DOE Filter Test Station, Filter Testing, 8) Hearing Conservation, 9) Indoor Air Quality (IAQ), 10) Hazardous Waste Site Safety / Health Management, 11) Confined Space, 12) Temperature Extremes, 13) Ergonomics, and 14) Lead Control.

7.7.4 Hanford Site Radiological Safety / Health Physics

The Hanford Site Radiological Control Manual (HSRCM) is the central document providing radiological procedure. [70] Document updates are the responsibility of PNNL, however DOE-RL is responsible for ensuring that procedures are followed. The prime contractors (FDH, BHI, PNNL) are to implement a Radiological Control Organization to provide relevant support to line managers and workers.

Radiological areas at the Hanford site are marked and surrounded with clearly marked barriers. Employees are prohibited from entering posted radiation areas without a specific purpose as defined in their job functions and responsibilities. Employees must have the required dosimeter, PPE / RPE, and training to enter the area (the **Access Control Entry System (ACES)** [71] is available for this check, See Section 8.2.1 on page 62 for a detailed description of this system), and must obey verbal and written radiological control instructions. Individuals requiring a dosimeter will be asked to provide information concerning occupational radiation exposure histories.

As low as reasonably achievable (ALARA) principles are followed at the site. *Individual worker dose shall be ALARA and should be less than 500 mrem per year. The design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2000 hours per year) shall be to maintain exposure levels below an average of 0.5 mrem per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in 10 CFR 835.202. This requirement is less restrictive than Article 1281.A of the DOE Radiological Control Manual.* [70]

7.8 Hanford Site Remediation Worker Training [63]

Due to the nature of remediation work and the potential for health hazards at the site, remediation workers require training based upon their job classifications, specific duties, tasks or assigned project.

A Health and Safety Orientation is offered by DOE Training Office within a few days of employment at the site to any of the prime, major sub-contractor and lower-tiered contractors. Additional training is provided, and in some instance mandatory, depending on the employee's assignment and potential for exposure to specific hazards.

Contractor supervisors provide information about training for each work assignment. The supervisor will assist in determining the appropriate level of training required. The DOE Training Office can be contacted to schedule specific training. Trained personnel should recognize that their actions directly affect contamination control, personnel radiation / chemical exposure and the overall radiological / chemical environment associated with their work.

Crafts and unionized workers also have apprentice, journeymen, and work leader levels associated with a specific trade so that young un-skilled labors are properly trained and advanced in their craft.

All training records for Hanford Employees regardless of contractor are kept in an electronic system called the **Training Records Information System** operated by FDH for DOE-RL. The DOE Training Office at the site is the contact for this system.

7.8.1 PHMC (FDH) Training [63]

Worker training is provided by a variety of PHMC Team training organizations, subject matter experts, outside vendors, and educational institutions. The FDH Qualification and Training Plan (HNF-MP-011) establishes standards to ensure that all training provided to PHMC employees meets contractual and regulatory requirements and prepares the work force to perform activities in a safe manner.

Training, qualification, and certification requirements for personnel are established by individual managers (line management) of FDH or the sub contractor / enterprise company with the guidance of Training Implementation Matrices or the Training Matrix.

Training materials support the following topics: 1) Integrated Safety Management System (ISMS) Overview, 2) Hazard and Environmental Impact Identification and Analysis, 3) Development and implementation of controls for hazards and environmental impacts, 4) Consequences of departing from the operating controls and procedures, and 5) Emergency Preparedness.

7.8.2 ERC (BHI) Training [72]

As the environmental restoration contractor, BHI follows the same 'training paths' as those employees working under the PHMC. BHI purchases these courses so that their workers are trained consistent to PHMC employees.

Specialized employee training is purchased from the PHMC. The primary work performed by BHI requires that field workers and supervisors have task-and hazard-specific training, such as that found in 29 CFR 1910.120. The OSHA 24-Hour or 40-Hour Hazardous Waste Worker and 8-hour annual refresher training, plus other training courses such as Radiation Worker are provided to BHI employees through the DOE Training Office or PHMC/FDH.

7.8.3 HAMMER (Hazardous Materials Management and Emergency Response Training and Education Center)

The Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) provides the skills, knowledge, and abilities necessary to improve worker/emergency responder health and safety. HAMMER is a 'national' classroom where all DOE or DOE contractor students have the opportunity to receive lectures as well as hands-on in the field training which greatly reduce the risks of accidents and fatalities. Training includes emphasis in fire response operations, occupational safety and health, emergency operations, environmental waste management, and use of new technologies. [73, 74]

7.9 Hanford Site Demographic / Human Resource Data

For the purpose of this Exposure Assessment Feasibility Study, data concerning total numbers of remediation workers were obtained and summarized in this document. Other demographic data (i.e. race, gender, age, work histories, etc.) were not obtained, but are available through various Hanford data systems. By identifying the remediation worker population and defining it's criteria, obtaining specific demographic data for subsequent phases of this study is possible.

For a 'snap-shot' of the current workforce, the **Hanford Site Roster (or Hanford People Core (HPC))** supported by PeopleSoft, Inc. software would be the best system for obtaining who is currently at the site. The system is used primarily for human resource purposes by each prime contractor (FDH/BHI/PNNL). All prime contractors except Johnson Controls use the Hanford People Core system. Johnson Controls uses a simple database system along with paper records to track their limited number of employees. **HPC** is also used by HEHF for periodic data dumps into the **Epidemiological Surveillance System (ESS)** [(75)] described in Section 8.2.3 on page 65 and by FDH for data dumps into the **Access Control Entry System (ACES)** [(71: P. 5)] described in Section 8.2.1 on page 62.

The primary data fields within the **HPC** include:

1) Name (First, Middle Initial, Last)
2) Social Security Number (SSN)
3) Hanford ID
4) Date of Birth
5) Gender
6) Company
7) Job Title
8) Pay Type
9) Area, Building, Room, Activity
10) Employee Start Date

Detailed demographic data (i.e. race, age, gender, medical history) for the remediation worker population exists in various systems across the site. Medical records provided by the Hanford Environmental Health Foundation may also provide a prime source for demographic data. As mentioned by a site contact, *the **Employee Job Task Analysis** (EJTA), the **Risk Management Medical Surveillance System** (RMMS), the **Epidemiological Surveillance System** (ESS), the **Return to Work** (RTW), and the **Hanford Radiological Exposure Monitoring System** (REMS) contain various amounts of demographic data as well as specific exposure or medical information.* [76] These systems are described in Section 8.0. Another site contact also suggested that **Hanford Radiological Exposure System** (REX) (described in Section 8.2.1 on page 60 and 61) would be useful for epidemiology studies because it contains personnel data. [77]

For tracking the entire remediation workforce from 1989 through the present, many of archived and current systems would need to be queried then complied together to form the data of interest. This would be necessary due to the movement of the remediation worker population. HAMTC members and other laborers at Hanford moved from contractor to contractor due to layoffs, changes in benefits, and changes in job interests or positions.

8.0 Hanford Remediation Worker Exposure Information

Overview

This section addresses Hanford Site exposure data and current measures for site risk assessment and safety management. The purpose of this section is to explain where chemical, radiological, and occupational medical data is kept, who it is kept for, and who is responsible for the maintenance and reporting of the data.

With the establishment of the Project Hanford Management Contract (PHMC) in October of 1996, Fluor Daniel Hanford (FDH) instituted a plan called the Integrated Environment, Safety and Health Management System (ISMS) was jointly established to better the quality, assessment, and tracking of environmental, safety and health data. Currently, Hanford is in the process of developing and refining safety and health data reporting procedure. Safety and health procedure is collectively referred to as the Hanford Occupational Health Process (HOHP) at the site.

The following section explains the ideals and purpose of the Hanford ISMS and HOHP. Note that the **Employee Job Task Analysis (EJTA)** and the **Automated Job Hazard Anaylsis (AJHA)** are new to the site and in preliminary stages. Data linkages between these and other systems have not yet been established.

Throughout this section, data systems are highlighted in bold type.

8.1 The Hanford Occupational Health Process (HOHP)

The ISMS Plan establishes a single, defined environmental, safety and health management system that integrates requirements into the work planning and execution processes to effectively protect the workers, public, and the environment. *As part of the ISMS, the* ***Employee Job Task Analysis*** *(EJTA) provides the primary mechanism to ensure that personnel have the appropriate medical qualification, training, and exposure monitoring based on their assigned job functions and the hazards to which they may be exposed. The EJTA, in conjunction with the* ***Automated Job Hazard Analysis*** *(AJHA) and exposure monitoring and reporting, provide the primary data input components to the HOHP. In addition to providing essential data for medical qualification and monitoring, the HOHP effectively supports other occupational medical evaluations and examinations such as pre-placement, voluntary periodic, return to work, and termination health examinations.*[63: Sec. 3.5.1.2]

The EJTA compiles employee-specific data regarding essential job functions, physical job requirements, special job requirements, medical qualifications, potential exposure hazards, exposure data, and training. The data collected on the EJTA represents a compilation of hazards and exposures associated with routine work activities, as well as hazards associated with non-routine work activities that can be predicted or anticipated. For non-routine work activities when exposures will or are likely to be greater than established criteria, EJTA exposure hazard data is supplemented by potential exposure hazard data from the AJHA . EJTA potential exposure hazard data also is supplemented with employee-specific exposure data reports from the ***Hanford Industrial Hygiene Exposure Database*** *(HIH2)* (Note this Database currently contains PHMC and some Pacific Northwest National Laboratory industrial hygiene data only) [78]. *The need to conduct personal exposure monitoring for chemical, radiation, physical (including non ionizing radiation), ergonomic and biological hazards will be determined as part of the AJHA process and will be conducted in accordance with FDH Industrial Hygiene and Radiological Control procedures that specify the use of standardized exposure data collection forms, exposure databases, instrument calibration and maintenance, exposure reporting, and exposure records storage and maintenance.*[63: Sec. 3.5.1.2]

***EJTA** is designed to:*

- *Provide a simple automated tool to aid the line manager in determining the necessary employee medical qualification (e.g., drivers, pilots, protective force personnel, respirator wearers, etc.) and monitoring examinations (asbestos, lead, noise, lasers, HAZWOPER, etc.)*

- *Assist line managers in determining the necessary whole body count, in-vivo monitoring, bioassay, etc. examinations*

- *Satisfy specific Americans With Disabilities Act (ADA), fitness for duty and return to work data needs*

- *Provide necessary data for pre-placement and termination health evaluations*

- *Identify the need for additional employee exposure assessment and monitoring data (e.g, personal or area exposure monitoring)*

- *Determine the necessary ES&H training based on the identified hazards*

- *Facilitate employee, manager, and industrial hygiene involvement in the overall hazard identification and occupational medical process*

- *Assist in identifying and managing applicable ES&H-related requirements*

- *Provide the data necessary to conduct comprehensive site wide health and epidemiological studies*

- *Maintain an inventory of completed EJTAs for review, and data analysis.*[63: Sec. 3.5.1.2]

For an example of the EJTA Database Entry Screen, refer to Exhibit 12.4 on pages 185 through 189 [255, 262].

The ***AJHA***:

(Note: Refer to Reference Tracking Number 76 in the Hanford References Tracking Database. Refer to Section 14.0 on page 258 for a description of this system.)

•Addresses environmental, industrial hygiene, industrial safety, nuclear safety, fire protection and radiological hazards and requirements

•Promotes worker involvement in the work planning process including hazard and environmental impact identification, evaluation, and control

•Integrates the appropriate ES&H personnel into the work planning process to effectively support hazard and environmental impact identification, evaluation, and document controls

•Supports the work planning team in determining the applicable standards and requirements and FDH implementing procedures associated with the identified hazards and environmental impacts

•Provides the mechanism for access and completion of necessary work permits, environmental documents and forms to support the work activity

•Supports determination of the activities' risk and complexity

•References the mandatory training based on the identified hazards and environmental impacts

•Delineates the need for pre-job walk downs and provides the basis for pre-job briefings

•Allows for early determination of personnel and area monitoring requirements (Radcon, Industrial Hygiene, Environmental, etc.)

•Supports a comprehensive system for medical monitoring of significantly exposed personnel

•Promotes configuration control of the Authorization Envelope (Safety Review Process)

•Provides support for co-located workers

•Supports the work planning team in determining the need for training on mock ups before beginning the work activity

•Provides the capability of documenting Lessons Learned to ensure that the information is readily available the next time the work activity is performed

•Assists the work planning team in ensuring that the work activity can be completed within the controls specified, and applicable regulations, consent orders and agreements, and permit conditions.[63: Sec. 3, Table 2]

Contractor Roles and Responsibilities within the Hanford Occupational Health Process (HOHP)

Fluor Daniel Hanford Environmental Safety and Health (FDH ES&H) develops and maintains the **EJTA**, the **AJHA**, and the exposure monitoring and reporting procedures to support the HOHP. FDH ES&H, along with the Hanford Environmental Health Foundation (HEHF), maintains the automated **EJTA** system. FDH is currently the sole owner of the **AJHA** and responsible for it's management. [63: Sec. 3]

At the facility level, all prime contractor and subcontractor managers complete an **EJTA** for each of their employees. The major subcontractor facility or project manager ensures the completion of EJTAs for all lower tiered subcontractor employees who will perform work within the major subcontractor, operated facility or project. The major subcontractors assess the adequacy of hazard controls when medical monitoring results indicate adverse health consequences to workers as a result of work place hazards. The idea behind the EJTA is to capture information on all employees at the site regardless of contractor. This has been a challenge and problem area for safety and health assessment and monitoring and the Hanford site.

8.2 Established Exposure Data Systems at the Hanford Site

There are numerous exposure data systems at the Hanford site that maintain radiological, industrial hygiene, and occupational medical data. The **EJTA** and the **AJHA** will use data from the following systems to achieve the goals set in the Hanford ISMS and HOHP. Note that a tabular presentation of the preceding information is contained in Exhibit 12.5 on pages 190 through 195. Site contacts for each system are also available with in the Exhibit. A flow diagram was also created for this section showing all data systems and how they may be related. This diagram (Figure 8.4A) is located on page 69.

8.2.1 Radiological Data Systems

Hanford Radiological Exposure Monitoring System (REMS)

The Hanford **REMS** contains dosimetry data from 1989 to 1996 for all employees at the Hanford Site. This dataset is composed of two separate databases. One contains the information on external exposures over time for individual employees (called **REM2**) while the other contains the internal dose data only (called **REM1**). [79, 76]

Data fields within **REM1** include:

1) site code
2) organization code
3) DOE Facility Name
4) birth date and birth year
5) person IDs (Social Security Number and Hanford ID)
6) name
7) gender
8) dose
9) dose uptake
10) radionuclide
11) dose date

Data fields within **REM2** includes:

1) site code
2) organization code
3) DOE Facility Name
4) birth date and birth year
5) person IDs (SSN and Hanford ID)
6) name
7) gender
8) occupational code
9) Facility Type
10) employment status (month start and month end)
11) DDE Photon (Deep Dose Equivalent)
12) DDE Neutron
13) Committed Effective Dose Equivalent (CEDE)
14) TEDE (Total Effective Dose Equivalent)

This system is maintained by the Hanford Environmental Health Foundation (HEHF) and is used within the **Department of Energy Radiological Exposure Monitoring System** (DOE-REMS) for annual DOE Occupational Radiological Exposure reporting. **DOE-REMS** is described in detail later in this Section.

Radiological Exposure System (REX)

The **Radiological Exposure System (REX)**, the primary radiological system at Hanford, is a relational database that resides on the Hanford Local Area Network. The system contains bioassay and whole body data as well as access to current Thermoluminescence Dosimeter (TLD) Data for all Hanford site employees. The system stores radiological training data, area/facility information, and demographic information. Referrals to stored microfilm and microfiche containing excreta/bioassay and training information are available within the system. Contracting companies are also tracked in **REX**. **REX** data feeds into the **Hanford REMS** where it stores the data over time. The **REX** system is managed by Battelle for the Pacific Northwest National Laboratory (PNNL). The Occupational Radiation Exposure (ORE) database was the predecessor to **REX** and began in 1981. **REX** replaced ORE in 1993. A new system using ORACLE/UNIX/Sun Work Station will replace **REX** in December 2000. [257, 258] Procedure manuals and software design documentation for REX is referenced in this document. [259, 260, 261]

Tables of interest available in **REX** include:

1) REX Person
2) Dose Master
3) Dose Summary
4) Ex_Results
5) Inv_Results
6) Int_Master
7) Int_Annual
8) Invivo_iso_master

Access Control Entry System (ACES)

The Oracle-based **Access Control Entry System (ACES)** provides 'checks' before an employee enters an area, complex, or work location. The system empowers the user (the employee doing the check such as a Health Physics Technician (HPT)) to determine training requirements, employee qualifications, personnel data, and entry. Training requirements include location requirements, permit requirements, and job role requirements. Employee qualifications include medical qualifications, training qualifications, and exposure qualifications. Personnel data includes organization code, company code, payroll number, name, and craft code. Entry data includes permit numbers, estimated dose, dosimeter number, job role, and reasons for entry rejection. The ACES is used at all Hanford locations or job sites where access is controlled by a Radiological Work Permit (RWP) or a Hazardous Waste Operating Permit (HWOP).

Data is fed into the ACES through a variety of systems. They include: 1) **Radiological Exposure System (REX)**, 2) **Hanford Environmental Health Foundation Scheduling System (HSS)** (described later in this chapter), 3) **Hanford People Core System (HPC)** (described in Section 7.9, on page 53), and 4) **Training Records Information System (TRI)** (also described in Section 7.9, on page 51). This data determines qualifications for entry.

ACES is used by the Project Hanford Management Contract (PHMC) contractors and PNNL. Fluor Daniel Hanford (FDH) has developed and currently manages the system. Bechtel Hanford, Inc. (BHI) does not use this system. [77] Because BHI employees are not apart of ACES, it would seem that not all employees at the site are properly tracked. For example, if a BHI employee enters an FDH facility owned area, the ACES system will not contain exposure history on that BHI employee. To remedy this problem, site managers explained that BHI employees entering an FDH area are to bring paper records showing exposure history. With written record, the BHI employee can be checked within the ACES system. [80]

8.2.2 Industrial Hygiene Data Systems

Prior to 1995, the Hanford Environmental Health Foundation (HEHF) was responsible for industrial hygiene record keeping. While HEHF is still involved IH support and consulting, they currently do not track all industrial hygiene exposure records. It is now the responsibility of the prime contractors (and in some cases major sub-contractors) to keep this information.

The following systems at the Hanford site may be useful for determining personal chemical exposure.

Hanford Industrial Hygiene System (HIH2)

The Century 2000-based **Hanford Industrial Hygiene System (HIH2)**, contains industrial hygiene exposure data for PHMC employees from 1996. Prior to 1996, a Flow Gemini System was used for IH exposure data record keeping. This system was the responsibility of HEHF. Data in HIH2 includes the monitoring of, but is not limited to, airborne agents, noise, heat, illumination, asbestos, lead, and isocyanates. It also contains personal samples categorized by Hanford ID, SSN, and project. Area samples are contained in a separate database at the site. [78]

Document Information System (DIS)

The **Document Information System** (DIS) is a Bechtel Hanford, Inc. industrial hygiene database containing IH exposure information by project for BHI, ThermoHanford, Inc. and CH2 Hill, Inc. Data date back to 1995 and include the monitoring of asbestos, lead, mercury, silica, and organic vapors. Personal exposures are also documented on employee medical records and sent to the Hanford Environmental Health Foundation (HEHF) for notification.[42]

Pacific Northwest National Laboratory Industrial Hygiene Paper Records

PNNL operated by Battelle conducts industrial hygiene practices separate from FDH and BHI. Industrial hygiene concerns at PNNL include, but are not limited to, the monitoring of laboratories used in support of the Hanford tank farms, animal research laboratories, and maintenance of 300 area buildings. Exposure data are maintained through a paper file system with data dating back to 1994. PNNL IH exposure data prior to 1994 reside with the HEHF. [81]

8.2.3 Occupational Medical Data Systems

As the Occupational Medical Services Contractor (OMSC), the Hanford Environmental Health Foundation is responsible for the tracking and maintenance of employee medical records. The following systems are currently be located at the HEHF facility. [82, 76]

HEHF Occupational Medical System (HOM)

This Flow-Gemini based system is a repository and goes back to May 7th, 1984. It is strictly the testing results performed during routine exams of all site employees. The data includes:

1) Demographics
2) Work History
3) Audiogram
4) ECGs (Electrocardiogram)
5) Pulmonary Function
6) X-Ray
7) Chemistry
8) Hematology
9) Urinalysis
10) Toxicology
11) Physician Findings
12) Work Restrictions (from mid 1993)
13) Scheduled Monitoring/Surveillance/Qualification programs
14) Clearances for Monitoring /Surveillance/Qualification programs

HEHF Medical Scheduling System (HSS)

The **HEHF Medical Scheduling System (HSS)** is similar to the **HOM** in that it provides general medical information on all site employees such as medical restrictions and data from physicals. This data is current for all employees in the system and is used to provide inputs into the ACES.

Risk Management Medical Surveillance System (RMMS)

The **Risk Management Medical Surveillance System (RMMS)** is the repository for the data captured by the **Employee Job Task Analysis (EJTA)**. The **EJTA** is fairly new to the site, so data stored in the **RMMS** will only date back to approximately 1997. Data on all site employees is available in this database. The system provides information on potential exposure hazards, work location, and job type. This system also contains additional tables and queries related to the **EJTA** / HOHP process.

Return to Work Medical Events (RTW)

The **Return to Work Medical Events (RTW)** database consists of the information needed to properly document lost time from work and for what medical reason. The system tracks all site employees. Fields include:

1) Site code
2) Hanford ID
3) Record status
4) Date Absence began
5) Diagnosis
6) Return to Work Date

Epidemiologic Surveillance System (ESS)

The **Epidemiologic Surveillance System (ESS)** integrates Hanford employee demographic information from the **HPC (Hanford Site Roster System)** and the **Return to Work (RTW)** medical events. These records are sent to DOE Head Quarters in Oakridge, Tennessee for coding and then returned to HEHF for further investigations.

8.3 DOE Database Systems

The DOE Radiological Exposure Monitoring System (DOE-REMS) [83, 84, 85]

Individual radiological monitoring data is centrally available through the **REX** system and also available through **HEHFs REMS**. **HEHF REMS** data is the data that is submitted to the **DOE Radiological Exposure Monitoring System (DOE-REMS)** operated by Science Applications International Corporation (SAIC). The **DOE REMS** data from 1986 is available over the Internet and may be queried for specific data interests. Special permission is required to obtain sensitive information in this database. Public domain data fields in this system include

1) year
2) operations office
3) site
4) reporting organization
5) facility type
6) labor category
7) occupation
8) monitoring status
9) TEDE
10) CEDE
11) Total Number Monitored
12) Dose Ranges
13) DDE Photon
14) DDE Neutron
15) SDE_WB (Shallow Dose Equivalent: Skin)
16) SDE_ME (Shallow Dose Equivalent: Extremity)

DOE-REMS data is also published and analyzed annually in the DOE Occupational Radiation Exposure Report. Reports are available through the REMS site from 1994 through 1997. A 1998 report will be available in 1999.

The DOE Occurrence Reporting and Processing System (ORPS)

Hanford environmental occurrences are required to be publicized (DOE Order 232.1A) and are tracked by the **DOE Occurrence Reporting and Processing System (ORPS)** [24]. The database is searchable by site and contains all emergency, unusual, and off-normal occurrence reports, including event descriptions and corrective actions. This system may be a source for both radiological and chemical potential exposures.

The following occurrences were recently reported: 1) Occurrence Report Number (ORN): RL--PHMC-PFP-1997-0023, An explosion occurred at the Plutonium Reclamation Facility resulting in an emergency response, 5/14/97, and 2) ORN: RL--PHMC-327FAC-1998-0002, Small Bottle of Suspect Material Discovered - Alert Level Emergency Declared, 1/28/98, and 3) ORN: RL--BHI-NREACTOR-1997-0006, Worker Cuts Into Energized 240 Volt Circuit, 3/25/97.[86, 87] A total of 550 occurrence reports were reported by the Hanford site in 1998.[88] The following Table presents the number of ORPS reports from 1990 through 1998.

Table 8.3 A: Number of ORPS Reports from 1990 to 1998 for the Hanford Site [24]

Site	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Hanford	435	1275	1131	815	729	660	541	541	550	6677

The ORPS also provides bulletins relating to occurrence reporting such as general site compliance issues and updates.

8.4 Other Useful Hanford Data Systems

The Tank Waste Information Network System 2

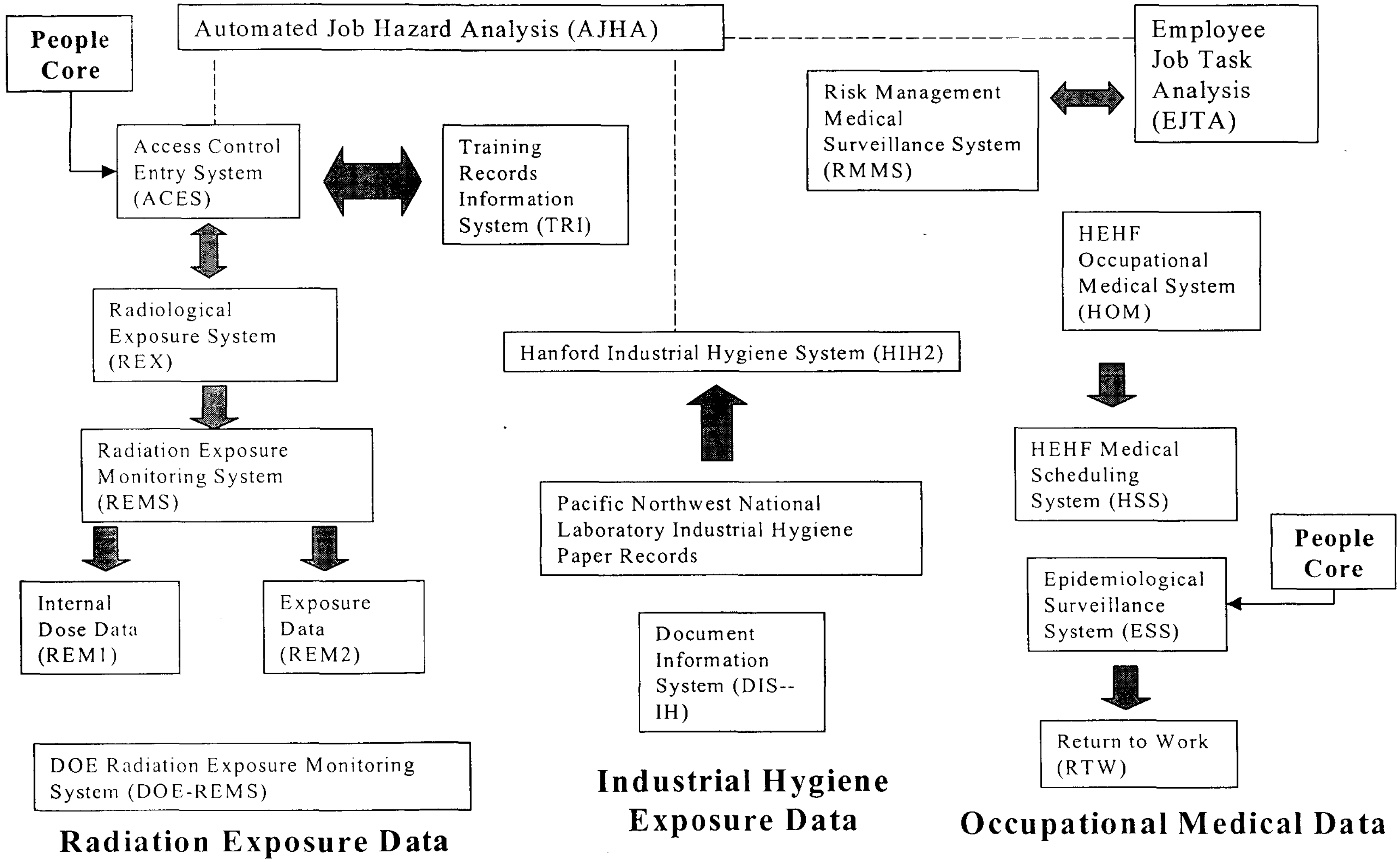
The **Tank Waste Information Network System 2 (TWINS2)** [89] is an on-line interface system that queries various tank characterization databases kept at the Hanford site. The system is managed by the Pacific Northwest National Laboratory and was instituted by the Washington State Department of Ecology for use in Tri-Party Agreement and regulatory mandated documents. Information obtainable from the system includes select queries from the following databases: 1) Best Basis Inventory, 2) Measurements, 3) Safety, 4) Sample Analysis, and 5) Vapor. Radiological and industrial hygiene data relating to specific tanks is also available through the interface, but is, however, minimal. [90] Data fields within the Industrial Hygiene database include:

1) Tank Name
2) Tank Riser
3) Survey Date
4) Measurement Type
5) Result Value
6) Reporting Limit
7) Units
8) Analysis Method
9) Monitoring Instrument Model
10) Monitoring Instrument Calibration
11) Comments on IH data

System for Tracking Remediation, Exposure, Activities, and Materials (STREAM) [91: P. 12]

The **System for Tracking Remediation, Exposure, Activities, and Materials (STREAM)** was demonstrated by Bechtel Hanford, Inc. as a 105-C Reactor technology in FY 1997. The system is described as a comprehensive database incorporating vital data required in the performance of D&D. No data fields were obtained from this database for this report. The use of this database in other Hanford projects was not reported.

Figure 8.4 A: Overview of Hanford Exposure Data Systems [92, 93, 94, 95] (Dotted lines indicate anticipated connections in data systems. Please refer to Section 8.2 for narratives on each data system.)



8.5 Summary of Hanford Radiological Exposure Monitoring Data

The 1994, 1996, and 1997 DOE Occupational Radiation Exposure Reports discuss Hanford radiation exposure trends. Refer to Table 8.5 A for a view of trends. There was significant increase from 1994 to 1995/early 1996 for Total Effective Dose Equivalent (TEDE) due to the increase in the mandatory submission of radiation exposure (individual) and personnel contamination (more than five employees) occurrence reports at the Hanford Site. [83: P. 3/22] However, the site collective TEDE decreased by 9% towards the end of 1996. At this time, the K Basins accounted for approximately 33% of the total collective TEDE for the site, the PFP accounted for approximately 24%, and the 200 East Tank Farm accounted for 14% of total collective TEDE.[84: P. 3/23]

Table 8.5 A: Collective Deep Dose Equivalent (person-rem) or Total Effective Dose Equivalent (TEDE) for Monitored DOE, DOE Contractor Employees and Visitors from 1989 through 1997 at the Hanford Site

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
(1) Collective Dose	619	330	252	239	NR	NR	NR	NR	NR
(1) TEDE	(2)NR	NR	NR	260.0	211.5	214.8	290.7	265.7	235.4

1) In 1989 through 1992, TEDE=DDE+AEDE (Deep Dose Equivalent + Annual Effective Dose Equivalent). In 1993 through 1996, TEDE=DDE+CEDE (Committed Effective Dose Equivalent)

2) NR = Not Reported in DOE Occupational Radiation Exposure Report.

While clean-up activities at K Basins increased in 1996, the collective dose was significantly reduced due to the installation of perimeter shielding and completion of a 'clean and coat' project. [84: P. 3/23] The site collective TEDE again decreased by 11% in 1997. [96: P. 3/24] No specific operational changes were identified by Hanford that resulted in a significant exposure reduction, however certain technologies were addressed as reducing worker exposures. They included 1) aerosol generation to apply a fixative (See Technology 23 on page 160) and 2) segmenting a six-ton crane using laser cutting. The Spent Nuclear Fuel (SNF) project has also worked by using new technology to reduce general area dose rates at the KE Storage Basin.

Summary area monitoring dosimeter reports from PNNL are available for 1993 through the present, however, no other summary data is available from Hanford.[97, 98, 99] (Exception: The Hanford Site Performance Report (Section 8.9 on page 73) does summarize Radiological Events). Summary reports are only available through the DOE REMS.

For this exposure assessment feasibility study, queries were made from the DOE REMS and graphed in Microsoft Excel to examine the Hanford remediation workforce in terms of occupational radiation exposures. Exhibit 12.6 on page 196 shows Hanford occupational radiation exposure summary data from 1986 through 1997 in order of decreasing exposure risk. It should be noted that this query could not select data specifically from 1989 through 1997. (100) Exhibits 12.7A through 12.7H on pages 199 through 206 show summary DDE (Deep Dose Equivalent) photon and DDE neutron exposure data from 1989 to 1997 for the top 15 job classifications showing the greatest exposure risk identified in Exhibit 12.6.

8.6 Summary of Hanford IH Exposure Monitoring Data

As previously identified in Section 8.2.2, Industrial Hygiene Monitoring Data is not kept in a centralized system for the entire site like radiological monitoring data. Essentially, each prime contractor (FDH, BHI, and PNNL) is responsible for their own reporting and tracking system, but must comply with DOE-RL oversight.

IH Exposure monitoring summary reports are not available by DOE-RL or the contractors at the site. Monthly or annual reports are not required by DOE-RL. Summary data is strictly obtained through the prime contractor industrial hygienist (IH). During the Hanford Site visit for this exposure assessment feasibility study, select summary data was obtained through the a BHI industrial hygienist. Refer to Exhibit 12.8 on pages 207 and 208 for the data. (101, 42)

Besides using Hanford IH data systems, chemical exposure data may also be obtained from the **DOE ORPS** or the Chemical Occurrences web-site. The Chemical Occurrence web-site provides summaries and reviews of the ORPS. *The DOE has been tracking, trending, analyzing, and compiling chemical safety concerns at its facilities since August 1992. These concerns have been summarized in monthly reports and analyzed in quarterly and annual reviews and posted on the site. Monthly reports present a quickly available summary of chemical safety occurrences (events and conditions) at DOE facilities including short descriptions of the more significant concerns. Quarterly reviews contain analysis of occurrences, causes, corrective actions, and lessons learned as well as some statistical analysis of chemical safety performance across the DOE complex as determined from ORPS monitoring.* (102)

8.7 Future Data Updates and Systems

At the time of the site visit for this study, the **EJTA** and **AJHA** were fairly 'new' (approximately 2 years old) and not completely implemented into the HOHP. It is recommended that the site be contacted at a later date for updates and developments in the process.

The ACES will also need follow up for future updates. It was mentioned by a site contact that the system will be converted in a few years to a work management system named the INDUS Total Exposure System.[77]

It was also mentioned that PNNL IH data may be converted to an electronic system in the future.

8.8 Summary of Hanford Beryllium

Due to notice DOE N440.1, a medical surveillance program specifically for beryllium workers (current and former) became available at Hanford. HEHF provides worker evaluations on a regular basis. Exhibit 12.9 on pages 209 and 210 shows Possible Beryllium Facilities at the Hanford site. [103, 104]

8.9 Other Exposure Data Sources

Other documents and sources available for Hanford occupational exposure research include:

The Hanford Site Performance Report

The Hanford Site Performance Report (HSPR) provides monthly status for work performed by the DOE-RL, PHMC through FDH and its subcontractors, ERC through BHI and its subcontractors, and PNNL for science and technology support. The report available online since February 1998 through the present provides information on current worker safety and health. Including reports on Radiological Events, Total OSHA Recordable Case Rate , OSHA, Recordable Cases by Project, Occupational Illness & Injury Cases/Days, OSHA Lost/Restricted Workday Case Rate, Lost/Restricted Workday Rate (Service Rate), and First Aid Case Rate. [105]

Other On-Line Services / Sites

Other Internet sources that may be useful for obtaining exposure information include: 1) the Computerized Accident Injury and Reporting System (CAIRS) [106], 2) the Medical Surveillance Information System [107], 3) the Comprehensive Epidemiological Data Resource (CEDR) [108] (Note: this maintains mostly pre-1989 data), 4) the Occupational Injury and Property Damage Summary (OIPDS) [109], 5) the DOE TIS (Technical Information System) [6, 110], and 6) the DOE Worker Health and Safety Web Site. [111]

8.10 Archival

Production period and early 1990 paper copy personnel files of all types (i.e. medical records, human resource records, IH / RAD records) are shipped and stored in a federal records repository in Seattle, Washington. For purposes of this study, electronic records from 1989 to the present are available at the Hanford Site.

9.0 Overview of Integrated Environmental Waste Management at the Hanford Site

The following narratives describe the management (i.e. treatment, storage, and final disposition) of waste streams at the Hanford site. In order to properly manage all Hanford wastes, the integration of on-site and/or off-site (other Department of Energy (DOE) site) facilities and contractors is necessary. Therefore, most contractors previously described in Section 7.0 have some role or responsibility in overall Hanford waste management. For example, the Environmental Restoration Contractor (ERC) Bechtel Hanford, Inc. is responsible for the management of environmental restoration (ER) activity wastes. In this section, the responsible contractor for the process or Hanford facility will be mentioned in each waste stream example. [112]

For these waste stream examples , refer to the waste stream disposition flow charts following the end of this section. The flow charts are divided into four areas including the 1) disposition of Hanford solid wastes, 2) the disposition of ERC activity wastes (i.e. contaminated media), 3) the disposition of Hanford tank wastes and contaminated liquid wastes, and 4) the disposition of Hanford Low-Level Mixed Waste (LLMW) and liquid Sanitary Wastes (SW).

Waste types / streams and their definitions were previously presented in Section 6.1 pages 22 and 23.

Later in this document, specific example activities relating to the treatment, storage, disposal, maintenance, operations, and management of Hanford wastes will be described in greater detail. Refer to Sections 10.0 through 10.6 pages 87 through 144 for primary Hanford projects and associated activities.

For convenience, Hanford facilities mentioned throughout each narrative are in bold type.

9.1 Low Level Radiological Waste (LLRW) and Low-Level Mixed Waste (LLMW) Disposition (Refer to Figures 9A on Page 83 and 9D on Page 86)

Source

Analytical laboratories, reactors, separations facilities, plutonium processing facilities, and waste management activities have generated Low Level Radioactive Waste (LLRW) and Low Level Mixed Waste (LLMW) to form existing inventories at the Hanford site. Analytical laboratories, research facilities, facility decommissioning, site-clean-up, waste management activities, and other onsite and offsite facilities continue to generate LLRW/LLMW volumes. [26]

Inventory

Hanford LLRW inventories as of January 1998 were reported as 180m^3 for the existing inventory and 130,319m^3 for the predicted total generation volume. 29,595m^3 of the total generation volume includes LLRW from smaller DOE sites such as the Rocky Flats Environmental Technology Site (RFETS) in Colorado.

Hanford LLMW inventories as of January 1998 were reported as 8,586m^3 for the existing inventory and 63,741m^3 for the predicted generation volume. (Note: the generation volume does not include the existing inventory.) Forty five cubic meters of the total LLMW generation volume includes LLMW from the on-site naval reactors program and includes 65m^3 LLMW from ER activities (See Section 9.2 for ERC activity waste (i.e. contaminated media disposition). [113, 114]

Treatment

The treatment of LLRW and LLMW waste streams at the Hanford site includes one or more the following activities: 1) sorting, repackaging, verification, and characterization at the **Waste Receiving and Processing facility (WRAP)** which is managed by Waste Management Federal Services of Hanford (WMFS) a sub-contractor of the Project Hanford Management Contractor (PHMC) Fluor Daniel Hanford (FDH), 2) laboratory analysis and characterization at the **Waste Sampling and Characterization Facility (WSCF)** also managed by WMFS, or 3) on and/or off-site commercial treatment including stabilizing, macroencapsulation, thermal processing (such as incineration at Idaho National Engineering and Environmental Laboratory's Waste Experimental Reduction Facility (WERF)) or non-thermal processing. Off-site non-thermal treatment will be conducted by Allied Technology Group, a sub-contractor to WMFS. [113, 114]

Storage

The interim storage of treated LLRW and LLMW waste at the Hanford site is conducted at: 1) the **WRAP**, and 2) the **Central Waste Complex (CWC)** managed by WMFS. [113, 114]

Disposal

Final disposition of all LLRW and LLMW at the site will primarily be on-site disposal at the Hanford **Low Level Burial Ground (LLBG)** also managed by WMFS. Other small Resource Conservation and Recovery Act (RCRA) regulated disposal sites are also located throughout the 200-Area for LLRW / LLMW disposal.[113, 114]

9.2 ERC Activity Waste (Contaminated Media) Disposition (Refer to Figure 9D, Page 86)

Source

Contaminated media is the direct result of past Hanford production maintenance and operations. It is classified as LLMW and LLRW contaminated soil, debris, and groundwater. It also includes HW debris, Asbestos, TRU debris, leachate from the **Environmental Restoration Disposal Facility (ERDF)**, and contaminated basin water. [115, 25]

Inventory

The estimated in-place volume of contaminated media at the Hanford site is estimated to be 1,411,242,049m^3 as reported in January of 1998. After collection, direct disposal or treatment, or in situ containment, total contaminated media is estimated to be 29,702,049m^3. As mentioned previously, all contaminated media and associated facilities are managed by Bechtel Hanford, Inc., Hanford's environmental restoration contractor. [115]

Treatment

Treatment of contaminated media includes processing measures such as pumping and treating contaminated ground water, filtration of landfill leachate and basin water at Hanford liquid effluent treatment facilities (Note: Liquid waste disposition will be discussed in Section 9.10 on page 82), and capping contaminated soils for in situ disposal. [115]

Disposal

For Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste sites containing LLRW / LLMW/HW soils and debris, collection through excavation and direct disposal is on-site at the **Environmental Restoration Disposal Facility (ERDF)**. Asbestos (non-radiological) wastes are disposed of at an off-site commercial facility. More dangerously characterized mixed HW debris (LLMW) and TRU debris are automatically transferred to WMFS for treatment and disposal. These disposal paths are described in Sections 9.1 and 9.3 on pages 75 and 77. [115]

9.3 Transuranic (TRU) and Transuranic Mixed (TRU Mixed) Waste Disposition (Refer to Figures 9A on Page 83 and 9D on Page 86)

Source

Transuranic (TRU) and Transuranic Mixed (TRU Mixed) wastes are generated in a similar manner to LLRW and LLMW as described previously, however, the major difference is that TRU / TRU Mixed wastes are radioactively contaminated with TRU isotopes (atomic numbers greater than 92 and half-lives longer than 20 years at concentrations exceeding 100 nanocuries of alpha-emitting radionuclides per gram) and are most often generated by operations at plutonium handling facilities. [26]

Inventory

Hanford TRU / TRU Mixed waste inventories as of January 1998 were reported as 16,320m^3 for the existing inventory and 8,029m^3 for the estimated site generation volume. 1,409m^3 of the generation volume includes TRU / TRU Mixed waste generated by ERC activities. [116]

Treatment

The treatment of TRU / TRU Mixed waste streams at the Hanford site includes one or more of the following activities: 1) retrieval of suspect drums and boxes, 2) sorting, repackaging, and characterization at the **WRAP**, and/or 3) analysis at the **T-Plant and TRU Waste Storage and Assay Facility.** [116, 12, 25]

Storage

The interim storage of TRU / TRU Mixed waste occurs at 1) the **T-Plant and TRU Waste Storage and Assay Facility**, 2) the **Retrievably Stored TRU Waste Facility**, 3) the **CWC,** and 4) the **WRAP**. [12, 116]

Disposal

Final disposition of TRU / TRU Mixed waste at the Hanford site will occur at an off-site facility such as the Waste Isolation Pilot Plant (WIPP) in New Mexico. [116]

9.4 High Level Waste (HLW) Disposition (Refer to Figure 9B on Page 84)

Source and Inventory

High Level Waste (HLW) existing inventory at the Hanford site as of February 1998 was 221,000m^3 for sludge, salt and liquid currently stored in 149 single-shell tanks and 28 double-shell tanks, 70m^3 for sludge from the Spent Nuclear Fuel program, and 3.5m^3 for cesium/strontium capsules from Facility Stabilization projects. No new volumes of HLW are predicted to be generated in the course of site remediation. [117]

Treatment

(Note: Contaminated liquid waste treatment will be discussed in Section 9.10 on page 82.)

The treatment of HLW at the Hanford site involves the following activities: 1) tank maintenance / storage and waste characterization and retrieval by the Project Hanford Management Contractor (PHMC) Fluor Daniel Hanford (FDH), and 2) waste pre-treatment (radionuclide separation) and HLW/ LAW (Low Activity Waste) immobilization (i.e. vitrification) by the DOE privatization contractor British Nuclear Fuels Limited (BNFL, Inc.). Approximately 10% of the HLW mass will be treated by BNFL while the remaining will be stabilized in the tanks. [117]

Storage

Interim storage of immobilized HLW (IHLW) will occur on-site within two cells at the **Canister Storage Building (CSB)** currently under construction in the 200 Area. This facility will be used in conjunction with spent nuclear fuel storage. [117]

Disposal

Final disposition for immobilized LAW (ILAW) will occur on-site at an ILAW Disposal Facility managed by BNFL. IHLW will be shipped to an off-site geologic repository such as Yucca Mountain in New Mexico. [117]

As of July 1999, FDH wishes to declare K-basin sludge as TRU waste. This TRU waste would be put in special barrels and filled with cement before being shipped to the Waste Isolation Pilot Project (WIPP) in New Mexico. [118] Classification of K-Basin sludge has not yet been decided.

9.5 Tank Farm Contaminated Equipment Disposition (Refer to Figure 9B on Page 84)

Source and Inventory

Contaminated equipment includes sampling equipment, augers, cranes, construction equipment, and stainless steel, lead-lined shielded receivers from tank farm operations. It is essentially LLRW, but is noted separately in this document so that generation and disposition may be presented. Past activities at Hanford have resulted in contamination of equipment so it is no longer suitable for use in on-going operations. Contaminated equipment volumes vary from year to year depending on the size of the project and the amount of equipment used.

Treatment / Disposal

Some of the equipment is potentially useable or recyclable in the future if the radioactive contamination can be removed or reduced to acceptable levels. In other cases, decontamination of the equipment may be desirable prior to disposal at Hanford burial grounds to minimize worker exposure or to reduce the volume of material that must be disposed of as radioactive waste. Currently, decontamination services are provided at **2706-T** and **221-T (T-Plant Canyon)** facilities.

9.6 Spent Nuclear Fuel (SNF) Disposition (Refer to Figure 9A on Page 83)

Source and Inventory

Spent Nuclear Fuel (SNF) was generated from the Hanford nuclear reactors and other neutron irradiation facilities at the site. Current inventories are not available for all SNF waste streams across the Hanford site, however, as reported in 1998, the **K-Basins** (East and West) house approximately 2100 metric tons of SNF currently stored in pools of water.(119) Other SNF streams include those in the **T-Plant, 324/325/327 Buildings**, the **Fast Flux Test Facility (FFTF)** and other sites in the **400 Area**, and **the Plutonium Finishing Plant (PFP)**. DE&S Hanford is the major sub-contractor involved with SNF remediation.(120)

Treatment

Treatment of SNF involves the following procedures 1) cleaning or washing, 2) packaging within Multi Canister Over packs (MCOs), and 3) cold vacuum drying.(119, 120)

Storage/Disposal

SNF final interim storage will occur at the **Canister Storage Building (CSB)** while awaiting final disposition at an off-site geologic repository such as Yucca Mountain.(120)

9.7 Special Nuclear Material (SNM) Disposition (Refer to Figure 9A on Page 83)

Source and Inventory

Special Nuclear Material (SNM) is comprised of a variety of materials ranging from process ashes and residues to fuel pins and assemblies (121) containing plutonium, uranium-233, or uranium enriched in the isotope-233 or 235 (27). SNM is located throughout the site and inventories of SNM are not readily defined. (120) SNM is managed by a variety of contractors including WMFS, DE&S Hanford , and Pacific Northwest National Laboratories operated by Battelle Memorial Institute.

Treatment

Treatment of SNM is dependant on the overall composition of the material. Options may include: 1) denitration, 2) calcination, 3) pyrolysis, 4) cementation, 5) packaging for disposal, or 6) oxidation. (120, 25: Sec. 3/37) A detailed description of select processes is described in Section 11.0, page 145. A **Plutonium Immobilization Plant (PIP)** is also currently being considered as a treatment process.

Storage

Interim storage of SNM may occur at 1) the **CSB**, 2) the **Plutonium Finishing Plant (PFP)**, 3) or other 'to be determined' on-site facility. (120)

Disposal

Final disposition for SNM will likely occur at a geologic repository but is currently 'to be determined.' (120)

9.8 Hazardous Waste (HW) Disposition (Refer to Figure 9D on Page 86)

Source and Inventory

Hazardous Wastes (HW) are generated by a wide range of activities including, 1) facility operations and maintenance, 2) new construction, 3) decontamination and decommissioning (D&D), 4) environmental restoration (ER), 5) waste management, 6) site services such as vehicle maintenance or painting, and 7) laboratory research. (12: Pp. 45-46, 26) Bechtel Hanford, Inc. the ERC is the primary contractor associated with the disposition of HW. Other site contractors will primarily deal with mixed wastes forms. It is estimated that 6,100 m^3 of HW will be generated at the site over the next 20 years. (26)

Treatment and Disposal

Currently, non-wastewater HW is stored at the **Nonradioactive Dangerous Waste Storage Facility (616 Building)** operated by WMFS and packaged and shipped to an offsite commercial facility for treatment and disposal.

9.9 Sanitary Waste Disposition (Refer to Figure 9C on Page 85)

Source and Inventory of Solid and Liquid Sanitary Waste

Sanitary Waste streams include municipal solid waste (i.e. paper), new construction debris, non-radioactive demolition debris, and wastewater. Liquid sanitary waste streams may contain certain RCRA-exempt chemical contaminants such as organic compounds, heavy metals, or cyanide from various HVAC systems, compressed air production, rainwater, boiler discharge, strainer back wash, laboratory wash waters, or air-monitoring systems located at Hanford facilities such as **PFP**, **222-S Laboratory Complex**, **T-Plant and associated laboratories**, the **Hanford power plant**, **PUREX**, and **B-Plant / WESF**. Wastewater volume is approximately 1.4 million m^3 per year. Solid sanitary waste volume was reported as 31,000 m^3 in 1994. [12: P. 47]

Disposal of Solid Sanitary Waste

(Note: Liquid sanitary waste disposition will be discussed in Section 9.10 page 82)

Disposal of solid sanitary waste occurred at the **Hanford Landfill** until 1996. The **City of Richland Landfill** will receive and dispose of most currently generated non-radioactive, non-hazardous solid waste. Solid waste transfer to the landfill will be contracted to a commercial waste hauler.

9.10 Liquid Waste Disposition (Refer to Figures 9B on Page 84 and 9C on Page 85)

Source and Volume

Liquid waste volumes are included within Sanitary Waste, LLMW, and HLW streams existing and generated at the Hanford site. WHFS is the contractor responsible for liquid waste management at the Hanford site.

Treatment, Storage, and Disposal

1. Non-hazardous / Non-radioactive Liquid Waste (Sanitary Liquid Waste) (Figure 9C)

The **300 Area Treated Effluent Disposal Facility (300 Area TEDF)** provides treatment of industrial waste water (Sanitary Waste / RCRA-exempt) through the removal of heavy metals and mercury. It also destroys organic compounds and cyanide. Sludge and spent ion exchange resins are generated as a result of the treatment process. Solids will go to the **200 Area Low-level waste burial grounds** for disposal and remaining treated liquid effluent will be monitored and discharged into the Columbia River. [12: P. 47]

2. 300 Area LLMW Liquid Waste (Figure 9C)

The **300 Area Treated Effluent Disposal Facility (300 Area TEDF)** also provides treatment of 300 Area liquid LLMW. Effluent from the 300 Area not discharged into the river is either stored at the **340 Waste Handling Facility** or packaged at the **325 Laboratory Facility** and eventually transported to the **200 area double shelled tanks (DSTs)** for disposal. Interim storage is also provided at the **307 Retention Basins** until liquid LLMW is treated at the **300 Area TEDF**.

3. 100 and 200 Area Liquid Wastes (LLMW and HLW) (Figures 9B and 9C)

The **200 Area Treated Effluent Disposal Facility (200 Area TEDF)** is a piping network for collecting and disposing of liquid effluents that have been treated at a generation facility. Facilities using the disposal network include the **PFP, 222-S Laboratory Complex, T-Plant and associated laboratories**, the **Hanford power** plant, **PUREX**, and **B-Plant / WESF**. The treated effluent is disposed of in 200 Area low level burial grounds and ponds.

The **200 Area Effluent Treatment Facility (200 Area ETF)** treats liquid waste from the **242A-Evaporator** (the facility that prepares condensate from liquid tank waste), the **K and N Basins** in the 100 Area, tank waste remediation activities, purge water from ground-water monitoring activities, and secondary waste from solid waste treatment and disposal facilities. Liquid waste from the **242A-Evaporator** awaiting treatment is temporarily stored at the **Liquid Effluent Retention Facility (LERF)** basins. Once it is treated, radioactive residues removed from the liquids are dried and concentrated to powder form, then disposed as LLMW in drums. The effluent is discharged to the soil column at a permitted land disposal site in the 200 Area. [11: P. 19, 12: P. 44]

Figure 9 A: Hanford Solid Waste Disposition Map

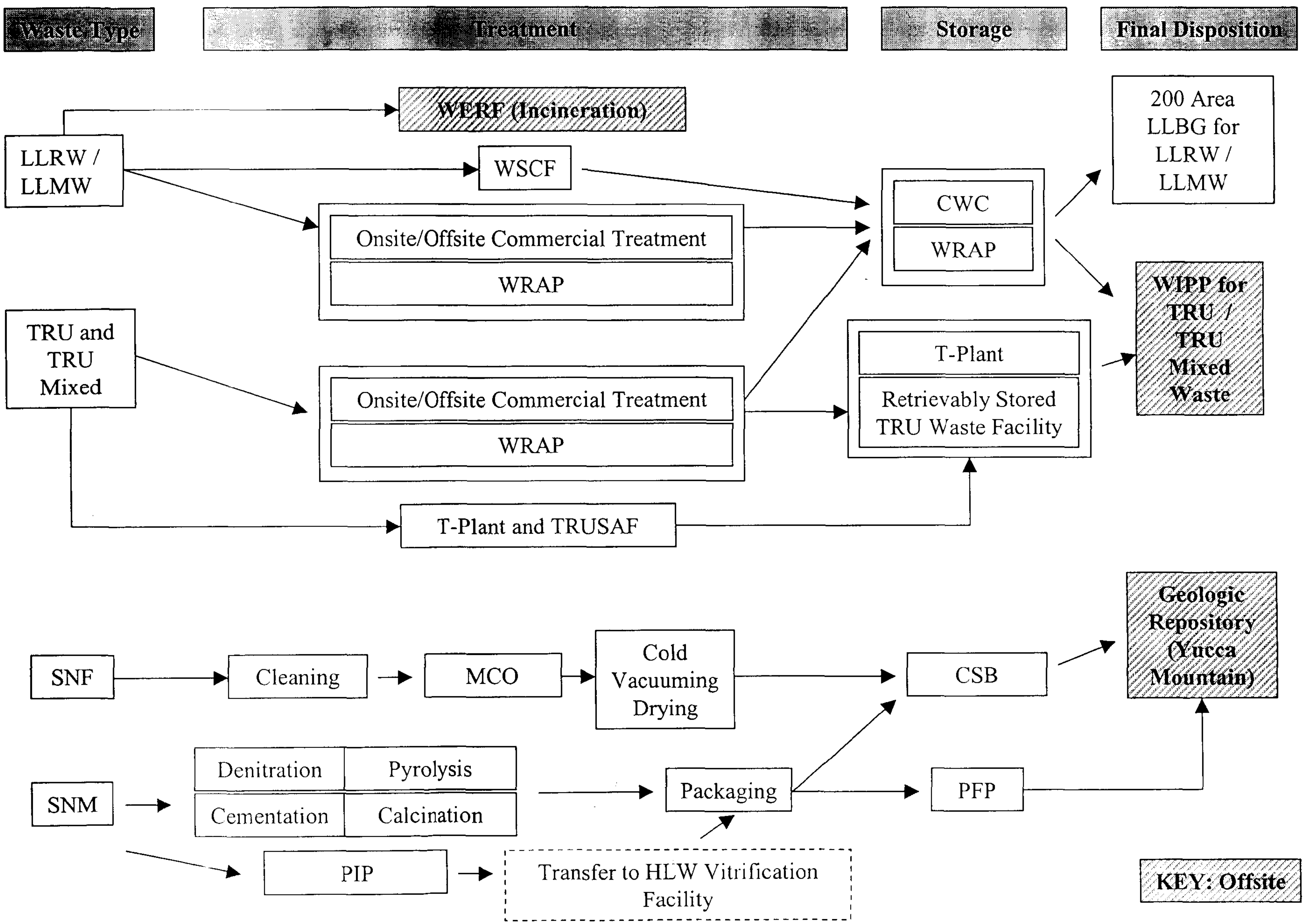


Figure 9 B: Hanford Tank Waste and Contaminated Liquid Waste Disposition Map

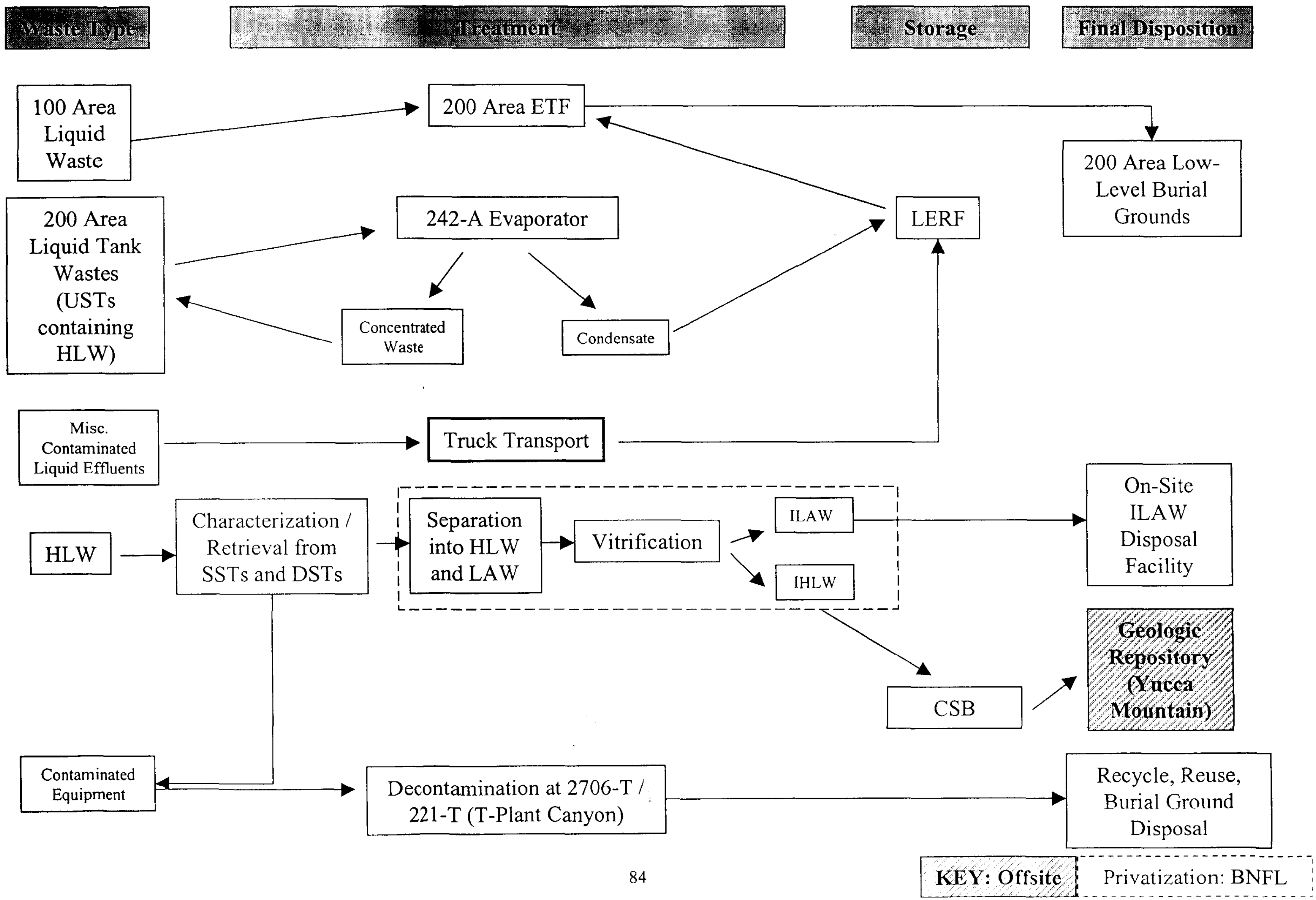


Figure 9 C: Hanford LLMW and Sanitary Liquid Waste Disposition Map

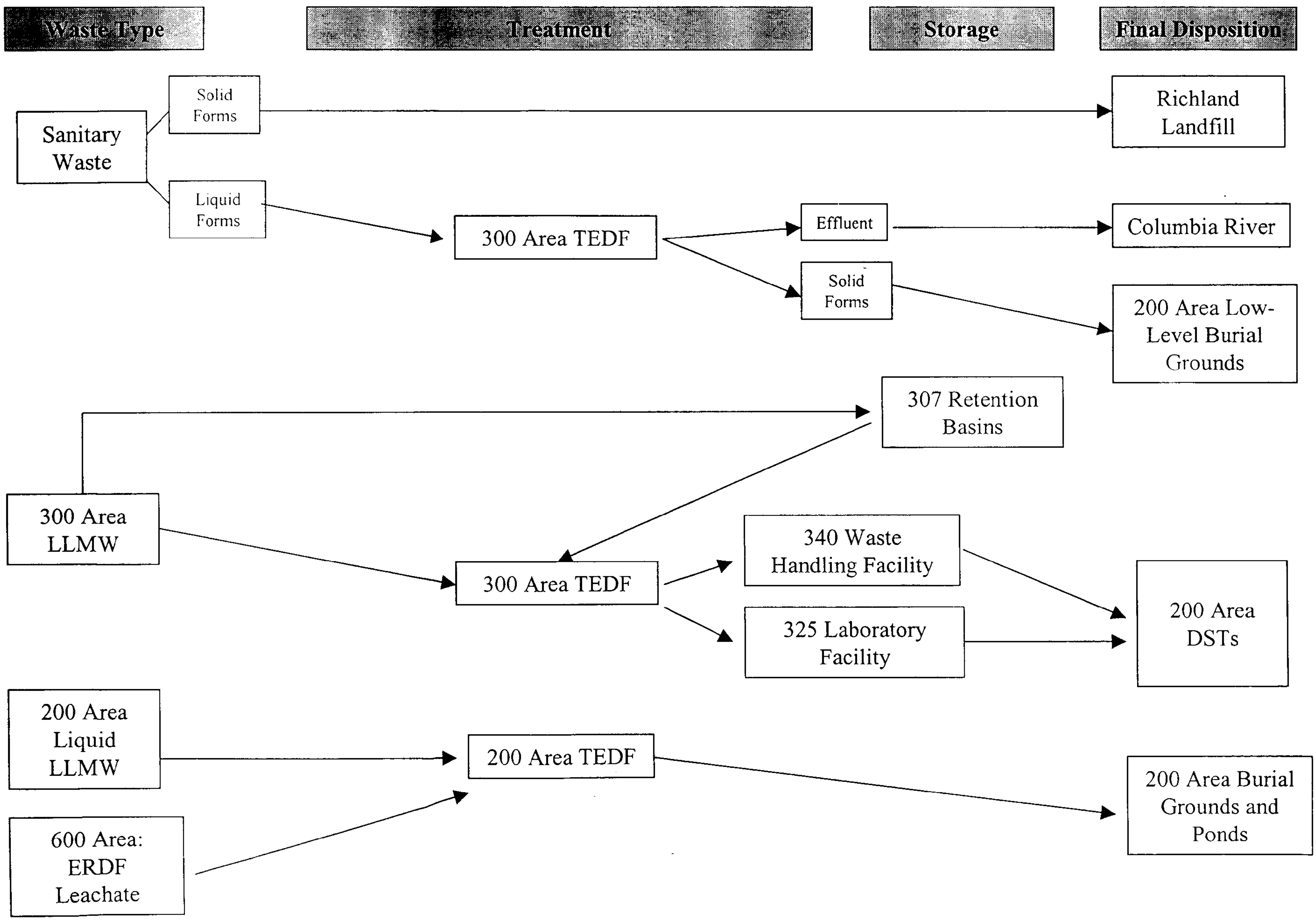
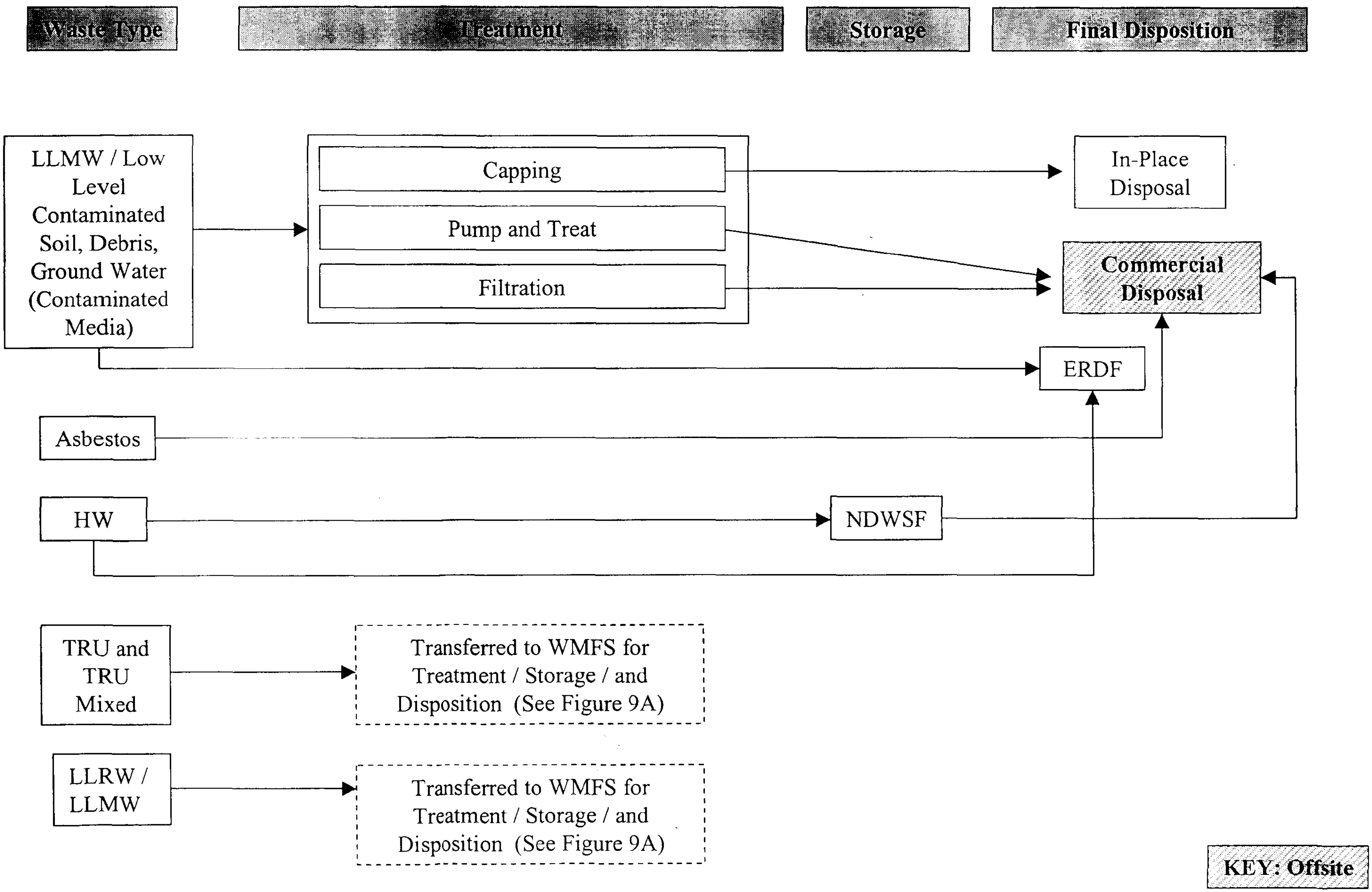


Figure 9 D: Hanford Environmental Restoration Contractor Activity Wastes (Contaminated Media) Disposition Map



10.0 Hanford Past, Present, and Future Remediation Worker Activities

For presentation purposes, Hanford site remediation worker past, present, and future activities (i.e. Hazardous Waste (HW), Decontamination and Decommissioning (De), Dismantlement (Di), and Clean-up Worker (CW) tasks as previously defined in Section 6.2: Remediation Worker Task Definitions on pages 24 to 27) are presented **by project**. Major site projects include: **Waste Management** (Solid and Liquid), **Spent Nuclear Fuel**, **Tank Waste Remediation System**, **Environmental Restoration**, and **Facility Transition**.

Within each of the five major projects at the Hanford site, the activities will include: 1) a full description of the task or activity; 2) wastes types associated with the activity; 3) specific contaminants of concern (COCs); 4) the associated regulatory driver(s); 5) task time lines and classifications (past: November 1989 to June 1998, present: June 1998 to June 1999, and future: June 1999 and beyond) [Note: 'beyond' for this report is classified as post 2006. DOE has stated their goal is to cleanup 90% of DOE sites by 2006. [25: ES-1]]; 6) the estimated number of workers per activity or task; and 7) the remediation task classification (HW, CW, De, or Di). Ranges for the estimated number of workers per task are LOW:<10, MED:11-75, and HIGH:>75. Exact numbers of workers are provided with the activity when available.

Facility profiles presenting necessary background information are also provided prior to activity presentations.

The activities in this section were selected according to the following criteria: 1) the activity was highly publicized; 2) the activity identifies particular COCs, exposure potential, and safety interests to remediation workers on a particular project; and 3) the activity was an example of work routinely performed across the site.

All activities described in Sections 10.1 through 10.6 will be presented in tabular format. (Table 13.2: Hanford Remediation Worker Activity Descriptions as Reported July 1999 on pages 237 through 246.)

10.1 Hanford's Waste Management Project (WM)

Waste Management Federal Service of Hanford, Inc. (WMFS) is the company responsible for solid and liquid waste management operations at the Hanford site. WMFS operates many site facilities that store, treat, examine, characterize and re-package solid and liquid waste types including LLRW, LLMW, and TRU / TRU Mixed wastes. WMFS does not manage HLW, but does, however, provide some HLW characterization and laboratory support services. [11, P. 16]

WMFS, Inc. is responsible for the management and operation of the facilities presented in Table 10.1 A: Waste Management Federal Service of Hanford, Inc. Solid and Liquid Waste Management Facilities.

Table 10.1 A: Waste Management Federal Service of Hanford, Inc. Solid and Liquid Waste Management Facilities

Facility Category	WMFS Facility Name
Solid Waste Characterization	**Waste Receiving and Processing (WRAP) Facility**, Waste Sampling and Characterization Facility (WSCF)
Solid Waste Treatment	**Waste Receiving and Processing (WRAP) Facility**, T-Plant Complex (221-T, 2706-T), M-91 Facility
Solid Waste Storage	Low-Level Burial Ground (LLBG), Mixed Waste Disposal Trenches, **Central Waste Complex (CWC)**, Non-Radioactive Dangerous Waste Storage Facility, TRU Storage and Assay Facility
Liquid Waste Treatment	242-A Evaporator, **200 Area Effluent Treatment Facility (ETF)**
Liquid Waste Storage /Disposal	**Liquid Effluent Retention Facility (LERF)**, 200 Area Treated Effluent Disposal Facility (TEDF), 300 Area Treated Effluent Disposal Facility (TEDF), 307 Retention Basins, 340 Waste Handling Facility

Note: Facilities in bold type are presented in greater detail throughout this section.

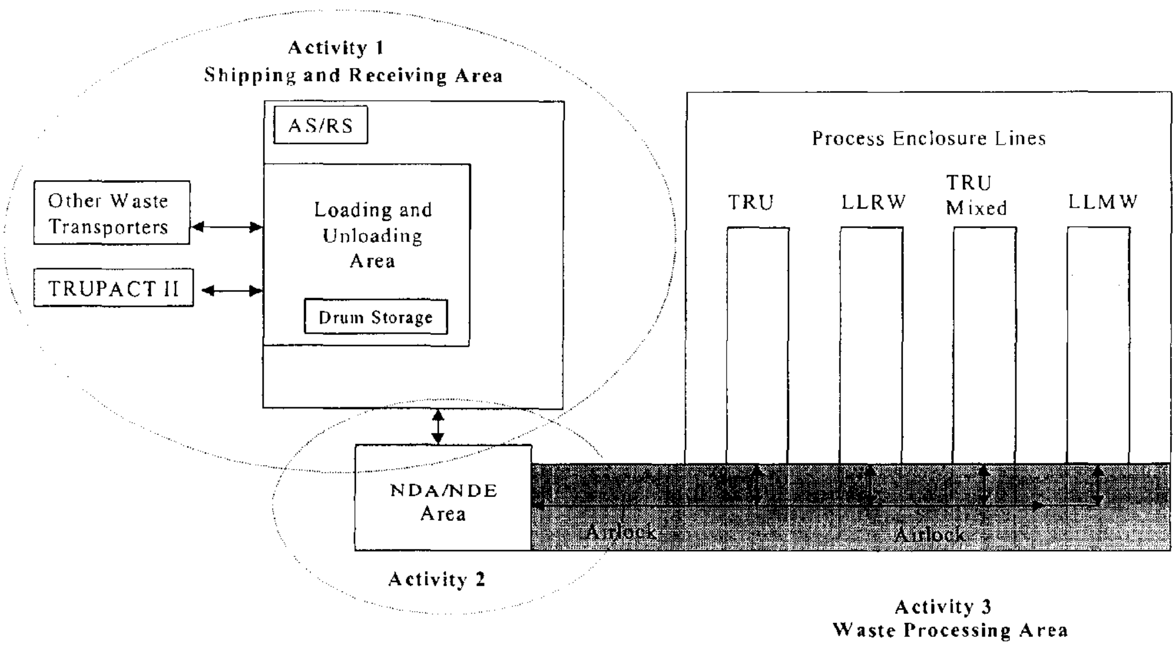
Integrated Management Considerations

Because the Hanford site conducts integrated environmental management practices (previously described in Section 9.0: Overview of Integrated Environmental Waste Management at the Hanford Site on page 74) many waste management projects are completed through a combination of contractors, unions, and facilities. Activity 8: 222-S Radioactive Liquid Waste Line Replacement on page 98 is an example of integrated work at the site.

WRAP Facility Profile:

The WRAP Facility, located in the 200W Area began operations in March 1997. The facility consists of a receiving and process unit called Module 1 or WRAP-1. Modules 2 and 2a designated for additional storage were discontinued in 1998. [122] WRAP-1 provides radioactive and mixed waste (i.e. LLRW, LLMW, and TRU / TRU Mixed waste) interim storage, treatment, verification, repackaging and decontamination services. It is unique in that it remotely characterizes the contents of hazardous and radioactive waste drums and boxes from on and off-site generators. Contents are x-rayed and analyzed by automated processes (i.e. computers and robotics).[123] Drums are then labeled and prepared for transport to a regulated site for disposal. Refer to Figure 10.1 B and the text for specific WRAP-1 activities.

Figure 10.1B: Waste Receiving and Processing Facility Module 1 (WRAP-1) Activities Diagram



Activity 1: WRAP-1: Shipping and Receiving (124: Sec. 2.4.3, 125)

The WRAP-1 shipping and receiving area contains two dock waste unloading stations and a drive-through bay to serve TRU packing transporter (**TRUPACT II**) container loading. An Automated Stacker / Retrieval System (**AS/RS**) for drum storage is also located in this area. As well as additional drum and box storage. Personnel use fork trucks, drum handling equipment, conveyers, an overhead bridge crane, and jib cranes to unload and move LLRW, LLMW, TRU, and TRU Mixed waste drums and boxes. A battery powered automated guided vehicle (AGV) is also used to transport drums between the shipping and receiving area and the Nondestructive Assay (NDA) and Nondestructive Examination (NDE) area (See Activity 2). Concrete and lead glass shielding is located around these various systems for worker protection. When personnel enter unshielded or higher contaminated areas, respiratory and appropriate personal protective equipment (PPE) is used.

After waste processing is completed (Refer also to Activity 3: WRAP-1: Waste Processing), certified TRU and TRU Mixed waste drums are loaded into TRUPACT II casks using the overhead crane. Processed LLRW and LLMW containers are loaded onto trucks at the loading dock for on-site storage or burial.

This activity is classified as a past, present, and future **HW task** performed by one to four (LOW: <10) workers per workday shift [122] (Refer to Section 7.4.1.: Hours of Work and Shifts on page 44 for shift information). Shipping and receiving activities began in March of 1997 and will continue until the WRAP-1 ceases operations predicted to be beyond 2006. Regulatory drivers associated with this activity include Resource Conservation and Recovery Act (RCRA), the Washington Administrative Code (WAC): 173-303 and the Tri-Party Agreement (TPA). Refer to page 92 and Table 10.1 C: WRAP-1 Hazardous Waste Contaminants of Concern for a description of COCs associated with workers performing tasks with and around drums and containers at the WRAP-1 facility.

Activity 2: WRAP-1: Nondestructive Examination and Assay (NDE/NDA) (124: Sec. 2.4.4, 125)

The Nondestructive Assay (NDA) and Nondestructive Examination (NDE) area prepares LLRW, LLMW, TRU, and TRU Mixed waste for processing through: 1) examination and weighing of the drum; 2) characterization through nondestructive assay (NDA); 3) nondestructive examination (NDE) through real-time radiography; and 4) chemical analysis of a head-gas sample. If characterization is not achieved through the above steps, physical sampling and analysis of the waste will be needed to identify dangerous wastes that are not able to be identified through any other characterization steps or process knowledge.

The area also contains a storage area for drums and containers coming or going through the waste process. Personnel use fork lifts to move boxes, the AGV to move drums, or manually haul containers into the NDE/NDA airlocked area where automated examination and assay will take place. The NDA equipment contains neutron generators. Shielding of assay systems and access to these devices are designed to meet federal, state, and site requirements. When personnel enter unshielded or higher contaminated areas, respiratory and appropriate personal protective equipment (PPE) is used.

This activity is classified as a past, present, and future **HW task** performed by one to two (LOW:<10) workers per shift.[122] NDE/NDA activities began in March 1997 and will continue until the WRAP-1 ceases operations predicted beyond 2006. Regulatory drivers associated with this activity include RCRA, WAC: 173-303, and the TPA. Refer to page 92 and Table 10.1 C: WRAP-1 Hazardous Waste Contaminants of Concern for a description of COCs associated with workers performing tasks with and around drums and containers at the WRAP-1 facility.

Activity 3: WRAP-1: Waste Processing [124: Sec. 2.4.5, Sec. 2.5, 125]

Waste drums are processed in four process enclosure lines located in WRAP-1 . These lines are sometimes referred to as gloveboxes. The TRU enclosure line consists of enclosure sections where drums enter, are opened and emptied, emptied drums are compacted, packets inside the drum are subjected to assay and x-ray, non-compliant items (i.e. HW) are removed (and sent to a mixed waste process line), waste is repackaged, and the repackaged drums are loaded out. The LLRW enclosure line operations are similar to those in the TRU line except drum supercompaction can be performed after repackaging. There are two mixed waste enclosure lines, one for TRU-containing restricted waste (TRU Mixed waste) and one for LLMW. The TRU Mixed waste enclosure line and the LLMW enclosure line sample, process and repackage non-compliant (i.e. HW) forms. The processed waste drums from all four enclosure lines are transported back through the airlock to the NDE/NDA area and then to shipping and receiving for shipment to a storage or disposal facility.

The waste process area serves as secondary containment when waste drums are opened. Personnel access to the area is restricted to step-off area and process airlocks. Most waste processing is remote and automated, however line maintenance is sometimes necessary. When personnel enter unshielded or higher contaminated areas in the processing area, respiratory and appropriate personal protective equipment (PPE) is used.

Process chemicals and materials stored and used in WRAP-1 include neutralizing agents, processing agents, and decontamination agents. These materials are stored in color coded 1 quart containers in segregated storage racks in the mixed waste process enclosures. In addition to process chemicals and materials, small quantities of various hazardous materials may be used during routine facility maintenance.

The waste processing activity is classified as a present and future **HW task** performed by 10 to 15 (MED: 11-75) workers per shift. (122) Waste processing activities began in September 1998 and will continue until the WRAP-1 ceases operations. This is predicted beyond 2006. Regulatory drivers associated with this activity include RCRA, WAC 173-303, and the TPA. Refer to the below and Table 10.1 C: WRAP-1 Hazardous Waste Contaminants of Concern for a description of COCs associated with workers performing tasks with and around drums and containers at the WRAP-1 facility.

Detailed Description of WRAP-1 Primary Contaminants of Concern

Waste to be processed at the WRAP-1 includes drummed and boxed LLRW, LLMW, TRU, and TRU Mixed wastes that have a container surface dose rate of less than 200 mrem/h (i.e. contact handled waste which is waste that is handled without radiation shielding). These wastes consist of both waste in retrievable storage (buried in trenches on and offsite) and waste newly generated at the site. It can include metal, glass, wood, paper, cloth, liquid, and powder.

Radiological hazards primarily include plutonium and americium. Strontium and cesium are also concerns. (124: Sec. 4.2)

Dangerous constituents (i.e. HW) in wastes generated prior to 1986 cannot readily be determined without complete characterization, however some drums are known to contain oil and lead. (126, P. 3) The following table lists other hazardous wastes of concern.

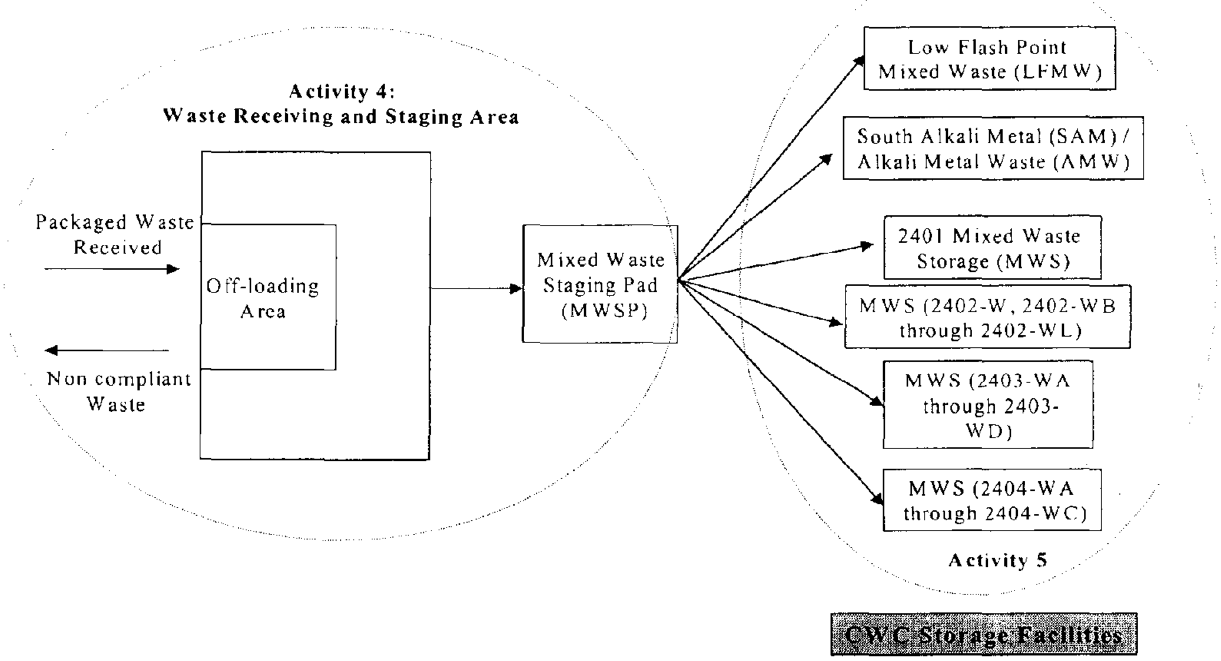
Table 10.1 C: WRAP-1 Hazardous Waste Primary Contaminants of Concern (124: Table 3.1)

Chemical COCs at the WRAP-1		
Ammonia	Ammonium nitrate	Beryllium
Cadmium	Cyclohexane	Dioxane
Hydrogen peroxide	Manganese	Mercury
Nitric Acid	Phosphoric acid	Propene
Sodium	Sodium hydroxide	Sodium hypochlorite
Sodium oxide	Styrene	Tetrahydrofuran
Tetralin	Vinyl chloride	Zirconium

Central Waste Complex (CWC) Profile:

The Cental Waste Complex (CWC) is a multifacility complex located within the 200-West area. Since September 1996, the complex has received and stored on-site and off-site generated radioactive solid wastes (i.e. LLRW, LLMW, TRU, TRU Mixed wastes). CWC operations include: 1) receiving and inspection of packaged and characterized waste; 2) staging; 3) storage; and 4) shipping. [127] Facilities within the complex are presented in Figure 10.1 D: Central Waste Complex (CWC) Activities Diagram.

Figure 10.1 D: Central Waste Complex (CWC) Activities Diagram



Activity 4: Central Waste Complex (CWC): Waste Receiving and Staging Area(128: P. 8-15, 129 Sec.13)

Personnel at the CWC Waste Receiving and Staging Area inspect, accept, and unload containerized LLRW, LLMW, TRU, and TRU Mixed waste packages received from the WRAP or other on/off-site waste generator. Transport off-loading operations are performed using handtrucks, forklifts, or cranes. No respiratory protective equipment (RPE) or PPE associated with airborne contaminants are required for these tasks due to waste containment system features.

Potential contaminants of concern associated with accidental release of waste containers in the receiving and staging area include: 1) radiological hazards (primarily plutonium and americium); and 2) chemical hazards such as polychlorinated biphenyl (PCB), lead, flammable organics (xylene, trimethylbenzene), mercury, cadmium, and barium.

This activity is classified as a past, present, and future **HW task** performed by MED:11-75 workers at the CWC. Waste receipt began in 1996 and will continue until the CWC ceases operations or reaches it's design capacity. This is estimated to extend through 2006. Regulatory drivers associated with this activity include RCRA, WAC 173-303, and the TPA.

Activity 5: CWC Storage Facilities (128, 129)

Personnel at CWC storage facilities transport LLRW, LLMW, TRU and TRU Mixed waste containers by forklift and handtruck from the Mixed Waste Staging Pad (MWSP) to appropriate storage areas and modules. Waste will reside in this area until final disposition is determined. Weekly container inspections with the use of a portable ladder are required in the storage area. No RPE or PPE associated with airborne contaminants is required for this task due to the containerized nature of the waste.

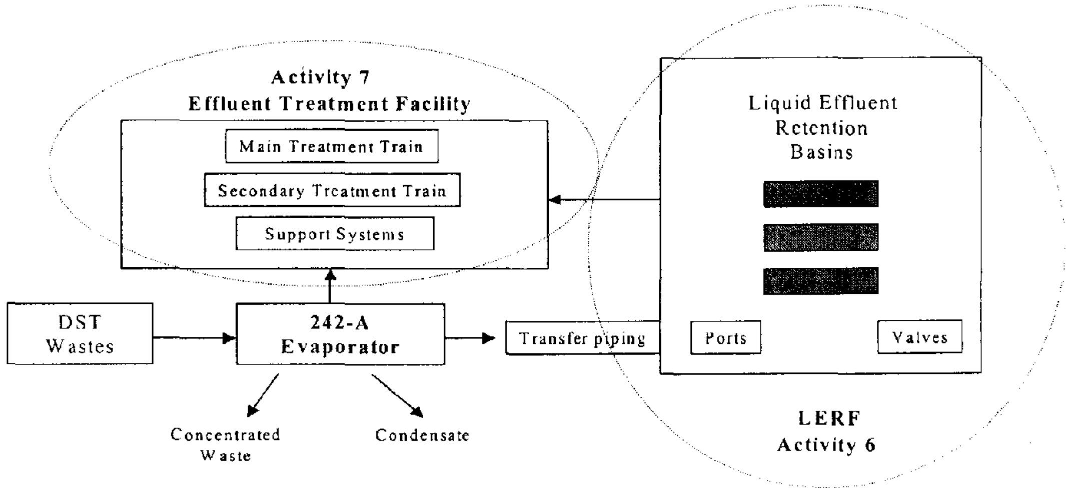
Contaminants of concern (COCs) associated with this activity will vary according to storage facility (See Figure 10.1 D: Central Waste Complex (CWC) Activities Diagram) for a list of CWC storage facilities). Radiological hazards include primarily plutonium and americium, however, radiological hazards at the South Alkali Metal (SAM) and Alkali Metal Waste (AMW) storage facilities also include radioactive sodium, cesium, and barium. Chemical hazards are the same as those described in Activity 4.

This activity is classified as a past, present, and future **HW task** performed by MED:11-75 workers at the CWC. Waste receipt began in 1996 and will continue until the CWC ceases operations or reaches capacity. This is estimated to reach 2006. Regulatory drivers associated with this activity include RCRA, WAC 173-303, and the TPA.

Liquid Effluent Retention Facility (LERF) and the Effluent Treatment Facility (ETF) Profiles:

The Liquid Effluent Retention Facility (LERF) and the Effluent Treatment Facility (ETF) are located in the 200-East area of the Hanford site and are used for interim storage (LERF) and treatment (ETF) of process condensate (designated as dangerous waste) from the 242-A Evaporator (a process facility that treats waste from the Double Shell Tanks). Figure 10.1 E: The Liquid Effluent Retention Facility / Effluent Treatment Facility Activities Diagram presents Hanford liquid waste management processes. (130: Pp. 1-36)

Figure 10.1 E: The Liquid Effluent Retention Facility / Effluent Treatment Facility Activities Diagra



Activity 6: LERF: Sampling and Monitoring (130: Pp. 1-36)

The Liquid Effluent Retention Facility (LERF) consists of three retention basins, associated transfer piping, sampling ports, valves, instrumentation and controls, and a basin support facility which includes a change trailer, a step-off pad area, and a storage building. Each basin has a double composite liner with a leachate collection system installed between the two liners. The basins receive and temporarily retain LLMW liquid waste (process condensate) until eventual treatment at the Effluent Treatment Facility (ETF) (See Activity 7 on page 96). Personnel at the LERF sample and monitor basin perimeters and the leachate collection system. They also monitor leaks through both automated and manual processes around facility transfer piping.

Hazards at the LERF include LLMW liquid waste within the basins, piping, and leachate collection system. Low releases of airborne radioactive sources such as volatile gases and water vapor containing tritium (*tritium activity is less than that required (10 CFR 30.72, Schedule C) for evaluation*) will occur at filtered vents, migration through liners and through sample ports when opened. Chemical COCs in liquid wastes include ammonia, inorganics, organics, and particulates. A more detailed look at chemical COCs within LLMW liquid waste will be addressed in Activity 7: Effluent Treatment Facility (ETF): Processing and Treatment . As far as radiological hazards, no individual isotopes are *greater than the 10 CFR 30.72, Schedule C quantities and no further radiological accidents will be analyzed.* RPE and PPE is utilized when necessary. [130: P. 14]

This activity is classified as a past, present, and future **HW task** performed by LOW: <11[131] workers at the LERF. LLMW liquid waste storage began in 1995 and will continue until the LERF ceases operations. This is predicted beyond 2006. Regulatory drivers associated with this activity include RCRA, WAC: 173-303, and the TPA.

Activity 7: ETF: Processing and Treatment [130: Pp. 1-36]

The Effluent Treatment Facility (ETF) is an automated waste water treatment facility where a primary treatment system treats and filters liquid effluent and a secondary treatment system receives and evaporates backwash. While much of the ETF is automated, personnel provide maintenance to the system and help package effluent concentrate (a powder form after treatment) by tightening drum lids by hand.

Hazards at the ETF include chemicals added as part of the treatment process, chemicals added to prevent corrosion, antifoaming agents added to the evaporator, and chemicals and low activity radionuclides from LERF effluent. There are no explosives in the system, although some of the chemicals added can react with each other. The chemicals added as part of the treatment process are sulfuric acid, sodium hydroxide, hydrogen peroxide, and sodium-hexametaphosphate. Table 10.1 F: LERF and ETF Chemical Hazards associated with Liquid Effluent presents effluent chemicals incoming to the ETF. RPE and PPE are utilized when necessary.

This activity is classified as a past, present, and future **HW task** LOW: <11 [131] at the ETF. LLMW liquid waste treatment began in 1995 and will continue until the ETF ceases operations. This is predicted beyond 2006. Regulatory drivers associated with this activity include RCRA, WAC 173-303, and the TPA.

Table 10.1 F: LERF and ETF Chemical Hazards associated with Liquid Effluent [130]

Organic Compounds within LERF and ETF Effluent		
1-Butanol	Acetone	Benzyl Alcohol
Chloroform	Methylene Chloride	Methyl Isobutyl Keytone
Pyridine	Tributyl Phosphate	
Inorganic Compounds within LERF and ETF Effluent		
Sodium	Potassium	Calcium
NH_4	Silicon	NO_3
SO_4	CO_3	Chlorine
Fluorine	PO_4	

222-S Analytical Laboratory Profile:

The 222-S Analytical Laboratory provides analytic chemistry support to waste management, chemical processing, and environmental programs at the Hanford site. The 222-S Complex located in the 200-West area includes numerous facilities which support the laboratory and waste handling activities. HLW is also analyzed and characterized at this lab. [132: P.1, 133]

Activity 8: 222-S Radioactive Liquid Waste Line Replacement

Remediation workers from multiple contractors, including WMFS, Inc., Fluor Daniel Northwest, Dyncorp Tri-Cities Services, and ICF Kaiser Hanford Company, constructed a hazardous and radioactive liquid waste (LLMW) transfer system from the 222-S Analytical Laboratory to a waste collection tank feeding into the 200-West area tank farms. The activity also included the decontamination and removal of the existing 222-S waste collection system which had been in place for almost 50 years. The effort required entry to service tunnels and hot cells to install the system back to the source of waste generation. [132, 134]

Hazards and COCs associated with these tasks included 'severe' radiological conditions (exposure to plutonium, americium, cesium and strontium), confined space, and the potential for exposure to mixed wastes. PPE such as impervious protective suits and supplied air respirators were used during the effort. [132: Sec. 3]

This activity is classified as two separate remediation tasks. The first, removal of the existing waste collection system, is classified as a past **De task** performed by MED: 11-75 workers. Construction and replacement of the line is classified as a past **HW task** performed by MED: 11-75 workers [135]. The entire project began in 1993 and was completed in 1997. Regulatory drivers associated with this activity included RCRA, WAC: 173-303, and the TPA. [136]

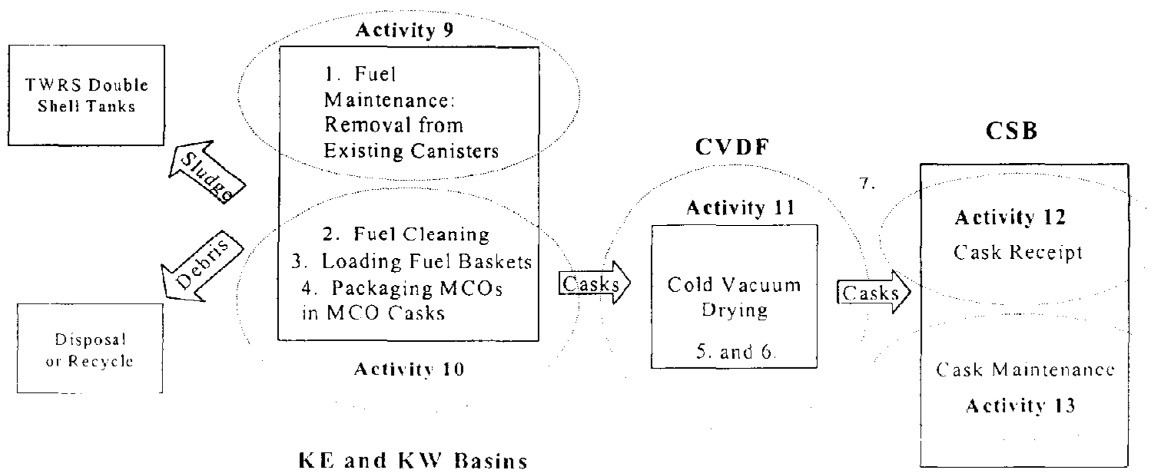
10.2 Hanford's Spent Nuclear Fuel Project

The Spent Nuclear Fuel (SNF) Project managed by the Project Hanford Management Contractor (PHMC) Fluor Daniel Hanford (FDH) and Duke Engineering and Services (DE&S) addresses the need to move spent nuclear fuel (SNF) from degraded storage conditions in the 105 K East (KE) and 105 K West (KW) Basins in the 100-K area to interim dry storage at the Canister Storage Building (CSB) in the 200 East Area. (137: Pp. 18-19, 138)

The SNF project began in 1994 along with the construction of the Canister Storage Building (CSB). At the end of fiscal year 1998, the CSB was 75% complete. Removal of SNF will begin in November 2000 at the KW Basin and one year later at the KE Basin. K Basin cleanup is expected to be completed by July 2007 including the removal of sludge, debris, and water, and deactivation of the basins. (137: Pp. 18-19, 119: Pp. 16-17) The area will then be turned over to the environmental restoration contractor (ERC) for decontamination and decommissioning.

As of September 1998, the planned steps of fuel removal include: 1) the removal of fuel assemblies from existing canisters; 2) cleaning the fuel; 3) placing the fuel into specially designed baskets; 4) inserting the baskets into Multi-Canister Overpacks (MCOs) which will be filled be with water; 5) shipping MCOs to a Cold Vacuum Drying Facility (CVDF) where they will be dewatered and dried; 6) sealing and leak testing MCOs; and 7) transporting MCOs to the CSB for interim storage. The following diagram (Figure 10.2 A) presents the SNF treatment / storage / disposal (TSD) process and activities in this section. (119: Pp. 16-17)

Figure 10.2 A: The Spent Nuclear Fuel Project Activities Diagram



Remediation Worker Spent Nuclear Fuel Activities

K Basin Profile:

Since 1963, the K basins have stored N Reactor fuel from the 100 N Area in opened and sealed canisters placed in underwater fuel storage racks. From 1978, canisters were transported in fuel transfer casks to the Plutonium-Uranium Extraction Plant (PUREX) for processing. In 1992, the decision to deactivate the PUREX Plant (See Activity 28) left 2,100 metric tons of zirconium alloy clad uranium metal fuel (i.e. spent nuclear fuel (SNF)) in the K Basins with no means for near term processing. Open canisters within the basins have released fission products and, combined with particulate matter, have settled to the bottom as sludge. Total K Basin sludge is estimated to be $67.5m^3$. (139: P. 1, 140: P. 1)

Activity 9: K Basin Canister Storage and Maintenance (141: Sec. 2.5)

K Basin activities involve the storage and handling of SNF from the N Reactor, sludge (HLW), radioactive debris (TRU), and contaminated debris (LLRW). SNF is contained in canisters which are placed in underwater storage racks on the bottom of the basin concrete floor. Personnel will reside on the work area grating (See Figure 10.2 B: Fuel Storage Basin Configuration) and use manual fuel handling tools such as canister hooks, tongs, and canister sealing and purging tools to move, retrieve, place, seal, and maintain SNF and canisters.

Hazards associated with these activities include radiological fission products including cesium, strontium, tritium, and the TRU isotopes Am^{241} and $Pu^{239/240}$ in basin water. There are no routine RCRA chemical wastes of concern. Occasionally hazardous wastes are generated in small volumes as a part of maintenance activities and are managed as LLMW and TRU Mixed wastes. Chlorine is used in routine maintenance of the sanitary and potable water systems and occasionally other chemicals are added to basin water. Radiological shielding and anti-C clothing and/or respiratory protection (includes respirators with particulate or supplied air respirators, self-contained breathing apparatus, and airline supplied air-suits and hoods) is used when necessary.(141: Sec. 7 and 8)

This activity is classified as a past, present, and future **CW task** performed by MED: 11-75 workers at the KE basin and MED: 11-75 workers at the KW basin.(142) Storage and maintenance activities will continue until fuel is completely removed from the basins. This is predicted for 2007. Regulatory drivers associated with this activity include CERCLA and the TPA.

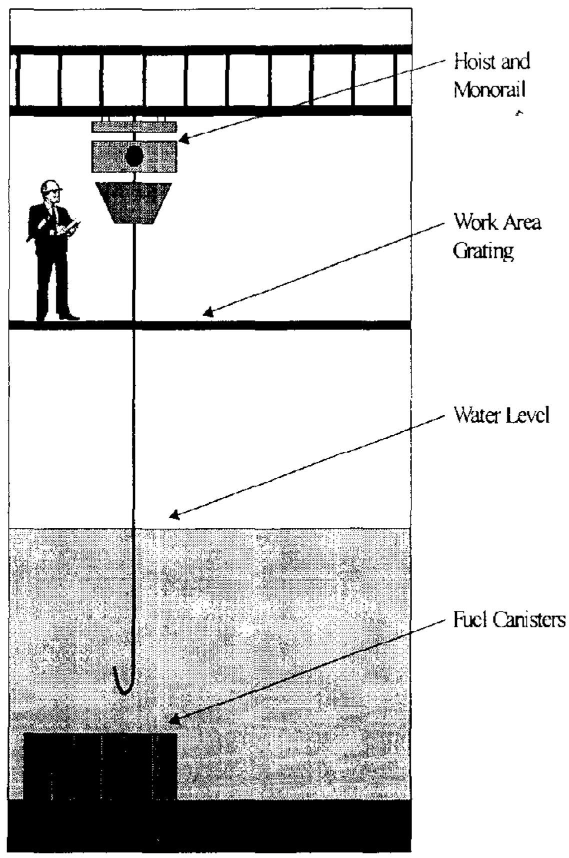
Activity 10: Packaging and Transport of SNF at the K Basins (143: P. 1)

Within basin pools, personnel will top load 'cleaned' SNF fuel baskets into Multiple Canister Overpacks (MCOs) which are specially designed to properly position SNF. The MCO will then be placed into the MCO cask (a containment and transportation device) filled with water. The MCO shield plug/lid will be placed on the MCO, the package lifted out of the pool, the cask lid installed, and the package placed on a trailer for transfer to the Cold Vacuum Drying Facility (CVDF) in the 100 K Area (See Activity 11) and then to the CSB in the 200 Area (See Activity 12). The MCO cask allows for further conditioning and temporary containment.

Hazards associated with these tasks include those contaminants described in Activity 9 and those hazards associated with MCOs listed in Table 10.2 C: MCO Radionuclide Inventory. After packaging, gas will be produced in MCOs through uranium corrosion, radiolysis, and fission gas release from SNF. For transfer to the CVDF, the MCO will be backfilled with inert gas, such as helium, argon, or nitrogen to minimize oxygen and hydrogen present in the MCO. These gases could become hazardous if not managed properly. Radiological shielding and anti-C clothing and/or respiratory protection is used when necessary.

Packaging and loading activities are classified as future **CW tasks** estimated to be performed by MED: 11-75 workers per shift. [142] Packaging and transport activities will begin in 2000 when associated facilities and operations are ready for SNF management. These tasks will continue until fuel is completely removed from the basins. This is predicted before 2006. Regulatory drivers associated with this activity include CERCLA and the TPA.

Figure 10.2 B: Fuel Storage Basin Configuration (141: Sec. 2/13)



Cold Vacuum Drying Facility (CVDF) Profile:

The CVDF will be housed in a separate new structure located to the west of the KW Basin Power Control Building. Construction is expected to begin at the end of FY 1999. CVDF will accept MCO casks from the K Basins and will dry the SNF in order to make it safer to transport and stage at the Canister Storage Building (CSB).

Activity 11: Processing MCO Casks at the CVDF [144: Sec. 2.4.1]

The processing area at the CVDF will house process bays in which transport trailers can be contained while free water is drained and a vacuum-gas purge process dries SNF. Within secondary confinement enclosures, personnel will perform initial inspection, cask lid removal, and system connections before the start of cold vacuum drying. During normal operations, personnel will only be required in the processing bay for routine surveillance. Personnel will then remotely control the vacuum pumping system and an MCO-tempered water system for performing MCO drying operations. Water from the MCOs (LLRW,TRU waste) will be sent to a process water tank room for treatment and on to the 200 Area liquid treatment facilities. At the end of cold vacuum processing, each MCO undergoes a pressurization test to confirm the generation of hydrogen from water is sufficiently low to be able to seal the MCO for safe shipment to the CSB within a specified time window.

Radiological hazards associated with this activity are described in Tables 10.2 C and 10.2 D. Chemical hazards include those described in Activity 10. RPE and PPE are required during initial receipt, cask lid removal, and surveillance and maintenance tasks.

This processing activity is classified as a future **CW task** estimated to be performed by 10 to 12 workers per shift (MED: 11-75) at the CVDF. [145] Cold vacuum drying will begin when facility construction is complete. This is predicted before 2000. Processing will continue until fuel is completely removed from the basins. This is predicted before 2006. Regulatory drivers associated with this activity include CERCLA and the TPA.

Canister Storage Building (CSB) Profile:

The CSB, located in the 200 E area is 75% complete as of January 1999. The CSB design consists of three equally sized concrete vaults covered by a concrete operating deck. Two of the vaults are equipped with 220 storage tubes in which 4 MCOs containing repackaged SNF can be placed and sealed. The other third vault remains for future SNF or HLW interim storage. The operating desk and other operation areas are enclosed in a steel building. [146]

Activity 12: Canister Storage Building (CSB): Wash Down Area [146: Sec. 2.2.5]

Personnel at the wash down area will receive MCOs by rail car or truck from the K Basins. Once the MCO/Cask is inside the area, remotely operated water spray equipment will wash down the cask and railcar or truck removing dust and road grime. After washing, a tow rope system will pull the casks into a load-in / load-out area for receipt into the CSB. PPE was not described for this task.

Radiological hazards associated with accidental container releases during this activity are described in Tables 10.2 C and 10.2 D. No chemical hazards were reported for this task.

This activity is classified as a future **CW task** predicted to be performed by LOW: <11 workers at the CSB. [147] This task (if implemented) will begin upon the completion of the CSB and the start up of SNF transport from the K Basins and CVDF. This is predicted before 2000. Regulatory drivers associated with this activity include CERCLA and the TPA.

Activity 13: Canister Storage Building (CSB): Operating Deck: Storing MCOs [146: Sec.2.2.2]

The operating deck area contains openings for personnel to place and remove MCOs in vault storage tubes. The deck will provide adequate shielding for workers on the deck and structural support for loads. The operating deck will also be serviced by a crane and a Shielded Cask / MCO Handling Machine which will transport MCOs inside the operating area to the storage tubes.

Radiological hazardous associated with accidental container releases during this activity are described in Tables 10.2 C and 10.2 D. No chemical hazards were reported for this task.

This activity is classified as a future **CW task** estimated to be performed by LOW: <11 workers at the CSB. [147] This task will begin upon the completion of the CSB and the start up of SNF transport from the K Basins and CVDF. This is estimated for the year 2000. Regulatory drivers associated with this activity include CERCLA and the TPA.

Table 10.2 C: Mass of One Multi Canister Over Pack (MCO) as of January 1996 (146: Sec. 1-10)

Radionuclide	Units	Average	Maximum
U	kg	2,800	3,287
Zr	kg	197	230
Pu	kg	5	100
Sn	kg	3	3
Al	kg	2	3
C	kg	2	2
All Other	kg	4	5
Total Mass For One MCO	kg	3,013	3,630

Table 10.2 D: Activity of One Multi Canister Over Pack (MCO) as of January 1996 (146: Sec. 1-10)

Radionuclide	Unit	Average	Maximum
Kr-85	Ci	937	2,440
Sr-90	Ci	14,000	27,941
Y-90	Ci	14,000	27,941
Cs-137	Ci	18,000	37,929
Ba-137m	Ci	17,067	35,906
Pm-147	Ci	1,440	8,180
Sm-151	Ci	229	344
Eu-154	Ci	171	804
Pu-238	Ci	167	496
Pu-239	Ci	300	499
Pu-240	Ci	173	378
Pu-241	Ci	7,840	35,021
Am-241	Ci	420	742
All Other	Ci	379	3,283
Total Activity for One MCO	Ci	77,320	182,692

10.3 Hanford's Tank Waste Remediation System Project (Integrated Tank Waste Management)

Hanford's Tank Waste Remediation System (TWRS) is currently managed by the Office of River Protection (ORP) which was established by the Department of Energy (DOE) in 1999 to organize all aspects of the tank farms including the 'privatized' contract for treating and immobilizing tank waste, and the non-privatized operations, maintenance, engineering, and construction activities.

Non-privatized operations are managed by the Project Hanford Management Contractors (PHMC) including Fluor Daniel Hanford Inc. as the lead contractor, supported by major subcontractors. Lockheed Martin Hanford is the subcontractor responsible for most of the ORP work scope outside the 'privatized' contract. This work includes tank waste storage and retrieval, and immobilized waste storage and disposal. Other subcontractors that provide support services include Waste Management Federal Service Hanford (WMFS), DE&S Hanford, DynCorp Tri-Cities Services, and B&W Hanford. Example support services include operating the 242-A Evaporator, the Liquid Effluent Retention Facility (LERF) and Effluent Treatment Facility (ETF), and the 222-S Laboratory. Subcontractors also provide solid waste treatment, storage, and disposal services, nuclear safety services, engineering and construction management services, infrastructure services (i.e. providing computer systems, roads, electricity, and water), and site security. Pacific Northwest National Laboratory is also providing technology research in support of TWRS. Refer to Section 9.0: Overview of Integrated Environmental Waste Management at the Hanford Site on page 74 for a view of integrated environmental site management. [119: Pp. 30-31, 148: P. 21]

British Nuclear Fuels Limited (BNFL Inc.), the TWRS 'privatization' contractor, is responsible for providing waste processing including designing, building, staffing, and operating the waste processing facilities. They are also responsible for financing, acquiring the permits and approvals for building and operating the facilities, and providing treatment and immobilization services to the government at fixed-unit prices. A 24-month design phase began in August of 1998 and construction of facilities is scheduled to begin in August 2000. Figure 10.3 A on page 107 presents privatized functions, inputs, and outputs and Figure 10.3 B also on page 107 presents the BNFL tank waste treatment schedule. [119, 148: P. 21]

PNNL also provides technical and management services to the ORP including assistance in developing and managing the BNFL Inc. contract. PNNL conducts research and technology development activities involving tank waste, vadose zone, and ground water evaluations. [148: P. 15]

Figure 10.3 A: Privatized Functions, Inputs, and Outputs [149]

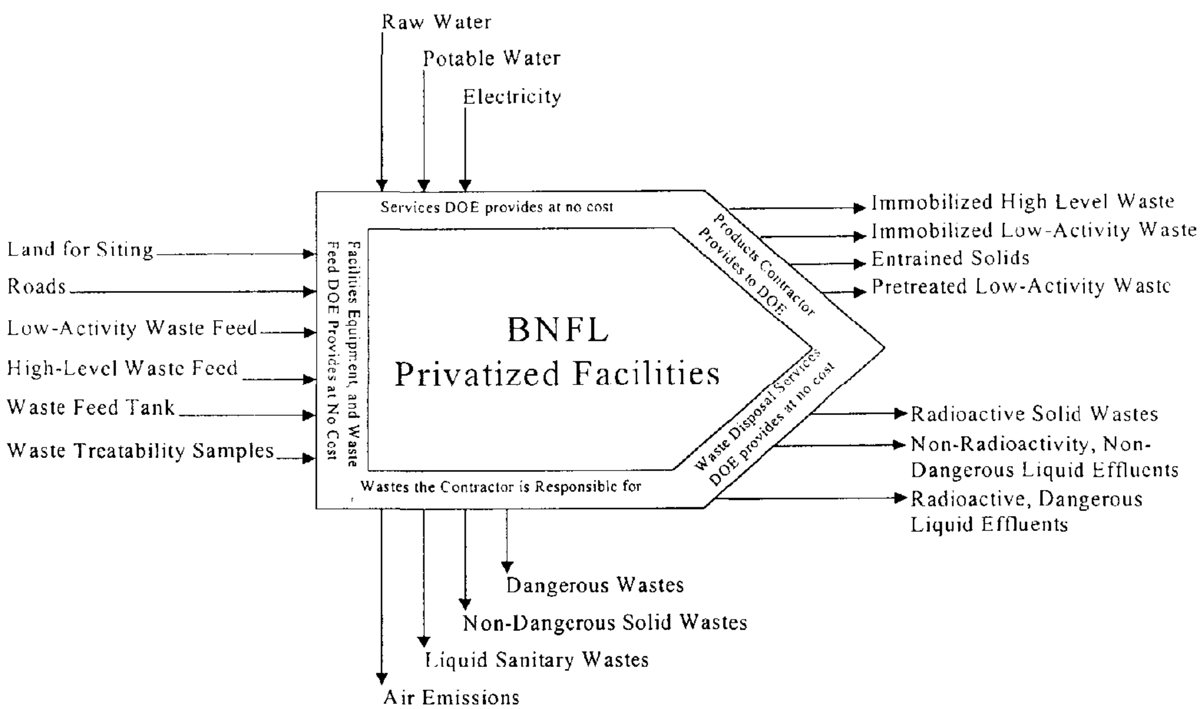
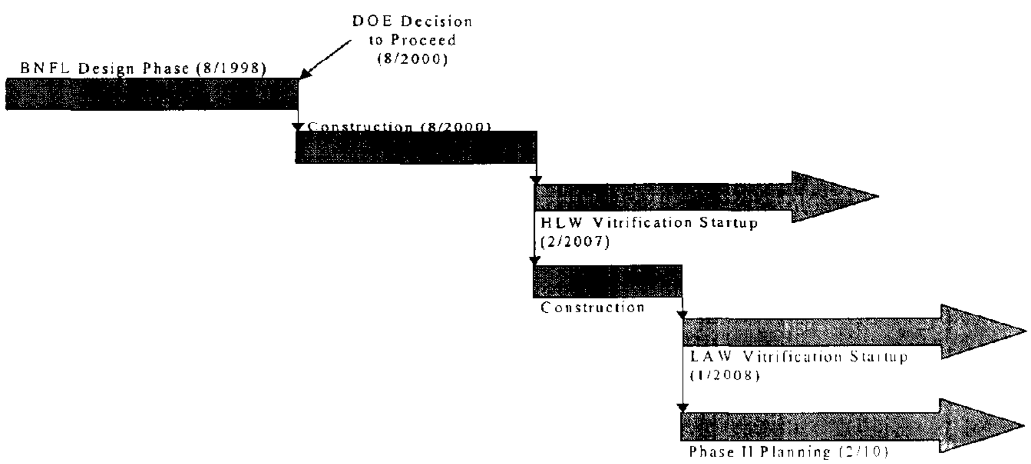


Figure 10.3 B: BNFL Waste Treatment Schedule [150]

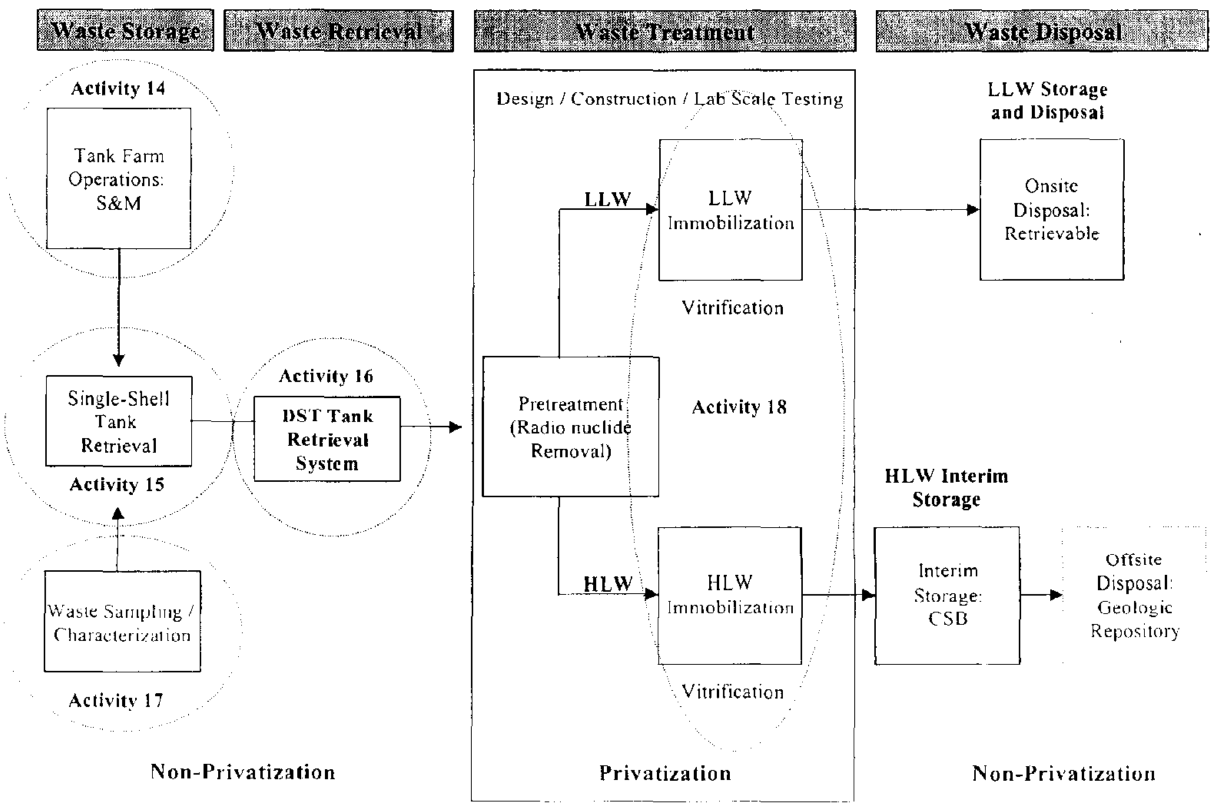


Remediation Worker TWRS Activities

200 East and 200 West Hanford Tank Farm Profile:

Collectively, the 200 East and 200 West areas at the Hanford Site include 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs). In the 200-E area, there are 25 DSTs and 66 SSTs. In the 200-W area, there are 3 DSTs and 83 SSTs. 67 SSTs in the 200 Area have leaked into soil and groundwater during the course of Hanford operations. As of February 1999, 119 of the 149 SSTs have completed interim stabilization. Maintenance, operations, and interim stabilization of the remaining 29 SSTs are current activities in the 200-E and 200-W tank farms. The 200 Area will also house the treatment and storage facilities dedicated to non-privatization and privatization missions and HLW integrated management. Figure 10.3 A presents an overview TWRS activities. (151)

Figure 10.3 A: Tank Waste Remediation System Activities Diagram



Activity 14: 200-E and 200-W Tank Farm Surveillance and Maintenance (S&M)

Personnel involved in routine SST and DST 'surveillance and maintenance' activities will 1) perform preventative tank farm equipment maintenance and repair, 2) survey tank safety operations for proper safety measures, 3) perform radiological surveillance tasks, 4) read active tank instruments for liquid waste levels, temperatures, pressure, flammable gas concentrations, and ventilation air flow, 5) and monitor the tank for leakage and airborne and surface contamination. Personnel performing these tasks will enter radiation zone areas approximately 54,000 times per year. [151, 152: Sec. 2.0]

Hazards associated with these duties include direct exposures to radiation and/or airborne radionuclides (LLRW / TRU). Risk is greater to those performing equipment maintenance tasks such as installation, repair, and removal due to the necessity of hands on only maintenance methods. Radiological and chemical hazards associated with SST and DST tank wastes are described in Activities 15 and 16. Industrial hygiene concerns across the tank farms are also described at the end of the TWRS activity section on page 116. RPE and PPE is required and procedures are followed according to DOE orders and documents including the Radiological Control Manual and Occupational Safety and Health Standards.

This activity is classified as a past, present, and future **CW task** performed by HIGH: >75 workers. Table 10.3 B: TWRS Workforce presents a detailed breakdown of the TWRS non-privatized workforce as of June 1998. Surveillance and maintenance activities at the tank farms have been occurring since 1989 and will continue to occur beyond 2006. Regulatory drivers associated with these activities include RCRA, CERCLA, and the TPA.

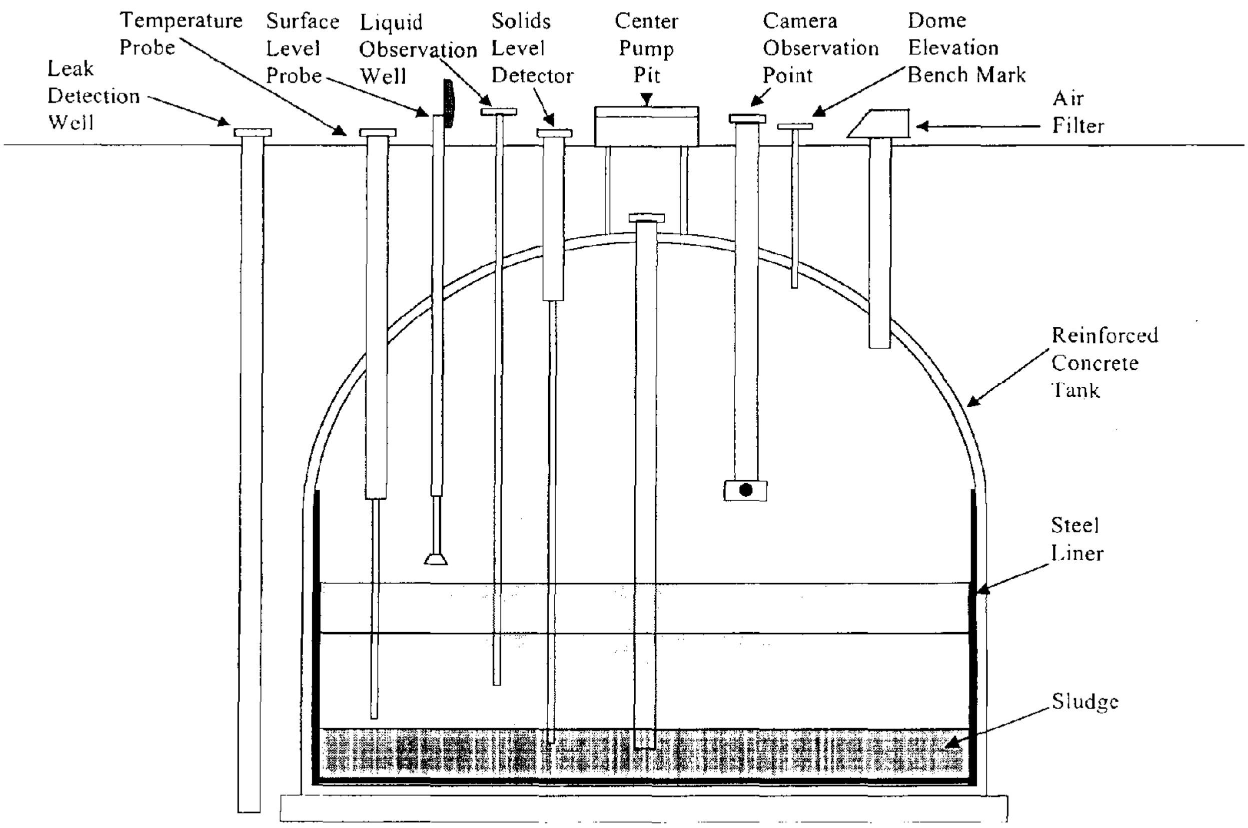
Table 10.3 B: The Lockheed Martin Hanford Tank Waste Remediation System (TWRS) Workforce as of June 1998 [153, 154]

Title	Number
Carpenters	3
Electricians	31
Health Physics Techs	100
Instrument Techs	30
Millwrights	5
Nuclear Process Operators	132
Tool Attendants	3
Insulators	3
Industrial Hygiene Techs	12
Painters	5
Plumber/Steam fitter	16
Station Operating Engineers	18
Welder	1
Person in Charge (PIC or Field supervisors)	30
Total	389

Tank 106-C Profile:

Tank 106-C is a 2 million liter capacity SST located in C Farm in the 200 East Area. Figure 10.3 C presents a cross-sectional view of a Hanford SST. The tank is currently non-leaking, but is considered to have the highest heat load of any Hanford SST. The tank contains identifiable waste layers. The bottom layer consists of uranium recovery waste and the remaining consists of high-heat, higher-plutonium-containing, soft sludge. Water has been added to the tank since 1971 to promote heat transfer and keep the waste wet. If the current cooling methods are stopped, the sludge and concrete structure will heat and may cause a possible radioactive release. Project W-320 was prepared and approved in August 1993 to retrieve the soft waste so that stabilization of the tank can be achieved. (155, 151, 156: Sec. 1-1)

Figure 10.3 C: Cross-sectional View of a Typical Single-Shell Tank (151)



Activity 15: Single Shell Tank (SST) (Tank 106-C) Retrieval [157, 158]

The 'high-heat' sludge in Tank 106-C is currently being stabilized by sluicing (See Technology 4, Section 11.5 on page 150) which removes sludge and liquids from the tank by mixing the tank contents with water and pumping out the resulting mixture. [151, 159] Personnel will maintain retrieval operations from above the ground.

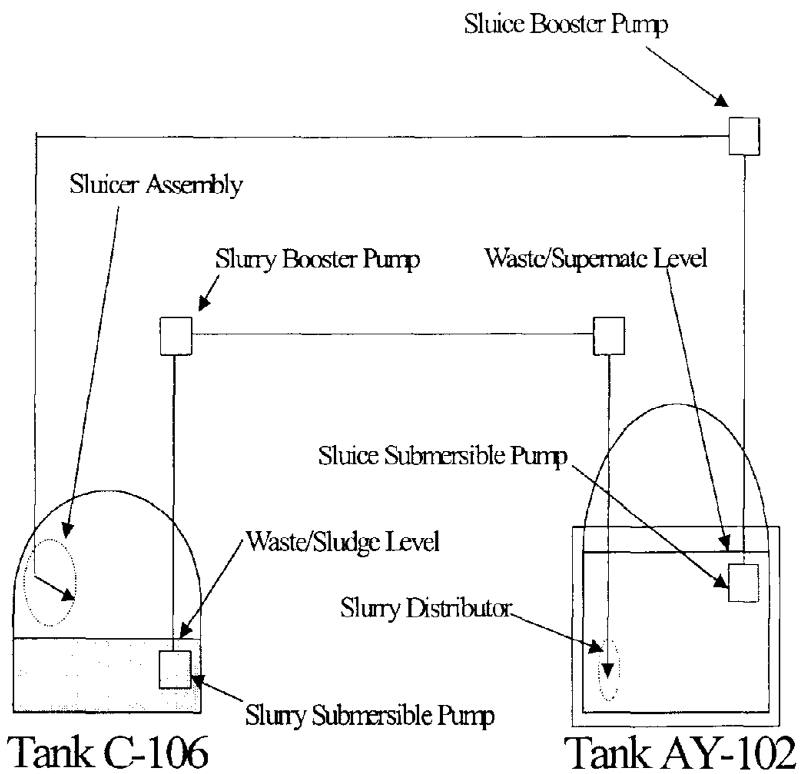
The sluicing waste transfer system (shown in Figure 10.3 D) consists of seismic switches, primary and secondary transfer pipes between tanks 106-C and 102-AY (a DST), a slurry distributor, syphon protection, pit cover blocks, seal loops, waste transfer equipment in pits, slurry pumps, sluice pumps, sluicers, valves, a raw water supply and transfer line flushing system, and a compressed air system. Through an in-tank imaging system, operations personnel are able to view the inside of the tank from a control room.

If failure occurs with any components of this system, retrieval operations are shut down so that personnel are able to perform maintenance activities. Conditions are determined with the imaging system before opening pits for maintenance, leak verification, or equipment inspection.

Hazards associated with these tasks include radiological and chemical hazards presented in Tables 10.3 F: SST Solid Waste Characterization Results and Table 10.3 G: SST Liquid Waste Characterization Results. Tank farm industrial hygiene concerns are described at the end of this section on page 116.

This activity is classified as a past, present, and future **CW task** performed by HIGH: >75 workers. Table 10. 3 B: TWRS Workforce on page 109 presents a detailed breakdown of the TWRS non-privatized workforce as of June 1998. Retrieval activities at the tank farms have been occurring since 1989 and will continue to occur beyond 2006. Regulatory drivers associated with these activities include RCRA, CERCLA, and the TPA.

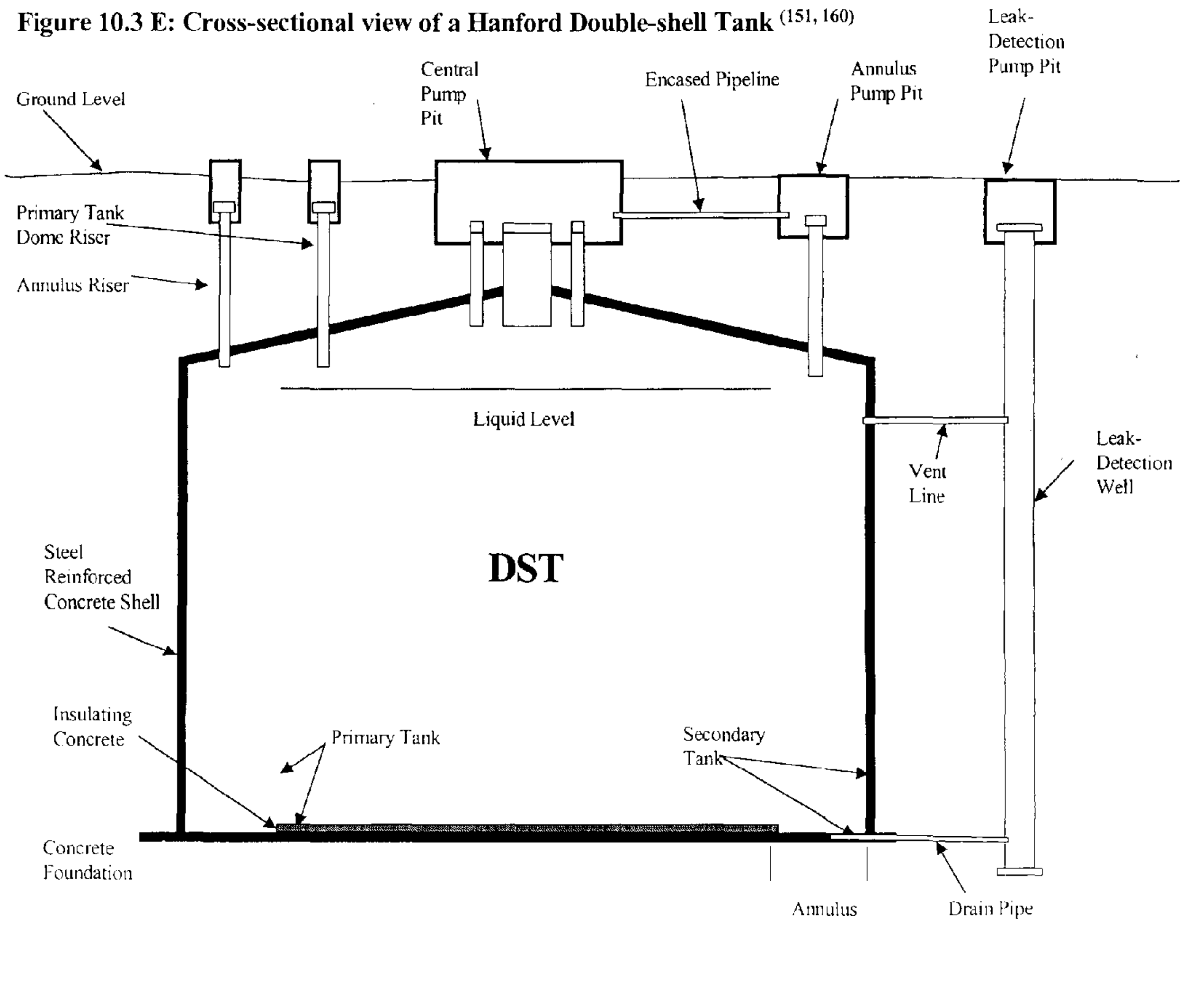
Figure 10.3 D: Sluice System Diagram [156]



Tank 101-AZ Profile:

Tank 101-AZ is located in the Aging Waste Facility (AWF) of the Hanford TWRS in the 200 East area. Figure 10.3 E presents a cross-sectional view of a Hanford DST. The tank contains approximately 1 million gallons of neutralized acidic waste, including 2 feet of solids settled on the bottom of the tank, in addition to solids that are presently suspended in the supernate by air lift circulators. The material stored in the tank and other Hanford DSTs have a high concentration of radioactive solids and a high rate of radioactive heat generation. In 1995, Tank 101-AZ was selected as the first DST to demonstrate a mixer pump retrieval system. This process test was entitled Project W-151. (151, 159, 155)

Figure 10.3 E: Cross-sectional view of a Hanford Double-shell Tank (151, 160)



Activity 16: Double Shell Tank (DST) (Tank 101-AZ) Retrieval (160, 159, 161)

Personnel performing retrieval tasks at Hanford DSTs operate equipment to control and monitor mixer pumps in an environmentally controlled structure at the tank farm. Activities also involve the removal of a non-essential equipment and the installation of all retrieval system equipment. RPE and PPE is required and procedures are followed according to DOE orders and documents including the Radiological Control Manual and Occupational Safety and Health Standards.

Hazards associated with these tasks include radiological and chemical hazards presented in Table 10.3 H: DST Tank Waste Liquids and Solids Analyte Concentrations and Table 10.3 I: Maximum Sample Activity Concentrations for DST Tank Waste. Tank farm industrial hygiene concerns are described at the end of this section.

This activity is classified as a past, present, and future **CW task** performed by HIGH: >75 workers. Table 10.3 B presents a detailed breakdown of the TWRS non-privatized workforce as of June 1998. Retrieval activities at the tank farms have been occurring since 1989 and will continue to occur beyond 2006. Regulatory drivers associated with these activities include RCRA, and the TPA.

Activity 17: Tank Waste Characterization: Tank Sampling (162)

Personnel will sample tank solids, supernatant, gas vapors, and soft slurry (all classified as HLW) through various sampling techniques including 1) rotary mode core sampling, 2) push mode core sampling, 3) retained gas sampling, 4) grab sampling, 5) auger sampling, and 6) vapor sampling.

Personnel performing the grab sample technique use a special sampling bottle that is contained in a cage to obtain liquid or soft slurry samples of waste. The bottle is stoppered and lowered to the desired level in the tank. The bottle is then opened filled with liquid and retrieved from the tank and is then re-stoppered. Characterization and analysis will then be performed at a waste characterization facility such as the 222-S Analytical Laboratory. PPE and RPE are used when mandated by DOE orders.

Hazards associated with these tasks include radiological and chemical hazards presented in Table 10.3 H: DST Tank Waste Liquids and Solids Analyte Concentrations and Table 10.3 I: Maximum Sample Activity Concentrations for DST Tank Waste. Tank farm industrial hygiene concerns are described at the end of this section on page 116.

This activity is classified as a past, present, and future **CW task** performed by HIGH: >75 workers. Table 10.3 B presents a detailed breakdown of the TWRS non-privatized workforce as of June 1998. Characterization and sampling activities at the tank farms have been occurring since 1989 and will continue to occur beyond 2006. Regulatory drivers associated with these activities include RCRA, CERCLA, and the TPA.

Activity 18: Tank Waste Treatment and Immobilization (Privatized) [150, 152, 148, 149]

Personnel will operate and maintain HLW and LAW treatment and immobilization facilities at the Hanford site. Once tank waste is transferred to BNFL, Inc., the waste will be treated to separate it into two fractions: HLW and LAW. Treatment will consist of removing cesium, strontium, technetium, and transuranics from the waste using processes such as ion exchange and precipitation and blending them into the HLW stream. The remaining larger volume of waste including soluble waste and chemicals removed from DST wastes will be blended into the LAW stream.

The HLW fraction will be vitrified as a borosilicate glass and poured into 2 foot wide and 15 ft tall stainless steel canisters then shipped to the Canister Storage Building (CSB) for interim storage until final disposal. The LAW fraction is scheduled to be vitrified in a separate facility, however BNFL, Inc. was given the option of recommending an alternate immobilization technology. Under the baseline plan, the vitrified LAW waste will be poured into stainless-steel boxes (4X4X6 feet).

Exposure potential for these treatment and immobilization activities will involve limited contact due to closed loop systems. Since these process have not been fully planned or analyzed, exposure potential cannot be fully assessed.

HLW treatment and immobilization activities are classified as future **CW tasks** performed by HIGH: >75 workers. Note that the BNFL privatized work force was not broken down into specific numbers of workers by occupation for this report. This was due to the lack of a site contact regarding BNFL. LAW treatment and immobilization activities are classified as future **HW tasks** performed by HIGH:>75 workers. HLW and LAW vitrification facility are predicted to begin immobilization sometime after 2006. Regulatory drivers associated with these activities include RCRA and the TPA.

Industrial Hygiene Concerns within Hanford Tank Farms

Hazards associated with these activities also include potential exposures to tank vapor which includes a mixture of ammonia, nitrous oxide, hexane, benzene, butanol and approximately 1000 other compounds. Asbestos gaskets located on tank riser pipes, heat stress, lead exposure from shielding and welding activities, and beryllium are also other industrial hygiene concerns within the tank farm areas. [154, 153]

Table 10.3 F: SST Solid Waste Characterization Results as of July 1996 [163]

C-106 SST Solids				
COMPONENT	LOW	HIGH	AVERAGE	UNITS
% Solids	-	-	55	-
%Water	-	-	45	-
Bulk Density	1.37	1.43	1.40	g/ml
F	86	720	403	mg/kg
NO_3	928	1,330	1,129	mg/kg
PO_4	-	-	93,700	mg/kg
SO_4	936	4,850	2,893	mg/kg
Al	30,000	40,900	35,450	mg/kg
Ba	-	-	4,890	mg/kg
Ca	-	-	11,900	mg/kg
Cr	984	1,350	1,167	mg/kg
Fe	52,100	64,100	58,100	mg/kg
La	-	-	5,960	mg/kg
Pb	-	-	1,060	mg/kg
Mg	461	6,560	3,511	mg/kg
Mn	1,840	14,100	7,970	mg/kg
P	-	-	9,210	mg/kg
K	-	-	1,470	mg/kg
Si	20,600	71,000	45,800	mg/kg
Na	35,800	117,000	76,400	mg/kg
U	0.00088	406	203	mg/kg
Zr	735	2,170	1,453	mg/kg
Total Organic Carbon	-	-	4,620	mg/kg
TRU	-	-	3,050	uCi/kg
T_{GAMMA}	-	-	363,000	uCi/kg
Pu - 239/240	1,530	5,520	3,367	uCi/kg
Rare Earths	-	-	450,000	uCi/kg
Cs-137	213,000	330,000	271,500	uCi/kg
Sr-89/90	6	1,980,000	990,03	uCi/kg

Table 10.3 G: SST Liquid Waste Characterization Results as of July 1996 [163]

C-106 SST Liquids				
COMPONENT	LOW	HIGH	AVERAGE	UNITS
% Solids	-	-	22.57	-
%Water	-	-	77.43	-
SPG	1.14	1.18	1.16	-
Cl	147	802	554	mg/l
CO_3	18,600	91,900	44,860	mg/l
F	15	530	164	mg/l
NO_2	2,985	13,248	9,750	mg/l
NO_3	1,400	112,220	67,156	mg/l
OH	0.029	0.324	0.176	mg/l
PO_4	846	11,100	4,039	mg/l
SO_4	3,520	6,470	4,995	mg/l
Al	34	752.6	270.1	mg/l
Bi	111	2,000	1,056	mg/l
Si	105	2,580	1,343	mg/l
Na	73,830	127,420	91,094	mg/l
U	162	958	560	mg/l
Total Organic Carbon	2,520	20,000	11,260	mg/l
ph	9.81	10.7	10.3	-
TRU	-	-	991.9	*u*Ci/l
TGAMMA	-	-	27,800	*u*Ci/l
PU-239/240	13.9	978	216	*u*Ci/l
AM-241	-	-	13.9	*u*Ci/l
CS-137	27,800	178,600	115,761	*u*Ci/l
SR-89/90	1,650	133,000	67,325	*u*Ci/l

Table 10.3 H: DST Tank Waste Liquids and Solids Analyte Concentrations as of August 1996 [160]

Analyte	Composite concentration (g/L)	
	DST solids	DST liquids
Ammonia (NH_3)	6.6 E+00	7.1 E+00
Antimony (Sb)	9.5 E-03	6.4 E-03
Arsenic (As)	5.7 E+00	8.7 E-03
Barium (Ba)	5.9 E+00	3.3 E-02
Beryllium (Be)	1.4 E-01	3.8 E-03
Cadmium (Cd)	2.6 E+01	7.0 E-02
Calcium (Ca)	2.6 E+01	1.3 E+00
Cerium (Ce)	2.6 E+00	5.8 E-02
Chromium (Cr^{+3})	1.5 E+02	-
Cobalt (Co)	6.5 E-01	8.8 E-03
Cyanide (Cn)	4.7 E-01	9.1 E-02
Dysprosium (Dy)	-	-
Lanthanam (La)	3.0 E+01	1.0 E+00
Mercury (Hg)	1.2 E-02	2.4 E-04
Neodymium (Nd)	7.0 E+00	5.6 E-03
Oxalate (C_2O_4)	2.8 E+02	-
Selenium (Se)	2.4 E-01	2.8 E-01
Sodium Hydroxide (NaOH)	2.3 E+02	2.1 E+02
Sodium (Na)	3.4 E+02	2.1 E+02
Tellurium (Te)	9.3 E-01	2.7 E-03
Thallium (Tl)	1.5 E+01	3.7 E-02
Total organic carbon (TOC) - oxalate	7.5 E+01	4.0 E+01
Uranium (U)	4.4 E+01	1.1 E+01
Vanadium (V)	4.1 E-02	2.1 E-03

Table 10.3 I: Maximum Sample Activity Concentrations for DST Tank Waste as of August 1996 [160]

Nuclide	Activity concentration (Bq/l)	
	DST Liquids	DST Solids
^{237}Np	9.2 E+04	9.9 E+08
^{137}Cs	8.8 E+10	9.8 E+10
^{14}C	5.8 E+04	1.0 E+05
^{760}Co	7.7 E+05	4.9 E+08
^{90}Sr	5.6 E+09	2.9 E+12
^{90}Y	5.6 E+09	2.9 E+12
^{129}I	4.4 E+01	4.1 E+06
^{241}Pu	3.4 E+05	1.7 E+09
^{238}Pu	2.8 E+03	6.7 E+07
^{134}Cs	1.3 E+04	not measurable
^{99}Tc	1.2 E+07	2.8 E+08
^{239}Pu, ^{240}Pu	1.2 E+06	4.4 E+08
^{241}Am	1.1 E+06	1.1 E+10
^{244}Cm	1.1 E+04	6.1 E+07

10.4 Hanford's Environmental Restoration Project (Site Decontamination and Decommissioning)

Hanford's Environmental Restoration Project is managed by the Environmental Restoration Contractor (ERC) Bechtel Hanford, Inc. (BHI). BHI is responsible for remediation of all soil and ground water operable units (remedial action (RA)), and the decontamination and decommissioning (D&D) of all existing Hanford buildings. D&D will require the disposition of more than 300 buildings currently in the surplus facility inventory, as well as more than 500 other buildings that will transfer to the Environmental Restoration (ER) Project for decommissioning from the Facility Stabilization (FS) Project (Section 10.5). [12: P. 39] ER activity at the Hanford site has been under way since 1987. BHI has been in charge of activities since 1994. Prior to 1994, Westinghouse Hanford conducted ER activities.

The ERC workforce is a mix of tiered subcontractors. The two major ERC contractors include CH2 Hill who provides technical, engineering, and scientific support and Thermo Hanford Inc. who provides radiological and industrial hygiene monitoring. Other lower-tiered sub contractors within the ERC include Westin, EnviroCon, and RCI Environmental, Inc. who are contracted to remediate dig sites in the 100 and 300 areas. The ERC also lets out miscellaneous construction contracts to smaller companies such as Thompson Mechanical. [44]

There are currently 72 (62 source and 10 groundwater) operable units at the site. This covers more than 220 square kilometers (85 square miles) of contaminated areas with radioactive and /or hazardous chemical materials. There are approximately 2,200 Hanford waste sites containing facilities, waste areas, and unplanned release sites. More than 600 cribs, trenches, ponds, ditches, and drains have received 1.7 trillion liters of liquid waste containing radioactive (678,000 curies) and hazardous chemical materials. [164: Sec. 6, P. 2]

ER specific projects include remediation of 100 square miles contaminated groundwater, contaminated soil, and facilities reactors. For 1998-1999, planned activities include: 1) completing the **N Area Deactivation** Project; 2) initiating the F Reactor and DR Reactor interim safe storage (ISS) projects; 3) completing the **C Reactor** interim safe storage project; 4) completing cleanup of 10 waste sites; 5) currently cleaning 23 waste sites; 6) removing 1 million tons of contaminated media from waste sites; 7) expanding the **Environmental Restoration Disposal Facility**; and 8) pumping and treating 2 billion liters of groundwater. Future activities include the remediation of approximately 367 waste sites, the D&D of 125 facilities, placing all reactors into interim safe storage; and removing approximately 6.3 million tons of contaminated media. [165: Pp. 29-31]

Remediation Worker Environmental Restoration Activities

The following activities are examples of typical ER tasks performed throughout the Hanford site. Activities are grouped by area in this section. The Appendix that accompanies this document presents a comprehensive list of the 2231 Hanford waste sites. Each waste site was classified according to remediation worker task (i.e. HW, De, Di, and CW). (See Section 6.2 on page 24 for task definitions). The list is presented according to Hanford operable unit. This data is kept in a Microsoft Access database for sorting, filtering and grouping waste sites of interest.

Exhibit 12.10 on pages 211 to 219 presents a selective list of contaminants of concern by operable unit. The Appendix and Exhibit 12.10 may be used together when reviewing the waste sites.

Figure 10.4 A: ER Activities Diagram

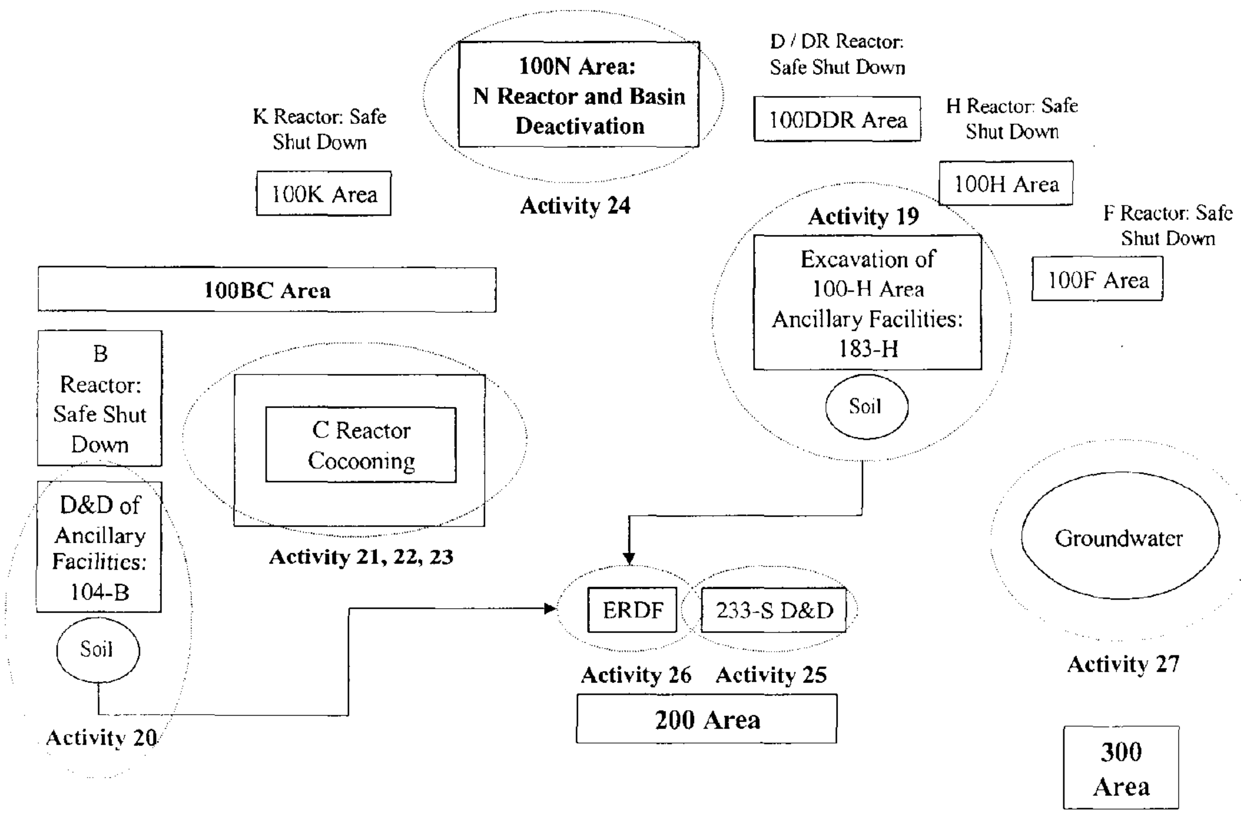


Figure 10.4 A presents an overview of example ER activities presented in this section.

Example 100 Area ER Activities

100 Area Remedial Action (Assessment and Remediation) and D&D Profile:

The 100 area adjacent to the Columbia River contains over 400 waste sites in six separate reactor areas containing 9 reactors and their ancillary facilities. During operations, large amounts of contaminated cooling water was disposed in cribs and trenches and leaked from waste transfer systems. Radioactive solid wastes were buried in unlined trenches. The ERC will clean up contaminated soils through excavation. (166)

In the 100 areas, facilities will be decontaminated and demolished and/or entombed with any wastes being disposed at the Environmental Restoration Disposal Facility (ERDF). Currently, all reactor facilities except N Reactor are in safe shut down mode (currently deactivated). C Reactor is completing interim safe storage (ISS) and other reactors will follow. (167)

Activity 19: Excavation of LLMW from the 183-H Solar Evaporation Basins (168, 169: P. 325, 170, 166)

The 183-H solar evaporation basins, operating between 1973 and 1985, were four concrete basins located in the 100-H Area that treated and stored routine and non-routine LLMW from N-Reactor Fuels Fabrication Facilities. Routine LLMW consisted of spent acid etch solutions (primarily nitric, sulfuric, hydrofluoric, and chromic acids) which reacted with excess sodium hydroxide before being transported to the 183-H basins. Routine wastes also included metal constituents such as copper, silicon, zirconium, nickel, aluminum, chromium, manganese, and uranium, which were in the form of precipitates. Non-routine LLMW consisted of unused chemicals and spent solutions from miscellaneous processes. The basins also received various hazardous wastes including cyanide, vanadium pentoxide, and formic acid.

Personnel at this facility will perform soil excavation tasks with heavy equipment and transport wastes to the Environmental Restoration Disposal Facility (ERDF). These activities are classified as future **HW tasks** performed by HIGH: >75 workers. Demolition activities were completed in 1998. Excavation is planned and should be completed prior to 2000. The regulatory drivers associated with these tasks are CERCLA, RCRA, and the National Environmental Policy Act (NEPA).

Activity 20: Decontamination, Demolition and Removal of LLRW / LLMW from 104-B Tritium Vault and Tritium Laboratory (171, 169: Pp. 33-34)

The 104-B-1 Tritium Vault and 104-B-2 Laboratory were used as tritium support and storage facilities from 1950 to 1955. The vault contained tritium shipping flasks stored on racks and the laboratory housed 63 cells recessed in the floor that stored vacuum casks containing irradiated target elements from 105-B and 105-C Reactors.

Beginning in September 1996, workers began decontamination activities (**De tasks**) by: 1) removing all materials (contaminated equipment) within the building; 2) removing radiological contamination (LLRW); 3) removing and segregating non-friable intact transite panels and lead based painted trim, wood, and metal (HW); and 4) surveying prior to demolition. After decontamination, workers performed demolition activities (**Di tasks**) using a track-hoe to demolish the building structure assisted by the use of a hydraulic impact hammer mounted on a tractor.

Prior to demolition, contaminated equipment, non-friable asbestos, and lead painted material was loaded into containers and shipped to either on-site or off-site disposal facilities. Shipping and disposal of HW containers is classified as a past **HW task** and shipping and disposal of LLRW is classified as a past **CW task**.

The number of workers associated with these activities is MEDIUM: 11-75. The regulatory drivers are CERCLA, NEPA and RCRA. All tasks were completed by October 1996.

105-C Facility Profile:

The reactor building 105-C, located in the 100B/C area, contains a reactor block, fuel storage basin, fuel examination facility adjacent to the fuel storage basin, inner and outer horizontal control rod (HCR) rooms, work area, fans and ducts for ventilation and recirculating inert gas systems, water cooling systems, and supporting offices, shops, and labs.

In 1997, 105-C began interim safe storage (ISS) activities which consisted of removing portions of the 105-C Building that where outside of shield walls surrounding the reactor block, removing or fixing loose contamination in areas within the shield walls, placing a new roof over the remaining structure, and installing a remote monitoring system inside the building. Activities will be completed in fiscal year (FY) 1999. [172, 173]

Activity 21: 105-C Safe Interim Safe Storage: Decontamination [173, 44]

Personnel in the 105-C facility area performed decontamination activities including: 1) removal of process piping, specific below grade tunnels, nonstructural equipment and material, and unfixed hazardous materials (HW) from the facility; 2) removal of sediment in the fuel storage basin transfer pits; 3) packaged sediment in disposal containers; 4) performed surface or near surface decontamination using mechanical methods such as ultrahigh-pressure water, shot blasting, ice blasting, and, grit blasting (See Section 11.0 for 105-C technology descriptions); 5) cleaned surfaces through methods such as chemical foams, gels, organic acid treatment, inorganic acid treatment, chelation treatment, and ultraviolet (UV)/ozone (UV light activation); and 6) abated asbestos and lead.

Personnel in the 105-C facility area also disposed of and transported (HW tasks) polychlorinated biphenyls (PCBs) and mercury containing equipment (HW) to on-site disposal areas.

In summary, hazards for workers performing these past and present **De task and HW tasks** included potential exposures to LLMW, LLRW, and HW waste types. Contaminants of concern include asbestos, lead, PCBs, mercury, and isotopes including plutonium-239/240, americium-241, and cobalt-60. The isotopes are generally most hazardous in the fuel transfer pits. Table 10.4 B summarizes 105-C hazards.

The number of workers associated with De tasks and HW tasks at the 105-C reactor building is MED: 11-75. These workers are represented by the Hanford Atomic Metal Trades Council (HAMTC). The regulatory drivers associated with this activity are CERCLA, RCRA, and NEPA. All tasks will be completed in 1999.

Activity 22: 105-C Safe Interim Safe Storage: Demolition (173, 44)

Personnel at 105-C reactor will demolish all reactor support structures such as water towers and other ancillary support structures outside the shield walls of the reactor using heavy equipment and other tools such as diamond wire saws, floor saws, and wall saws. Demolition of the existing roof is planned in coordination with the construction of a new roof that will be constructed for safe storage enclosure (SSE). This task is described in Activity 23.

Potential hazards associated with the 105-C facility are presented in Table 10.4 B. The primary hazardous waste type associated with this activity is LLRW with specific potential exposures to plutonium-239/240, americium-241, and cobalt-60.

This activity is classified as a past and present **Di task** performed by MED: 11-75 workers in the 105-C facility area. These workers are represented by the Hanford Atomic Metal Trades Council (HAMTC). The regulatory drivers associated with this activity are CERCLA, RCRA, and NEPA. All tasks were completed in 1999.

Activity 23: 105-C Safe Storage Enclosure: Cocooning (173, 44, 174)

Personnel constructed a new roof using heavy equipment consisting of prefabricated steel joists and steel joist girders with a stainless steel sheet metal roofing deck. Open areas between the roof and the top shield wall were enclosed with the same material. The roof structure was anchored to the top of the shield wall. All penetrations made during construction were sealed.

Potential hazards associated with the 105-C facility are presented in Table 10.4 B. The primary hazardous waste type associated with this activity is LLRW with specific potential exposures to plutonium-239/240, americium-241, and cobalt-60.

This activity is classified as a present **CW task** performed by MED: 11-75 (approximately 25) workers. These workers are represented by the Central Washington Building and Construction Trades Council. Scientec, a lower-tiered sub contractor to BHI was also providing support for this activity. The regulatory drivers associated with this activity are CERCLA, RCRA, and NEPA. All tasks will be completed in 1999.

Table 10.4 B: Summary of 105-C **Hazards as of December 1996 as Reported by the 'Final Hazard Classification and Auditable Safety Analysis for the 105-C Reactor Interim** Safe Storage **Project** [173]

Hazard	Potential Accidents	Mitigation/Control
Biological	- Snake bites - Insect bites - Inhalation of disease vector for bird/rodent guano	- Personnel training - Proper footwear - Proper clothing - Multistage high efficiency particulate air (HEPA) filtration
Gravitational	- Falling - Slip/trip - Struck by falling roof panel - Struck by wall, roof collapse - Laceration from unguarded fan - Struck by loose light fixture - Heavy loads	- Elevators refurbished - Temporary power & lighting systems - Laydown areas established - Scaffolding not used in place of elevators - Transportation and waste routes identified and upgraded - Removal of all nonessential equipment and services - Fall protection - Hand rails - Lifting & rigging procedures - Crane inspection
Heat/Cold Extremes	- Person exposed to temperature extremes	- Adequate rest during times of excessive heat - Additional clothing provided
Transportation	- Vehicle collision - Individual struck by vehicle - Vehicle structural failure	- Packaging and transport considers: - Structural integrity - Shielding - Containment - Dimensional envelopes - Identify waste routes and upgrade as necessary - Load and slope of waste route - Traffic controls
Electrical	- Shock from erroneously energized circuits - Shock while installing temporary power/lighting system	- New temporary power & lighting system provided - All old supplies cut off at source - Preconceptual engineering study prior to equipment reactivation - Existing panel boards, conduits, conductors and controls deengergized - OSHA approved temporary wiring harness - Ground fault protection system on temporary power & lighting system

Table 10.4 B (continued) : **Summary of 105-C Hazards as of December 1996 as Reported by the 'Final Hazard Classification and Auditable Safety Analysis for the 105-C** Reactor Interim Safe Storage **Project**[173]

Hazard	Potential Accidents	Mitigation/Control
Noise	- Damage from using loud equipment	- Hearing protection - Remote equipment handling - Limit time exposed to source
Radiological - Internal Uptake	- Internal uptake from disturbing contaminated material	- Facility characterization - Application of fixative - Protective clothing - Respiratory protection - Controlled area established - Area boundaries posted - Local confinement - Flexible exhaust/supply ventilation duct-work - Multistage HEPA filtration & air monitoring - Effluent monitoring
Radiological - External Exposure	- Exposure to external radiation fields	- Facility characterization - Facility shielding - Temporary shielding - Remote operation for selected areas
Chemical	- Exposure to miscellaneous unknown chemicals - Exposure to vapors caused by chemical reaction with decontamination agents	- protective clothing - Respriatory protection - Immediate containerization of waste - Remote operations
Corrosive	- Exposure to corrosives while draining lines	- Protective clothing - Respriatory protection
Fire	- Started by welding/cutting activity - Started by electrical fault	- Fire watches - Fire detection and alarm systems - Fire protection by local authority - Notification of central fire control (911) - Portable fire extinguishers

Table 10.4 B (continued): Summary of 105-C **Hazards as of December 1996 as Reported by the 'Final Hazard Classification and Auditable Safety Analysis for the 105-C** Reactor Interim Safe Storage **Project** [173]

Hazard	Potential Accidents	Mitigation/Control
Confined spaces	- Person enters confined space and is overcome by lack of oxygen	- Respiratory protection program - Hazardous atmosphere testing program
Asbestos	- Person inhales asbestos fibers	- Use of proven abatement/removal procedures - Encapsulation of contaminants - Respriatory protection - Multistage HEPA filtration & air monitoring
Heavy Metals	Worker inhales lead dust from shields or paint or mercury fumes from broken containers (switches or level indicators) while dismantling shielding, electronics or control panels	- Immediate containerization of waste - Protective clothing - Respriatory protection - Multistage HEPA filtration & air monitoring

N Reactor Profile:

N Reactor, located in the 100-N Area, is the last of Hanford's nine reactors to undergo deactivation beginning in 1992. Currently (end of 1998), final activities are underway so that the reactor can be placed under surveillance and maintenance (S&M) until the facility is finally dispositioned. [137, 91, 37]

The 105-N building is one of the major facilities in the 100-N area undergoing deactivation. It contains the N Reactor, the fuel basin, operating rooms, and safety system. Ancillary facilities are also located in the area and will be deactivated.

Activity 24: N Reactor (105-N) Deactivation [175]

Personnel at the 105-N facility have performed numerous deactivation activities in order to achieve S&M in the area. The following activities have been performed: 1) restarting existing equipment (i.e. cranes); 2) removing, characterizing, packaging, and transporting equipment fluids, HW, and unattached equipment and materials (LLRW, TRU) to the 200 Areas for use, reuse, recycling, storage, or disposal as waste; 3) draining basins and tanks (LLRW, TRU); 4) removing and transporting contaminated water and residuals to the 200 areas for disposal (LLRW); 5) removing, packaging and transporting contaminated sediment, hardware, and pieces of lithium target to the 200 areas for storage or disposal (LLRW, LLMW); 6) elimination, decontamination or stabilization to fix loose contamination of temporary and permanent radiation zones; 7) de-energizing support systems (i.e. electrical and HVAC); 8) performing structural repairs as necessary for S&M; 9) sealing building penetrations; and 10) performing routine S&M such as health and safety inspections, routine maintenance, and weed control.

De tasks are performed when personnel perform LLRW, TRU, HW, LLMW, and TRU Mixed waste removal, drainage, decontamination, and de-energizing duties. **HW tasks** are performed when personnel survey and monitor, repair, characterize, package, and transport HW, LLMW, and TRU Mixed wastes removed from the facilities. **CW tasks** are performed when personnel survey and monitor, repair, characterize, package, and transport LLRW and TRU wastes removed from the facilities. PPE and RPE are used as required by Radiological Work Permits.

Hazards associated with these activities include those radiological hazards listed in Table 10.4 C. Chemical hazards include lead, mercury and PCBs, but were reported as very low in concentrations.

Personnel performing activities achieving 100-N area deactivation are classified as past and present De, HW, and CW tasks performed by HIGH: >75 remediation workers. Deactivation was completed in 1998. The regulatory driver associated with these activities is CERCLA.

Table 10.4 C: Radioactive Inventories at 105-N as of 1997 [175]

Isotope	Radioactive Inventory (Ci)
H-3	6.40e+04
Ca-41	2.10e+01
C-14	9.55e+03
Co-60	5.37e+04
Ni-59	2.90e+01
Ni-63	3.98e+03
Cl-36	7.50e+01
Sr-90	1.43e+01
Zr-93	1.50e+01
Mo-93	2.60e-01
Nb-94	2.13e+00
Tc-99	3.30e-02
Ag-108	4.00e-02
Cs-137	4.00e+01
Eu-152	5.80e+01
Eu-154	2.90e+01
Pu-239	1.00e+00
Am-241	3.00e-01

Example 200 Area ER Activities

200 Area Remedial Action (Assessment and Remediation) and D&D Profile:

The 200 area located in the center of the Hanford site consists of approximately 700 waste sites located in and around the 200-E and 200-W areas. Soil contamination from liquid and solid wastes contain LLRW, LLMW, and HW (chemical) constituents from past spent fuel processing practices. Clean-up goals in the 200 E and 200 W areas will be typically achieved by isolating contaminated soils and with barriers. Waste will be transported to the Environmental Restoration Disposal Facility (ERDF) located just outside the 200 E and W areas, technically called the 600 Area. The ERDF will be presented in this section due to it's geographical location. (176)

200 Area facilities will be decontaminated, decommissioned, and demolished with wastes disposed of at the ERDF. The exceptions are the 200 area canyon facilities (B-Plant, T-Plant, U-Plant, PUREX, REDOX and Uranium Oxidation Plant), which will be demolished in place and covered with barriers. (167)

Activity 25: 233-S Decontamination and Decommissioning (177)

The 233-S Plutonium Concentration Facility, comprised of the 233-S Process Building and 233-SA Exhaust Filter Building, was operational from 1952 until 1967. Over time, the facility underwent severe degradation. D&D was therefore initiated in 1997.

The major areas of concern in preparing the 233-S Facility for removal are the process cell, the process pipe trench, and the load out and decontamination room. These areas contain the major portion of fissile material inventory (LLRW, TRU) and are severely contaminated. Other COCs in the facilities include asbestos, hexone, methylene chloride, neptunium, nitric acid, americium, plutonium, and ruthenium.

Personnel at the 233-S facility: 1) removed fissile material; 2) removed facility equipment and systems through cutting, grinding, welding, crimping and bagging; and 3) performed surface decontamination through the use of potable water, various types and sizes of scrub brushes, spill absorbent, grates, non-phosphate detergent, wipes/towels, and buckets/wash tubs. These activities are classified as past and present **De tasks.**

Personnel at the facility also: 1) conducted radiation surveys and analyses for characterization of facility waste; and 2) packaged, transported and disposed of the wastes. These activities are classified as past and present **HW and CW tasks**.

Personnel removed building structures by conventional demolition (heavy equipment) in 1999. The activity is classified as a present **Di task**.

The number of workers associated with 233-S Facility D&D are presented in Table 10.4 D. The associated regulatory driver is CERCLA.

Table 10.4 D: 233-S Environmental Restoration Contractor (BHI) Personnel and Job Functions [177]

Work Team		Job Function
Title	#	
RCT	4	Carry out RCT functions
Site Safety Officer (SSO)	1	Carry out SSO functions
Sampling Team Leader	1	Supervise sampling activities
Samplers	2 - 6	Perform sampling activities
Riggers	2	Erect scaffolding, rigging
Decontamination and Decommissioning (D&D)	6	D&D
Operators	1	Crane Operator
Supervisor	1	Supervise and direct work activities
Quality Services	1	Perform inspection and surveillance

Activity 26: LLMW, LLRW, and HW Disposal at the Environmental Restoration Disposal Facility (ERDF)

The ERDF, a RCRA-compliant landfill authorized under CERCLA located in the 600 area, is a multi-celled burial trench that is capable of receiving / disposing LLRW, LLMW, and HW. Only two cells were initially constructed, with plans to build up to four additional cells. Operations began in July of 1996.

Personnel transport waste from remediation areas to the ERDF in containers or dump trucks. When waste arrives (in the form of bulk soils and solid wastes), it is received, unloaded, and compacted (soils only) in an active cell in a fashion similar to commercial landfill operations. A system for placing loads into the cell is followed in order to control the drop and the speed of the drop, thereby minimizing dust potential. Sprays are used during the placement process to further minimize dust. Normal placement does not require respiratory protection, however, instrumentation and other surveillance procedures are in place to alert personnel of non-typical conditions.

COCs at the ERDF include a variety of radioisotopes and hazardous materials such as those radioisotopes listed in Table 10.4 E and solid wastes (pipes, scaffolding, wood, etc.) containing aluminum and lead. Lead cadmium rods are also contaminants of concern. The estimated total annual dose expected for all personnel involved in ERDF operations (activities such as container handling, spreading waste, cutting metal waste, and compaction) is 3,384 person-mrem.

Operations at the ERDF are classified as past, present, and future **HW tasks** performed by MED: 11-75 workers. [178] Operations at the ERDF will continue until all waste site and facilities requiring remediation are excavated, decommissioned, or capped using barriers. This is predicted beyond 2006. Expansion of the ERDF is currently underway. [37, 179, 180]

Table 10.4 E: Estimated ERDF Radionuclide Inventories as of January 1998 [180]

Radionuclide	Estimated ERDF Inventory When Filled to Capacity[a] (total Ci)
^{241}Am	2.28E+02
^{242m}Am	4.96E+02
^{243}Am	1.84E+01
^{14}C	2.91E+03
^{113m}Cd	1.45E+01
^{144}Ce	1.64E+02
^{243}Cm	1.30E+00
^{244}Cm	3.50E+02
^{58}Co	6.09E+03
^{60}Co	2.31E+03
^{134}Cs	1.80E+02
^{137}Cs	6.56E+03
^{152}Eu	1.35E+04
^{154}Eu	3.04E+03
^{155}Eu	2.63E+02
^{56}Fe[d]	1.78E+07
^{59}Fe	1.64E+02
^{3}H	5.37E+04
^{40}K	2.34E+04
^{54}Mn	8.79E+02
^{59}Ni	3.50E+06
^{63}Ni	1.61E+06
^{147}Pm	4.20E+03
^{238}Pu	4.23E+01
$^{239/240}Pu$	9.08E+02

Table 10.4 E (continued): Estimated ERDF Radionuclide Inventories as of January 1998 (180)

Radionuclide	Estimated ERDF Inventory When Filled to Capacity [a] (total Ci)
^{241}Pu	2.31E+05
^{242}Pu	9.34E-01
^{226}Ra	1.37E+03
^{228}Ra	3.96E+00
^{106}Ru	3.29E+01
^{125}Sb	2.80E+02
^{151}Sm	6.57E+02
^{126}Sn	1.66E-02
^{89}Sr	4.61E+01
^{90}Sr	3.90E+03
^{99}Tc	7.30E+03
^{228}Th	5.96E+02
^{232}Th	1.24E+01
^{232}U	1.21E-04
$^{233/234}U$	5.26E+03
^{235}U	7.30E+01
^{236}U	4.82E-01
^{238}U	6.58E+03
^{93}Zr	4.12E+04

a = The Total mass of waste, if the ERDF is filled to capacity, is (9.12E+06 m^3) (1600 kg/m^3) (1,000 g/kg) = 1.46E+13 g. It is emphasized that the estimate of total ERDF inventory when filled is extremely conservative because the worst-case concentrations for one waste site are multiplied by the total volume of the ERDF when filled to capacity. This grossly over estimates the total radiological inventory.

Example 300 Area ER Activities

300 Area Remedial Action (Assessment and Remediation) and D&D Profile:

The 300 area lies at the south end of the Hanford site, along the Columbia River and consists of approximately 100 waste sites. The liquid and solid wastes disposed of to the ground contain radiological and hazardous materials primarily from fuel fabrication and laboratory activities. Clean up will be achieved by excavation of soils and solid wastes, for disposal in the ERDF.

The 300 area facilities will be decontaminated, decommissioned, and demolished with wastes disposed of at the ERDF. Refer to the 100 area and 200 area sections for example soil excavation and D&D ER activities. (181, 167)

Groundwater Management

Activity 27: Groundwater Treatment (91, 37)

In terms of the groundwater management project, personnel at the Hanford site have: 1) installed and maintained (i.e. repaired and monitored) groundwater pump and treat systems; 2) operated five separate pump and treat systems across the 100 and 200 areas; 3) packaged, transported, and disposed contaminants such as chromium at the ERDF; 4) operated extraction units used to remove carbon tetrachloride, strontium, technetium, and uranium from underground plumes; 5) decommissioned 100 below grade wells across the site; and 6) drilled new production wells with special heavy equipment.

Installation, maintenance, decommissioning and operations activities associated with LLRW and TRU wastes are classified past, present and future **CW tasks** performed by MED: 11-75 workers. Installation, maintenance, operations, decommissioning, packaging, transportation, and disposal activities associated with LLMW, TRU mixed, and HW are classified as past, present, and future **HW tasks** performed by MED:11-75 workers. Activities began in approximately 1994 and will continue past 2006. The associated regulatory driver is CERCLA.

10.5 Hanford's Facility Stabilization (FS) Project

Hanford's Facility Stabilization (FS) Project is managed by Fluor Daniel Hanford (FDH) and FDH's sub-contractor B&W Hanford. Their responsibilities include stabilization and deactivation of Hanford aging nuclear materials processing facilities and the surveillance and maintenance (S&M) of deactivated facilities awaiting final disposition. Safe, stable, and secure onsite storage of nuclear materials awaiting disposition is also a primary objective of the FS project. [(119)] DynCorp Tri-Cites Services, another sub-contractor to FDH, provides infrastructure support services to the FS project.

The major FS projects at the site include the stabilization and deactivation of: 1) the **Plutonium / Uranium Extraction Plant (PUREX)**; 2) the **B-Plant**; 3) the **Plutonium Finishing Plant (PFP)**; and 4) selected 300 area facilities including **308, 324, and 327** Buildings..

The following FS activities provide examples of stabilization, deactivation and storage tasks. The PUREX plant deactivation process, completed in 1997, can be used as an example activity for other canyon facility deactivation tasks like B-Plant and PFP. B-Plant deactivation was completed in September 1998 which also involved the decoupling of the adjoining **Waste Encapsulation and Storage Facility (WESF)** whose systems relied on B-Plant for a number of years. [(119)] PFP stabilization began in December 1996 and is not expected to be completed until 2005 due to arising obstacles. In May 1997, a chemical storage tank exploded at the PFP and stopped all stabilization activities until the end of 1998.

Remediation Worker Facility Stabilization Activities

PUREX Plant Profile:

The 200 East area Plutonium / Uranium Extraction (PUREX) plant, Hanford's most advanced processing facility, operated from 1956 to 1972 and 1983 to 1988. A brief stabilization run was conducted from 1989 to 1990. [182] Full scale deactivation began in 1994 and ended in May of 1997. PUREX deactivation is currently used as a model for future deactivation projects.

Activity 28: PUREX Stabilization and Deactivation [137, 183]

Personnel at the PUREX plant performed the following activities in order to achieve facility deactivation and stabilization: 1) the removal (bagout) of uranium-contaminated nitric acid and other process solutions from PUREX systems; 2) flushing organic solutions from process systems; 3) loading cold chemicals, organics, plutonium / uranium bearing liquids, uranium-contaminated nitric acid into tankers and other transport systems for storage or disposal; 4) cleaning, structural decontamination, and removal of contaminated equipment (LLRW), piping, and inner structures, and 5) consolidation, reduction, and elimination of HVAC systems, monitoring equipment, process systems, tanks, electrical, and fire systems. [12]

Removal, flushing, reduction/elimination and cleaning/decontamination of structures containing LLRW, TRU, HW, LLMW, and TRU Mixed are classified as past **De tasks** performed by HIGH: >75 workers at PUREX. Packaging and transport of LLRW, and TRU wastes are classified as past **CW tasks** performed by HIGH: >75 workers [184] at the PUREX plant. Packaging and transport of HW, LLMW, and TRU Mixed wastes are classified as past **HW tasks** performed by performed by HIGH: >75 [184] workers at the PUREX plant.

Hazards associated with deactivation include those contaminants mentioned above. Radiological contaminants include plutonium and uranium. PPE and RPE is used according to radiological work permits and DOE orders.

The regulatory drivers associated with PUREX stabilization and deactivation include CERCLA and the TPA.

Activity 29: PUREX Surveillance and Monitoring

S&M of the PUREX plant includes the surveillance and monitoring of the 202-A Building (PUREX Facility Building), ancillary buildings, and their associated equipment within the PUREX perimeter fence. Personnel at the PUREX plant will: 1) operate the surveillance, monitoring, and control system for routine monitoring (a SAMCONS I&C skid unit); 2) conduct environmental monitoring such as continuous stack particulate sampling and iodine sampling; 3) conduct quarterly internal and external surveillances which involve checking for indications of structural defects, roof deterioration, posting deficiencies, contamination migration, suspect hazardous materials, hazardous conditions, unlabeled containers, unidentified friable asbestos, failed lights, and water, animal or insect intrusion, and 4) conduct routine radiological S&M (posting, access control, work place air monitoring, and radiological surveys as directed by the radiation work permit (RWP.)

Hazards to S&M personnel at the PUREX facility include primarily radiological hazards. Other COCs include lead, mercury, silver, silver salts, chromium, and cadmium located in the PUREX storage tunnels. (185) The storage tunnels and containment building house the only HW left in the facility. Hazards associated with these materials are minimal due to their remote locations and existing form. (186)

S&M of 202-A building and ancillary facilities except the containment building and storage tunnels is classified as a past, present, and future **CW task** conducted by HIGH: >75 workers (184) at the PUREX. S&M of the containment building and storage tunnels containing HW is classified as a past, present, and future **HW task** conducted by HIGH: >75 workers (184).

S&M tasks began prior to PUREX deactivation, approximately in 1992. S&M will continue beyond 2006. Regulatory driver associated with the activity include CERCLA and RCRA.

Activity 30: Surveillance and Maintenance of Radioactive Strontium and Cesium at the Waste Encapsulation and Storage Facility (WESF) (119, 15, 187)

The WESF stores 1,929 capsules of highly-radioactive strontium and cesium removed from Hanford's HLW underground storage tanks and from B-Plant. Personnel survey and maintain the HLW capsules that are stored in large pools of water. Nuclear process operators perform similar duties to those described in Activity 9. Workers will stand on a grating and use handling tools such as canister hooks and tongs to move and maintain the underwater capsules. Personnel will also perform corrective, preventative, process system and equipment calibrations and modification maintenance measures as well as performing pool decontamination and containment if the capsules were to leak.

These tasks are classified as past, present, and future **CW tasks** performed by MED: 11-75 workers at the WESF. WESF HLW storage began in approximately 1996 and is expected to continue to 2020. WESF will eventually become upgraded into a model nuclear materials storage facility until the material can be prepared for disposal. Regulatory drivers associated with this activity include CERCLA, RCRA, and the TPA.

308 Fuels Development Laboratory (FDL) Building Profile:

The 308 FDL, formerly called the Plutonium Fabrication Pilot Plant located in the 300 Area, opened in 1960 in support of fuels development technology and fabrication. The pilot plant supported facilities including N-Reactor in the 100-N Area and the Fast Flux Test Facility in the 400 Area. The 308 FDL was deactivated in 1994 to a minimum maintenance mode.

Activity 31: 308 Fuels Development Laboratory Building Deactivation [188: P.1, 189: P. 2, 190]

Personnel at the 308 FDL 1) cleaned and removed LLRW, contaminated equipment, and special nuclear material (SNM), and TRU wastes 2) decontaminated structures, 3) performed asbestos abatement, and 4) disposed LLMW and HW generated by deactivation and decommissioning operations. Specifically personnel removed the plutonium inventory, cleaned out and stabilized plutonium oxide and enriched uranium oxide (UO_2) residues and powders in equipment and duct work and wiped, sprayed, and sealed fifty glove boxes and six open-faced laboratory hoods. The glove box decontamination process included: 1) stabilization of alpha contamination in glove boxes where mixed oxide (MOX) powders and pellets (*mixed-oxide fuel is a bend of plutonium and uranium oxides that is used as a fuel for nuclear power plants* [252]) were once pressed and sintered into reactor fuel during fuel fabrication; 2) wipe-down of inner surfaces using damp rags that were later dried and disposed as solid waste; 3) spraying boxes with modified acrylic latex; 4) covering glove ports with specially fitted metal plates and polyolefin; 5) placing 'shrink-wrap' material containing tar-like adhesives on plates and ports, and 6) activating the adhesive so that crevices could be sealed.

All deactivation and decommissioning activities are classified as past **De tasks** performed by MED: 11-75 workers except those removal activities involving SNM. SNM removal is classified as a **CW task**. Disposal of LLMW and HW (such as standard laboratory chemicals including acids, neutralizers, cleansers, and reagents) is classified as a past **HW task** performed by LOW: <11 workers. The regulatory driver associated with these tasks is CERCLA.

324 and 327 Facility Profiles:

The 324 Facility formerly called the Waste Technology Engineering Laboratory is located in the Hanford 300 Area and contains 'B Cell' which currently houses approximately three million curies of cesium and other isotopes. Deactivation processes began in 1996.

The 327 Facility originally called the Radiometallurgy Building is currently known as the Post-irradiation Testing Laboratory (PTL) located in the 300 Area of the Hanford site. PTL houses eleven high density metal shielded hot cells, two concrete unlined water filled storage basins (interconnected), and a dry storage cell. Deactivation is also simultaneously being conducted at the 327 hot cells. Deactivation activities are expected to be completed by the end of 2000. Facility transfer to the ER project is scheduled in 2005. [191, 192]

Activity 32: 324/327 Facility Safe Shutdown [60, 193]

From 1989 to 1995, the Pacific Northwest National Laboratory (PNNL) operated by Battelle Memorial Institute owned and operated the 324 and 327 Facilities. Safe shut down activities were conducted by PNNL workers during this time period. Descriptive D&D tasks were unavailable for this report. PNNL workers are presented in Table 10.5 A. In 1996 this workforce left PNNL and joined the FDH/B&W team in support of further deactivation tasks.

The 324/327 safe shutdown activity is classified as a past **De task** performed by MED: 11-75 PNNL workers. COCs in the facilities include LLRW and TRU wastes including cesium, spent nuclear fuel (SNF), and radiological metallurgical samples. The associated regulatory driver is CERCLA.

Table 10.5 A: Number of PNNL/Battelle Workers Involved in Safe Shut Activities in the 324 and 327 Facilities* [60, 193]

Year	Number of Technicians**	Number of Radiological Control Techs	Total Number of Remediation Workers
1989	25	7	32
1990	25	8	33
1991	25	11	36
1992	28	11	39
1993	28	11	39
1994	33	13	46
1995	33	14	47

* In 1996 the PNNL Remediation workforce was transferred to FDH/B&W due to facility transfer of 324 and 327.
** The technicians were not covered under a collective bargaining agreement while employed by Battelle. RCTs were represented by the HAMTC.

Activity 33: 324/327 Facility Deactivation [192]

Deactivation of the 324 and 327 facilities involves hot cell (A, B, C, D) clean out and the removal of legacy waste which includes HLW (cesium), SNF, LLRW contaminated equipment, 'German Logs' from the B cell which are identified as vitrified high heat sources (HLW) made available for the Federal Republic of Germany during the 1980's, and radiological metallurgical samples from the 327 facility.

Personnel at both facilities will: 1) perform preventative maintenance, repair and calibration of failed, malfunctioning, and stable equipment; 2) perform surveys of safety systems and equipment; and 3) monitor nuclear material storage areas. These tasks are classified as past, present, and future **CW tasks** performed by HIGH: >75. [194]

Personnel at hot cell facilities will: 1) operate remote equipment such as the plasma-arc cutting tool; 2) remotely remove one-gallon buckets of cell waste; 3) store and prepare for the removal of 350 legacy fuel storage containers of cesium-137 capsules, pellets, and powder; 4) package cesium powder and pellets in Type-W over-packs; and 5) ship over-packs to the WESF for storage. These tasks are classified as past, present, and future **CW tasks** performed by HIGH: >75. [194, 119, 191, 183] The regulatory drivers associated with these activities are CERCLA and the TPA.

10.6 Miscellaneous 400 Area Remediation Activities

Fast Flux Test Facility (FFTF) Profile:

The Fast Flux Test Facility (FFTF), located in the 400 area, is a 400 megawatt (thermal) sodium-cooled, fast flux test reactor designed to test fuels and materials for advanced nuclear power plants. Operation began in 1982 and ended in April 1992. In 1993, the DOE ordered FFTF be placed in safe shutdown mode. The FFTF is currently managed as a separate DOE and joint FDH and PNNL standby surveillance and maintenance project and sub-contracted to B&W Hanford. The future role of FFTF is undecided. [15, 195]

Activity 34: Fast Flux Test Facility (FFTF) Shutdown

Completed shutdown activities include reactor de-fueling, washing irradiated fuel assemblies (HLW) and placing them in interim dry storage, and shutting down auxiliary plant systems. In 1995, personnel performed **De tasks** at the FFTF through de-fueling. Personnel at the FFTF also performed **CW tasks** through packaging within Bottom-Loading Transfer Casks and transport activities. These process were conducted in closed loop systems and operated from control room areas.

During transition to shutdown mode at FFTF, all assemblies were under 1.5 kW decay heat generation rate. Due to the decay period (250 days), the available radionuclide inventory in the fuel assemblies was reduced. Kr^{85} was then the only noble gas of concern. For failure events, 99% of the dose would come from cesium and 1% from tellurium.

These De and CW tasks are classified as past activities performed by MED: 11-75 workers. Future activities will include the construction of a sodium storage facility near the FFTF and eventually removing sodium coolant. The regulatory drivers are CERCLA and TPA.

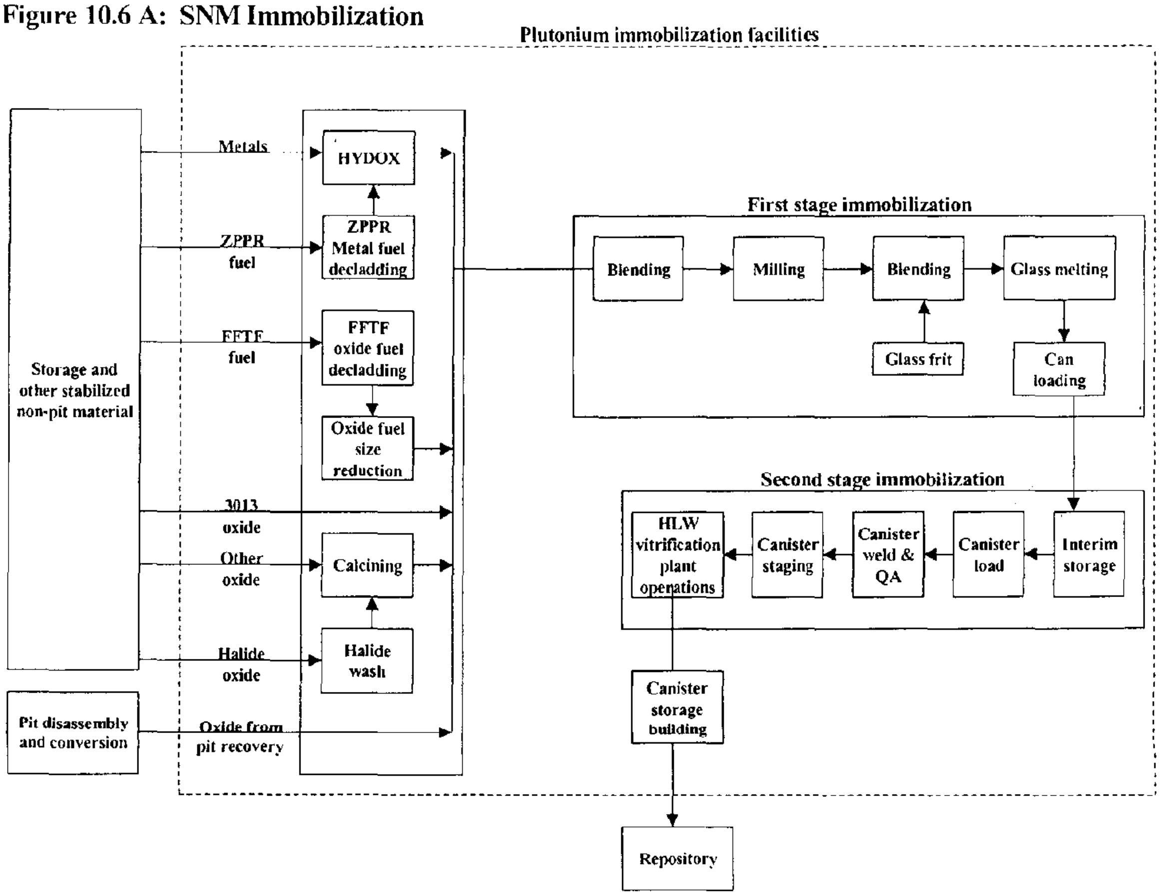
Activity 35: Plutonium Immobilization Plant (PIP): SNM Treatment [196]

The Plutonium Immobilization Plant (PIP) plans to accept plutonium feed (SNM, pit and non-pit material) in the form of clean oxides, impure metal, plutonium alloys, impure oxides, uranium / plutonium oxides, alloy reactor fuel, and oxide reactor fuel and, through a glass immobilization process, convert the plutonium into a immobilized form that can be disposed of in a HLW repository. The PIP is currently in design mode and plans to use existing and future Hanford facilities such as the Fuels and Materials Examination Facility (FMEF) and BNFL's future HLW vitrification plant for the process. The treatment process is presented in Figure 10.6 A: SNM Immobilization. Operation and management has not yet been determined.

Future personnel at the PIP will: 1) operate a shipping and receiving area; 2) manage incoming and out going material; 3) operate closed loop plutonium conversion processes; 4) operate glass processing systems; and 5) load canisters. Waste types associated with the PIP include SNM, HLW, TRU, LLRW and HW.

Treatment, storage and disposal of SNM and HLW is classified as a future **CW task** performed by an unknown number of workers. Treatment, storage and disposal of LLRW, TRU and HW is classified as a future **HW task** performed by an unknown number of workers. Construction is planned to begin in 2000 and end in 2004 and the operations phase is expected to begin in the year 2004. Regulatory drivers associated with the PIP include CERCLA and the TPA.

Figure 10.6 A: SNM Immobilization



11.0 Identification of Past, Present, and Future Remediation Worker Task Technologies at the Hanford Site

11.1 Introduction

Technology Management at Hanford is an integral part of the PHMC. Technology Management works to improve the technical site-wide baseline with players involved in project direction, sub-contractor operations, PNNL, Site Planning and Integration, and the Hanford Site Technology Coordination Group (STCG). Hanford's technology management division provides identification, acquisition, and dissemination of applications. [197] Technologies are generated from both private and public sectors and include primary and priority focus on the 177 tanks in the 200 East/West Areas, C Reactor in the 100-C Area, and the K-Basins (SNF) in the 100-K Area.

Selected Hanford technologies in this section and Table 13.3: Past, Present and Future Remediation Worker Technologies at the Hanford Site on pages 247 through 257 are grouped according to Remediation worker task (i.e. CW, HW, De and Di task). Thirty-three technologies were selected according to one or more of the following: **1)** the technology indicated potential hazards to the remediation worker, **2)** the technology was highly publicized at the site, or **3)** the technology provided insight to remediation worker activities. Each technology is: **1)** described according to Hanford site technology needs, current practices and technical description, **2)** categorized according to the number of workers using the technology related to a given task (i.e.: LOW:<11, MED: 11-75, HIGH: >75), and **3)** described as either deployed/past/present (already approved and routinely used at the site) or demonstrated/proposed (approved for testing purposes but not yet approved for routine use). The advantages and disadvantages of each technology are also described with emphasis on the benefits and hazards to site workers utilizing the technology.

A comprehensive list of Hanford technologies is presented in Exhibit 12.11: Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Site by Listed Technical Information Source as of July 1999 on pages 220 to 228. The technologies in this Exhibit and Table 13.3 were selected from the following sources: **1)** the Focus Area Technology Summaries collectively called the Rainbow Series [198, 199, 200, 201, 202, 203], **2)** an ERC web-site focusing on C Reactor Technologies [204], **3)** the Hanford Technology Management web-site [197, 205, 206, 207], **4)** a TWRS web-site focusing on baseline [208] and Leak Detection, Monitoring, and Mitigation (LDMM) Technologies [209], **5)** the Office of Science and Technology (OST) web-site [210], and 6) the on-line Tank Focus Area Technology List [211].

11.2 Hanford's Tank Waste Remediation System (TWRS) (201: Pp. 97-101)

Hanford's TWRS under the responsibility of Lockheed Martin Hanford, Inc. is looking to prepare one or more SSTs for closure by bringing innovative technology and processes to the site. In situ characterization technologies and technologies needed for retrieval of waste from potentially leaking tanks are high priorities for this full-scale demonstration activity. Currently, numerous TWRS technologies have been deployed and/or demonstrated at the 200 E/W tank farms. Some technologies are described in detail in the CW Task Technologies section of this document.

11.2.1 Tank Safety Issues (201: Pp. 97-98)

Tank safety issues include flammable gas generation into the dome spaces of the tanks. Demonstration mixer pumps have been installed in some of the tanks and have reduced hazards. Work is now focused on modeling and designing similar mitigation systems for other tanks. For example, the Water Jet Cutting of Saltwell Casing (See Technology 1) was recently deployed.

Ferrocyanides and organics also pose significant safety issues. Ferrocyanide residues left in tank waste pose a risk of exothermic chemical reactions if the wastes are allowed to dry out and spontaneously generate heat. Previous work in this area has indicated that it is likely much of the ferrocyanide has been chemically broken down and no longer poses a threat. Work is planned to conduct aging studies to determine whether ferrocyanide degradation is a true concern.

The organic safety issue results from organic complexants and organic degradation products of solvents that have been added to the SST's as a result of Hanford operations. (201) Exothermic chemical reactions could occur if there is an adequate concentration of fuel and oxidizer in the waste, (sodium nitrate/nitrite may be present in SST's to exothermically oxidize organic compounds) and if the waste is partially dried and heated to approximately 180 degrees C. The use of the Light Duty Utility Arm (LDUA) (See Technology 6 in CW Task Technologies Section) with a moisture detection end effector has been utilized to determine whether in situ conditions in a tank are safe.

11.2.2 Tank Waste Characterization (201: Pp. 98-99)

In 1995, the Advanced Hot Cell Analytical Technology (AHCAT) was deployed for rapid characterization of tank waste core samples. Many technologies were developed simultaneously in order to deploy AHCAT. They included: techniques in scanning analysis, laser ablation mass spectroscopy, raman probe (See Technology 2 in CW Task Technologies Section), near infrared (NIR) spectroscopy, thermogravimetric off gas analysis, organic complexant analysis, and inductively coupled plasma/mass spectroscopy. Other technologies are under development for in situ use.

11.2.3 Tank Waste Pretreatment (201: P. 99)

Tank waste pretreatment technologies include sludge washing of HLW sludges (See Technology 9 on page 152), technetium removal from supernatant waste (supernatant waste is the liquid waste standing above the salt cake or precipitate), and solid / liquid separation (settle / decant). LAW is separated from HLW as a result of these pretreatment technologies.

11.2.4 Tank Waste Retrieval, Transfer, and Closure

The function of waste retrieval and transfer technologies is to remove the waste from the tank and transfer the waste to a treatment facility. (208: P. 2) Fluor Daniel Hanford, Inc. assumes responsibility for the retrieval and closure phases of the TWRS due to technical and regulatory requirements. Therefore, other contractors besides Lockheed Martin Hanford, Inc. may have a larger role in these phases of TWRS. System demonstrations such as the Vehicle-Based Waste Retrieval System (ARD, Inc.) (Technology 5 on page 151) have been conducted in response to the retrieval effort.

The primary method for transfer of retrieved waste is through a pipeline, however, alternatives have been proposed including containerization and truck transfer. These alternatives would likely increase radiological exposure and truck usage.

11.2.5 Tank Waste Treatment and Immobilization (208: Pp. 5-12)

Immobilization initiatives include those technologies demonstrated or deployed in the effort to treat LLW / LAW and HLW in large quantities. The following ex situ waste treatment technologies have been considered possible routes: **1)** Ceramic Waste Forms (Technology 11), **2)** Vitrification, **3)** Calcination (Technology 15), **4)** Alternate Glass Compositions (such as Borosilicate glass which contains silicon dioxide, boron trioxide, sodium oxide, and lithium oxide), **5)** Separation Technologies, **6)** Off-Gas Treatment Technologies for Radionuclides, and **7)** Grouting (solidification) of Retrieved Tank Waste. In July of 1998 BNFL, Inc. became responsible for tank waste treatment at the site. (30) A facility will be completed by February 2007 for on-site treatment of HLW and LAW. (Refer to Section 10.3 on page 106 for a detailed view of the TWRS project and BNFL's role in HLW treatment and disposal).

11.3 C Reactor Interim Safe Storage Project (Large Scale D&D Demonstration)

The C Reactor Interim Safe Storage project managed by Bechtel Hanford, Inc. involves placing a 46-year-old reactor in an interim safe-storage mode. When this work is completed, the C Reactor will be the first production reactor in the DOE complex to be placed in safe storage in a significantly smaller, safer facility, shielding the reactor's core from the environment for up to 75 years, or until final disposition.

C Reactor is providing a stage for showcasing innovative D&D technologies. At least 20 technologies and approaches will be field tested to demonstrate safer, less expensive, and more efficient ways of decommissioning aging nuclear facilities. In FY97, 11 of these innovative technologies were demonstrated, of which eight have since been adopted, replacing baseline technologies. Four of these technologies have been deployed at other Hanford Site projects and DOE complex facilities.[118]

11.4 Spent Nuclear Fuel Project Technologies

The SNF project managed by DE&S (Duke Engineering & Services, Inc.) (See Section 10.2 on page 99 for a detailed description of specific activities) encompasses 15,471 fuel assemblies in 19 open spent-fuel pools and 1,163 assemblies in dry storage [29]. Removing this highly radioactive fuel from the K-Basins (which contain 80% of DOE's inventory of SNF) is one of the highest clean-up priorities at the Hanford site. The Canister Storage Building (CSB) is currently being constructed near the 200 East Area to store the fuel in safe dry conditions [11: P. 10].

11.5 CW Task Technologies

Technology 1: Water Jet Cutting of Saltwell Casing (212)

As mentioned in Section 11.2.1: Tank Safety Issues on page 146, flammable gas in Hanford tanks is a safety concern. Presently, liquid wastes are pumped from the tanks. This process requires a flow path to allow accumulated gases to escape from the saltwell casing into the dome space of the tank. The high-pressure abrasive Water Jet system, a HLW / Mixed Waste maintenance technology, provides a method for cutting away the saltwell casing in the tanks to provide an escape path for accumulated flammable gases. The number of workers using this technology falls within the MED: 11-75 range. (213) Refer to Table 10.3 B on page 109 for a detailed look at the tank farm work force.

Advantages in terms of worker exposure include: **1)** safe operation within the tank through a remote gear and drive system, **2)** minimized risk and exposure to contamination, **3)** effective cutting of the opening in the steel casing, and **4)** compliance with safety assessments. No disadvantages in terms of worker exposure were reported for this technology.

This technology was deployed in May of 1997 within Tank A-101 in the 200 Area.

Technology 2: Cone Penetrometer Raman Spectroscopy (201: Pp. 24-27, 214, 215)

A gross gamma detector has historically been the primary monitoring instrument used to indicate waste location and potential migration of leaks, but offers limited capability to locate waste plumes between or at the bottom of existing wells. An alternative to this method is Cone Penetrometer Raman Spectroscopy, a Mixed Waste (MW) maintenance / characterization technology.

Raman spectroscopy is an advanced optical method to detect and identify chemical compounds and the cone penetrometer provides a path for tank waste characterization. The combination provides an in situ method for soil analysis and has the capability to reach depths below existing drywells. The number of workers needed to this technology falls within the MED: 11-75 range.(213)

Advantages of this technology include: **1)** lower cost in monitoring activities, **2)** time savings for locating and identifying contaminants, **3)** reduced risk of contaminant exposure to workers or equipment, and **4)** minimal secondary waste from borehole logging (an older technology) for disposal. As a disadvantage, Level D PPE must be used with this technology.

The Raman Spectroscopy technology was tested at the 222-S Laboratory in 200 W Area starting in June 1997 and ending August 1997. The cone penetrometer has been used since the early 1990's. Cone Penetrometer Raman Spectroscopy was deployed in FY 1998.

Technology 3: Annulus Inspection Ultrasonic Crawler Robot [216]

Currently, tank corrosion in Hanford's DSTs is controlled primarily by maintaining the waste at a high pH, generally pH>12, which is well above the acidic corrosive range that attacks carbon steel. Steel coupons inserted into the tanks to determine effects of corrosion provide limited data. As an alternative technology, the Annulus Inspection Ultrasonic Crawler Robot, a HLW / Mixed Waste maintenance technology, provides the capability to examine the integrity of Hanford's DSTs using an ultrasonic sensor. The number of workers needed to operate this technology falls within the LOW: <11 range.

Advantages in the use of this technology include: **1)** critical data for monitoring corrosion and ensuring tank wall integrity, **2)** support for a periodic maintenance and measurement program, and **3)** elimination of current practices that involve excessive chemical additions for pH control. Disadvantages include: **1)** cost, **2)** the water line could freeze, and **3)** the path of the robot is limited to certain areas of the tank.

In November 1996, the robot crawler was successfully demonstrated in DST 241-AW-103. It was then deployed in FY 1998.[206]

Technology 4: The Sluicer [217: P. 4, 154]

The sluicer, a past/present HLW / Mixed Waste retrieval and treatment technology, is the baseline device used since the early 1990's in the Hanford SSTs. Refer to Activity 15 in Section 10.3 on page 111 for a description of the sluicing activity. The sluicing process uses a high flow rate jet of water introduced through a nozzle (Hanford nozzle) [218] that is aimed to break up and suspend moist, solid waste such as sludge or wet salt cake. The tool has now been upgraded (i.e. Enhanced Sluicer) and used in conjunction with other technologies including the Light Duty Utility Arm (LDUA), various crawler robots, and the Extended Reach End Effector (EREE) in efforts for tank waste retrieval and breakage of the hard heels. The number of workers associated with this technology falls within the MED: 11-75 range.[213]

No advantages were reported for this technology, however, this baseline technology is effective in that worker exposure potential is decreased due to the fact that the worker is not directly breaking up the salt cake. Disadvantages include: **1)** high usage of water created and the potential for sluicing water and suspended tank waste to leak to the soil, **2)** ineffective means for dislodging the tank hard heel, and **3)** slow process time.

Technology 5: Vehicle-Based Waste Retrieval System (from ARD, Inc.) [219]

Hanford needs to remove 99% of SST waste (HLW / Mixed Waste) including dislodging hard heels or sludge cakes. The baseline current approach in achieving this goal is referred to as past-practice sluicing (See Technology 4). The stand alone sluicer has since been proven to be an ineffective means in breaking the tank hard heels.

The ARD Environmental, Inc. robot crawler, a proposed HLW / Mixed Waste retrieval technology, (there are also other versions of this technology available by other companies) is a remotely deployed vehicle for effectively removing waste from tanks with a high-pressure cleaning and solution removal device (i.e. the sluicer). The number of workers needed to operate this technology falls within the MED: 11-75 range.[213]

The combination of the two technologies include the following advantages: **1)** reduces quantities of water, **2)** minimizes potential for leaking of cleaning-process solutions, **3)** provides flexibility for moving the sluicing function to positions on the tank floor, and **4)** gives higher force than sluicing by locating the cleaning tool (sluicer) directly on the hard heel. Disadvantages include: **1)** cost, and **2)** slow to dislodge harder simulants due to the low pressure of the water system in the demonstration.

The demonstration for this technology was off-site on May 2, 1997. In August of 1997, the ARD robot was proposed to be used in tank 106-C in the 200 Area, but no documentation was found on the results of this demonstration or date of deployment.

Technology 6: Magnetometer [220]

Currently, tank bottom location involves manually calculating the distance recorded on controlled construction as-built drawings. As a part of the tank waste characterization project, the waste depth needs to be assured. The magnetometer, a proposed HLW maintenance technology, provides an improved waste depth estimating method. It is placed manually into the tank where a sensor operates on the principle of a magnetic field. The number of workers associated with this technology falls within the MED: 11-75 range.[213]

Advantages associated with the magnetometer include: **1)** the ability to accurately measure depth of shallow tank waste, **2)** provides a reliable method to assist with locating the bottom of a waste storage tank, and **3)** provides enhanced safety and effectiveness of related tank programs. Disadvantages include possible exposure or contact to HLW / Mixed Waste (i.e. the magnetometer is manually lifted out of the tank, read at ground level, and rinsed with water) and possible exposure to magnetic fields, however no supporting documentation was found on either of these assumptions.

A demonstration was conducted in SST, AX-104, in the Fall of 1997. Based upon the demonstration, it was planned to be used in conjunction with the Light Duty Utility Arm (LDUA) in FY 1998, however, FY 1998 projects revealed that this did not happen.[206, 207]

Technology 7: Light Duty Utility Arm (LDUA) [201; Pp. 34-37]

The Light Duty Utility Arm, a proposed HLW / Mixed Waste characterization and pre-retrieval technology, is a mobile manipulator system that can deploy a variety of end effectors and tools (i.e. sluicer) weighing up to 75 pounds to perform operations ranging from characterization and inspection to retrieval operations. The tools and sensors can be deployed off-axis from the tank-access riser and uses existing penetrations in tank domes. The number of operators needed to use this technology falls within the MED: 11-75 range.[213]

Advantages of the LDUA include: **1)** improved tank inspection, **2)** improved waste sample collection, **3)** reduced contamination and worker exposure, and **4)** improved quality and quantity of data. No disadvantages in terms of worker exposure were reported.

The LDUA and Extended Reach End Effector (EREE, Technology 8) were scheduled for deployment in Tank AX-104 in FY 1998, however, FY 1998 deployments and demonstrations revealed that this did not happen.[206, 207] Operators were scheduled to receive training in early FY 1998.

Technology 8: Extended Reach End Effector (EREE) [221, 217]

Currently, access to the inside areas of the tanks is limited to available risers that are not obstructed with installed instruments or equipment. Collection of waste samples is therefore limited to areas directly under available risers. The Extended Reach End Effector (EREE), a proposed HLW / Mixed Waste characterization and pre-retrieval technology, can remedy this problem. Using the system, operators can reach into underground waste-storage tanks to collect samples and perform in-tank operations. The number of operators needed for this technology falls within the MED: 11-75 range.[213]

Advantages for this technology include: **1)** improved tank inspection, **2)** improved waste sample collection, **3)** reduced contamination and worker exposure, **4)** improved quality and quantity of data, and **5)** approved for use in flammable gas tanks. No disadvantages in terms of worker exposure were noted.

Both the EREE and LDUA technologies were currently scheduled for deployment in Tank AX-104 in FY 1998, however, FY 1998 deployments and demonstrations revealed that this did not occur.[206, 207] Operators will receive special training for this technology and practice sample-retrieval operations in a non-radioactive environment at the Hanford Tanks Technology Test Facility.

Technology 9: Enhanced Sludge Washing (ESW) (201: Pp. 49-52, 222)

The proposed baseline method for pre-treating tank waste (HLW/ Mixed Waste) is Enhanced Sludge Washing (ESW), also known as caustic leaching. ESW is the combination of caustic leaching, chromium oxidation and water washing of sludge. ESW removes non-radioactive components from the sludge so that the solid phase is left for the HLW treatment process. The number of workers associated with this technology falls within the MED: 11-75 range.(213)

Advantages associated with technology include **1)** does not increase HLW volume due to preparation of HLW for treatment and disposal, **2)** significant cost and risk reduction, and **3)** fills the current technology gap. No disadvantages were reported for this technology in terms of worker exposure, however packaging and disposing of chemical wastes may increase the risk of exposure to the hazardous waste (HW) task worker.

This technology is proposed and to be deployed in FY 2004. Currently, testing has been completed on approximately half of the 49 different samples of sludge at the site.

Technology 10: Leak Detection Pits (217: P. 3)

Leak Detection Pits, a current HLW / Mixed Waste maintenance and treatment technology, are designed to collect leakage that occurs and migrates along channels in the concrete foundation of the tanks. Radiation detectors, level monitors, and specific gravity instruments are located in the bottom of each pit. The number of workers associated with this technology falls within the MED: 11-75 range.(213)

Advantages with this technology include: **1)** early leak detection. Disadvantages include: **1)** limited number of pits available for utilization, and **2)** possible exposure to HLW, however no documentation was found to support this assumption.

Currently, four double shell tanks (DSTs) in the AX tank farm are equipped with pits. No documentation was recovered explaining whether more pits will be created in the remaining 173 underground storage tanks (USTs) at the site.

Technology 11: Ceramic Waste Forms (208: P.7)

Ceramification is a proposed HLW / LAW Treatment Technology. Ceramics are achieved by high-temperature treatment after the retrieval, separation, and pre-treatment of tank waste. Ceramics will immobilize HLW and LAW by using nepheline, monazite, and corundum. Ceramics are stable, durable, and considered very leach resistant. The number of workers associated with this technology falls within the MED: 11-75 range.

Advantages associated with this technology include: **1)** alternative to vitrification (disadvantages between the two processes are relatively the same), **2)** yields similar volumes compared to vitrification, **3)** treats both HLW and LAW. Disadvantages include: **1)** requires the following facilities: retrieval and transfer systems, separations facilities, waste processing facilities, interim storage facilities for HLW and disposal facilities for LAW, and **2)** the potential exposure for Plutonium High Fired Oxide (PHFO) is increased due to the use of high temperature in this technology, however no documentation was obtained to verify this assumption..

Technology 12: Cold Vacuum Drying Process (223)

Spent fuel has historically been removed in railroad cars designed to accommodate radiation and heat. The cars were loaded in the 100 areas and unloaded in the railroad tunnel of PUREX, where fuel was placed into the PUREX canyon for processing. Drying was not required prior the shipment.

The cold vacuum drying process, a proposed SNF treatment and transport technology, removes water from multi-canister over packs (MCO's). The process consists of heating the MCO, draining the bulk water, vacuum drying residual water, heated recycle drying, and final verification of water removal. The number of workers associated with this technology falls within the MED: 11-75 range.

Advantages associated with this technology in terms of worker exposure and the environment include: **1)** safe limits of pressurization in the MCO during shipment, **2)** safe shipment of fuel for the spent nuclear fuel program, and **3)** reduces water usage. Disadvantages include: **1)** early demonstration tests have revealed both equipment and design problems (specifics were not documented), and **2)** there is the possibility of worker exposure to LLRW and TRU waste types from MCO waste water. Please see Tables 10.2 C and Tables 10.2 D on page 105 for contaminants of concern relating to MCOs.

A one-fifth scale pilot test was conducted from May 1996 through February 1997. Final demonstration tests have improved and the cold vacuum drying process is expected to enter service in the summer of 1999.

Technology 13: Spent Fuel Sorter with Conan Manipulator Arm [224]

The current approach for sorting fuel in the bottom of the K-Basins is for an operator to stand on a grating over a pool and use tools with long handle extensions to reach down through the water to grapple the fuel elements in canisters on the pool floor. Operators receive a radiation dose of 3 to 6 mrems per hour above the K-East basin and less than 1 mrem per hour above K-West basin.

A manipulator, a proposed SNF treatment technology, attached to an underwater sorting table in the K-Basins provides capabilities for separating inner and outer fuel elements for inspection and cleaning. Operations of the manipulators will be controlled from a remote center located away from the basin. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages in terms of worker exposure include: **1)** increased safety and reduced radiation exposures, **2)** improved visibility, **3)** improved quality of inspection, and **4)** lower cost through reduced reworking. Disadvantages include: **1)** limitations in the initial design were revealed during the demonstration (i.e. the 'claws' were not effective in removing certain pieces, therefore, new manipulator attachments needed to be used to conduct fuel-loading tasks), and **2)** identification of fuel loading ergonomic problems. Design changes, such as a lazy-susan design for fuel baskets, corrected ergonomic problems and enhanced productivity.

This demonstration was conducted in FY 1996, ended in FY 1997, and was transferred into an operator training facility. A proposed deployment date has not been determined.

Technology 14: Spent Fuel (Primary) Cleaning Machine [225]

Removing sludge from fuel elements is currently performed by operations similar to the current approach for sorting spent fuel. Operator radiation exposure is also a concern with current processes.

The Primary Cleaning Machine, a proposed SNF treatment technology, is designed to effectively clean the fuel rapidly and remotely without allowing dispersion of suspended solids. The underwater fuel-cleaning machine with water jets offers thorough removal of sand and sludge from the fuel elements. The solids are then filtered from the water before it is returned to the basin. The number of operators associated with this technology falls within the MED: 11-75 range.[213]

Advantages of this technology include: **1)** reduced radiation exposure to workers, **2)** reduced use of water, **3)** effective removal of sludge and particles not visible with manual methods, **4)** greater reliability from automatic washing action, **5)** enhanced process to dry the fuel, and **6)** improved final safety of eventual storage conditions. No disadvantages associated with this technology were reported.

The first spent fuel primary cleaning machine was expected to be delivered in November of 1997. No documentation was found as to whether this technology was successfully demonstrated at the site. Following acceptance testing, the unit will be used for operator training.

11.6 HW Task Technologies

Technology 15: Calcination (208: Pp. 8-9)

Calcination is the process of removing water and heating waste to a temperature sufficiently elevated to decompose some of chemical compounds such as hydroxides or nitrates. Calcination is an alternative to vitrification, but differs because calcination temperatures will not cause the reacting materials to melt and form a glass. The calciner is a device that heats the feed material to a calcination temperature of 700 degrees C where the chemical and organic destruction occurs and outputs a solid waste product. The number of workers involved in this technology falls within the MED: 11-75 range.

Advantages of this technology in terms of worker exposure include: **1)** output of a solid waste product that is not glass which can be disposed of via on/off site. Disadvantages include: **1)** the increased risk of Plutonium High Fired Oxide being created in the process, however no documentation was found to verify this assumption.

Calcination is proposed ex situ Mixed Waste treatment technology. Facilities have not yet been established for this process.

Technology 16: Pyrolysis (203: Pp. 44-46)

Plutonium-contaminated combustible residues (Mixed Wastes) are currently stored at the Hanford site. The combustibles consist of paper, plastics, rags, gloves, ion-exchange resins, filters, and oil- and grease-contaminated residues. Currently, the only approach addressing all combustible safety issues is to destroy the HW matrix using incineration.

Pyrolysis, a proposed Mixed Waste treatment technology, is a pyrochemical technique that uses a high-temperature, chemically inert environment to break down and volatilize polymeric materials. It is tailored specifically for the glove box environment and is an alternative to incineration. The number of workers involved in falls within the MED: 11-75 range.

Advantages associated with this technology include: **1)** alternative to incineration, **2)** reduces current volumes of combustible wastes at DOE sites, and **3)** performed in glove so there is minimized risk of exposure. No disadvantages were documented for this technology.

LANL (Los Alamos National Laboratory) has recently designed and completed testing a gas-tight pyrolysis reactor. The reactor will allow for more material to be processed per pyrolysis run. Condensation, caustic scrubbing, and catalytic oxidation accompany the pyrolysis reactor process. Processing authorization was expected in October of 1996. No other updates were found.

Technology 17: Macro-encapsulation of Mixed Waste Debris (Polyethylene Macro-encapsulation) (226, 227)

The current approach for dealing with mixed waste at the Hanford site is to construct additional RCRA-compliant facilities to allow for long-term storage and monitoring of the waste drums. Hanford's Central Waste Complex (CWC) presently stores 35,000 drums of mixed waste and 5,000 drums of mixed waste debris.

Macro-encapsulation technology, a recently deployed LLMW, HW, and TRU Mixed treatment technology, is an alternative means for treating mixed hazardous waste / debris for disposal. Waste is size-reduced through an industrial extruder process and packed into piping that is permanently welded then disposed of at a Low-Level Burial Ground. Polyethylene is used in the piping to form a low-permeability barrier between the waste and the leaching media. The number of workers associated with this technology falls within the MED: 11-75 range.

Advantages with this technology include: **1)** cost savings of greater than 50% compared to incineration, **2)** treatment of waste for disposal, rather than storing it in RCRA-compliant buildings, **3)** a treatment option for non-combustible waste (unlike incineration), and **4)** portability and waste volume reduction of approximately 75%. Disadvantages in terms of worker exposure include: **1)** fire hazards are noted as common to industrial extruder processes, **2)** molten polyethylene can cause severe burns, and **3)** Level B or C personnel protection is required in the used of this technology.

During the August - September 1997 deployment of macro-encapsulation, 880 drums of mixed waste debris were compacted and encapsulated.

Technology 18: Mobile X-Ray System for Examination of LLW Burial Boxes (ELS) (228)

Currently, manual inspection by operations personnel is required for verifying LLW in burial boxes. Manual inspection is performed at Hanford's 2706-T facility near the T-Plant.

As an alternative to manual inspection, the mobile x-ray system, a current LLMW treatment technology, can inspect LLMW containers without exposure to workers. With the imaging technology, compliance-mandated inspections are conducted remote and non-intrusively, providing reliable, recordable data on container contents. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages to this technology include: **1)** cost savings, **2)** time savings (i.e <1 hour/box throughput (saves 15 hours/box), **3)** burial box integrity, **4)** reliable, non-intrusive inspection, and **5)** enhanced worker safety from minimized handling and exposure. No disadvantages with this technology were reported.

The technology was deployed in FY 1998 at the Hanford site.

Technology 19: WRAP (Waste Receiving and Processing Facility) [123]

The WRAP facility, a current Mixed Waste treatment technology, provides remote verification, characterization, treatment, and repackaging of radioactive solid wastes for permanent disposal including the processing of LLRW, LLMW, TRU Waste, TRU Mixed Waste, and HW. Many technologies are located within the facility including:

1) Supercompaction System for Compaction of Low-Level Waste [229]
2) Automated Guided Vehicles for Waste Drum Transport [230]
3) Glovebox Non-Destructive Packet Assay Monitor (PAM) System [231]
4) Drum Delidder / Relidder Assembly [232]
5) Boxed Waste Assay System [233]
6) Glovebox X-Ray System for Non-Destructive Examination (NDE) of Packets [234]
7) Automated Stacker Retrieval System [235]
8) X-Ray Non-Destructive Examination Imaging [236]
9) Imaging Passive / Active Neutron Assay System [237]

Advantages of the facility in terms of worker exposure include: **1)** most waste handling operations are performed robotically to minimize worker exposure. Disadvantages associated with the WRAP facility may include the potential for exposure to mixed waste during packaging and transport. The number of workers associated with the WRAP facility falls within the HIGH: >75 range.

WRAP facility construction began in April, 1994 under contract with PCL Construction. The facility was completed in June 1996 and is currently operated by Waste Management Federal Services of Hanford, Inc.

Technology 20: Cleanable Steel High Efficiency Particulate Air Filter [200: Pp.36-38]

Currently, glass HEPA filters used at the Hanford site to treat mixed waste are fragile and can be destroyed when wet or under extreme conditions. Filter failure can lead to additional clean-up and environmental contamination.

A cleanable stainless steel HEPA filter, a proposed Mixed Waste treatment technology, represents a solution to the identified problems related to filter failure and waste disposal. The pleated cartridges are made by fusing stainless steel fibers into a sheet. The cartridges are then packed into a 2' x 2' x 1' frame. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages associated with this technology include: **1)** significant cost savings due to a reduction in additional clean-up cost, **2)** increased reliability, and **3)** can withstand high temperatures, pressure and moisture conditions. Disadvantages may include increased exposure to those workers cleaning the filter, however no documentation was found associated with this assumption.

Potential applications for this technology have been reviewed for various DOE sites including Hanford, but the technology has not been recently deployed.

Technology 21: Portable Acoustic Wave Sensor (PAWS) Systems for Volatile Organic Compounds (202: Pp. 34-38)

Sensors are needed to characterize VOC (i.e. carbon tetrachloride) contamination at the Hanford site. The Portable Acoustic Wave Sensor System (PAWS), a proposed HW treatment technology, consists of one or more surface acoustic wave (SAW) sensors utilizing sorbent coating to detect chlorinated hydrocarbons (CHCs) and VOCs. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages for this technology include: **1)** conducts continuous real-time monitoring, **2)** cost savings, and **3)** small, portable, user friendly. No disadvantages with this technology were reported.

A downhole PAWS system was developed and recently demonstrated at Hanford for in situ monitoring of isolated VOCs in vadose zone bore-holes.

Technology 22: ResonantSonic Drilling (198: Pp. 159-161, 238)

A means for accessing underground regions within and adjacent to contaminated sites are required for environmental characterization, monitoring, and remediation.

ResonantSonic Drilling, a current Mixed Waste treatment technology, uses a combination of mechanically generated vibrations and rotary power to penetrate the soil. This drilling is used for characterization borings to determine location and extent of contamination. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages associated with ResonantSonic Drilling include: **1)** efficient, **2)** drilling waste is minimized through not using drilling fluids and cuttings, **3)** minimized exposure of personnel to wastes because of faster drilling and reduced waste generation, **4)** contamination is minimized, and **5)** able to reach inaccessible areas. Disadvantages include: **1)** like all drilling methods, produces noise levels that are considered hazardous to workers not wearing proper protection, and **2)** Level D personnel protection is used.

Field demonstrations of ResonantSonic drilling technology were conducted at the Hanford Site from 1991 through 1994. Deployment has not yet been scheduled.

11.7 De Task Technologies

Technology 23: Aerosol Fog System for Fixing Radioactive Contamination [239]

Subsurface or pit facilities associated with the tank farms contain fixed, removable, and potentially airborne radioactive contamination. PPE and tent closures are routinely used during maintenance activities. In addition to PPE and/or tent closures, the aerosol fog system, a current LLRW treatment technology, applies a sticky coating capture over the tank-farm work site and other areas to be decontaminated. The coating-capture composed of monosaccharides and polysaccharides fixes the radioactive contaminants so that workers can enter the area and perform routine activities under enhanced ALARA conditions. The number of workers applying the coating falls within the LOW: <11 range.

Advantages in terms of worker exposure include: **1)** remote, in-situ application that reduces human exposure and enhances worker safety, **2)** reduced time, effort and cost required for preventative radiation-protection, **3)** minimized immediate decontamination activity required, **4)** 25% reduction in secondary waste due to the elimination of PPE and tent material, and **5)** effective capture protection that lasts for many weeks. No disadvantages in terms of worker exposure were noted with this technology.

This technology was demonstrated at 244-A Lift Station in November of 1996, termed effective, and then deployed. It is used on an on-call basis purchased through Encapsulation Technologies, Inc.

Technology 24: Decontamination of Piping Systems Using Hydrolasers [240]

Currently, decontamination of circulation piping remains in place and shielding is added to manage worker exposure. As an alternative, a mobile high-pressure pump unit called a hydrolaser, a current LLRW decontamination technology, delivers a high-pressure water jet to safely remove radioactive deposits in contaminated piping systems and flushes the material to a nearby drain. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages of hydrolasers include: **1)** effective removal of radioactive deposits in partially blocked piping, **2)** increased safety and reduced worker exposure through removing radioactive deposits 'remotely', **3)** decontamination with less water and no acids which would generate Mixed Wastes, and **4)** cost savings. No disadvantages were reported for this technology.

The deployment of hydrolasers was completed at K-East Basin in May of 1997. In addition to the K-East Basin, project W-058 (200W to 200E waste transfer piping) has incorporated hydrolasing as the method of decontamination for maintenance and repair.

Technology 25: Concrete Grinder (Shaver/Spaller) [241, 242, 243]

The concrete grinder, a proposed LLRW decontamination technology, is a hand-held concrete and coating removal tool that includes a 5" diamond grinding wheel and vacuum port for dust extraction suitable for flat surfaces. The device performs radiological decontamination for large areas or hot spots. Other similar devices are the concrete shaver and the concrete spaller. Decisions for using the appropriate tool are based upon the type and size of the surface to be decontaminated. The number of workers associated with the grinder technology falls within the MED: 11-75 range.[213]

Advantages for this technology include: **1)** less vibration for the operator than previously used tools, **2)** hand-held and lightweight, **3)** increased performance, efficient, and **4)** adaptable to existing HEPA vacuum systems for dust free operations. Disadvantages include: **1)** workers must be careful to ensure that the vacuum hose stays connected properly and that a suitable vacuum level is maintained, and **2)** may not appropriate for use on concrete floors and slabs with a significant number of obstructions.

The baseline demonstration was conducted during October 1997 through November 1997 in two C Reactor sample rooms used on walls and floors. The tool is to be put in the 'tool box', for more effectively completing project work scope.

Technology 26: Lead "TechXtract" Chemical Decontamination [244]

Lead "TechXtract" Chemical Decontamination, a proposed Mixed Waste decontamination technology, is a sequential chemical extraction process for the removal of radionuclides, PCBs, and other hazardous organic and inorganic substances from solid materials such as concrete, brick and steel. The technology uses chemical formulations and engineered applications to achieve significant penetration and removal of these contaminants from at and below the surface of these materials. The number of workers associated with this technology falls within the LOW: <11 range. Specifically two De workers and 1 RCT.

Advantages associated with this technology include: **1)** a very high percentage of cleaned material released, **2)** a safe work place environment for decontamination, **3)** simple to deploy, **4)** production rate is large scale. Disadvantages include: **1)** a manual hoist system (used for lifting the material to be decontaminated) that should be automated to decrease a risk of worker fatigue, **2)** brick / material holders on the hoist system should be adapted to process other types of metals, and **3)** some skill required.

The technology demonstration was conducted May 8 and 13, 1998 and is presently being evaluated for cost.

Technology 27: Reactor Stabilization Technology (Coating Applicators) [245]

Reactor Stabilization, a proposed LLRW decontamination technology, includes a dual coating system applied by a conventional paint spray pump and gun at the reactor front face. Coatings applicators were offered by two coating companies, RedHawk and Master-Lee. The baseline coating used is Rust-Oleum No. 769. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages of both coating applicators include: **1)** better contamination fixation and immediately adheres, and **2)** dual coating of polymeric film over foam base provides complete coverage. Disadvantages include **1)** application of improved coatings is more time consuming and labor intensive, **2)** application of the improved technology is simple, but needs more specialized and trained personnel, and **3)** exposure potential is not reduced and PPE (Level unknown) is required.

The demonstration was conducted from August 1997 to March 1998 for laboratory assessments, and March 19 and 24, 1998 for the field demonstration.

Technology 28: Self Contained Pipe Cutting Shear [246]

The Lukas model LKE 70 is a self contained pipe cutting shear, a proposed LLRW decontamination technology, that does not require any hydraulic fluid lines. This shear has a built-in accumulator that uses approximately 1 pt of hydraulic fluid. The tool provides the ability of cutting pipes attached to walls without needing to loosen the pipe hangers, hydraulic fluid supply lines and/or an electric cord to operate the tool. The number of workers utilizing this technology falls within the MED: 11-75 range.[213]

Advantages of the cutting shear include: **1)** reduces the need for hydraulic fluid supply lines and/or an electric cord (battery powered), **2)** reduces the chance of creating airborne contamination when compared to saws (due to a 'clean cut'), and **3)** reduces the chance of contamination release from internally contaminated pipes when compared to saws. Disadvantages include: **1)** the tool had difficulty cutting a 3 inch pipe, **2)** the tool seemed to have some difficulties in tight and congested areas, and **3)** PPE is required but the Level is unknown.

The demonstration was performed in March 1997 at the Hanford C Reactor. Deployment has not yet been reached.

Technology 29: High-Speed Clamshell Pipe Cutter [247]

The High-Speed Clamshell Pipe Cutter, a proposed Mixed Waste / LLRW decontamination technology, is a light-weight, split frame pipe lathe for severing and/or beveling in-line pipe. For D&D projects the clamshell is used for both radiological and non-radiological large-bore piping. The demonstration in the Water and Gas Tunnels at C reactor was done to challenge the current technology of cutting large-bore piping with an oxyacetylene torch. The torch technology required operations with a fire-watch person on duty. The number of workers utilizing this technology falls within the MED: 11-75 range.[213]

Advantages of the High-Speed Clamshell Pipe Cutter include: **1)** easily used by two persons in confined areas, **2)** no welder qualification required, **3)** short cutting times, **4)** no flame, smoke, or applied heating involved (fire watch is not necessary), and **5)** control cutting remotely. Disadvantages involved with this technology include: **1)** may require prior surface treatment to ease use.

The demonstration was conducted on December 15-19, 1998. Depending on the outcome of other technology demonstrations including the RESRAD-Build mathematical modeling of residual radiation dosages in the Water and Gas Tunnels, the pipe cutter could be used extensively.

Technology 30: Asbestos Conversion System [199: Pp. 126-127, 248]

Over time, asbestos waste has accumulated in the Hanford Central Landfill and has reached capacity. The Asbestos Conversion System thermally converts (entering a 2,200-degree F furnace for 1 hour) the asbestos in asbestos containing material (ACM) into a totally nonhazardous substance. The result is an asbestos free recyclable aggregate material for reuse as backfill and roadbed cover. ACS reduces waste volume by 70 percent. The number of workers utilizing this technology falls within the MED: 11-75 range.[213]

Advantages to this technology include: **1)** substantial volume reduction, **2)** eliminates the asbestos portion of the waste stream, and **3)** cost savings. Disadvantages in terms of worker exposure include: **1)** uses extremely hot furnace for conversion.

A full-scale, non-radioactive demonstration was completed in 400 area at Hanford. The technology was deployed soon after in December of 1995.

11.8 Di Task Technologies

Technology 31: Hydraulic Shears/Concrete Breakers/Concrete Pulverizers (249: Pp. 22, 238)

Brute force equipment has been used at the Hanford site for demolition tasks since the end of site production and the beginning of the environmental restoration mission (1989). Demolished material is often recycled.

Large scale equipment used for demolition activities include hydraulic shears, concrete breakers, and concrete pulverizers: current LLRW, and TRU dismantlement technologies. This equipment will continue to be used in the remediation process. The number of workers associated with these technologies falls within the HIGH: >75 range.

Advantages of these technologies include: **1)** a safer area after demolition, and **2)** materials from old structures can be recycled after demolition. Disadvantages reported for large scale demolition technologies include **1)** generation of secondary wastes, **2)** requires manual intervention and operation, and **3)** no minimized exposure to workers (PPE required).

Technology 32: Dust Suppression System (250)

Currently, innovative technology is not used to suppress dust created by demolition activities at the Hanford site. In order to control dust clouds generated by demolition rams, a water-based dust suppression system, a proposed LLRW / Mixed Waste dismantlement technology, was demonstrated at C Reactor in March of 1998. The system consisted of a 540 gallon water tank, a u-shaped spray-nozzle ring, a fire hose, and a foot or hand shut-off mechanism. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages of this technology include: **1)** reduce the risk of spreading contamination, **2)** efficient dust suppression at point of dust generation, **3)** labor reduction, and **4)** reduce water consumption compared to baseline technology (or spraying water directly from a fire hose). No disadvantages were reported with this technology.

Technology 33: Liquid Nitrogen-Cooled Diamond Wire Concrete Cutter [251]

The baseline tools for cutting large concrete walls and floors are conventional water-cooled diamond-wire and concrete wall saws. As an alternative, the Liquid Nitrogen-Cooled Diamond Wire Concrete Cutter, a proposed LLRW dismantlement technology, cuts through reinforced concrete walls, floors, and structures both radiological and non-radiological and does not require wire cooling with water. The number of workers associated with this technology falls within the LOW: <11 range.

Advantages of this technology include: **1)** relatively easy to set up, **2)** short setup time, **3)** no multiple steps, **4)** no cooling water for the saw, so no secondary liquid waste. Disadvantages in terms of worker exposure include: **1)** liquid nitrogen can cause frost injuries and asphyxiation (PPE was not reported, but assumed to be used), **2)** generation of large amount of dust, **3)** need large HEPA filtration system, and **4)** wire overheating.

The demonstration for this technology was conducted at C reactor March 23-31, 1998.

Exhibit 12.1: Citizens Advisory Committee on Public Health Service Activities Contact List

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Exhibit 12.1 (continued): Citizens Advisory Committee on Public Health Service Activities Contact List

Membership (continued)

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Liaison Representatives

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Exhibit 12.1 (continued): Citizens Advisory Committee on Public Health Service Activities Contact List

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Exhibit 12.2: Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
001	Storekecpers	STOREKEEPER Performs complex warehousing work involving a broad knowledge of receiving, disbursing and shipping material. Performs work such as filling material orders, answering inquiries regarding stock and shipment, arranging for special deliveries, investigating complaints, locating lost shipments, maintaining storage yards, performing inventories, transferring materials, marking and identifying materials, storage bins and/or racks, and assisting in the storage, packaging and shipping of hazardous materials. Operate forklifts, order pickers, carts. Involved in warehouse operations and utilize computers and automatic data processing equipment in the performance of the above functions. May train and direct others.	Teamsters, Local 839
004/052 /053	Nuclear Chemical Operator, Operator Trainees, D&D Workers (Other Titles: Nuclear Reactor Control Operator, Reactor Fuels Operator, Metal Fuels Operator)	NUCLEAR CHEMICAL/PROCESS OPERATOR - JOURNEYMAN Responsible for carrying out assignments in many different areas covering a wide variety of products and processes, in operating diversified equipment, in performing a sequence of complex operations. Work with a minimum of supervision and take the lead in performing work including troubleshooting, indoctrination of new employees, emergency procedures, and similar items. May direct others. NUCLEAR CHEMICAL OPERATOR (NUCLEAR OPERATOR) Responsible for the operation of diversified equipment, performing a sequence of complex operations, generally, in accordance with operational procedures. OPERATOR TRAINEE Operate equipment and perform a variety of functions. following standard operating procedures. Perform and assist on complex operations under direction. DECONTAMINATION/DECOMMISSION WORKER (BHI/THI Seniority Code 003**) Perform any and all work required to stabilize, decontaminate, disassemble and/or package items identified for stabilization, decontamination and/or decommissioning including any property, facility, structure, equipment or system such as piping, machine, electrical, ventilation or others. Must be able to use a variety of supplies, tools and equipment in the decontamination disassembly or packaging process.	Nucleonics, OCAW, Local 1-369

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) (39, 49)

*Seniority Group Number	Job Title	Job Description	Local Union
005	Stationary Operating Engineers, Chlorinators (Other titles: Chief Power Operator, Power Operator Jrn., Power Operator, Chief Operator Power)	STATIONARY OPERATING ENGINEER- Responsible for the critical control of utility equipment, building heating and ventilation systems, closed-loop cooling, vacuum pumps, compressors, DOP testing and air balance functions, the operation of boilers and related auxiliary equipment, process water supply equipment, water treatment, refrigeration, electrical generators and process air conditioning equipment. CHLORINATOR SERVICEMAN - Fully qualified chlorinator serviceman. Diagnose trouble and make complex repairs on all types of chlorine feeding equipment. Perform operation related to servicing chlorinating equipment, such as setting up equipment and sterilizing lines, tanks, basins, etc. May perform Stationary Operating Engineer functions.	Operating Engineers, Local 280
011	Sheetmetal - Jrn. Sheetmetal - Apprentice	SHEETMETAL - JOURNEYMAN Fully qualified journeyman. Perform all types of sheetmetal work involving layout, shearing, punching, fabrication and erection of complicated and other sheetmetal installations. Set up and operate sheetmetal tools. Direct others. SHEETMETAL - APPRENTICE Fabricate and erect sheetmetal installations of simple design. Assist on and perform complex work under direction of a journeyman. Set up and operate sheetmetal tools. Is enrolled in and must complete the Fluor Daniel Hanford, Inc./HAMTC Joint Apprenticeship Program.	Sheetmetal Workers, Local 66

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
012	Track Inspectors, Track Equipment Operators-I, Trackmen	TRACK INSPECTOR - Responsible for thorough visual inspection and recording of conditions of the railroad track system, including right-of-way. Familiar with and trained in Federal Railroad Administration (FRA) standards. Be able to detect deviations in the track system which are not in compliance with FRA standards. Report all deviations from standards and recommend remedial action for correction to management. May perform other duties in seniority group 012. TRACK EQUIPMENT OPERATOR I - Perform construction and maintenance work on railway trackage and right-of-way using tie extractor-inserter equipment, ballast tamping equipment and other similar types of powered equipment. TRACKMEN - Perform construction and maintenance work on railroad trackage right-of way using section gang machines, rail grinder, rail drilling machines and other similar types of track maintenance equipment. Perform construction and maintenance work on railroad trackage and right-of-way.	Operating Engineers, Local 280
013	Crane Operators	CRANE OPERATOR- Operates all types of cranes, including crawler, rubber tired, locomotive, and overhead gantry (as assigned). Cranes may be equipped for hoisting of for earth or material movement. Rig buckets, hooks, etc. Responsible for hand lubrication of equipment. Operators should be proficient in robotics and remote operation and advanced technology as those skills become necessary for the performance of the assigned work.	Operating Engineers, Local 280
013B	Heavy Equipment Operators	HEAVY EQUIPMENT OPERATOR - Operate all types of heavy equipment including, but not limited to, bulldozers-track and rubber tired, road graders, scrappers, traxcavator, bucket loader, road roller, large trenching machines, rock crushers, and other types of power equipment. Operate remote controlled equipment and robotics as these skills become necessary for the performance of the assigned work.	Operating Engineers, Local 280

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
014	Heavy Truck Driver, Truck Driver Light, Lube and Tiremen, Servicemen, Bus Driver	HEAVY TRUCK DRIVER Operate semi-trailer, and truck and trailer; transit mix; motor crane; A-frame; fuel truck; three-axle truck; dump truck; fork lift; two-axle flat bed; water truck; farm tractor, and related equipment; passenger bus; perform taxi, chauffeur, and wrecker services. Wash and clean vehicles, make minor repairs incidental to driving; such as, changing tires, etc. Also includes towing of trash trailer with two-axle trucks, loading and unloading of vehicles, and perform general labor functions as assigned. Utilize material moving equipment such as manual or power-driven hand trucks, wheel barrows, etc. in the duties of moving, lifting, stacking, loading or unloading Perform ground and shrubbery maintenance including mowing, pruning, trimming, weeding and snow removal. Utilize and operate all ground and shrub maintenance equipment in performance of the above tasks. TRUCK DRIVER LIGHT - Operate truck and trailer equipment such as, dump truck having a struck measure capacity including sideboards of other apparatus which increases the capacity to less than six yards, two axle flat bed or water truck, fuel truck under 1500 gallons, forklift 6 ton or less than 12 ton), farm tractor and related equipment. Includes towing of trash trailer with 2 axle trucks and the loading and unloading of vehicles. Make minor truck repairs. LUBE AND TIREMAN Perform lubrications, oil changes, fuel vehicles, clean vehicles, and conduct visual maintenance safety inspections while lubricating on trucks, buses, sedans, and other designated equipment. Change, repair, and vulcanize tires on all Hanford mobile equipment including large construction equipment where feasible. Drive and road test all equipment and possess the Commercial Drivers License. Perform written documentation to support all assigned tasks Receive, inventory, maintain and document fuel, lubricant, antifreeze, solvent, and 'Other assigned inventories as directed by management. Transport materials with a fork lift or assigned vehicle as required to support the Hanford fleet. Assist shop supervisor and Hazardous Waste Coordinators in handling, movement, and clean up of hazardous materials. Perform general shop clean up as required. SERVICEMAN Perform general laboring functions as assigned. Utilize material moving equipment such as manual or power-driven hand trucks, wheel barrows, etc. in the duties of moving, lifting, stacking, loading or unloading. Perform ground and shrubbery maintenance including mowing, pruning, trimming, weeding and snow removal. Utilize and operate all ground and shrub maintenance equipment in performance of the above tasks.	Teamsters, Local 839

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
015	Carpenters - Jrn.	CARPENTER-JOURNEYMEN - Fully qualified journeyman. Perform all types of shop and field carpentry work, new or repair, such as layout and fabrication of cabinets, structural framing, complex forms, etc. Set up and operate power woodworking tools. Layout work for and direct others.	Carpenter / Millwright, Local 2403
018	Laboratory Instrument Specialist, Instrument - App.	LABORATORY INSTRUMENT SPECIALIST - Install and maintain highly complex instruments, control systems, and related equipment used in the Laboratory to generate, accumulate, and record scientific data from experimental operations and processes. Assemble instrument components into complex workable systems as designed to accomplish stated results. Work from sketches, prints, or oral instructions. May direct others. INSTRUMENT - APPRENTICE - Routine installation, calibration, and maintenance, of ordinary instruments and instrument systems. Assist on and perform complex work under direction of a technician. Is enrolled in and must complete the Fluor Daniel Hanford, Inc. / HAMTC Joint Apprenticeship Program.	IBEW, Local 77
021	Linemen, Assistant Linemen	LINEMAN Fully qualified lineman performing all types of electrical line work involving complex construction and maintenance of outside electrical transmission, distribution and communication circuits, such as hot-line installations, expert troubleshooting, clearance taking, and switching operation. Direct others. ASSISTANT LINEMAN Assist on and perform construction and maintenance work on outside electrical transmission, distribution and communication circuits. Perform complex work under direction. May operate heavy line truck and mechanical equipment. Direct ground men.	IBEW, Local 77

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
022	Electrician - Jrn., Electrician App.	ELECTRICIAN JOURNEYMEN - All around journey, performing all types of electrical work, such as layout of construction wiring, installation, and maintenance of complicated electrical equipment, including switchgear, generating, substation, distribution and control equipment, etc. Take electrical clearance and perform switching operations on high voltage electrical clearance and perform switching operations on high voltage electrical circuits. Perform expert trouble shooting and writing on complicated equipment and/or rewind motors and generators. Direct work of others and perform any assigned electrical work of lesser skill. ELECTRICIAN APPRENTICE - Install, test, repair and maintain non-complex electrical equipment and circuits. Assist on and perform complex work under direction of a journeyman. Is enrolled in and must complete the Fluor Daniel Hanford, Inc. /HAMTC Joint Apprenticeship Program.	IBEW, Local 77
022A	Substation Operator	SUBSTATION OPERATOR - Responsible for the operation of an electrical transmission substation. Perform all operations required to maintain service at specific levels; in emergencies diagnose trouble and take appropriate action. Make line and equipment tests.	IBEW, Local 77
022C	Substation Electrician	SUBSTATION ELECTRICIAN - JOURNEYMAN An electrician, performing all types of electrical work, such as layout of construction wiring, installation, and maintenance of complicated electrical equipment, including switchgear, generating, substation, distribution and control equipment, etc. Take electrical clearances and perform switching operations on high voltage electrical circuits. Perform expert trouble shooting and wiring on complicated equipment and/or rewind motors and generators. Direct work of others and perform any assigned electrical work of lesser skill.	IBEW, Local 77

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
022D	Meter Relay Technician	METER RELAY TECHNICIAN - Perform troubleshooting, testing, calibrations, and maintenance on protective relaying, meter, and supervisory control systems and equipment to meet the requirements of the electrical distribution facilities. Direct the work of others and perform any assignments in the substation electrician classification.	IBEW, Local 77
023	Millwright - Jrn. Millwright-App.	MILLWRIGHT - JOURNEYMAN Fully qualified journeyman capable of making all types of repairs. Lay out, fabrication, assemble, and install machinery and equipment. Test, diagnose, repair and maintain machinery and equipment. Operate power-driven tools, such as drill presses, hack saws, and related types of equipment. Work to close tolerances. Direct others. MILLWRIGHT - APPRENTICE Make ordinary mechanical repairs on diverse equipment. Assist on and perform complex work under direction of a journeyman. Is enrolled in and must complete the Fluor Daniel Hanford, Inc./HAMTC Joint Apprenticeship Program.	Carpenter / Millwright, Local 2403
024 / 040	Plumber Steamfitter -Jrn., Plumber Steamfitter - App., Welders	PLUMBER STEAMFITTER JOURNEYMEN - Fully qualified journeyman. Perform expert installation, maintenance, layout, fabrication, and repair work on all piping systems, plumbing assemblies, and equipment falling within the jurisdiction of the Plumber-Pipefitter Journeyman classification at Fluor Daniel Hanford, Inc. Set up and use tools and equipment, either hand or power tools, as needed to perform the aforementioned work. PLUMBER STEAMFITTER APPRENTICE - Work on routine installations and repairs of piping and plumbing systems and assist on and perform complex work under direction of journeyman. Set up and operate power tools. Is enrolled in and must complete the Fluor Daniel Hanford, Inc. Joint Apprenticeship Program. WELDER - Individuals fully qualified in the skills and techniques of welding formations of every description and character by any mode or method.	Plumber / Steamfitters, Local 598

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
025	Painter-Jrn., Painter/ Carpet Installer-Jrn.	PAINTER-JOURNEYMEN - Fully qualified journeyman who performs high-grade brush and spray painting. Work may involve preparing surfaces; removal and/or encapsulation of lead based paint and trade related products; applying perfa-tape; mixing paints and matching colors. Lay floor covering such as linoleum and tile. PAINTER/CARPET INSTALLER - JOURNEYMEN Fully qualified journeyman who performs high-grade brush and spray painting: including parking lot, road and cross walk striping. Work may involve preparing surfaces; removal and/or encapsulation of lead based paint and trade related products; applying perfa-tape; mixing paints and matching colors. Lay floor covering such as linoleum, tile, carpet and pad.	Painters, local 1789
031	Cement Finisher-Plasterer-Jrn., Cement Finisher-Plasterer-Trn.	CEMENT FINISHER - PLASTERER- JOURNEYMEN- Fully qualified individual performing all types of concrete work, such as coloring, grouting, patching, finishing, curing, block-laying and/or all around plaster work. Direct others. CEMENT FINISHER - PLASTERER- TRAINEE - Perform ordinary concrete and plastering work. Assist on and perform complex work under direction.	Nucleonics, OCAW, Local 1-369
032	Master Process Crane Operators, Crane Operators (Process)	MASTER PROCESS CRANE OPERATOR - Operates cranes of special design to handle process work in process building, knowledgeable for the operation of all process cranes; direct and train others. CRANE OPERATOR (PROCESS) - Operates cranes of special design to handle process work in process buildings.	Operating Engineers, Local 280

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
033	Boilermaker - Jrn, Boilermaker - App.	BOILERMAKER-JOURNEYMEN-Fully qualified Boilermaker performing all types of complex boiler and heavy gauge plate work involving the repair and maintenance of boilers and related equipment. Layout, fabricate, and install complicated steel plate assemblies. Direct others. BOILERMAKER-APPRENTICE Fabricate and install steel plate assemblies of simple design. Perform ordinary maintenance job. Assist on and perform complex jobs under direction of a Boilermaker Journeyman. Is enrolled in and must complete the Fluor Daniel Hanford, Inc. / HAMTC Joint Apprenticeship Program.	Boilermakers, Local 242
034	Glazier / Glassworker-Jrn., Glazier/Glassworker-Spec.	GLAZIER / GLASSWORKER-JOURNEYMEN Fully qualified Glazier/Glassworker performing all phases of glass work, such as cutting, grinding, polishing, and installing glass. GLAZIER / GLASSWORKER-SPECIALIST Fully qualified Glazier/Glassworker, performing all phases of glass work including cutting, grinding, polishing and installing glass, and including all phases of work with lead glass.	Painters, Local 1789
035	Ironworker/ Riggers-Jrn.	IRONWORKER/RIGGER - JOURNEYMEN - Fully qualified Ironworker/Rigger. Perform all types of complex rigging and iron work. Rigging involves loft and field jobs, such as splicing wire rope, building wire slings, erection of metal scaffolding and staging. Structures built of scaffolding and all difficult load slinging. Inspect, maintain, and repair complex rigging equipment. Inspection and change out of wire rope. Iron work involves the fabrication, erection, and dismantling of steel structures, placing and setting reinforcing, etc. Iron work includes fabrication, erection/installation, and dismantling of ladders platforms and catwalks.	Ironworkers, Local 14

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
037	Insulators-Jrn., Insulators-App.	INSULATOR-JOURNEYMEN - Perform all types of work involving the installation, and removal of various types of insulation and insulating material while observing all regulations related to insulating materials. Direct others. INSULATOR-APPRENTICE - Perform routine work involving installation and removal of insulation and insulating materials while observing all regulations related to insulating materials. Work under the direction of a journeyman.	Asbestos Workers, Local 120
049	Research and Development Machinists, Machinists-Jrn., Machinists-App.	RESEARCH AND DEVELOPMENT MACHINIST- Fabricates experimental laboratory apparatus, tools, dies, fixtures, gauges, and components from common and exotic materials requiring the use of advanced machining techniques and machine tools. Plan, lay out, and fabricate equipment working from models, sample pieces, sketches, prints, oral instructions, or stated end function. May lead others in the fabrication and assembly, by sequential operations, of intricate, customer-inspected equipment and other duties as assigned. MACHINIST - JOURNEYMAN Fully qualified machinist performing complex work to close tolerances. Set up and operate both manual and CNC equipment such as lathes, shapers, grinders, milling machines, and other machine tools and equipment. Lay out, fabricate and assemble parts. Perform diversified and complex repair work. Direct others. MACHINIST - APPRENTICE Perform ordinary assembly and repair work and simple setup and machining to close tolerances. Perform more complex work under direction of a journeyman including operation of CNC equipment. Is enrolled in and must complete the Fluor Daniel Hanford, Inc./HAMTC Joint Apprenticeship Program.	Machinists, Local 1951

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
054A	Health Physics Technicians (Other Titles: Radiological Control Technician Trainees, RCT, Senior RCT)	RADIOLOGICAL CONTROL TECHNICIAN TRAINEE - Provide general assistance to radiological control personnel performing contamination and radiation control functions. As qualified perform less complex monitoring, surveying and sampling on the project and its environs. RCT - Provide radiological control functions including, contamination and radiation exposure control, area posting, area radiological monitoring for control proposes, radiological release of materials, surface survey for radiological characterization, and track radiological exposures for access control. Duties may include working with routine and/or special detection equipment. SENIOR RCT - Provide radiological control functions including, contamination and radiation exposure control, area posting, area radiological monitoring for control proposes, radiological release of materials, surface survey for radiological characterization, and track radiological exposures for access control. Duties may include working with routine and/or special detection equipment and will assist in the training of Trainees or RCTs.	IBEW Local 984

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) (39, 49)

*Seniority Group Number	Job Title	Job Description	Local Union
056	Shop Material Take-off and Coordinator - Senior, Shop Material Take-off and Coordinator	SHOP MATERIAL TAKE-OFF AND COORDINATOR-SENIOR- Perform material take-offs from drawings, blueprints and sketches and develop material and equipment lists; prepare material requisitions, store orders, cross orders, work orders, as necessary to procure material and services; follow-up on procurement, locating materials, arranging for shipments, delivery and check off on receipt; maintain control of locked storage yards, including inventory, transfers, proper marking and identification of materials and storage (bins/racks); coordinate project need date with material delivery dates; provide weekly material status reports; maintain files on drawings, catalogues, requisitions, orders, etc. May perform material cost estimates and other related work. SHOP MATERIAL TAKE-OFF AND COORDINATOR -Perform material take-off, control and procurement functions. Duties include work, such as, making drawing take-offs to develop material and equipment lists and process material control and procurement assignment, such as, developing information and writing material requisitions, store orders, cross orders, etc.; maintaining files on drawings, catalogues, requisitions, etc; procurement and follow-up work, such as locating, obtaining material, arranging for shipment, delivery, checking of items, etc. Perform related work as assigned.	Nucleonics, OCAW, Local 1-369
060	Chemical Technologists	CHEMICAL TECHNOLOGIST- Perform routine analytical analysis on a variety of samples by chemical, physical, instrumental, and radiochemical methods, using a variety of laboratory instrumentation and equipment. Also, perform assignments of diverse, specialized and complex nature requiring the full knowledge of analytical laboratory techniques and procedures. May direct the activities of others, and give on-the-job training to less experienced personnel.	Nucleonics, OCAW, Local 1-369

Exhibit 12.2 (Continued): Hanford Atomic Metal Trades Council (FDH / BHI Job Descriptions) [39, 49]

*Seniority Group Number	Job Title	Job Description	Local Union
061	Hot Cell Technicians	HOT CELL TECHNICIAN (HCT)- The responsibilities of a HCT is to perform operations historically performed by the HCTs prior to their organization, associated with hot cells and to support the facilities that house the hot cells, Buildings 324 and 327, in tasks of a radiological manner. Operates a variety of remote/non-remote material handling/transfer equipment; assist in design of such equipment; support maintenance of fissionable material inventories; test fissionable material; package waste; and decontaminate equipment related to hot cell operations. Will also pretest and troubleshoot the new process equipment; set-up, operate, and maintain equipment related to hot cell work; monitor hot cell systems and perform data collection to work plans and procedures.	Nucleonics, OCAW, Local 1-369
062	Industrial Hygiene Technicians (Other titles: Health Physics Technicians	INDUSTRIAL HYGIENE TECHNICIAN- Perform routine sampling and monitoring tasks, using established procedures, to support the Industrial Hygiene effort within the Lockheed Martin Hanford Corporation. Keep associated records. Also perform routine functional checks of Industrial Hygiene equipment and, as assigned by management, carry out special studies and sampling and assist in training and communications.	IBEW, Local 984

* FDH and BHI use the same seniority group codes. The seniority group code plays the role of classifying groups of workers as well as determining seniority for HAMTC employees.
** 003 classification was created so that BHI/THI could establish a definitive D&D workforce and differentiate the group from 004 personnel.

Exhibit 12.3: Pacific Northwest National Laboratory Hanford Atomic Metal Trades Council (HAMTC)

*Seniority Groups	Job Classifications	Local Unions
100	Insulator Journeyman	Asbestos Workers Local No. 120
105	Carpenter Journeyman Carpenter Trainee	Carpenters & Millwrights 2403
145	Millwright Journeyman Millwright Apprentice Millwright Trainee	Carpenters & Millwrights 2403
185	Millwright Welder Journeymen Millwright Welder Trainee	Carpenters & Millwrights 2403
140	Material Coordinator	**Technical Engineers No. 141
135	Power Operator Journeyman Power Operator	Operating Engineers Local No. 280
160	Senior Radiation Protection Technologist Radiation Protection Technologist Radiation Protection technologist Trainee	IBEW Local No. 984
115	Electrician Journeyman Electrician Apprentice Electrician Trainee	***IBEW Local No. 77-140
130	Laboratory Instrument Specialist	***IBEW Local No. 77-140
125	Laboratory Machinist Machinist Journeyman Machinist Apprentice Machinist Trainee	Machinists Local No. 1951
128	Laboratory Instrument Optician Instrument Optician Instrument Optician Trainee	Machinists Local No. 1951

Exhibit 12.3 (Continued): Pacific Northwest National Laboratory Hanford Atomic Metal Trades Council (HAMTC)

*Seniority Groups	Job Classifications	Local Unions
185	Machinist Welder Journeyman Machinist Welder Trainee	Machinists Local No. 1951
150	Painter-Carpet Installer Journeyman Painter Journeyman Painter Trainee	Richland Painters No. 1789
155	Plumber-Steamfitter Journeyman Plumber-Steamfitter Apprentice Plumber-Steamfitter Trainee	Plumbers and Steamfitters Local 598
185	Plumber-Steamfitter Welder Journeyman Plumber-Steamfitter Welder Trainee	Plumbers and Steamfitters Local 598
165	Truck Driver - Light Serviceman	Teamsters Local No. 839
166	Storekeeper - B	Teamsters Local No. 839
167	Groundskeeper	Teamsters Local No. 839
170	Sheet Metal Journeyman Sheet Metal Apprentice Sheet Metal Trainee	Sheet Metal Workers Local No. 66
185	Sheet Metal Welder Journeyman Sheet Metal Welder Trainee	Sheet Metal Workers Local No. 66
200	Aerosol Technician Chemistry Technician General Research Technician	OCAW Local No. 1-369
210	Ironworkers	Iron Workers Local No.14
220	Boilermakers	Boilermakers Local No. 242

* PNNL Seniority Group Codes differ from FHD and BHI. The data presented above is dated 1992.
**Technical Engineers No. 141 is no longer a HAMTC represented union.
*** IBEW Local No. 140 is no longer in existence.

Exhibit 12.4: Example Data Entry Forms for the Employee Job Task Analysis (EJTA) (255,262)

EJTA Business Sensitive 7/19/99

Resp. Co.: HID: Name: Status: EJTAID:

HR Manager Name:
Org Code:
Tracking Code:
Payroll Number:
Job Title:
COCS:
Occupation:

Prime Contractor:
Level 2 Subcontractor:
Level 3 Subcontractor:
Primary Area:
Other Area Info:
Shift:
Other Shift Info:
Admin. Employer:
Other Admin. Employer:

Signatures

	Name:	Date:
Manager		
Industrial Hygienist		
Employee		

Creation Date:
Send To Medical Date:
Effective Date:

Essential Functions

Essential Function 1:

Essential Function 2:

Essential Function 3:

Essential Function 4:

Essential Function 5:

Essential Function 6:

Essential Function 7:

Essential Function 8:

Comments:

Exhibit 12.4 (continued): Example Data Entry Forms for the Employee Job Task Analysis (EJTA)
(255,262)

EJTA — Business Sensitive — 7/19/99

Resp. Co.: HID: Name: Status: EJTAID:

Medical Qualifications

1	Crane Operator	Yes,No
2	Driver With CDL	Yes,No
3	Fissile Material Handler	Yes,No
4	Respirator Wearer	Routine,NonRout,No
4a	Schedule for respirator exam	Now,Later
5	Personnel Security Assurance Program	Yes,No
6	Quality Control Inspector	Yes,No
7	Nuclear Reactor Operator	Yes,No
8	Tower Climber	Yes,No
9	Hanford Patrol	Yes,No
9a	Hanford Patrol Security Police OfficerII	Yes,No
9b	Hanford Patrol Security Police OfficerII	Yes,No
9c	Security Officer	Yes,No
10	Firefighter	Yes,No
10a	HAZMAT	Yes,No
11	Underwater Diver	Yes,No

Exhibit 12.4 (continued): Example Data Entry Forms for the Employee Job Task Analysis (EJTA) (255,262)

EJTA	Business Sensitive	7/19/99

Resp. Co.:	HID:	Name:	Status:	EJTAID:

Normal Physical Activities

-- = Activity is never or rarely performed.
1 = The frequency of the activity is up to one-third of the time.
2 = The frequency of the activity is greater than one-third of the time.

1	Sitting	1,2
2	Standing	1,2
3	Walking (Even Surfaces)	1,2
4	Walking (Uneven Surfaces)	1,2
5	Running	1,2
6	Kneeling	1,2
7	Crawling	1,2
8	Climbing Legs Only	1,2
9	Climbing (Hands And Legs)	1,2
10	Reaching Above Shoulders	1,2
11	Bending	1,2
12	Twisting	1,2
13	Straight Pulling	1,2
14	Repetitive Motion	1,2
15	Pulling Hand over Hand	1,2
16	Pushing	1,2
17	Lifting Carrying >50 lbs	1,2
18	Lifting Carrying 20 to 50 lbs	1,2
19	Fine Finger Movement	1,2
20	Uses Both Hands	1,2
21	Uses Both Legs	1,2
22	Operating Heavy Equipment	1,2
23	Operating Motor Vehicles	1,2
24	Operating Machinery	1,2
25	Computer Work Station	1,2
26	Material Handling Equipment	1,2
27	Confined Areas	1,2
28	Work in Hot Environments	1,2
29	Work in Cold Environments	1,2

Exhibit 12.4 (continued): Example Data Entry Forms for the Employee Job Task Analysis (EJTA) (255,262)

EJTA Business Sensitive 7/19/99

Resp. Co.: HID: Name: Status: EJTAID:

Other Exposure Information

1	Radiation Worker II	Yes,No
2	High Vibration	Yes,No
3	Licensed Pesticide Applicator	Yes,No
4	Greenhouse Work; WBGT => 80F	Yes,No
5	Impermeable Clothing	Yes,No
6	Physically Stressful Environments	Yes,No
7	Bloodborne Pathogens	Yes,No
7a	High Risk (e.g. Healthcare providers)	Yes,No
8	Work at a hazardous waste site	Yes,No
8a	Required to wear a respirator for 30 days or more per year	Yes,No
8b	Due to exposure or potential exposure to chemical(non-rad) hazards	Yes,No
9	Laboratory Animals	Yes,No
9a	Laboratory Animal Handler	Yes,No
9b	Primate Worker - General	Yes,No
10	Wildlife/Wild Animals	Yes,No
10a	Wild Mammal Handler	Yes,No
10b	Fowl/Avian Worker	Yes,No

Exhibit 12.4 (continued): Example Data Entry Forms for the Employee Job Task Analysis (EJTA) (255,262)

EJTA Business Sensitive 7/19/99

Resp. Co.: HID: Name: Status: EJTAID:

Potential Exposure Hazards

Blank = Employee does not work with or around this hazard
1 = Exposure less than Criteria
2 = Exposure greater than Criteria but less 30 Days per Year
3 = Exposure greater than criteria and 30 Days or More per Year
Qd = Quantitative Data Available
Hz = Hazardous Waste Related

			1	2	3	Qd	Hz
1	Arsenic Inorganic		_	_	_	_	_
2	Asbestos		_	_	_	_	_
3	Benzene		_	_	_	_	_
4	Beryllium		_	_	_	_	_
5	Cadmium Inorganic		_	_	_	_	_
6	Formaldehyde		_	_	_	_	_
7	Lead Inorganic		_	_	_	_	_
8	Noise		_	_	_	_	_
9	Laser Light		_	_	_	_	_
10	Paints/Resins	Yes,No					
10a	Lead		_	_	_	_	_
10b	Chromium		_	_	_	_	_
10c	Solvents		_	_	_	_	_
11	Welding	Yes,No					
11a	Nickel (SS)		_	_	_	_	_
11b	Chromium (SS)		_	_	_	_	_
11c	Metal Fumes		_	_	_	_	_
11d	Other Welding		_	_	_	_	_
12	Carcinogens (if not checked elsewhere)	Yes,No					
12a	A1 or OSHA		_	_	_	_	_
12b	Other Carcinogens		_	_	_	_	_
13	Particulates	Yes,No					
13a	Coal Dust		_	_	_	_	_
13b	Synthetic Vitreous Fibers		_	_	_	_	_
13c	Other Particulates		_	_	_	_	_
14	Chlorinated Solvents		_	_	_	_	_
15	Other Solvents		_	_	_	_	_
16	Other Corrosives		_	_	_	_	_
17	Isocyanates		_	_	_	_	_
18	Epichlorohydrin		_	_	_	_	_
19	Chlorine		_	_	_	_	_
20	PCBs		_	_	_	_	_
21	Ammonia		_	_	_	_	_
22	Mercury		_	_	_	_	_
23	Other Chemicals		_	_	_	_	_

Exhibit 12.5: Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
ACES (Access Control Entry System)	Oracle	RAD Exposure Data, Training Data, Work Location	PHMC Employees, PNNL	FDH	David B. Ottley, Health Physics MailStop: H6-34 Location: 2440STVCN/2209/RCHN 509-376-8124
AJHA (Automated Job Hazard Analysis)	MS Access	Hazard Analysis for Projects or Job Tasks	PHMC Employees, PNNL	FDH	Gary Gottfried, AJHA Coordinator MailStop: H6-23 Location: 2440STVCN/2604/RCHN 509-373-1771
BHI People Soft System	People Soft	Contains Human Resource Data for BHI and sub contractors.	BHI / THI / CH2Hill	BHI	Connie Hettel, HR MailStop: H0-08 Location: 3350GWW/1A05/RCHN Richland, WA 99352 509-375-9683
DIS (Document Information System)	NA	Contains BHI IH exposure information by project. Asbestos, Lead, Mercury, Silica, Organic Vapors. Personal exposures are documented on medical records sent to HEHF.	BHI / THI / CH2Hill	BHI	Sheldon Coleman, Industrial Hygienist 509-376-8481

Exhibit 12.5 (continued): Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
EJTA (Employee Job Task Analysis)	Oracle / Delphi	Potential (Risk) and Actual IH and RAD Exposure Data, Work Location, Type of Work	All Site Employees	HEHF and FDH	Joseph Samuels 3090 George Washington Richland, WA 99352 509-373-3144
ESS (Epidemiologic Surveillance System)	NA	Integrates Demographics (from Site Roster Information) and RTW medical events. Records are coded at DOE-HQ in Oakridge (ORA) and returned for investigations.	All Site Employees	HEHF	Buffy LaDue, Epidemiologist P.O. Box 100, H1-75 Richland, WA 99352 509-373-0188
FDH People Soft System	People Soft	Contains Human Resource Data for FDH and sub-contractor / enterprise company employees.	FDH / PHMC Employees	FDH	Dorothy Hansen, Manager HR MailStop: H2-16 Location: 2425STVCN/154/RCHN Richland, WA 99352 509-376-8180
Hanford Site Roster	People Core	Incorporates All Site Employee Personnel Information (Demographic Information including Name, SSN, ESSN (Hanford ID), DOB, Sex, Company, Job Title, Pay Type, Area, Bldg, Room, Age, etc.)	All Site Employees	FDH, HEHF	Can provide Access: Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025

Exhibit 12.5 (continued): Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
HIH2 (Hanford Industrial Hygiene System)	Century 2000	Contains IH exposure information on Airborne Agents, Noise, Heat, Alumination, Asbestos, Lead, Isocyanate. Contains Personal Area Samples by Hanford ID, SSN, and project. Area samples are contained in another database.	FDH / PHMC Employees Only	FDH	Elton Hewitt, Industrial Hygienist MailStop: H6-32 Location: 2440STVCN/2604/RCHN 509-372-3081
HOM (HEHF Occupational Medical System)	Flow Gemini	Demographics, Work History, Vision, Audiogram, ECG, Pulmonary Function, X-Ray, Chemistry, Hematology, Urinalysis, Toxicology, Physician Findings, Work Restrictions (from mid-1993), Scheduled Monitoring / Surveillance / Qualifications Programs, Clearances for Monitoring / Surveillance / Qualifications programs	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025
HSS (Health Services System)	NA	Medical Exam Scheduling Data (Data fed into ACES)	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025
Johnson Controls Human Resource Data	Elec / Paper System	Contains Human Resource Data for Johnson Controls.	Johnson Control Employees	Johnson Controls	Michael E. Tenvooren Job Title: Site Manager Location: MO258//300 P.O. Box 750 Richland, WA 99352 509-373-3401

Exhibit 12.5 (continued): Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
PNNL IH Records	Paper Only	Contains PNNL / Battelle IH exposure information.	PNNL / Battelle	PNNL / Battelle	Abby L. Nicholson, Industrial Hygienist MSIN: P7-75 902 Battelle Boulevard P.O. Box 999 Richland, WA 99352 Bus: 509-376-0345
PNNL People Soft System	People Soft	Contains Human Resource Data for PNNL / Battelle Operated Employees.	PNNL / Battelle Employees	PNNL / Battelle	Kirby J. Denslow, Workforce Planning Specialist 902 Battelle Boulevard MSIN: K1-34 P.O. Box 999 Richland, WA 99352 509-375-6733
REM1	NA	Internal Dose Data : Name, DOB, Hanford ID, Gender, Dose_Rec_N, Year Uptake, Radionucli, Dose_Uptak	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025
REM2	NA	Radiation Exposure Monitoring : Name, Hanford ID, Sex, DOB, Occupation, Facility Type, Monitoring Status, Start and End Dates, DDE_Photon, DDE_Neutron, CEDE, TEDE, SDE_WB, SDE_ME) External Data	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025

Exhibit 12.5 (continued): Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
REMS (HEHF)	NA	1989-1996 Hanford Site Employee Radiological Exposure Data. Contains data from two other systems, REM1 and REM2.	All Site Employees	HEHF Contractor	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025
REX (Radiation Exposure Records)	IBM DB2	Primary Radiological Exposure Monitoring System at Hanford. Internal and External Data as well as demographic data. Detailed information available through this system up to last 2 years.	All Site Employees	PNNL / Battelle	Jay MacLellan, Research Scientist Senior, Radiological and Health Technologies, PNNL P.O. Box 999 Richland, WA 99352 509-376-7247
RMMS (Risk Management Medical Surveillance System)	NA	Repository of data captured on the EJTA. Contains additional tables and queries related to the EJTA / HOHP process. Potential Exposure Hazards, Work Location, Job Type.	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025
RTW (Return to Work)	NA	Return to Work Medical Events (RTW Date, Date Condition Began, Diagnosis)	All Site Employees	HEHF	Barbara J. Caldwell, Data Administrator/Systems Analyst P.O. Box 100 H1-54 Richland, WA 99352 509-376-6025

Exhibit 12.5 (continued): Hanford Data System Details (Demographic and Exposure Data Systems Combined)

System Name	Database Format	Uses / Fields	Covers Who	Company Responsible	Contact
STREAM	NA	The system is described as a comprehensive database incorporating vital data required in the performance of D&D.	BHI (D&D workers at 105-C Reactor)	BHI	NA
TRI (Training Records Information System)	NA	Employee Training Information (What training, When Trained), Data fed into ACES.	All Site Employees	FDH	Office of Training
TWINS2	NA	An on-line interface system that queries various tank characterization databases.	TWRS workforce (limited)	PNNL	NA

NA=Not Available

Exhibit 12.6: Hanford Occupational Radiation Exposure Summary Data 1986 through 1997 in Order of Decreasing Exposure Risk

Site	Occupation	Rank	Exposure Risk	Total Number Monitored	Number with Meas. Dose	% with Measurable Dose	Total Collective Dose (TEDE)	Average Meas. Dose (TEDE)	DDE Photon	DDE Neutron	SDE-WB (Skin)	SDE-ME (Extremity)
HANFORD SITE	Technicians	1	78.28	2,924	1,134	38.78%	228,877	202	275,449	12,075	344,133	1,241,988
HANFORD SITE	Handlers/Laborers/Helpers	2	77.44	2,485	966	38.87%	192,440	199	231,765	3,720	285,537	547,262
HANFORD SITE	Radiation Monitors/Techs.	3	68.08	4,838	2,517	52.03%	329,372	131	481,802	74,453	608,300	870,802
HANFORD SITE	Operators, Plant/ System/Utili	4	67.89	9,083	4,198	46.22%	616,634	147	837,625	249,867	1,016,001	1,597,134
HANFORD SITE	Misc. Repair/Construction	5	52.24	3,316	1,161	35.01%	173,217	149	739,168	7,339	826,724	540,893
HANFORD SITE	Pipe Fitter	6	47.11	3,237	1,107	34.20%	152,487	138	707,822	18,521	776,191	481,192
HANFORD SITE	Science Technicians	7	43.21	2,551	1,127	44.18%	110,233	98	108,144	21,925	143,316	752,956
HANFORD SITE	Sheet Metal Workers	8	39.96	728	216	29.67%	29,092	135	53,829	2,919	60,154	67,860
HANFORD SITE	Mechanics/Repairers	9	39.18	1,830	505	27.60%	71,704	142	174,190	14,325	214,558	292,728
HANFORD SITE	Electricians	10	27.71	3,820	1,182	30.94%	105,860	90	202,997	43,477	248,601	293,832
HANFORD SITE	Engineering Technicians	11	24.52	2,819	606	21.50%	69,109	114	157,963	48,176	171,621	162,464
HANFORD SITE	Painters	12	20.64	893	269	30.12%	18,430	69	26,483	5,385	33,619	27,829
HANFORD SITE	Carpenters	13	20.32	1,045	307	29.38%	21,236	69	88,497	1,237	98,910	44,376
HANFORD SITE	Misc. Precision/Production	14	20.00	30	8	26.67%	600	75	570	40	834	3,180
HANFORD SITE	Health Technicians	15	18.97	78	15	19.23%	1,480	99	1,480	90	3,296	5,548
HANFORD SITE	Misc. Technicians	16	12.93	3,964	814	20.53%	51,258	63	90,595	24,700	108,391	108,906
HANFORD SITE	Misc. Professional	17	12.63	3,926	845	21.52%	49,589	59	42,762	8,830	55,688	208,279
HANFORD SITE	Machinists	18	12.14	502	118	23.51%	6,093	52	11,945	1,350	23,803	25,735

Collective TEDE = person-mrem
Average Measurable TEDE = mrem
Exposure Risk = Collective TEDE/Total Number Monitored (mrem)

Exhibit 12.6: Hanford Occupational Radiation Exposure Summary Data 1986 through 1997 In Order of Decreasing Exposure Risk

Site	Occupation	Rank	Exposure Risk	Total Number Monitored	Number with Meas. Dose	% with Measurable Dose	Total Collective Dose (TEDE)	Average Meas. Dose (TEDE)	DDE Photon	DDE Neutron	SDE-WB (Skin)	SDE-ME (Extremity)
HANFORD SITE	Janitors	19	11.71	1,321	243	18.40%	15,474	64	13,312	2,686	16,124	33,822
HANFORD SITE	Security Guards	20	11.58	4,063	1,130	27.81%	47,062	42	44,572	34,848	54,214	78,306
HANFORD SITE	Misc. Sercive	21	10.67	900	192	21.33%	9,604	50	10,728	2,556	13,739	33,915
HANFORD SITE	Health Physicist	22	9.86	637	125	19.62%	6,284	50	9,356	798	12,660	14,603
HANFORD SITE	Scientist	23	9.45	7,800	1,680	21.54%	73,715	44	75,375	16,756	99,647	346,614
HANFORD SITE	Masons	24	9.36	86	22	25.58%	805	37	1,955	100	2,602	1,225
HANFORD SITE	Equipment Operators	25	8.29	1,161	239	20.59%	9,629	40	14,975	591	23,320	39,298
HANFORD SITE	Admin. Support and Clerical Se	26	7.82	5,191	806	15.53%	40,569	50	33,410	17,863	42,702	81,783
HANFORD SITE	Welders and Solderers	27	7.77	409	70	17.11%	3,179	45	24,139	934	26,383	6,710
HANFORD SITE	Manager - Administrator	28	7.48	25,419	3,997	15.72%	190,016	48	289,145	87,906	338,653	280,427
HANFORD SITE	Miscellaneous	29	6.48	2,736	360	13.16%	17,732	49	15,979	1,742	21,919	83,865
HANFORD SITE	Engineer	30	5.77	17,168	2,497	14.54%	99,039	40	200,695	54,634	236,393	162,290
HANFORD SITE	Truck Drivers	31	3.80	2,146	315	14.68%	8,165	26	15,236	1,569	23,491	16,338
HANFORD SITE	Firefighters	32	3.47	967	161	16.65%	3,352	21	4,723	2,059	6,374	4,833
HANFORD SITE	Misc. Transport	33	3.21	229	29	12.66%	735	25	1,595	0	2,546	1,275
HANFORD SITE	Doctors and Nurses	34	1.90	478	48	10.04%	910	19	6,830	570	8,586	1,096
HANFORD SITE	Bus Drivers	35	1.61	80	7	8.75%	129	18	199	50	281	311
HANFORD SITE	Machine Setup/Operators	36	1.33	12	1	8.33%	16	16	26	0	37	27

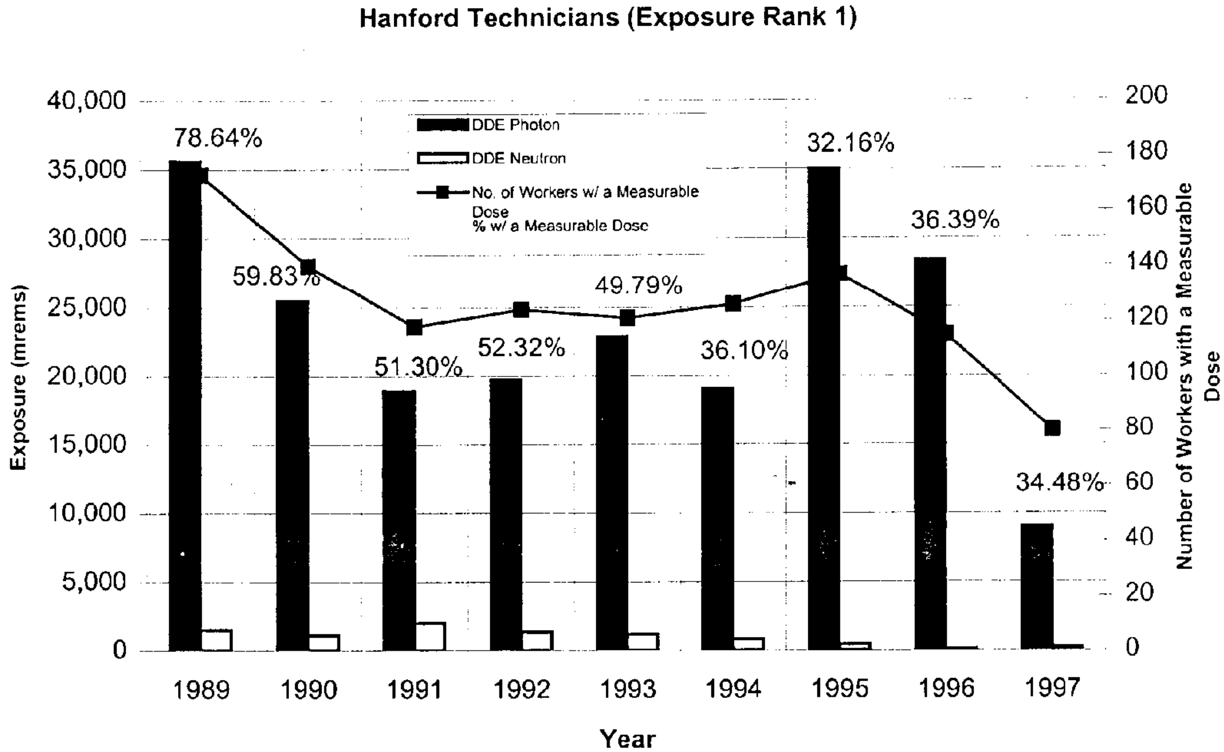
Collective TEDE = person-mrem
Average Measurable TEDE = mrem
Exposure Risk = Collective TEDE/Total Number Monitored (mrem)

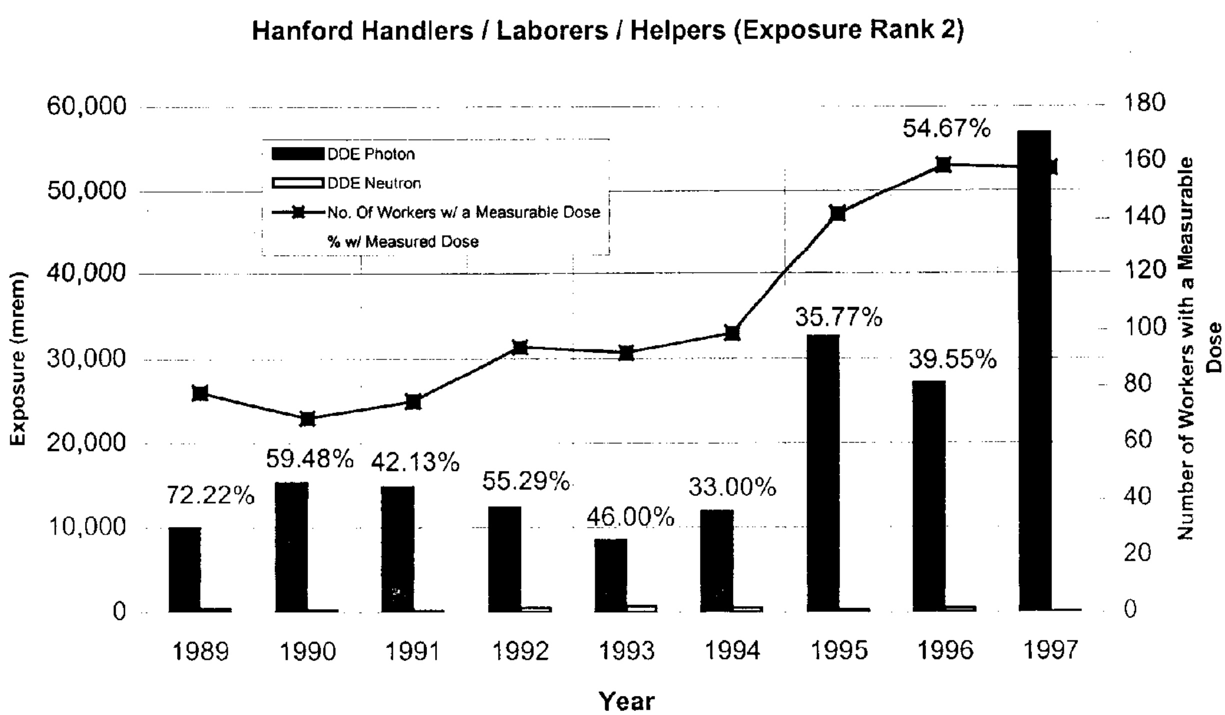
Exhibit 12.6: Hanford Occupational Radiation Exposure Summary Data 1986 through 1997 In Order of Decreasing Exposure Risk

Site	Occupation	Rank	Exposure Risk	Total Number Monitored	Number with Meas. Dose	% with Measurable Dose	Total Collective Dose (TEDE)	Average Meas. Dose (TEDE)	DDE Photon	DDE Neutron	SDE-WB (Skin)	SDE-ME (Extremity)
HANFORD SITE	Unknown	37	1.06	6,967	137	1.97%	7,400	54	20,435	1,210	20,829	29,089
HANFORD SITE	Miners/Drillers	38	1.03	29	2	6.90%	30	15	40	30	238	228
HANFORD SITE	Food Service Employees	39	0.00	1	0	0.00%	0	0	10	0	10	0
HANFORD SITE	Groundskeepers	40	0.00	2	0	0.00%	0	0	0	0	10	10
HANFORD SITE	Sales	41	0.00	4	0	0.00%	0	0	0	0	0	0

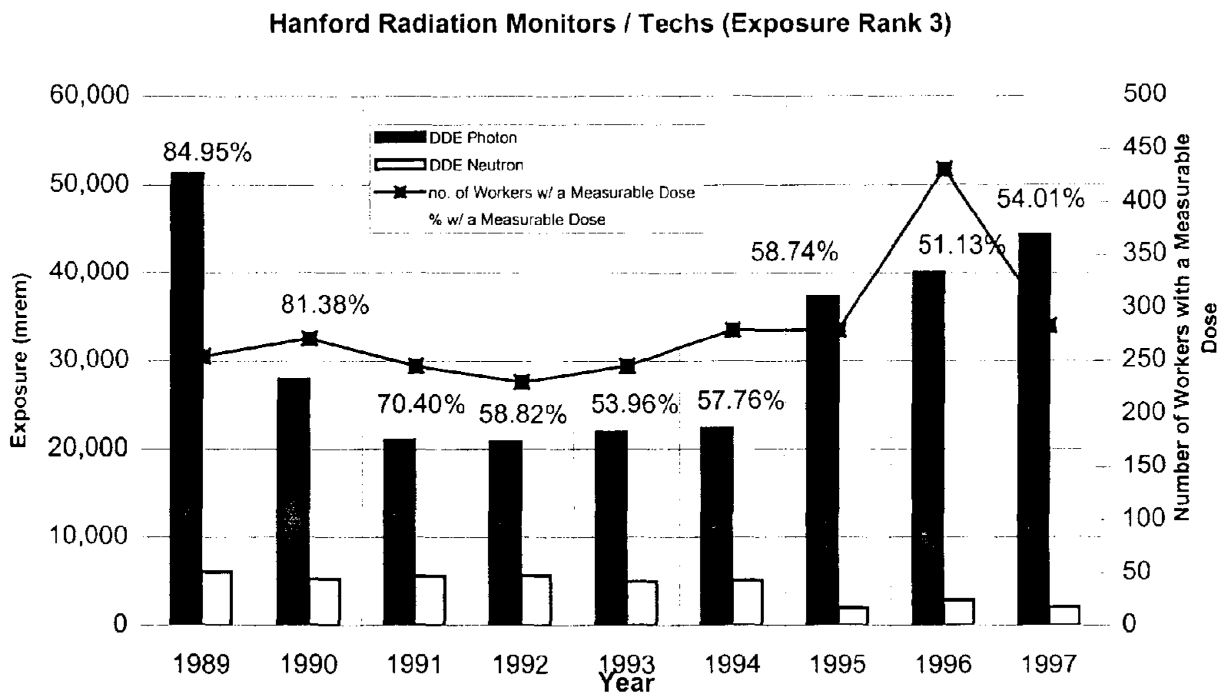
Collective TEDE = person-mrem
Average Measurable TEDE = mrem
Exposure Risk = Collective TEDE/Total Number Monitored (mrem)

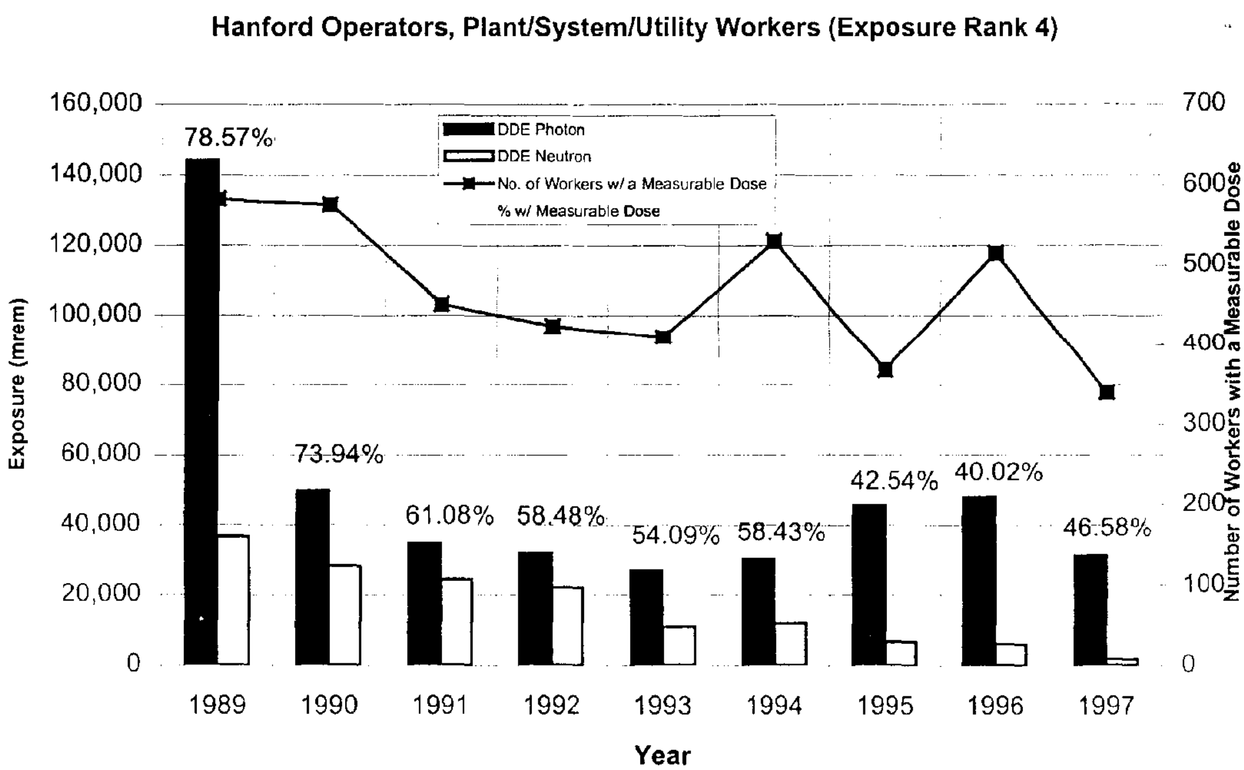
12.7 A: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Technicians and Handlers / Laborers / Helpers



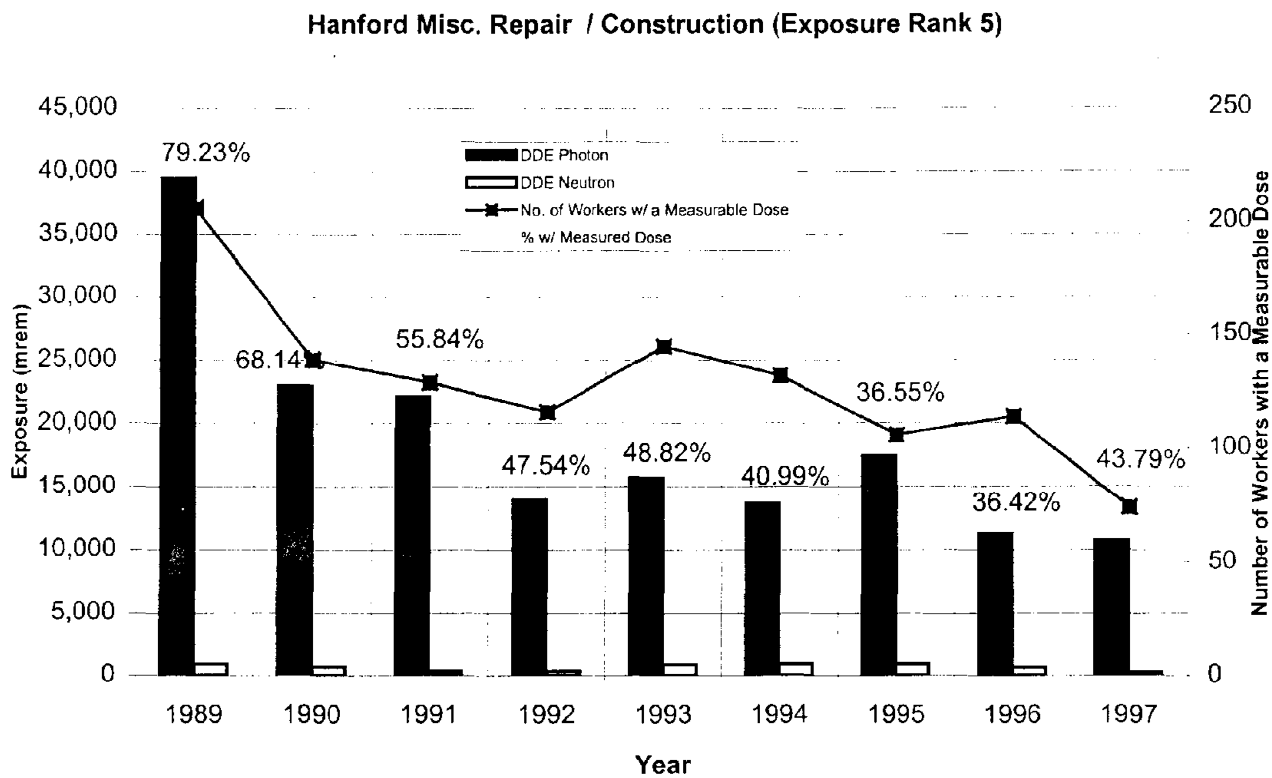


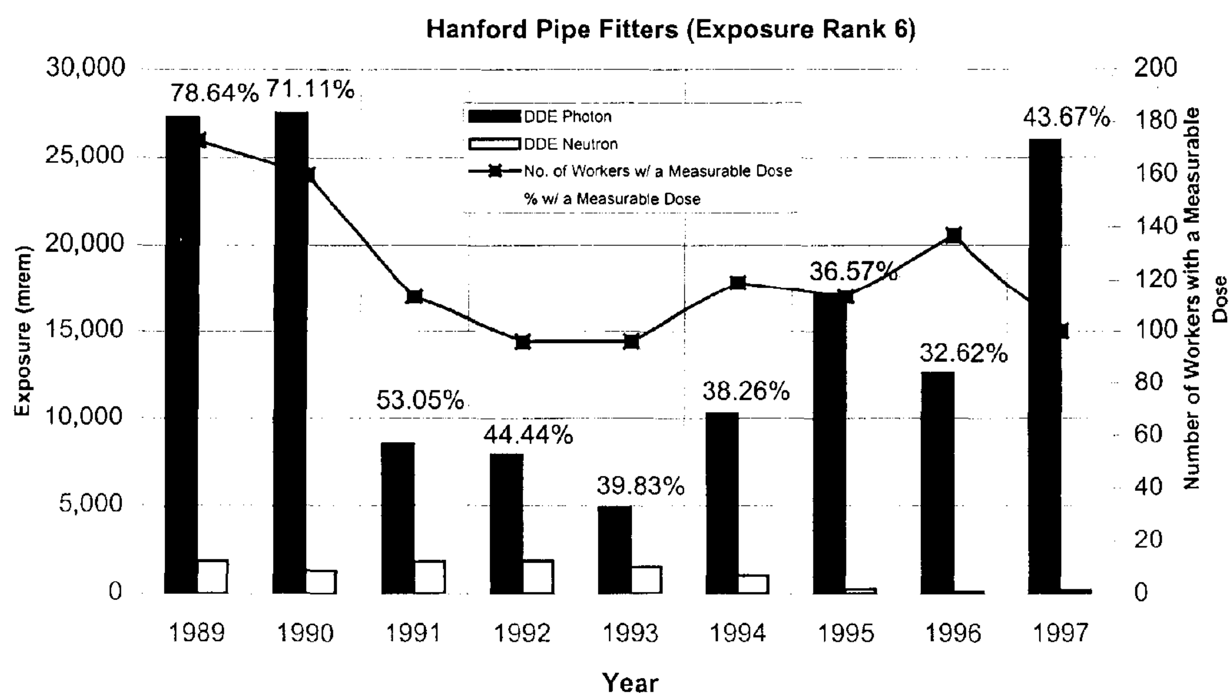
12.7 B: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Radiation Monitors / Techs and Hanford Operators, Plant/System/Utility Workers



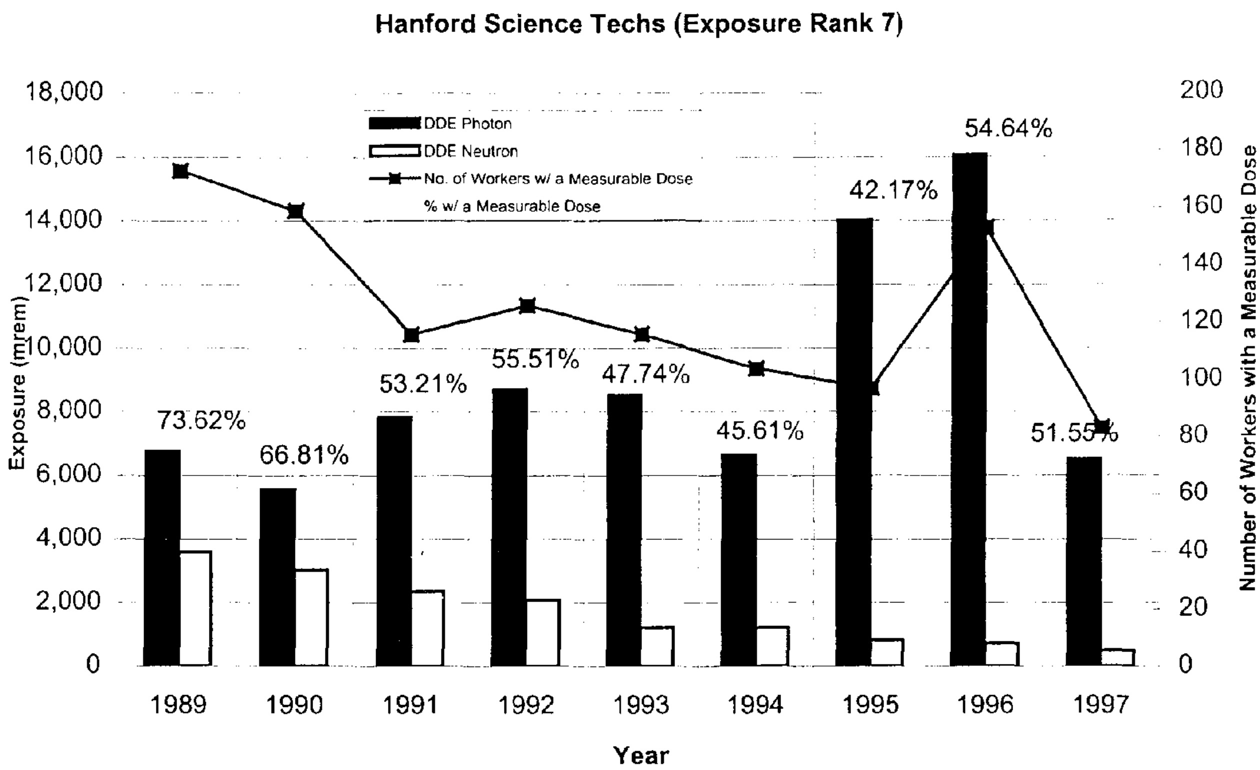


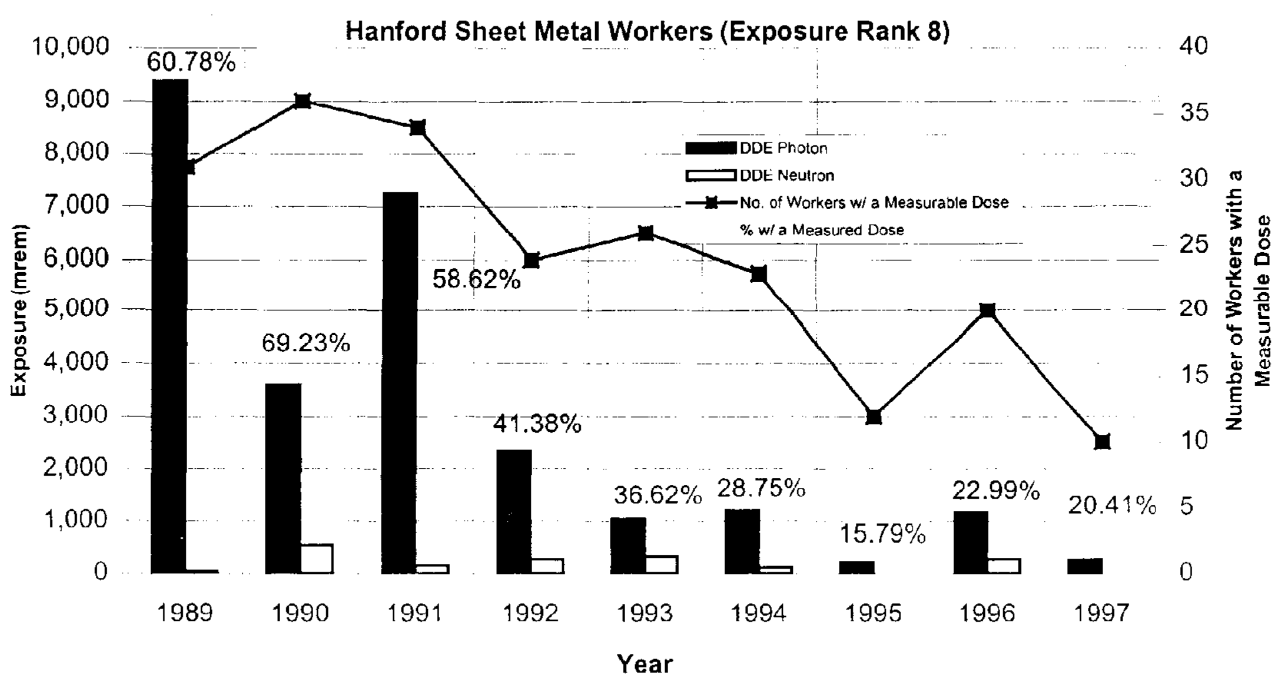
12.7 C: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Misc. Repair / Construction and Hanford Pipe Fitters



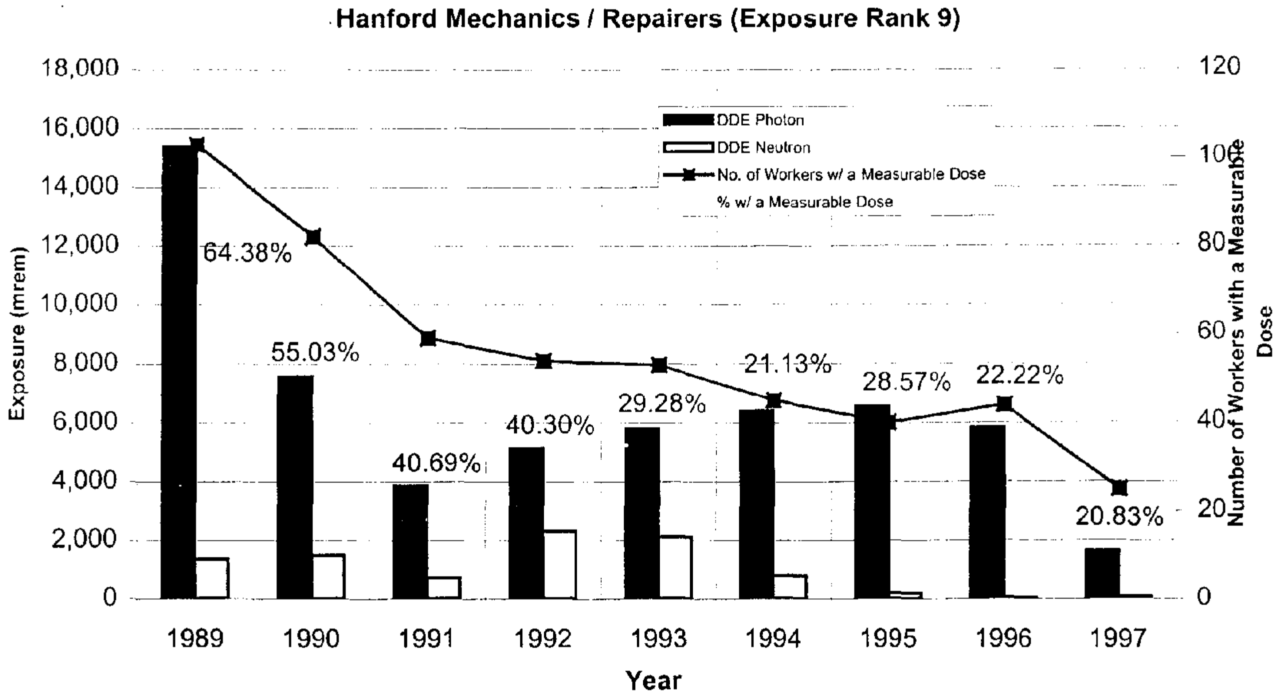


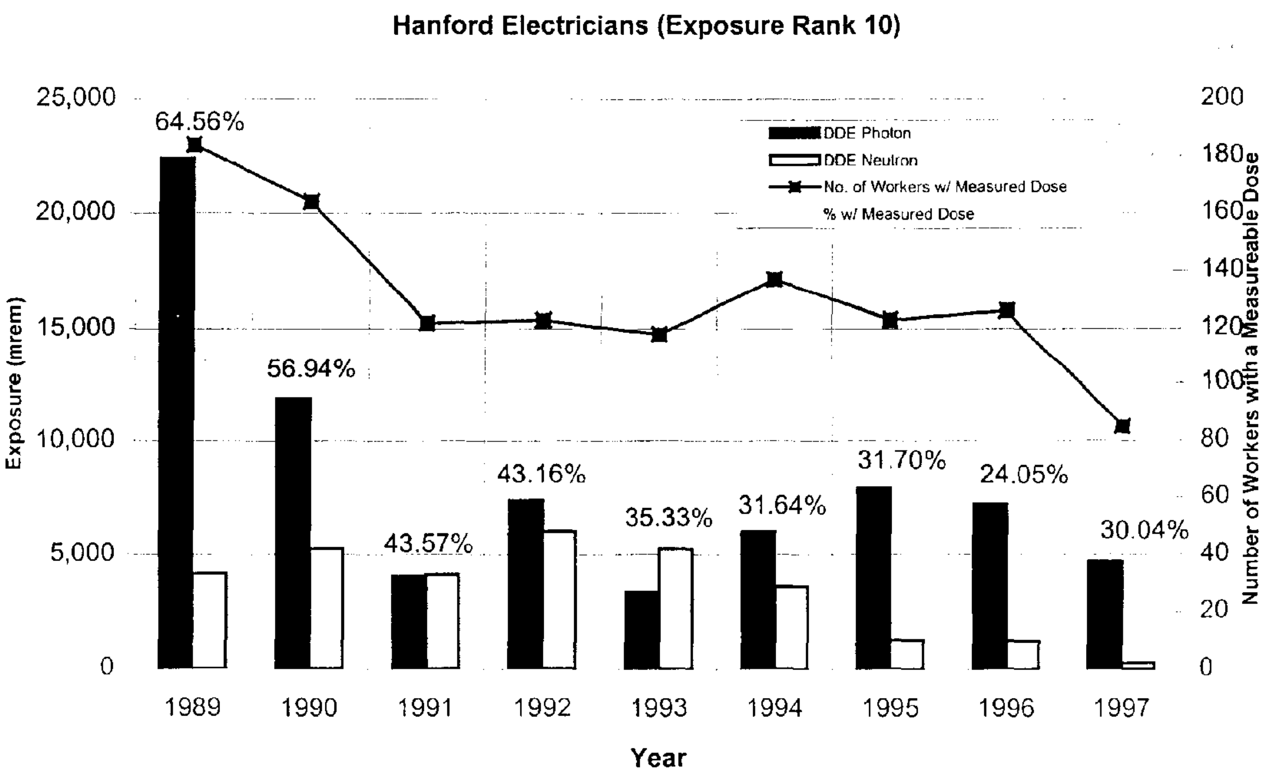
12.7 D: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Science Techs and Hanford Sheet Metal Workers



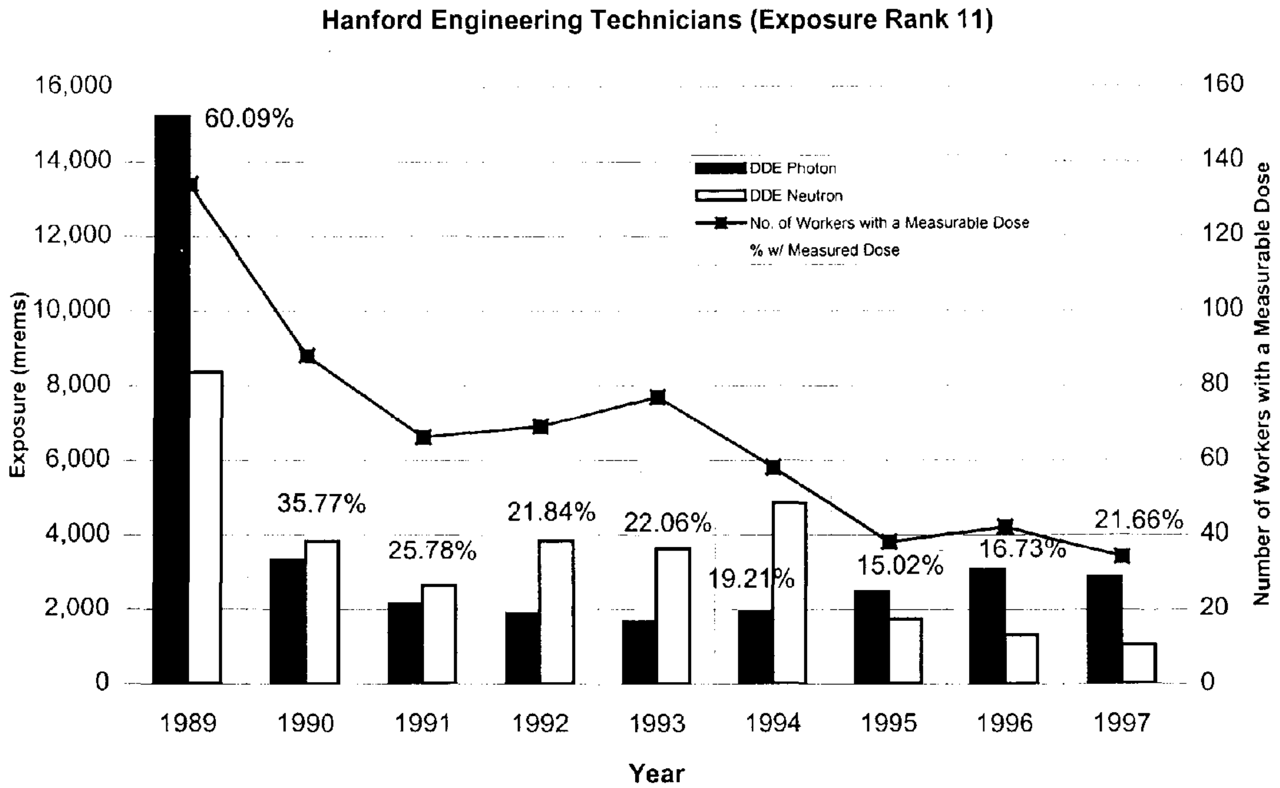


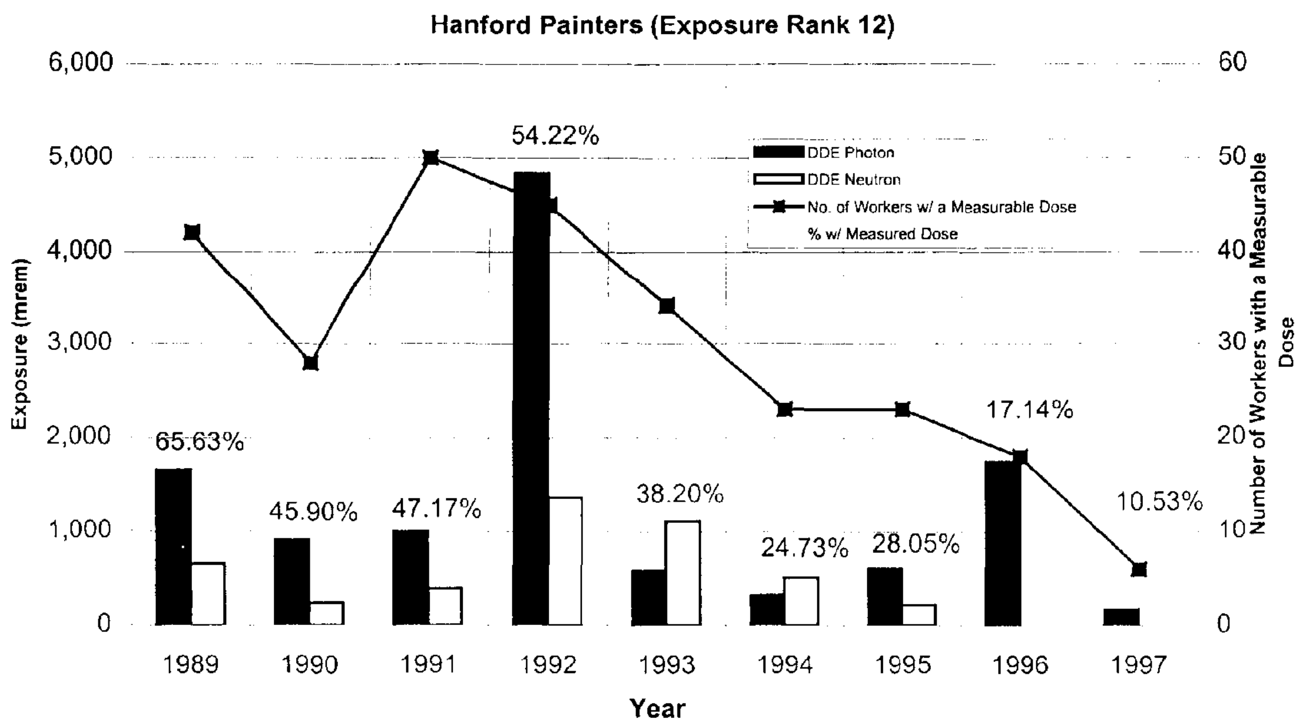
12.7 E: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Mechanics / Repairers and Electricians



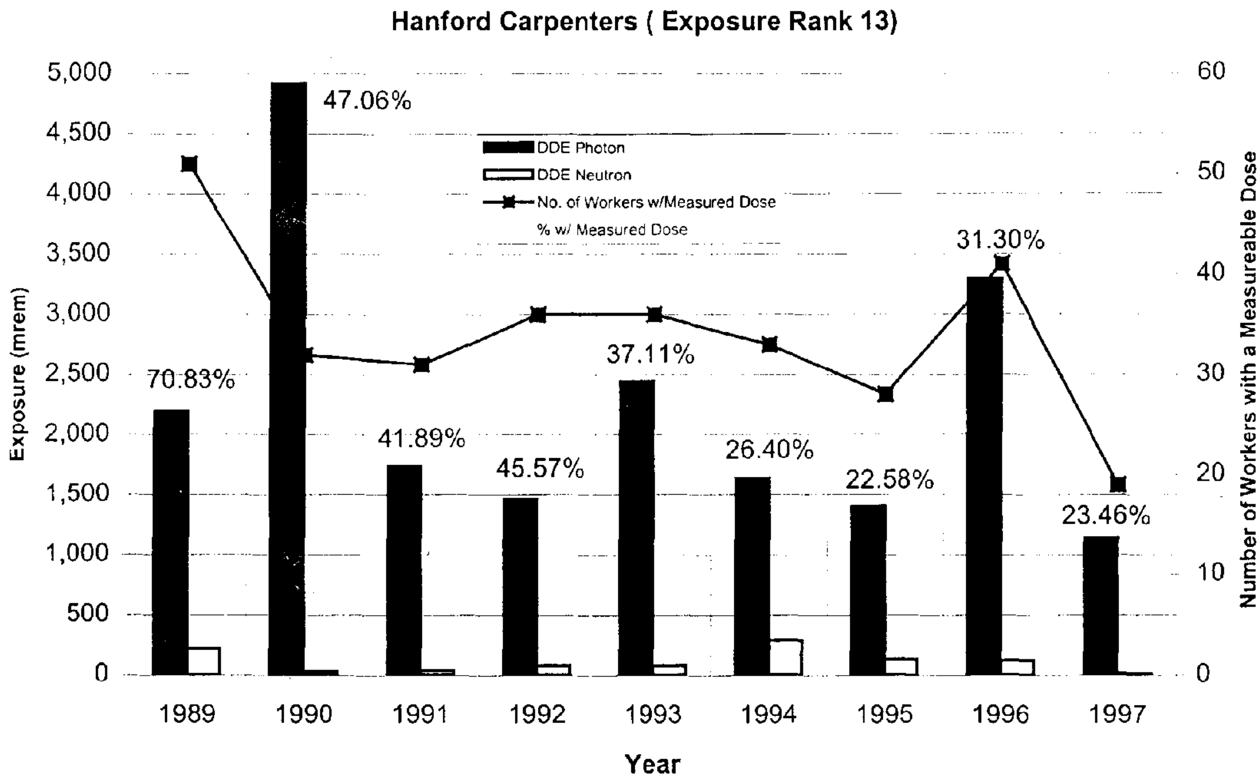


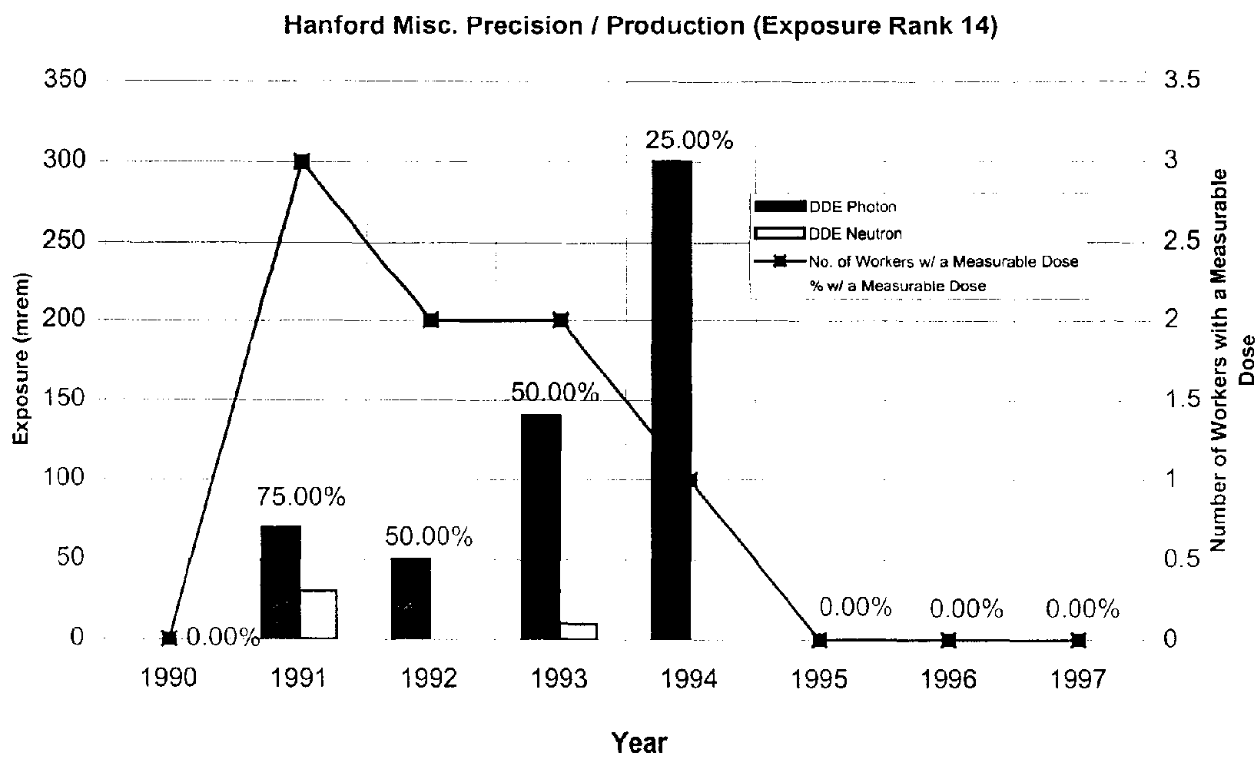
12.7 F: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Engineering Technicians and Hanford Painters



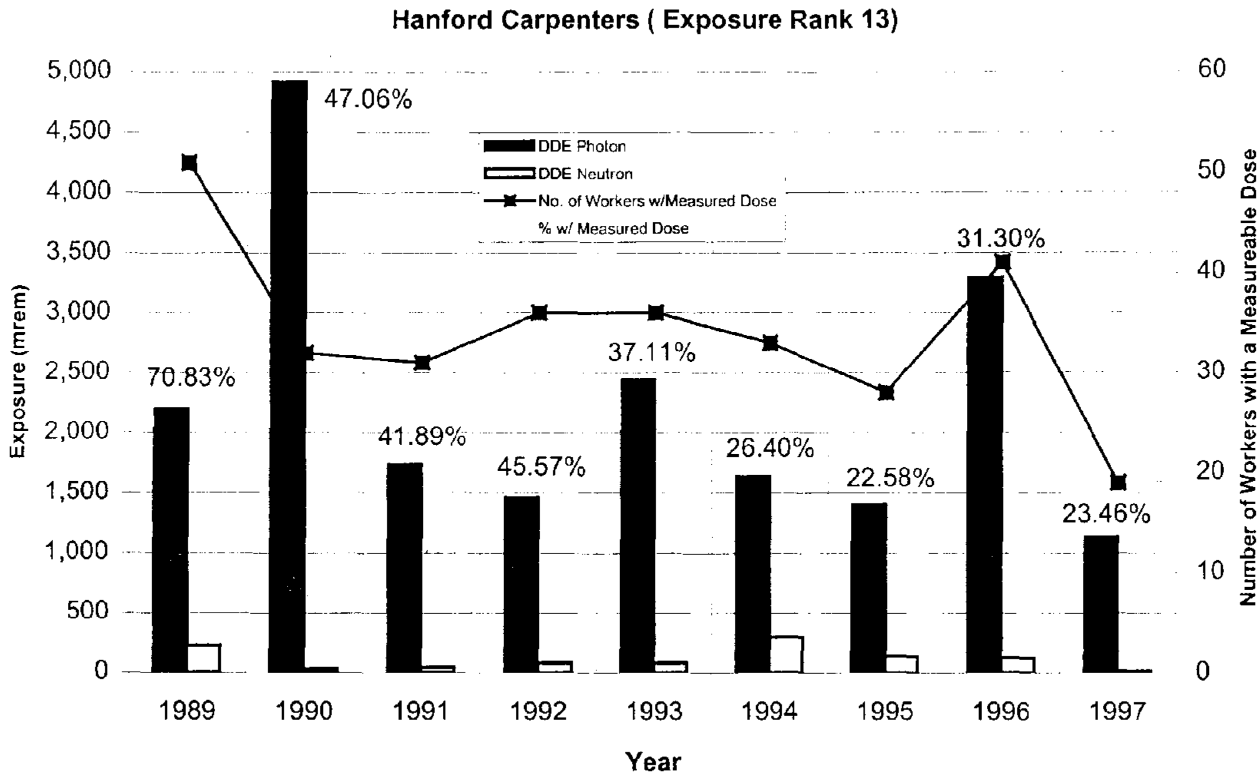


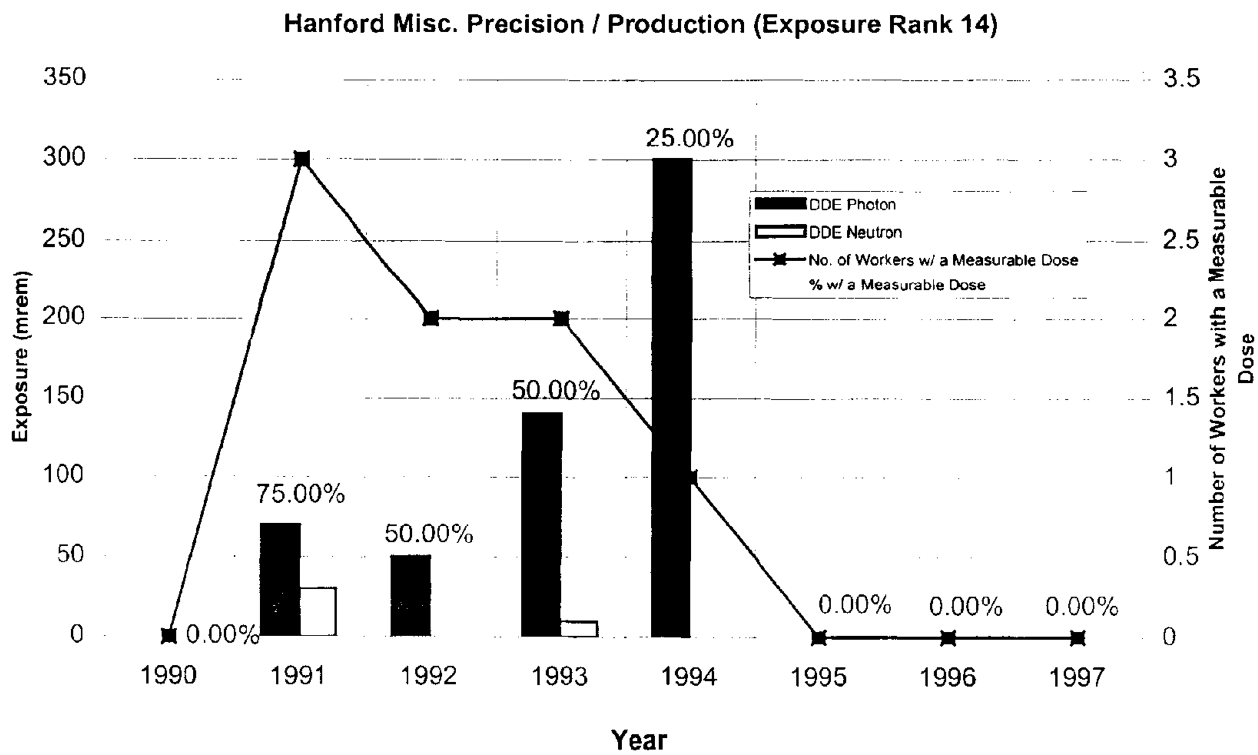
12.7 G: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Carpenters and Hanford Misc. Precision / Production





12.7 G: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Carpenters and Hanford Misc. Precision / Production





12. 7 H: Summary Deep Dose Equivalent (DDE) Exposure Data 1989 to 1997 for Hanford Health Technicians

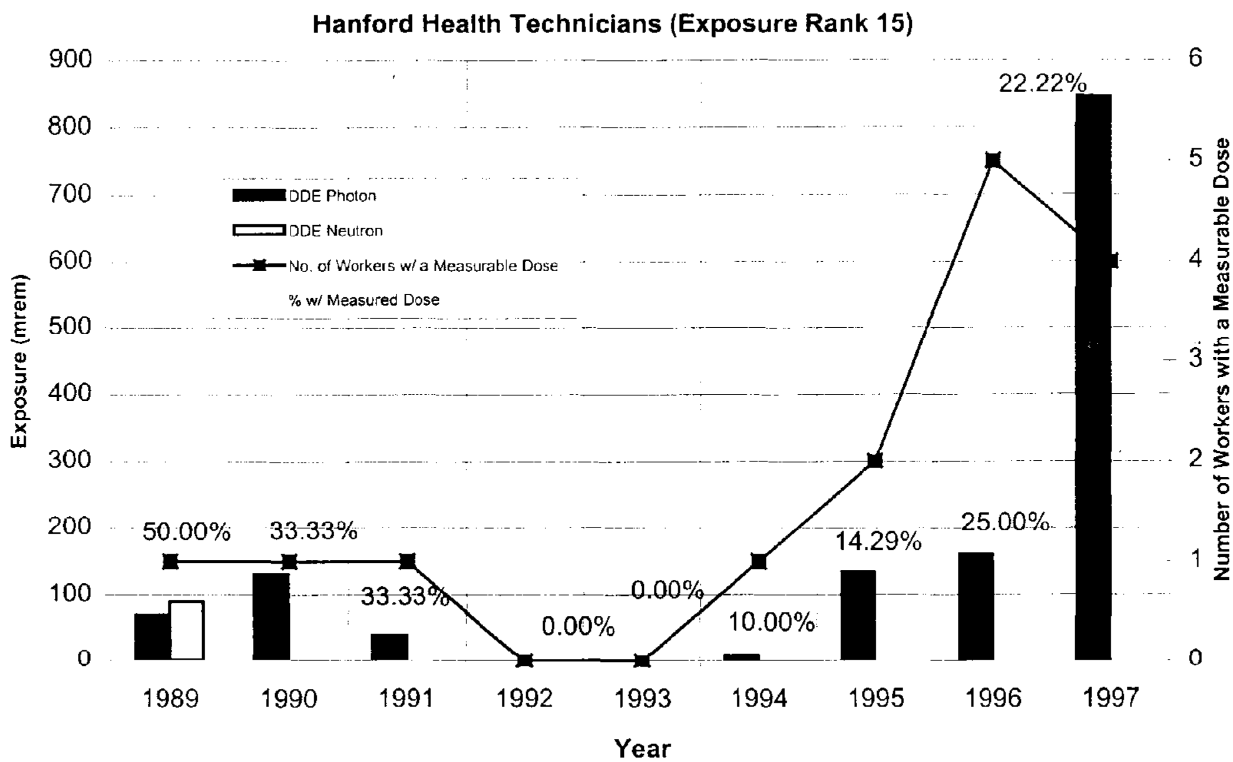


Exhibit 12.8: BHI Industrial Hygiene Exposure Data [101]

(Note: Notations refer to the Project / Area / Room / Date / and Time Weighted Average (TWA))

Asbestos Insulation Removal

1. Glove bag, 190C/S. Mezzanine (10/96)
   *TWA's-0.02, 0.03, 0.02 f/cc
2. Glove bag, 100N/182/N Control Room (11/94)
   *TWA's-0.74, 2.7 f/cc
3. Enclosure, 200W/2719WA (2/97)
   *TWA's-0.17, 0.23, 0.15 f/cc
4. Enclosure, 100N/109N Acid Tanks (9/96)
   *TWA's-1.2, 1.2, 0.95, 1.2, 1.5, 2.4 f/cc
   *Inside change room-0.02, 0.02 f/cc
   *Outside containment (13 samples)-<0.01 f/cc

Transite Removal

1. Outdoor, 200W/2720 (5/97)
   *STEL's-0.07, 0.05, 0.04, 0.06 f/cc
   *TWA's-0.01, 0.03, 0.04, 0.02 f/cc
2. Indoor, 300/3702 (4/96)
   *STEL's-0.14, 0.12, 0.27 f/cc
   *TWA's-0.1 f/cc (occluded with dust)

Lead Coatings

1. Torch cutting, paint intact (100C/190C, 1/97)
   *Highest measurement-7 *u*g/m3
   *TWA-2 *u*g/m3
2. Torch cutting, paint removed (100N/105N, 3/97)
   *Highest measurement-3,600 *u*g/m3
   *TWA's-288, 1,243 *u*g/m3

Handling of Metallic Lead

1. Lead bricks (100C/, 6/97)
   *Highest measurement-100, 170 *u*g/m3
   *TWA's-19, 32 *u*g/m3
2. Removing lead shot (100C/105C, 7/96)
   *TWA's (unventilated chute)-87, 78, 85, 30 *u*g/m3
   *TWA's (ventilated chute)-15, 18 *u*g/m3

Exhibit 12.8 (Continued): BHI Industrial Hygiene Exposure Data [101]

(Note: Notations refer to the Project / Area / Room / Date / and Time Weighted Average (TWA))

Mercury

1. Trench clean out, 100C/105C (5/96)
   *TWA's-0.062m, 0.033, 0.017, 0.026, <0.003 mg/m3

2. Asbestos removal, tunnels 100C/105C (12/96)
   *TWA's-<0.012 mg/m3
   *Colorimetric badges

Quartz

1. ERDF truck driver, ERDF (3/97)
   *TWA-<0.045 mg/m3
2. Scabbing of concrete, 300/313 (9/97)
   *TWA's-0.04, 0.03, <0.01 mg/m3

Organic Vapors

1. Applying spray adhesive, 100C/105C 94/97)
   *n-Hexane (TWA's)-8, 56, 11, 47 82 ppm
2. Scabbing concrete, 300/313 (9/97)
   *Butanol (SUMA) - 15 ppm
   *Butanol (instrument readings) - 1 to 20 ppm
3. Soil remediation, North Slope (7/97)
   *Di-Methyl Amine (TWA's) - <0.6 ppm

Exhibit 12.9: Possible Beryllium Facilities at the Hanford Site

Building Number	Facility Name	Status
MSL-5	Uplands Office Lab	In Use
RTL-520	Research Test Lab	In Use
100-DR	(Demolished)	Gone
202-S	Redox Canyon / Service Facility	Vacant
209-E	Tank Farm Waste Support	In Use
222-T	Office and Admin. Building	Vacant
231-Z	Materials Engineering Lab	Vacant
234-5Z	Plutonium Fabrication Facility	In Use
241-A	A Tank Farm	In Use
271-B	B Plant Support Building	NA
272-AW	Tool Crib Only	In Use
272-WA	Tool Crib Only	In Use
272-W	Machine Shop Building	In Use
303-F	Hazardous Waste Storage	Vacant
303-J	Material Storage Building	Vacant
303-K	Hazardous Waste Storage	Vacant
304	Conc. Storage Area	Vacant
305-B	Hazardous Waste Storage	In Use
306	Metal Fabrication Building	Divided
306-W	Fuels Development Building	In Use
306-E	Fuels Development Building	In Use
308	Fuels Development Building	In Use
309	Sp-100 GES Test Facility	Vacant
311TF	Tank Farm	NA
313	Fuels Manufacturing Building	In Use
314	Engineering Fuel Development Lab	Vacant
318	Radiation Calibration Lab	In Use

Exhibit 12.9 (Continued): Possible Beryllium Facilities at the Hanford Site

Building Number	Facility Name	Status
324	Chemical Engineering Building	In Use
325	Radio Chemical Building	In Use
326	Physics and Metal Building	In Use
327	Radiometallurgy Building	In Use
328	Plant Operations Building	In Use
329	Chemical Science Building	In Use
331	Life Science Building	In Use
333	Nuclear Fuels Manufacturing Building	Vacant
1154	Radio Maintenance Shop	In Use
1706-KE	Waste Studies Semiworks	In Use
1713-F	(Demolished)	Gone
2101-HV	Tool Crib Only	In Use
2714-W	Laundering Area / Pond	Gone
3708	Radio Analytical Lab	Vacant
3712	Special Fuels Storage	Vacant
3716	Storage Building	In Use
3718	Office and Storage Building	In Use
3720	Material and Environmental Science Lab	In Use
3731-A	Graphite Machine Shop	Vacant
3745-B	Positive Ion Accelerator	Vacant
3751-A	(Demolished)	Gone
EDL	Lab	In Use
PSL	Lab	In Use
6th St. Warehouse	6th St. Warehouse	In Use
1234/36/50/52	JA Jones Warehouse	In Use
2400	2400 Stevens	In Use

Note: These facilities will apply to all Hanford employees, not just the Remediation Worker. [104]

Exhibit 12.10: DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
100 BC	100-BC-1	52	Aluminum Sulfate, Asbestos, Boron, Cadmium, Calcium Oxide, Carbon-steel, Chlorine, Chromium, Lead, Lead Acid in Batteries, Mercury, Paint Waste, Sodium Dichromate, Solvents, Sulfuric Acid	Americium-241, Calcium-41, Carbon-14, Cobalt-60, Cesium-137/234, Chromium-51, Europium-152/153/154/155, Nickel-63, Plutonium-238/239/240, Sanitary Sewage, Strontium-90, Tritium, Uranium, Uranium-238, Zinc-65
100 BC	100-BC-2	27	Aluminum, Aluminum Sulfate, Asbestos, Calcium Oxide, Chemical Solvents, Chlorine, Hydraulic Oil, Lead, Lithium-Aluminum alloy, Mercury, Nitric Acid, Paint Waste, Palladium, Petroleum, Sodium Sulfamate, Sodium Dichromate, Sodium Hydroxide, Sodium Oxalate, Sulfuric Acid	Americium-241, Calcium-41, Carbon-14, Cesium-137, Chromium-51, Cobalt-60, Europium-152/154/155, Nickel-63, Plutonium-152/238/239/240, Sanitary Sewage, Strontium-90, Tritium, Zinc-65
100 D/DR	100-DR-1	62	Aluminum Sulfate, Asbestos, Calcium Oxide, Chlorine, Chemical Decontamination Wastes and Solvents, Lead, Leaded Gasoline, Mercury, Paint Waste, PCBs, Potassium Borate, Sludge, Sulfuric Acid, Sodium Dichromate, Sodium Oxylate, Sodium Sulfate	Carbon-14, Cesium-134/137, Cobalt-60, Europium-152/154/155, Manganese-54, Nickel-63, Plutonium-238/239/240, Sanitary Sewage, Strontium-90, Tritium, Uranium
100 D/DR	100-DR-2	36	Asbestos, Aluminum, Cadmium, Chemical Solvents, Decontamination Chemicals, Engine Coolant, Gandolium Nitrate, Gasoline, Lead, Lithium, Oxalic Acid, Paint Waste, PCBs, Potassium Borate, Sludge, Sodium, Sodium Dichromate, Sodium Fluoride, Sodium-Potassium Alloy, Sulfuric Acid	Cobalt-60, Manganese-54, Sanitary Sewage
100 F	100-FR-1	53	Aluminum Sulfate, Asbestos, Cadmium, Calcium Oxide, Chlorine, Chromic Acid, Citric Acid, Lead, Mercury, Nitric Acid, Oxalic Acid, Sodium Oxylate, Sodium Sulfamate, Sulfamic Acid, Sulfuric Acid, Sodium Dichromate, Sodium Fluoride	Carbon-14, Calcium-41, Cesium-137, Chromium-51, Cobalt-60, Europium-152/154/155, Iodine-131, Nickel-63, Plutonium-238/239/240, Radium-226, Sanitary Sewage, Strontium-90, Tritium, Uranium-234/235/238, Zinc-65
100 F	100-FR-2	20	Cadmium, Chemical Solvents, Hydrochloric Acid, Lead, Nitric Acid, Paint Waste, Silica Gel, Sulfuric Acid	Cesium-137, Plutonium-238/239, Sanitary Sewage, Strontium-90
100 H	100-HR-1	32	Aluminum, Aluminum Sulfate, Calcium Oxide, Chlorine, Copper, Hydrofluoric Acid, Manganese, Nitric Acid, Oxalic Acid, PCBs, Silicon, Sodium Fluoride, Sodium Dichromate, Sulfuric Acid	Calcium-41, Carbon-14, Cesium-134/137, Chromium-51, Cobalt-60, Europium-152/154/155, Nickel-63, Plutonium-239/240, Sanitary Sewage, Strontium-90, Tritium, Uranium-235/238, Zinc-65

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
100 H	100-HR-2	17	Chemical Solvents, Coal Ash, Paint Waste, Sodium Chloride	Carbon-14, Cesium-137, Cobalt-60, Tritium, Europium-152/154, Plutonium-239/240, Sanitary Sewage, Strontium-90
100 K	100-KR-1	8	Clean-out Slurry, Process Waste	Low Level Radionuclides (in soil around trenches)
100 K	100-KR-2	86	Acidic/Caustic Solutions, Aluminum Oxide, Aluminum Sulfate, Aluminum, Arsenic, Asbestos, Barium, Brine Waste, Cadmium, Calcium Oxide, Chemical Solvents, Chloride, Chlorine, Chromium, Dry Bauxite, Ethylene Glycol, Gasoline, Inorganic and Organic Lab Waste, Lead, Paint Waste, Potassium, Selenium, Sludge, Silver, Sodium, Sodium Dichromate, Sodium Silicate, Sodium Hydroxide, Sulfuric Acid, Zirconium Alloy	Carbon-14, Cesium-134/137, Cobalt-60, Europium-152/154/155, Nickel-63, Plutonium 239/240, Plutonium, Sanitary Sewage, Solid Radioactive Waste, Strontium-90, Tritium, Uranium
100 N	100-NR-1	88	Acidic/Caustic Solutions, Aluminum Sulfate, Aluminum, Ammonia, Asbestos, Calcium, Calcium Oxide, Chloride, Chlorine, Chromium, Copper, Diesel Fuel, Diethylthiourea, Fluoride, Hydrazine, Hydrogen Peroxide, Lead, Mineral Oil, Morpholine, Neutralized Waste, Nickel, Petroleum, Phosphoric Acid, Polyacrylamide, PCBs, Process Chemicals, Separan, Sodium Dichromate, Sodium Hydroxide, Sulfuric Acid, Total Petroleum Hydrocarbons, Volatile Organic Compounds, Zinc	Antimony-124/125, Barium-140, Cerium-141/144, Cesium-134/137, Chromium-51, Cobalt-58/60, Iodine-131, Iron-59, Manganese-54/56, Neptunium-239, Niobium-95, Phosphorus-32, Plutonium-238/239/240, Ruthenium-103/106, Sanitary Sewage, Sodium-24, Strontium-89/90, Technetium-99, Tellurium-132, Tritium, Xenon-133, Zinc-65, Zirconium-95
200	200-BP-1	1	Solid Waste (RCRA Site)	None
200	200-BP-2	1	None	None
200	200-BP-6	21	Acidic/Caustic Solutions, Asbestos, Calcium Silicate, Chemical Solvents, Cleaning Agents, Fiberglass, Halogenated Hydrocarbons, Mercury, Monosodium Phosphate, Nitric Acid, PCBs, Silicate, Sodium Carbonate, Sodium Hydroxide, Sulfuric Acid	Americium-241, Cesium-137, Cobalt-60, Plutonium-239, Strontium-90

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-BP-7	83	Asbestos, Bismuth Phosphate, Caustic Flush Water, Decontamination Wastes, Ferrocyanide, First/Second Cycle Waste, Ion Exchange Waste, Lanthanum Fluoride, Lead, Non-Complexed Waste, Organic Wash Waste, PUREX Coating Waste, REDOX Waste, Sludge, Tributyl Phosphate, Magnesium Zincfluorosilicate Wash	Cesium-137, Fissile Material, High Level Waste, Low Level Wastes, Plutonium, Sanitary Sewage, Stronium-89/90, Uranium, Ytterbium-90
200	200-BP-8	1	Solid Waste (RCRA Site)	None
200	200-BP-9	1	Vitrification Process Waste (liquid waste)	Vitrification Process Waste (liquid waste)
200	200-BP-10	1	None	None
200	200-BP-11	5	Ammonia, Carbon Tetrachloride, Purged Groundwater, Inorganic Constituents, Volatile/ Semi-volatile Organic Constituents, Spent Halogenated and Non-halogenated Solvents	Unknown Radionuclides
200	200-CS-1	7	Acid Fractionator Condensate, Chemical Sewer Waste, Sodium Hydroxide, Sodium Nitrite	Radioactive Waste Liquids (activity level unknown), Laundry Wastewater
200	200-CW-1	29	Acid Fractionator Condensate, Ammonium Flouride, Ammonium Nitrate, Cadmium, Cadmium Nitrate, Chemical Sewer Waste, Hydrazine, Potassium Hydroxide, PUREX Corrosive Waste, Nitric Acid, Sludge, Sodium Hydroxide, Sulphuric Acid	Cerium/Promethium-144, Cesium-137, Plutonium, Strontium-90, Uranium
200	200-CW-2	13	2-4-D Acid, Herbicides, Copper Sulfate, Sodium Chlorate, Solvent Naptha	Fission Products, Low Level Solid Waste, Radioactive Cooling Water
200	200-CW-3	7	Sludge	Low Level Radioactive Waste
200	200-CW-4	6	Decontamination Waste Solutions, Sludge, Sodium Hydroxide	Low Level Radioactive Waste, Plutonium
200	200-CW-5	17	Chemical Sewer Waste, Sludge	Americium, Cesium, Fission/Activation Products, Low Level Waste, Radioactive Cooling Water, Plutonium, Strontium, Transuranic Waste

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-IS-1	84	Aluminum, Aluminum Fluoride, Aluminum Nitrate, Aluminum Sulfate, Bismuth, Calcium Nitrate, Chromium, Decontamination Solutions, Dilute Lab Waste, Ferric Nitrate, Hexone, Iron, Lead, Magnesium Nitrate, Nitric Acid, Paraffin Hydrocarbons, Potassium Hydroxide, Potassium Fluoride, Sludge, Sodium, Sodium Chromate, Sodium Fluoride, Sodium Hydroxide, Sodium Nitrate, Tributyl Phosphate, Uranyl Nitrate Hexahydrate	Americium-241, Antimony, Cerium, Cesium-137, Low Level Waste, Niobium, Plutonium 138/139/238/239/240, Ruthenium, Strontium-90, Tellurium, Thorium, Uranium-234, Yttrium
200	200-LW-1	8	Decontamination Waste, Lab Waste, Nitrates	Low Level Waste, Plutonium
200	200-LW-2	17	Acetone, Acidic Lab Waste, Decontamination Solutions, Lab Hood Waste, Hydrofluoric Acid, Nitrate, Nitric Acid, Phosphate, Sodium, Sodium Dichromate, Sulfuric Acid	Fission Products, Low Level Waste, Plutonium, Transuranics
200	200-MW-1	42	Ammonium Nitrate, Calcium Chloride, Calcium Nitrate, Lab Waste, Nitrate, Nitric Acid, Sodium Chloride, Sodium Hydroxide, Soltrol, Uranium Nitrate Hexahydrate	Cesium-134, Low Level Waste, Strontium-85, Transuranic Fission Products, Uranium
200	200-NO-1	6	Mineral Oil, PCBs	Plutonium, Transuranic Waste, Tritium
200	200-PO-2	49	Acid from PUREX, Ammonia, Asbestos, Barium, Cadmium, Calcium Carbonate, Chromium, Combustible/Flammable Oil, Lead, Mercury, Nitric Acid, Potassium Hydroxide, Silica Gel, Silver, Sodium Hydroxide, Sodium Nitrite, Sulfuric Acid	Cesium-137, High Level Waste, Ruthenium-106, Strontium-90, Plutonium, Uranium
200	200-PO-3	128	Acid/Concentrator Waste from PUREX, Bismuth Phosphate, Citric Acid, Decontamination Waste, Dilute Non-complexed Waste, Double-shell Slurry, Ferrocyanide, Ion Exchange Waste, Laboratory Waste, Lead, Non-Complexed Waste, Organic Wash, Phosphate, Sludge, Sodium Aluminate, Sodium Hydroxide, Sodium Nitrate, Sump Waste, Tank Farm Condensate, Toluene, Tributyl Phosphate	Cerium-144, Cesium-134/137, Cobalt-60, High Level Waste, Low Level Waste, Neptunium, Plutonium, Ruthenium-103/106, Sanitary Sewage, Solid Radioactive Mixed Waste, Strontium-90, Uranium-223, Zirconium-95/Niobium
200	200-PO-6	2	2-Butoxyethanol, Dioxane, Hydrogen Peroxide, Isopropyl Ether, Methyl Ethyl Ketone, Phosphoric Acid, Sodium Azide	None

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-PW-1	10	Ammonium Nitrate, Carbon Tetrachloride, Nitrate, Organic Waste, Phosphate, Sodium, Solvents, Sulfate, Tributyl Phosphate	Americium, Low Level Waste, Plutonium, Transuranics, Uranium
200	200-PW-2	30	Aluminum, Ammonia Scrubber Waste, Acetone, Acid Waste-PUREX, Aluminum Nitrate, 1-Butanol, 2-Butanone, Hydrogen Fluoride, Mercury, Nitrate, Nitric Acid, Phosphoric Acid, Potassium Hydroxide, Silica Gel, Sludge, Sodium, Uranyl Nitrate Hexahydrate, Tributyl Phosphate, Uranium Trioxide	Americium-241, Cerium-144, Cesium-137, Fission Products, Mixed Waste, Cobalt-60, Europium-154, Plutonium, Strontium-90, Thorium, Uranium
200	200-PW-3	12	Hexone, Methyl Isobutyl Ketone, Nitrate, Organic Waste, Phosphate, Sodium Dichromate, Tank Condensate, Tributyl Phosphate Soltrol Organics	Beta/Gamma Activity (Contaminated piping / cement), Fission Products, Unirradiated Uranium
200	200-PW-4	16	Acidic Waste, Ammonia, Chemical Sewer Waste, Nitric Acid, Sodium, Polyvinyl Chloride	Beta/Gamma Activity (Contaminated soil), Low Level Mixed Waste, Uranium oxide
200	200-PW-5	9	Acidic Process Condensate, Ammonium Nitrate, Sodium	Beta/Gamma Activity (Contaminated Process Condensate)
200	200-PW-6	8	Laboratory Waste, Silica	Alpha/Beta/Gamma Activity (Contaminated Process Effluent), Americium-241, Cesium-137, Plutonium-238/239/240, Strontium-89/90, Uranium, Transuranic Process Waste
200	200-RO-1	5	None	Contaminated Process Effluent
200	200-RO-2	7	Aluminum Oxide, Aluminum Silicate, Asbestos, Hexone	Low Level Mixed Waste, Soil Contamination
200	200-RO-3	20	Asbestos, Hexone, Laboratory Waste, Liquid Organic Waste, Lead, Nonradioactive Dangerous Waste, Sodium Nitrate, Sodium Hydroxide	Americium, Fission Products, Low-Level Radiological Waste, Plutonium, Solid Radioactive Waste, Transuranics
200	200-RO-4	60	Ammonium Nitrate, Carbonate, Decontamination Waste, Double-Shell Slurry Feed, Laboratory Waste, Lead, Ion Exchange Waste, Nitrate, Noncomplexed Waste, Fractionization Waste, Organic Wash Waste, REDOX Coating Waste, Sodium, Sodium Aluminate, Sodium Dichromate, Sodium Hydroxide, Zirconium-Niobium	High Level Waste, Cesium-137, REDOX High-Level Waste, PUREX Low Level Radioactive Waste, Plutonium-239, Sanitary Sewage, Strontium-90, Radioactive Mixed Waste, Uranium

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-SC-1	14	Acidic/Alkali Waste, Nitrate, Sodium Hydroxide	Beta/Gamma Activity (Contaminated Process Effluent), Low Level Fission Products
200	200-SO-1	5	Acids, Lead, Solvents	Americium, Plutonium, Strontium
200	200-SS-1	6	Antifreeze, Alkaline Liquids, Barium Chloride, Diesel Fuel, Hydrochloric Acid, Waste Acids, Nitric Acid, Paint Waste, Sodium Dichromate, Sodium Hydroxide, Solvents	None
200	200-SS-2	2	Acrolein, Aluminum Chloride, Benzene, Butoxyethanol, Butyl Ethanol, Butyl Lithium, Carbon Trichloride, Chromium, Butyl Cellosolve, Diethyl Ether, Dioxane, 1,2-Bis (2-Chlorethoxy) Ethane, Ether, Ethyl Acetate, Ethyl Ether, Polyethylene Glycol Monoethyl Ether, Heptane, Hexane, Hydrazine, Hydrogen Sulfide, Isopropyl Ether, Lithium Hydride, Magnesium Bromide, Methanol, Nitrobenzoyl Chloride Picric Acid, Sodium Peroxide, Toluene, Triethylborane, Tetrahydrofuran, Tetrahydronaphthalene, Unsymmetrical Dimethyl Hydrazine	Possible Radiologically Contaminated Building Foundation and Manholes
200	200-ST-1	51	None	Sanitary Wastewater
200	200-SW-1	28	Asbestos, Calcium Chloride, Diesel Fuel, Formamide, Lead, Paint Waste, PCBs, Septic Tank Sludge, Sodium, Sodium Silicate, Chemical Solvents, Toluene, Xylene	Alpha/Beta/Gamma Activity (Contaminated Ash), Americium, Plutonium, Sanitary Sewage
200	200-SW-2	5	Acidic Waste, Laboratory Waste, Lead, Uranyl Nitrate Hexahydrate (UNH)	Cesium, Depleted Uranium, Irradiated Fuel elements, Low Level Mixed Waste, Mixed Fission product, Ruthenium-106, Plutonium, Strontium, Transuranic Dry Waste
200	200-TP-1	2	None	Contaminated Debris (rubble, pipes)
200	200-TP-2	3	Asbestos, Petroleum, Tank Farm Hazardous Waste	Cesium-134/137, Europium-154/155, Strontium-90
200	200-TP-3	1	Possible Hazardous Waste Contamination	None

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-TP-4	17	Alkali Metal Hydroxide, Carbonates, Carbon Tetrachloride, Herbicides, Lead, Mercury, Oxides	Cesium-137, Liquid Mixed Waste, Low Level Radioactive Waste, Plutonium-239, Strontium-90, Transuranic Waste
200	200-TP-5	51	Aluminum, Aluminum Fluoride, Bismuth Phosphate, Chlorine, Evaporator Waste, Ion Exchange Waste, Iron, Lead, Magnesium, Nitric Acid, Non-Complexed Waste, Organic Wash Waste, Potassium, REDOX Waste, Sludge, Sodium, Tributyl Phosphate	Cerium, Cesium-134/137, High Level Waste, Low Level Waste, Nobelium, Plutonium, Ruthenium, Sanitary Sewage, Strontium-90, Uranium, Uranium Oxide, Zirconium
200	200-TP-6	27	Bismuth Phosphate, Decontamination Waste, Ion Exchange Waste, Lead, Laboratory Waste, Tributyl Phosphate	Cesium-137, Fission Products, Low Level Mixed Waste, Plutonium, Strontium-90, Radioactive Liquid Waste, Ruthenium
200	200-TW-1	34	Bismuth Phosphate, Ferrocyanide, Fluoride, Phosphate, Nitrate, Nitrite, Sodium, Sodium Aluminate, Sodium Hydroxide, Sodium Silicate, Sulfate, Tributyl Phosphate	Cesium-137, Cobalt-60, Plutonium, Ruthenium, Tank Farm Radioactive Wastes, Strontium-90, Uranium
200	200-TW-2	28	Ammonium Nitrate, Bismuth Phosphate, Fluoride, Nitrate, Nitrite, Phosphate, Potassium, Sludge, Sodium, Sodium Aluminate, Sodium Hydroxide, Sodium Oxalate, Sodium Silicate, Sulfate	Alkaline Radioactive Liquid Wastes, Plutonium, Transuranic Waste and Fission Products
200	200-UP-2	14	Carbon, Corrosive Condensate/Hazardous Waste from U Plant, Paint Waste, Sodium, Solvents	Fission Products, Low Level Radiological and Mixed Wastes, Thorium, Uranium
200	200-UP-3	39	Aluminum, Asbestos, Bismuth Phosphate, Cadmium, Carbonate, Chromium, Decontamination Waste, Ferrocyanide, Iron, Lead, Nitrate, Nitric Acid, Nitrite, Petroleum, Phosphate, REDOX Waste, Sodium, Tributyl Phosphate	Cesium-137, Fission Products, Plutonium, Sanitary Sewage, Strontium-89/90, Uranium
200	200-UR-1	93	Diesel Fuel, Nitric Acid, PCBs, Sodium Hydroxide, Uranyl Nitrate, Uranium Nitrate Hexahydrate	Americium-241, Cesium-134/137, Cerium-144, Europium-155, Fission Products, Ruthenium-106, Strontium-90, Plutonium-239, Uranium-235, Uranium Trioxide
200	200-ZP-2	3	Halogenated Solvents, Laboratory Chemical Waste, Paint Waste, PCBs, Refrigerants, Thinners	Low Level Waste, Sanitary Sewage

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
200	200-ZP-3	6	WRAP Facility Nonradioactive Dangerous Waste	Low Level Waste, Low Level/Mixed Waste, Sanitary Sewage, Transuranic Waste
300	300-FF-1	38	Aluminum Hydroxide, Ammonium Bifluoride, Chromic Acid, Copper Cobalt, Ethylene Glycol, Hydrofluoric Acid, Nitric Acid, Sodium Hydroxide, Sulfuric Acid	Plutonium, Sanitary Sewage, Uranium
300	300-FF-2	403	Aluminum, Ammonium Hydroxide, Barium, Bismuth, Bromine Solution, Cadmium, Chromic Acid, Chromium, Copper-Silicon Alloy, Chloride, Copper, Ethyl Acetate, Ethylene Glycol, Fluoride, Hydrofluoric Acid, Hydroflourosilic Acid, Lead, Lithium, Mercury, Methyl Ethyl Ketone, Methylene Chloride, Methylene Nitrate, Nitric Acid, Phosphoric Acid, Potassium, Potassium Chloride, PCBs, Perchloroethylene, Petroleum Naphtha, Sodium Chloride, Sodium Hypochlorite, Sodium Dichromate, Sodium Hydroxide, Sodium Nitrate, Sodium-Potassium Sulfate, Sulfuric Acid, Trichloroethylene, 1,1,1-Trichloroethane	Americium, Cesium, Cobalt, Fluoride Ions, Ruthenium, Uranium Trioxide, Plutonium, Sanitary Sewage, Strontium, Thorium, Uranium, Uranium Nitrate
600	100-IU-1	8	Decontamination Solution, Pesticides/Herbicides, Transite Shingles	Sanitary Waste
600	100-IU-2	40	Asbestos, Acidic Waste, Carbon Tetrachloride, Chemical Solvents, Flammable Solvents, Gasoline, Lead, Paint Waste	Sanitary Wastewater, Sanitary Sewage
600	100-IU-3	39	Aluminum, Asbestos, Lead, Magnesium, Pesticides/Herbicides	None
600	100-IU-4	1	Sodium Dichromate	None
600	100-IU-5	1	Chromium, Hydrofluoric Acid, Nitric Acid, Petroleum	None
600	100-IU-6	25	Aluminum, Asbestos, Lead, Paint Waste	Plutonium, Low Level Radioactive Waste (Process Effluent, Ash)
600	200-IU-1	6	Asbestos, Paint Waste	Sanitary Sewage
600	200-IU-2	4	Stainless Steel	None
600	200-IU-3	7	Laboratory Waste, Nitrate	Sanitary Wastewater, Sanitary Sewage

Exhibit 12.10 (Continued): DOE Hanford Areas, Selected Operable Units, and Selected Waste Sites with Associated Contaminants of Concern as of December 1998 (as Reported by the Hanford Site Waste Management Units Report [169])

Management Area	Operable Unit	Number of Waste Sites	Selected Contaminants of Concern: Chemical	Selected Contaminants of Concern: Radiological
600	200-IU-5	10	Asbestos, Petroleum	Sanitary Sewage
600	200-IU-6	3	None	Sanitary Sewage
600	1100-IU-1	6	Asbestos, PCBs	Sanitary Sewage
600	NONE	2	Lead, PCBs, Petroleum Oil	None
1100	1100-EM-1	10	Antifreeze, Battery Acid Waste, Benzene with N-Butyl Lithium,-Bis (2-Ethylhexy) phthalate, Butyl Cellosolve, Butyl Ethanol, Carbon Disulfide, Carbon Trichloride, Picryl Chloride, 2,4-Dinitrorescorcinal, 2,4-Dintrophenol, Ethyl Ether, Ethylene Glycol, Glycol Dimethyl Ether, Hexadinitrophenylamin, Hydraulic Oil, Nitric Acid, Paint Waste, PCBs, Perchloric Acid, Picric Acid, Solvents, Tetrahydrofuran, 2,4,6-Trinitrorescorcinol, Trinitrotoluene, Zirconium	Plutonium Oxides
1100	1100-EM-2	9	Antifreeze, Aliphatic Hydrocarbons, Degreasers, Hydraulic Oil, Paint Waste, 1,1,1-Trichloroethane	None
1100	1100-EM-3	7	Acids, Antifreeze, Degreasers, Oil Sludge, Paint Waste, Solvents	Cesium-134, High Level Waste Slurry

Exhibit 12.11: All Past, Present and Proposed Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site listed by Technical Information Source as of July 1999

'The Rainbow Series'

Subsurface Technologies [198]

Subsurface Fluid Flow Sensors
Thermal Enhanced Vapor Extraction System
In-Well Vapor Stripping
In Situ Treatment of Mixed Contaminants in Groundwater
In Situ Bioremediation
Passive Soil-Vapor Extraction (Barometric Pumping)
Tunable Hybrid Plasma
Six-Phase Soil Heating Multiple Array
In Situ Bioremediation of Chlorinated Solvent DNAPLs
In Situ Gaseous Reduction System
In Situ Redox Manipulation
Chemically Enhanced Barriers
MAG*SEP Groundwater Remediation
ResonantSonic Drilling
Stabilization of Boreholes by Freezing
Innovative Subsurface Stabilization
Minimum-Additive Waste-Stabilization Program
In Situ Vitrification and Stabilization of Transuranic/Mixed Waste
Graphite DC-Arc Furnace
Secondary Treatment of Offgas Using Nonthermal Plasma
Subsurface Barrier-Emplacement Development
Closure of High-Level Waste Tanks Using Stabilized Contaminated Soils and Debris

D&D Technologies [199]

Technologies at Hanford's C-Reactor (Listing in Section 14.3)
CORPEX Nuclear Decontamination Process
Depleted Uranium Recycling/Products
Immobilization of Asbestos Using Mineralogical Conversion
Technetium and Actinide Solvent Extraction
Separation of HTO Using Membranes Tritium Membrane Test
Water-Soluble Chelating Polymers for Removal of Plutonium and Americium from Waste Water

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

MW Characterization, Treatment, and Disposal Technologies [200]

Cleanable Steel High Efficiency Particulate Air Filter
Extractive Organic Pretreatment of Solid
Macroencapsulation of Mixed Waste

Tank Waste Technologies [201]

Advance Hot Cell Analytical Technology - Laser Ablation/Mass Spectroscopy
Near Infrared Spectroscopy
Raman Probe/Cone Penetrometer
Electrical Resistance Tomography/Cone Penetrometer Tank Leak Detection and Monitoring
Light Duty Utility Arm System
Waste Retrieval and Tank Closure Demonstration
Retrieval Process Development
Retrieval Enhancements
Enhanced Sludge Washing
Acidic Cesium/Strontium/Transuranic/Technetium Removal at Idaho
Cesium Removal
Technetium Removal Studies on Hanford Waste
Mobile Evaporator
Solid/Liquid Separations
Countercurrent Decanting
Caustic Recovery and Recycle
Form of Immobilization of Low-Level Waste
Vitrification of Ion Exchange Resins

Characterization and Monitoring Technologies [202]

Portable Acoustic Wave Sensor Systems for Volatile Organic Compounds
Surface Acoustic Wave Array Detectors
Analog Site for Characterization of Contaminant Transport Through Fractured Rock
Intrenational Environmental Assessment/JCCEM Contaminant Transport Studies
Electrical Resistance Tomography for Subsurface Imaging
Acoustic Characterization of Wastes in Double-Shelled Underground Storage Tanks
Neural Network Raman Cone Penetrometer Signal Extraction and Enhancement
In Situ Sensor Development: Ultrasonic Density Measurement Probe
Ultrasonic Sensors for In Situ Monitoring of Physical Properties
Process Monitoring and Control: Ammonia Measurements in Offgases

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Plutonium Remediation Technologies [203]

Plutonium Stabilization and Packaging System
Trade Study on End State of Ash Residues (ESAR)
Polycubes
Pyrolysis

BHI Environmental Restoration Contractor Technologies [204]

Compact Subsurface Soil Investigation System
Concrete Grinder
Concrete Shaver
Concrete Spaller
Dust Suppression System
Gamma Ray Imaging
Heat Stress Monitoring System
High-Speed Clamshell Pipe Cutter
Laser Assisted Ranging and Data Systems (LARADS) Radiological Map
Lead "TechXtract" Chemical Decontamination
Liquid Nitrogen-Cooled Diamond-Wire Concrete Cutter
Mobile Integrated Temporary Utility System (MITUS)
Position-Sensitive Rad Monitoring
Reactor Stabilization
RESRAD-Build
Seal Seam Sack Suits
Self Contained Pipe Cutting Shear
System for Tracking Remediation, Exposure, Activities, & Materials
Two Dimensional Linear Motion System
Wireless Remote Radiation Monitoring System

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Technology Deployments / Demonstrations at Hanford (197, 205, 207, 206)

Tank Corrosion Sensor (Corrosion Monitoring)
Aerosol Fog System for Fixing Radioactive Contamination
Inductively Coupled Plasma/Mass Spectrometer (ICP/MS) System
Interstitial Liquid Level Monitoring System
High Radiation Photogrammetry
Pipe Coupling Assembly (HILTAP)
Temperature-Controlled Worker Protection System
Water Jet Cutting of Saltwell Casing
Macroencapsulation of Mixed-Waste Debris
Mobile X-Ray System for Examination of LLW Burial Boxes
Decontamination of Piping Systems Using Hydrolasers - SNF
Cost Effective Vehicle Parts Washer
Annulus Inspection Ultrasonic Crawler Robot
Vehicle-Based Waste Retrieval System (ARD)
Cone Penetrometer Raman Spectroscopy
Arm-Based Waste Retrieval System (Delphinus/Eagle Tech)
Extended Reach End Effector
Vehicle-Based Waste Retrieval System (ESG)
Arm-Based Waste Retrieval System (GreyPilgrim)
Magnetometer
Tank Prototype Corrosion Probe
Strippable Coating
Cold Vacuum Drying Process
Spent Fuel Sorter with Conan Manipulator Arm
Spent Fuel Cleaning Machine
SNF Sludge Processing
3-D Digital Camera Photogrammetry
Hanford Tank Waste Operations Simulator (HTWOS)
Remote Ultrasonic Tank Inspection (RUTI) System
Glovebox X-Ray System for Non-Destructive Examination (NDE) of Packets
Boxed Waste Assay System
Drum Delidder / Relidder Assembly

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Technology Deployments / Demonstrations at Hanford (continued) [197, 205, 207, 206]

Glovebox Non-Destructive Packet Assay Monitor (PAM) System
Surface Coating Thickness Measurements on Irradiated Fuel
2-D Gamma Camera
Nested Fixed Depth Fluidic Sampler
Directional Drilling
InfraRed Chemical Plume Monitoring System
Decontamination of Lead Bricks Using CORPEX Chelate Chemistry
Microencapsulation of Salt Waste using Polyester Resins
K Basin Sludge Treatment Process

Leak Detection, Monitoring and Mitigation (LDMM) Technologies [209]

Borehole Logging
Mass Balance
Time Domain Reflectometry
Tracer Gas
No Action
Past-Practice Sluicing
Limited Sluicing
Robotic Sluicing
Mechanical Retrieval
Subsurface Barriers

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Office of Science and Technology [210]

Cesium Removal Using Crystalline Silicotitanate
Field Raman Spectrograph
Hanford Canyon Disposition Initiative
In Situ Bioremediation for Hanford Carbon Tetra Plumes
Oxidation and Separation of Non-Pertechnetate Species in Hanford Waste
Sludge Washing
In Situ Grout
Retrieval Using Alkali Solutions
Retrieval Using Acid Solutions
Mechanical Retrieval
Houdini Waste Retrieval System
Pneumatic Retrieval
Chemical Jet Grout Encapsulation
Freeze Walls
Jet Grout Curtains
Permeation Chemical Grouting
Wax Emulsion Permeation Grouting
Silica, Silicate Permeation Grouting
Polymer Permeation Grouting
Formed-in-Place Horizontal Grout Barriers
Circulating Air Barriers
Radio-Frequency Desicating Subsurface Barriers
Sheet Metal Piling Subsurface Barriers
Close-Coupled Injected Chemical Barriers
Induced Liquefaction Barriers
Slurry Walls
Deep Soil Mixing
Soil Fracturing Longwall Mining
Modified Sulfur Cement
Sequestering Agents
Reactive Barriers
Impermeable Coatings
Microtunneling
In Situ Vitrification

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Office of Science and Technology (Continued) [210]

Soil Saw
Truck Transfer
LR-56(H) Truck for Transporting Liquid Radioactive Waste
Ceramic Waste Forms
Retrieval and Transfer Systems
Separations Facilities
Waste Processing Facilities
Interim Storage Facilities for HLW
Disposal Facilities for LAW
Joule-Heated Ceramic Lined Melters
Induction Melters
Microwave Melters
Plasma-Arc Melters
Transferred Plasma Melters
Fuel-Fired Melters
Cold-Crucible Melters that Use a Cooled-Glass Skull on the Melter Walls to Prolong Melter Operating Life
Spray Calciners
Rotary Calciners
Fluid Bed Calciners
Indirect Fired Calciners
Electrically Heated Calciners
Borosilicate Glass
Soda Lime Glass
Separations Technologies
Off-Gas Treatment Systems for Radionuclides
Grouting of Retrieved Tank Waste
Vadose Zone Characterization System
Absorptive Stripping Voltammetry
Automated Analysis Tool for Waste Feed Tanks
Boresampler
CDI Remote Characterization System
Cone Penetrometer Support: Opearation, Maintenance, and R&D Activity Conducted on the OTD
Cone Penetrometer Vehicle
Corrosion Probe
Crosshole Compressional and Shear Wave Seismic Tomography
Cryogenic Cutting
Data Fusion

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Office of Science and Technology (Continued) (210)

Direct Sampling Ion Trap Mass Spectrometer System (DSITMS)
Fiber Optic Probe for Trichloroethylene in Soil and Groundwater
Field-Deployable VOC Analyzer
Gamma Cam (TM) Radiation Imaging System
HaloSnif
HeavyWeight Cone Penetrometer
High Resolution Imaging Using Holographic Impulse Radar Array
Hydraulic Conductivity Measurement and Stabilization Verification
In Situ Corona - Treatment of Nonvolatile Organic Contaminants
In Situ Permeable Flow Sensor
Indoor Radiation Mapping Using Laser Assisted Ranging and Data Systems
Laser Ablation/Mass Spectroscopy (LA/MS)
Laser Cutting and Size Reduction
LDUA - Supervisory Data Acquisition and Supervisory Control System
LDUA Stereo Viewing System
Material Handling and Waste Conveyance
Membrane-Supported Particle-Bound Ligands for Cesium Removal
MIT Multi-Metal Emission Monitor
Non-Destructive Examination End-Effector
Oxy-Gasoline Torch
Portable Analyzer for Chlorinated Compounds
Portable Selective Hot Spot Removal System
Remote Viewing System
Robotic End Effector for Inspection of Storage Tanks
Sodium Silicate Flowable Grout
Stabilization of Salt Using Encapsulation with Polyester Resin
Stabilized Contaminates Using Arrow-Pak Polymer Macroencapsulation
Surface Acoustic Wave Array Detectors
Surface Contamination Monitor and Survey Information Management System (SCM/SIMS)
Thermal Conversion of Asbestos
Topographical Mapping System (TMS)/Laser Range Finder (LRF)
Unsaturated Flow Apparatus
Variable Geometry Truss

Exhibit 12.11 (Continued): All Past, Present and Future Remediation Worker Technologies Deployed and/or Demonstrated at the Hanford Site

Tank Focus Area Technologies

Annulus Cleaning
Borehole Miner
Cesium Removal
Cone Penetrometer Deployment System
Confined Sluicing End Effector
Corrosion Probe
Countercurrent Decanting
Enhanced Sludge Washing
Enhanced Sluicing Systems
Extendible Nozzle and Borehole Miner
Extended Reach End Effector
Flygt Mixer
Fluidic Sampler
Grout vs. Glass Study
Gunite Tank Retrieval System
Gunite Tank Isolation and Closure
Laser Ablation/Mass Spectrometer (LA/MS)
Leachate Solids, Control of
Light-Duty Utility Arm (LDUA)
MultiPoint (Grout) Injection
Near Infrared Spectroscopy (NIR)
Out-of-Tank Evaporator
Pipe Plugging & Cutting
Product Acceptance
Pulse Jet Fluidic Mixer
Pulsed Air Mixer
Raman Probe
Russian Pulsating Mixer Pump
Salt Removal, SRS
Solid-Liquid Separation
Strontium, and Transuranic Removal from Acidic Tank Waste
Tank 20 Closure
Topographical Mapping System
Vitrification of Crystalline Silicotitanate
Vitrification
Waste Loading Improvements

Table 13.1: Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers
Hanford Site Wide	-	**Fluor Daniel Hanford, Inc.** H5-20 P.O. Box 1000 Richland, WA 99352-1000 Contacts: Dorothy Hansen, Human Resources (HR) MS: H2-16 Location: 2425STVCN/154/RCHN Richland, WA 99352 509-376-8180 Gerald F. Saskowsky, Labor Relations (LR) MS: H8-24 Location: 2420STVCN/255/RCHN Richland, WA 99352 509-373-1813	= 1789 (the Total of PHMC Sub-Contractors considered Remediation Workers, the addition of the below PHMC Subs and ENCOs) =2221 (All PHMC Remediation Workers)	Project Hanford Management Contractor (PHMC) / Management and Integration of 6 Sub-Contractors and 6 Enterprise Companies (ENCOs)	-	Management, Operations, Integration of all PHMC contractors.	-
Hanford 200 Areas	HW, CW Tasks	Lockheed Martin Hanford (PHMC Sub) H7-07 P.O. Box 1500 Richland, WA 99352-1505 Contact: See FDH, Inc.	393	Tank Waste Remediation System (TWRS) 1. Solid, Hazardous, Radiological, Mixed Waste, and HLW TSD facility Workers 2. Nuclear Power Plant Maintenance Workers	1. Nuclear Chemical Operator Jrn. 2. HPT-Senior 3. Electrician-Jrn. 4. Instrument Specialist 5. Nuclear Chemical Operator Work Leader	HLW / Mixed Waste Characterization / Retrieval, TSD, Maintenance and Operations	1. 127 2. 91 3. 30 4. 27 5. 27

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford Site Wide	HW, CW Tasks	Waste Management Federal Service of Hanford (PHMC Sub) H6-10 P.O. Box 700 Richland, WA 99352-0700 Contact: See FDH, Inc.	337	Waste Management 1. Solid, Hazardous, Radiological, and Mixed Waste TSD facility Workers 2. Nuclear Power Plant Maintenance Workers	1. Nuclear Chemical Operator jrn. 2. Chemical Technologist 3. HPT-Senior 4. Nuclear Chemical Operator-Work Leader 5. Instrument Specialist	HW, TRU, TRU Mixed, LLRW, LLMW Treatment Storage, Transportation, and Disposal, HLW Characterization	1. 86 2. 76 3. 55 4. 20 5. 19
Hanford 100 Area K Basins	CW Tasks	Duke Engineering and Services Hanford, Inc. (PHMC Sub) H5-30 P.O. Box 350 Richland, WA 99352-0350 Contact: See FDH, Inc.	93	Spent Nuclear Fuel 1. Solid, Hazardous, Mixed Waste, and SNF TSD facility Workers 2. Nuclear Power Plant Maintenance Workers	1. HPT-Senior 2. Reactor Fuels Operator-Jrn. 3. Reactor Fuels Operator- Work Leader 4. Electrician Jrn. 5. Truck Driver - Heavy	Spent Nuclear Fuel Treatment, Storage, Transportation, and Disposal	1. 22 2. 19 3. 17 4. 7 5. 6

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford: PFP, PUREX, B-Plant/300 Area, FFTF	CW, HW, De Tasks	Babcock and Wilcox (B&W) Hanford Company (PHMC Sub) H5-31 P.O. Box 1200 Richland, WA 99352-1200 Contact: See FDH, Inc.	403	Facility Stabilization 1. Solid, Hazardous, Mixed Waste, and Radiological TSD facility Workers 2. Construction & Demolition Workers 3. Nuclear Power Plant Maintenance Workers	1. HPT-Senior 2. Nuclear Chemical Operator - Jrn. 3. Stationary Operator-Jrn 4. Hot Cell Tech 5. Electrician-Jrn.	Pre-stabilization surveillance and maintenance, stabilization (removal and storage of wastes or early deactivation), and Post-stabilization surveillance and maintenance. Safe Shut Down.	1. 70 2. 69 3. 44 4. 29 5. 27
Hanford Site Wide	HW Tasks	DynCorp Tri-Cities Services, Inc. (PHMC Sub) H5-33 P.O. Box 1400 Richland, WA 99352-1400 Contact: See FDH, Inc.	531	Infrastructure Services 1. Solid, Hazardous and Mixed Waste TSD facility Workers	1. Truck Driver - Heavy 2. Stationary Operating Engineer 3. Electrician Jrn. 4. Storekeeper 5. Plumber/Steam-fitter	Facility Maintenance and Site Services	1. 66 2. 31 3. 29 4. 24 5. 22

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford/ All Areas	CW Tasks	Fluor Daniel Northwest, Inc. (ENCO) B7-50 P.O. Box 1050 Richland, WA 99352-1050	25	Engineering and Architecture Services	1. Ironworker/Rigger Jrn. 2. Truck Driver-Heavy 3. Crane Operator 4. HPT-Lead Assignment 5. Plumber/Steam-fitter-Jrn.	Design and Construction of Treatment, Storage, and Disposal Facilities and Structures	1. 12 2. 5 3. 2 4. 1 5. 1
Hanford Site Wide	HW Tasks	Waste Management Federal Services Northwest (ENCO) 345 Hills Street Richland, WA 99352 Contact: See FDH, Inc.	6	Waste Management 1. Solid, Hazardous and Mixed Waste TSD facility Workers	1. Truck Driver - Heavy	HW, LLRW, LLMW Treatment Storage, Transportation, and Disposal	1. 6
Hanford Site Wide	CW Tasks	Numatec Hanford Corporation (ENCO) H5-25 P.O. Box 1300 Richland, WA 99352-1300	1	Technology Innovation	1. Machinist-Research & Development (R&D)	Radiological and Mixed Waste Technology R&D	1. 1

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford Site Wide	CW, HW Tasks	PHMC Non Union Laboratory / Technician Workers Contact: See FDH, Inc.	432	All PHMC (Management and Integration) Laboratory (Bench-Scale) Workers	1. Tech-Engineering 2. Tech-Scientific 3. Engineering Tech 4. Industrial Hygienist and IHT (Technician) 5. Scientific Tech	Radiological, Hazardous Waste, and Mixed Waste Research and Development, Sampling and Surveying	1. 248 2. 109 3. 31 4. 26 5. 12
Hanford Site Wide	HW, De Tasks	**Bechtel Hanford, Inc.** 3350 George Washington Way Richland, WA 99532 LR Contact: Sam Lyon MailStop: H0-08 Location: 3350GWW/1A21/RCHN, (509)-372-9464 HR Contact: Connie Hettel MailStop: H0-08 Location: 3350GWW/1A05/RCHN, (509)-375-9683	340	Environmental Restoration / 1. Solid, Hazardous and Mixed Waste TSD facility Workers 2. Construction & Demolition Workers 3. Asbestos Abatement	1. RCT 2. D&D Worker 3. Truck Driver - Heavy 4. Electrician 5. Ironworker/Rigger	Decontamination and Decommissioning of all existing buildings, Safe Shut Down, Safe Storage, Transportation and Disposal of Mixed, Hazardous and Radiological Wastes	1. 95 2. 84 3. 59 4. 13 5. 9

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford 300 Area (324 & 327 Facilities)	CW, HW Tasks	**Pacific Northwest National Laboratory / Battelle Memorial Institute** 902 Battelle Boulevard P.O. Box 999 Richland, WA 99352 HR Contact: Kirby Denslow, MSIN: K1-34, (509)-375-6733	255 = PNNL /HAMTC	Environmental Science, Research and Technology	1. Instrument Specialist 2. RPT 3. Power Operator 4. Electrician 5. Pipefitter	Maintenance and Operations / Crafts	1. 31 2. 26 3. 24 4. 22 5. 21
			1689 = Non-union		NA	Laboratory Bench Scale Technologies (R&D)	NA
Hanford 200, 300 Area	HW, De Tasks	**Johnson Controls, Inc.** Controls Group P.O. Box 750 Richland, WA 99352 Contact: Michael E. Tenvooren, Site Manager (509-373-3401)	11	Energy Savings Performance 1. Nuclear Power Plant Maintenance Workers	1. Misc. Crafts (Electricians) 2. RCTs	Systems Maintenance, Deactivation	1. NR 2. NR

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford Site Wide	HW, CW, De, Di Tasks	**HAMTC** (Hanford Atomic Metal Trades Council) 1305 Knight Street Richland, WA 99352 Contact: John Jeskey, FDH MailStop: T4-62 Location: MO438/A105A/200W (509)-373-2210	2530 (3-month average reported by the HAMTC) 2395 (total of FDH, BHI, PNNL, and JC HAMTC Workers as reported by Contractor)	Union Council / 1. Solid, Hazardous, Mixed Waste, and HLW TSD facility Workers 2. Construction & Demolition Workers 3. Nuclear Power Plant Maintenance Workers	1. Nuclear/Chemical Operators / Technologists, D&D Workers, Hot Cell Techs 2. Health Physics Techs 3. Electricians 4. Operating Engineers 5. Drivers and Storekeepers	HLW/MW/ LLRW TSD Transportation. Systems Maintenance, Deactivation, Dismantlement of buildings and equipment.	1. 692 2. 450 3. 338 4. 322 5. 221
Hanford Site Wide	CW Tasks	**Central Washington Building and Construction Trades Council** (Building Trades, BT) Contact: Richard Burglund, President (509-545-1446) or John Jeskey, FDH MailStop: T4-62 Location: MO438/A105A/200W (509)-373-2210	204	New Construction / Skilled Crafts	1. Pipe-fitters 2. Laborers 3. Misc. Crafts	Reactor Cocooning (Interim Safe Storage), TSD Facility Construction	1. NR 2. NR

Table 13.1 (continued): Contacts and Demographic Description of Prime and Subcontractor Remediation Workers at the Hanford Site

Facility/ Area	Assoc. Tasks	Contractor / Contacts	# of Rem. Workers	Project Responsibility / Industry Profile	Top 5 Remediation Job Titles	Primary Job Tasks	* No. Of Workers (TOP 5)
Hanford Site Wide	All	**Total Number of Hanford Remediation Workers:** = HAMTC Represented Employees + FDH Non-Union Laboratory Workers + PNNL Non-Union Laboratory Workers + Building Trade Workers	4720	All Projects / Industry Profiles	1. Nuclear/Chemical Operators/Techs, D&D Workers, Hot Cell Techs, Researchers 2. Health Physics Techs 3. Electricians 4. Operating Engineers 5. Drivers and Storekeepers	HLW/MW/ LLRW TSD Transportation. Systems Maintenance, Deactivation, Dismantlement of buildings and equipment. Research and laboratory work.	1. 692 2. 450 3. 338 4. 322 5. 221

Table 13.2: Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 200 West / WM	HW	124: Sec. 2.4.3, 125, 122	**Activity 1: WRAP-1: Shipping and Receiving** Personnel use fork trucks, drum handling equipment, conveyers, an overhead bridge crane, and jib cranes to unload and move LLRW, LLMW, TRU, and TRU Mixed waste drums and boxes into processing areas. Processed containers are also loaded and shipped out of the facility.	Mixed	RCRA / WAC / TPA	March 1997 to >2006	>10 years	LOW: <10
Hanford / 200 West / WM	HW	124: Sec. 2.4.4, 125, 122	**Activity 2: WRAP-1: Nondestructive Examination and Assay (NDE/NDA)** The NDE/NDA area prepares LLRW, LLMW, TRU, and TRU Mixed waste for processing. Personnel use fork lifts to move boxes, the AGV to move drums, or manually haul containers into the NDE/NDA airlocked area where automated examination and assay will take place.	Mixed	RCRA / WAC / TPA	March 1997 to >2006	>10 years	LOW: <10
Hanford / 200 West / WM	HW	124: Sec. 2.4.5 and 2.5, 125, 122	**Activity 3: WRAP-1: Waste Processing** Waste processing takes place in four different processing lines (gloveboxes) separately designated for TRU, TRU mixed, LLMW, and LLRW. Personnel will remotely process waste packages within the lines.	Mixed	RCRA / WAC / TPA	Sept. 1998 to >2006	>10 years	MED: 11-75
Hanford / 200 West / WM	HW	128: Pp.8-15, 129	**Activity 4: Central Waste Complex (CWC): Waste Receiving and Staging Area** Personnel at the CWC Waste Receiving and Staging Area inspect, accept, and unload containerized LLRW, LLMW, TRU, and TRU Mixed waste packages received from the WRAP or other on/off-site waste generator.	Mixed	RCRA / WAC / TPA	1996 to >2006	>10 years	MED: 11-75
Hanford / 200 West / WM	HW	128, 129	**Activity 5: CWC Storage Facilities** Personnel at CWC storage facilities transport LLRW, LLMW, TRU and TRU Mixed waste containers by forklift and handtruck from the Mixed Waste Staging Pad (MWSP) to appropriate storage areas and modules. Waste will reside in this area until final disposition is determined. Weekly container inspections with the use of a portable ladder are required in the storage area.	Mixed	RCRA / WAC / TPA	1996 to >2006	>10 years	MED: 11-75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 200 East / WM	HW	130: Pp. 1-36, 131	**Activity 6: LERF: Sampling and Monitoring** Personnel at the LERF sample and monitor basin perimeters and the leachate collection system. They also monitor leaks through both automated and manual processes around facility transfer piping.	Mixed	RCRA / WAC / TPA	1995 to >2006	>10 years	LOW: <11
Hanford / 200 East / WM	HW	130: Pp. 1-36, 131	**Activity 7: ETF: Processing and Treatment** The Effluent Treatment Facility (ETF) is an automated waste water treatment facility where a primary treatment system treats and filters liquid effluent and a secondary treatment system receives and evaporates backwash. While much of the ETF is automated, personnel will provide maintenance to the system and will help package effluent concentrate (a powder form after treatment) by tightening drum lids by hand.	Mixed	RCRA / WAC / TPA	1995 to >2006	>10 years	LOW: <11
Hanford / 200 West / WM	HW, De	136, 132: Sec. 3, 134	**Activity 8: 222-S Radioactive Liquid Waste Line Replacement** Remediation workers constructed a hazardous and radioactive liquid waste (LLMW) transfer system from the 222-S Analytical Laboratory to a waste collection tank feeding into the 200-West area tank farms. The activity also included the decontamination and removal of the existing 222-S waste collection system.	Mixed	RCRA / WAC / TPA	1993 to 1997	4 years	MED: 11-75
Hanford / 100 K / SNF	CW	141: Sec. 2.5 and Sec. 7 and 8, 142	**Activity 9: K Basin Canister Storage and Maintenance** K Basin activities involve the storage and handling of SNF from the N Reactor, sludge (HLW), radioactive debris (TRU), and contaminated debris (LLRW). SNF is contained in canisters which are placed in underwater storage racks on the bottom of the basin concrete floor. Personnel will reside on the work area grating and use manual fuel handling tools such as canister hooks, tongs, and canister sealing and purging tools to move, retrieve, place, seal, and maintain SNF and canisters.	Radiological	CERLA / TPA	1992 to 2007	15 years	MED: 11-75
Hanford / 100 K / SNF	CW	143: P. 1, 142	**Activity 10: Packaging and Transport of SNF at the K Basins** Within basin pools, personnel will top load 'cleaned' SNF fuel baskets into Multiple Canister Overpacks (MCOs) which are specially designed to properly position SNF. The MCO will then be placed into the MCO cask (a containment and transportation device) filled with water. The MCO shield plug/lid will be placed on the MCO, the package lifted out of the pool, the cask lid installed, and the package placed on a trailer for transfer.	Radiological	CERCLA / TPA	<2000 to >2006	>6 years	MED: 11-75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 100 K / SNF	CW	144: Sec. 2.4.1, 145	**Activity 11: Processing MCO Casks at the CVDF** Within secondary confinement enclosures, personnel will perform initial inspection, cask lid removal, and system connections before the start of cold vacuum drying. During normal operations, personnel will only be required in the processing bay for routine surveillance. Personnel will then remotely control the vacuum pumping system and an MCO-tempered water system for performing MCO drying operations.	Radiological	CERCLA / TPA	<2000 to 2006	>6 years	MED: 11-75
Hanford / 200 E / SNF	CW	146: Sec. 2.2.5, 147	**Activity 12: Canister Storage Building (CSB): Wash Down Area** Personnel at the wash down area will receive MCOs by rail car or truck from the K Basins. Once the MCO/Cask is inside the area, remotely operated water spray equipment will wash down the cask and railcar or truck removing dust and road grime. After washing, a tow rope system will pull the casks into a load-in / load-out area for receipt into the CSB.	Radiological	CERCLA / TPA	<2000 to 2006	>6 years	LOW: <11
Hanford / 200 E / SNF	CW	146: Sec. 2.2.2, 147	**Activity 13: Canister Storage Building (CSB): Operating Deck: Storing MCOs** The operating deck area contains openings for personnel to place and remove MCOs in vault storage tubes. The deck will provide adequate shielding for workers on the deck and structural support for loads. The operating deck will also be serviced by a crane and a Shielded Cask / MCO Handling Machine which will transport MCOs inside the operating area to the storage tubes.	Radiological	CERCLA / TPA	<2000 to >2006	> 10 years	LOW: <11
Hanford / 200 Areas / TWRS	CW	151, 152: Sec. 2.0, 154, 153	**Activity 14: 200-E and 200-W Tank Farm Surveillance and Maintenance** Personnel involved in routine SST and DST 'surveillance and maintenance' activities will 1) perform preventative tank farm equipment maintenance and repair, 2) survey tank safety operations for proper safety measures, 3) perform radiological surveillance tasks, 4) read active tank instruments for liquid waste levels, temperatures, pressure, flammable gas concentrations, and ventilation air flow, 5) and monitor the tank for leakage and airborne and surface contamination.	Radiological	RCRA / CERCLA / TPA	1989 to >2006	>20 years	HIGH: >75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 200 Areas / TWRS	CW	157, 158, 151, 159	**Activity 15: Single Shell Tank (SST) (Tank 106-C) Retrieval** Personnel will maintain single shell tank retrieval operations from above the ground. They will operate retrieval technologies such as the sluicer and perform maintenance activities when retrieval systems are down.	Radiological	RCRA / CERCLA / TPA	1989 to >2006	>20 years	HIGH: >75
Hanford / 200 Areas / TWRS	CW	160, 159, 161	**Activity 16: Double Shell Tank (DST) (Tank 101-AZ) Retrieval** Personnel performing retrieval tasks at Hanford DSTs operate equipment to control and monitor mixer pumps in an environmentally controlled structure at the tank farm. Activities also involve the removal of a non-essential equipment and the installation of all retrieval system equipment.	Radiological	RCRA / CERCLA / TPA	1989 to >2006	>20 years	HIGH: >75
Hanford / 200 Areas / TWRS	CW	162	**Activity 17: Tank Waste Characterization: Tank Sampling** Personnel will sample tank solids, supernatant, gas vapors, and soft slurry (all classified as HLW) through various sampling techniques including 1) rotary mode core sampling, 2) push mode core sampling, 3) push mode core sampling, 4) retained gas sampling, 5) grab sampling, 6) auger sampling, and 7) vapor sampling.	Radiological	RCRA / CERCLA / TPA	1989 to >2006	>20 years	HIGH: >75
Hanford / 200 Areas / TWRS	CW	150, 152, 148, 149	**Activity 18: Tank Waste Treatment and Immobilization (Privatized)** Personnel will operate and maintain HLW and LAW treatment and immobilization facilities at the Hanford site. Once tank waste is transferred to BNFL, Inc., the waste will be treated to separate it into two fractions: HLW and LAW. Treatment will consist of removing cesium, strontium, technetium, and transuranics from the waste using processes such as ion exchange and precipitation and blending them into the HLW stream. The remaining larger volume of waste including soluble waste and chemicals removed from DST wastes will be blended into the LAW stream.	Radiological	RCRA / CERCLA / TPA	2006 to ?	Unknown	HIGH: >75
	HW							HIGH: >75
Hanford / 100 H / ER	HW	168, 169:P.325, 170, 166	**Activity 19: Excavation of LLMW from the 183-H Solar Evaporation Basins** The 183-H solar evaporation basins, operating between 1973 and 1985, were four concrete basins located in the 100-H Area that treated and stored routine and non-routine LLMW from N-Reactor Fuels Fabrication Facilities. Personnel at this facility will perform soil excavation tasks with heavy equipment and transport wastes to the Environmental Restoration Disposal Facility (ERDF).	Mixed	CERCLA / RCRA / NEPA	1998 to 2000	2 years	HIGH: >75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 100 B / ER	CW, HW, De, Di	171, 169: P.33-34	**Activity 20: Decontamination, Demolition and Removal of LLRW / LLMW from 104-B Tritium Vault and Tritium Laboratory** The 104-B-1 Tritium Vault and 104-B-2 Laboratory were used as tritium support and storage facilities from 1950 to 1955. The vault contained tritium shipping flasks stored on racks and the laboratory housed 63 cells recessed in the floor that stored vacuum casks containing irradiated target elements from 105-B and 105-C Reactors. Personnel performed decontamination, demolition, excavation, and packaging/transferring activities in the area.	Mixed and Radiological	CERCLA / RCRA / NEPA	Sept. 1996 to Oct. 1996	1 to 2 months	MED: 11-75
Hanford / 100 C / ER	HW, De	173, 44	**Activity 21: 105-C Safe Interim Safe Storage: Decontamination** Personnel in the 105-C facility area performed decontamination activities including 1) removal of process piping, specific below grade tunnels, nonstructural equipment and material, and unfixed hazardous materials (HW) from the facility, 2) removal of sediment in the fuel storage basin transfer pits, 3) packaged sediment in disposal containers, 4) performed surface or near surface decontamination using mechanical methods such as ultrahigh-pressure water, shot blasting, ice blasting, and, grit blasting, 5) cleaned surfaces through methods such as chemical foams, gels, organic acid treatment, inorganic acid treatment, chelation treatment, and ultraviolet (UV)/ozone (UV light activation), and 6) abated asbestos and lead. Personnel in the 105-C facility area also disposed of and transported polychlorinated biphenyls (PCBs) and mercury containing equipment (HW) to on-site disposal areas.	Mixed and Chemical	CERCLA / RCRA / NEPA	1997 to 1999	2 years	MED: 11-75
Hanford / 100 C / ER	Di	173, 44	**Activity 22: 105-C Safe Interim Safe Storage: Demolition** Personnel at 105-C reactor will demolish all reactor support structures such as water towers and other ancillary support structures outside the shield walls of the reactor using heavy equipment and other tools such as diamond wire saws, floor saws, and wall saws. Demolition of the existing roof is planned in coordination with the construction of a new roof that will be constructed for safe storage enclosure (SSE)	Radiological	CERCLA / RCRA / NEPA	1997 to 1999	2 years	MED: 11-75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 100 C / ER	CW	173, 44, 174	**Activity 23: 105-C Safe Storage Enclosure: Cocooning** Personnel constructed a new roof using heavy equipment consisting of prefabricated steel joists and steel joist girders with a stainless steel sheet metal roofing deck. Open areas between the roof and the top shield wall were enclosed with the same material. The roof structure was anchored to the top of the shield wall. All penetrations made during construction were sealed.	Radiological	CERCLA / RCRA / NEPA	1997 to 1999	2 years	MED: 11-75
Hanford / 100 N / ER	CW, HW, De	175	**Activity 24: N Reactor (105-N) Deactivation** Personnel at the 105-N facility have performed numerous deactivation activities in order to achieve S&M in the area. The following activities have been performed: 1) restarting existing equipment (i.e. cranes), 2) removing, characterizing, packaging, and transporting equipment fluids, HW, and unattached equipment and materials (LLRW, TRU) to the 200 Areas for use, reuse, recycling, storage, or disposal as waste, 3) draining basins and tanks (LLRW, TRU), 4) removing and transporting contaminated water and residuals to the 200 areas for disposal (LLRW), 5) removing, packaging and transporting contaminated sediment, hardware, and pieces of lithium target to the 200 areas for storage or disposal (LLRW, LLMW), 6) elimination, decontamination or stabilization to fix loose contamination of temporary and permanent radiation zones, 7) de-energizing support systems (i.e. electrical and HVAC), 8) performing structural repairs as necessary for S&M, 9) sealing building penetrations, and 10) performing routine S&M such as health and safety inspections, routine maintenance, and weed control.	Mixed / Chemical / Radiological	CERCLA	1992 to 1998	6 years	HIGH: >75
Hanford / 200 Area / ER	De, Di, HW, CW	177	**Activity 25: 233-S Decontamination and Decommissioning** Personnel at the 233-S facility 1) removed fissile material, 2) removed facility equipment and systems through cutting, grinding, welding, crimping and bagging, and 3) performed surface decontamination through the use of potable water, various types and sizes of scrub brushes, spill absorbent, grates, non-phosphate detergent. wipes/towels, and buckets/wash tubs. Personnel at the facility also 1) conducted radiation surveys and analyses for characterization of facility waste, and 2) packaged, transported and disposed of the wastes. Personnel removed building structures by conventional demolition.	Mixed / Chemical Radiological	CERCLA	1997 to 1999	2 years	MED: 11-75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 600 Area / ER	HW	37, 179, 180, 178	**Activity 26: LLMW, LLRW, and HW Disposal at the Environmental Restoration Disposal Facility (ERDF)** Personnel transport waste from remediation areas to the ERDF in containers or dump trucks. When waste arrives (in the form of bulk soils and solid wastes), it is received, unloaded, and compacted (soils only) in an active cell in a fashion similar to commercial landfill operations. A system for placing loads into the cell is followed in order to control the drop and the speed of the drop, thereby minimizing dust potential. Sprays are used during the placement process to further minimize dust.	Mixed and Chemical	CERCLA / RCRA	July 1996 to >2006	> 10 years	MED: 11-75
Hanford / 100, 200, 300 Areas / ER	HW, CW	91, 37	**Activity 27: Groundwater Treatment** In terms of the groundwater management project, personnel at the Hanford site have 1) installed and maintained (i.e. repaired and monitored) groundwater pump and treat systems, 2) operated five separate pump and treat systems across the 100 and 200 areas, 3) packaged, transported, and disposed contaminants such as chromium at the ERDF, 4) operated extraction units used to remove carbon tetrachloride, strontium, technetium, and uranium from underground plumes, 5) decommissioned 100 below grade wells across the site, and 6) drilled new production wells with special heavy equipment.	Mixed and Radiological	CERCLA	1994 to >2006	>10 years	MED: 11-75
Hanford / 200-E / FS	De, CW, HW	12, 137, 183, 184	**Activity 28: PUREX Stabilization and Deactivation** Personnel at the PUREX plant performed the following activities in order to achieve facility deactivation and stabilization; 1) the removal (bagout) of uranium-contaminated nitric acid and other process solutions from PUREX systems, 2) flushing organic solutions from process systems, 3) loading cold chemicals, organics, plutonium / uranium bearing liquids, uranium-contaminated nitric acid into tankers and other transport systems for storage or disposal, 4) cleaning, structural decontamination, and removal of contaminated equipment (LLRW), piping, and inner structures, and 5) consolidation, reduction, and elimination of HVAC systems, monitoring equipment, process systems, tanks, electrical, and fire systems.	Mixed / Chemical / Radiological	CERCLA / RCRA	1994 to May 1997	3 years	HIGH: >75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 200-E / FS	CW, HW	185, 186, 184	**Activity 29: PUREX Surveillance and Monitoring** Personnel at the PUREX plant will 1) operate the surveillance, monitoring, and control system for routine monitoring (a SAMCONS I&C skid unit), 2) conduct environmental monitoring such as continuous stack particulate sampling and iodine sampling, 3) conduct quarterly internal and external surveillances which involve checking for indications of structural defects, roof deterioration, posting deficiencies, contamination migration, suspect hazardous materials, hazardous conditions, unlabeled containers, unidentified friable asbestos, failed lights, and water, animal or insect intrusion, and 4) conduct routine radiological S&M (posting, access control, work place air monitoring, and radiological surveys as directed by the radiation work permit (RWP)	Mixed / Radiological / Chemical	CERCLA and RCRA	1992 to >2006	>10 years	HIGH: >75
Hanford / 200-E / FS	CW	119, 15, 187	**Activity 30: Surveillance and Maintenance of Radioactive Strontium and Cesium at the Waste Encapsulation and Storage Facility (WESF)** Personnel survey and maintain the HLW capsules that are stored in large pools of water. Nuclear process operators perform similar duties to those described in Activity 9. Workers will stand on a grating and use handling tools such as canister hooks and tongs to move and maintain the underwater capsules. Personnel will also perform corrective, preventative, process system and equipment calibrations and modification maintenance measures as well as performing pool decontamination and containment if the capsules were to leak.	Radiological	CERCLA / RCRA / TPA	1996 to 2020	>20 years	MED: 11-75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 300 Area / FS	De, CW	188: P.1, 189: P. 2, 190	**Activity 31: 308 Fuels Development Laboratory Building Deactivation** Personnel at the 308 FDL 1) cleaned and removed LLRW, contaminated equipment and special nuclear material (SNM), and TRU wastes 2) decontaminated structures, 3) performed asbestos abatement, and 4) disposed LLMW and HW generated by deactivation and decommissioning operations. Specifically personnel removed of the plutonium inventory, cleaned out and stabilized plutonium oxide and enriched uranium oxide (UO2) residues and powders in equipment and duct work and wiped, sprayed, and sealed fifty glove boxes and six open-faced laboratory hoods. The glove box decontamination process included 1) stabilization of alpha contamination in glove boxes where mixed oxide (MOX) powders and pellets were once pressed and sintered into reactor fuel during fuel fabrication, 2) wipe-down of inner surfaces using damp rags that were later dried and disposed as solid waste, 3) spraying boxes with modified acrylic latex, 4) covering glove ports with specially fitted metal plates and polyolefin, 5) placing 'shrink-wrap' material containing tar-like adhesives on plates and ports, and 6) activating the adhesive so that crevices could be sealed.	Mixed / Chemical and Radiological	CERCLA	1994	< 1 year	MED: 11-75
	HW							LOW: <11
Hanford / 300 Area / FS	De	60, 193	**Activity 32: 324/327 Facility Safe Shutdown** From 1989 to 1995, the Pacific Northwest National Laboratory (PNNL) operated by Battelle Memorial Institute owned and operated the 324 and 327 Facilities. Safe shut down activities were conducted by PNNL workers during this time period. Descriptive D&D tasks were unavailable for this report.	Mixed	CERCLA	1989 to 1995	5 to 6 years	MED: 11-75
Hanford / 300 Area / FS	CW	192, 194, 119, 191, 183	**Activity 33: 324/327 Facility Deactivation** Personnel at the both facilities will 1) perform preventative maintenance, repair and calibration of failed, malfunctioning, and stable equipment, 2) perform surveys of safety systems and equipment, and 3) monitor nuclear material storage areas. Personnel at hot cell facilities will 1) operate remote equipment such as the plasma arc cutting tool 2) remotely remove one-gallon buckets of cell waste, 3) store and prepare for the removal of 350 legacy fuel storage containers of cesium-137 capsules, pellets, and powder, 4) package cesium powder and pellets in Type-W over-packs, and 5) ship over-packs to the WESF for storage.	Radiological	CERCLA / TPA	1996 to 2005	> 10 years	HIGH: >75

Table 13.2 (continued): Hanford Remediation Worker Activity Descriptions as Reported July 1999

Facility / Area/ Project	Task Type	Information Resource (s)	Activity Title and Description	Primary Exposure Type	Regulatory Driver (s)	Activity Time Line	Duration	Workers per Activity/ Task
Hanford / 400 Area / Misc.	De, CW	15, 195	**Activity 34: Fast Flux Test Facility (FFTF) Shutdown** Completed shutdown activities include reactor de-fueling, washing irradiated fuel assemblies (HLW) and placing them in interim dry storage, and shutting down auxiliary plant systems. In 1995, personnel performed **De tasks** at the FFTF through de-fueling. Personnel at the FFTF also performed **CW tasks** through packaging within Bottom-Loading Transfer Casks and transport activities. These process were conducted in closed loop systems and operated from control room areas.	Mixed and Radiological	CERCLA / TPA	1993 to 1998	5 years	MED: 11-75
Hanford / 400 Area / Misc.	CW, HW	196	**Activity 35: Plutonium Immobilization Plant (PIP): SNM Treatment** Future personnel at the PIP will 1) operate a shipping and receiving area, 2) manage incoming and out going material, 3) operate closed loop plutonium conversion processes, 4) operate glass processing systems, and 5) load canisters. Waste types associated with the PIP include SNM, HLW, TRU, LLRW and HW.	Mixed Chemical and Radiological	CERCLA / TPA	2004 to ?	> 10 years	Unknown

Table 13.3: Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CW Task and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
200 Area TWRS	Deployed (Past/Present) CW Task	Mainten. of HLW / Mixed Waste	**Technology 1: Water Jet Cutting of Saltwell Casing** A high-pressure abrasive water-jet system provides a method for cutting away the saltwell casing in waste storage tanks to provide an escape path for accumulated flammable gases. (212)(213)	MED: 11-75	1. Limited Contact 2. Remote	1. Safe operation within the tank through a remote gear and drive system 2. Minimized risk and exposure to contamination 3. Effective cutting of opening in the steel casing 4. Compliance with safety assessments.	N/A
200 Area TWRS	Deployed (Past/Present) CW Task	Mainten. / Charact. of Mixed Waste	**Technology 2: Cone Penetrometer Raman Spectroscopy** Raman spectroscopy is an advanced optical method to detect and identify chemical compounds and the cone penetrometer provides a path for tank waste characterization. The combination provides an in situ method for soil analysis. (201: Pp. 24-27,214, 215)(213)	MED: 11-75	1. Contact 2. PPE Required 3. Outdoor 4. Airborne	1. Lower cost in monitoring activities 2. Time savings for locating and identifying contaminants 3. Reduced risk of contaminant exposure to workers or equipment 4. Minimal secondary waste from borehole logging for disposal	1. Sites require Level D protection.
200 Area TWRS	Deployed (Past/Present) CW Task	Mainten. of HLW / Mixed Waste	**Technology 3: Annulus Inspection Ultrasonic Crawler Robot** This technology provides the capability to examine the integrity of Hanford's DSTs using an ultrasonic sensor. The robot provides confidence that tanks are sound and remain acceptable for extended life beyond the design life. (216)	LOW: <11	1. Limited Contact 2. Remote	1. Provides critical data for monitoring corrosion and ensuring tank wall integrity 2. Support for periodic maintenance and measurement program 3. Elimination of current practices that involve excessive chemical additions for pH control.	1. Cost 2. Water line could freeze. 3. Path of the robot is limited.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
200 Area TWRS	Deployed (Past / Present) CW Task	Retrieval, Treatment of HLW / Mixed Waste	**Technology 4: The Sluicer** Uses a high flow rate jet of water introduced through a nozzle and aimed to break up solid waste and sludge. (217: P.4, 154)(213)	MED: 11-75	1. Limited Contact	1. Decreased worker exposure in that the operator is not directly breaking up the salt cake. This is a remote process.	1. High use of water 2. Ineffective means for dislodging the tank hard heel 3. Slow
200 Area TWRS	Demonstrated (Proposed) CW Task	Retrieval of HLW / Mixed Waste	**Technology 5: Vehicle-Based Waste Retrieval System (ARD)** The ARD robot crawler is a remotely deployed vehicle for effectively removing waste from tanks with a high-pressure cleaning and solution removal device. (219)(213)	MED: 11-75	1. Limited Contact 2. Remote	1. Reduced quantities of water 2. Minimized potential for leaking of cleaning-process solutions. 3. Flexibility for moving the sluicing function to positions on the tank floor 4. Higher force than sluicing by locating the cleaning tool (sluicer) directly on the hard heel	1. Cost 2. Slow to dislodge harder simulants due to the low pressure of the water system in the demonstration.
200 Area TWRS	Demonstrated (Proposed) CW Task	Mainten. of HLW / Mixed Waste	**Technology 6: Magnetometer** The magnetometer technology provides an improved waste depth estimating method. It is placed manually into the tank where a sensor operates on the principle of a magnetic field. (220)(213)	MED: 11-75	1. Contact 2. PPE Required	1. Provides accurate measurements of the depth of shallow tank waste 2. Reliable method to assist with locating the bottom of a waste storage tank 3. Enhanced safety and effectiveness of related tank programs.	1. Possible exposures to tank wastes (the magnetometer is manually lifted out of the tank, read at ground level, and rinsed with water) 2. Possible exposures to magnetic fields. (No supporting documentation found.)
200 Area TWRS	Demonstrated (Proposed) CW Task	Character. and Pre-Retrieval of HLW / Mixed Waste	**Technology 7: Light Duty Utility Arm (LDUA)** A mobile manipulator system that can deploy a variety of end effectors and tools weighing up to 75 pounds to perform operations ranging from characterization and inspection to retrieval operations. The tools and sensors can be deployed off-axis from the tank-access riser. (201: Pp. 34-37)(213)	MED: 11-75	1. Limited Contact 2. Remote	1. Improved tank inspection 2. Improved waste sample collection 3. Reduced contamination and worker exposure 4. Improved quality and quantity of data.	N/A

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
200 Area TWRS	Demonstrated (Proposed) CW Task	Character. and Pre-Retrieval of HLW / Mixed Waste	**Technology 8: Extended Reach End Effector** The Extended Reach End Effector is an important tool for tank characterization and retrieval. Using the system, operators can reach deep into underground waste-storage tanks to collect waste samples for analysis and perform other in-tank operations. (221, 217)(213)	MED: 11-75	1. Limited Contact	1. Improved tank inspection 2. Improved waste sample collection 3. Reduced contamination and worker exposure 4. Improved quality and quantity of data.	N/A
200 Area TWRS	Demonstrated (Proposed) CW, HW Task	Treatment of HLW / Mixed Waste	**Technology 9: Enhanced Sludge Washing** ESW is the combination of caustic leaching, chromium oxidation and water washing of sludge. ESW is a waste pretreatment process to remove key non-radioactive components from the sludge so that the solid phase is left for the HLW treatment process. (201: Pp. 49-52, 222)(213)	MED: 11-75	1. Possible Contact 2. PPE Required	1. Avoids HLW volume increase. 2. Significant cost and risk reduction 3. Fills current technology gap.	1. Increased risk to the HW task worker who will package and dispose non-radiological wastes. This exposure potential was, however, not documented.
200 Area TWRS	Deployed (Past/Present) CW Task	Mainten. and Treatment of HLW / Mixed Waste	**Technology 10: Leak Detection Pits** Designed to collect leakage that occurs and migrates along channels in the concrete foundation of the tanks. (217: P.3)(213)	MED: 11-75	1. Possible Contact 2. PPE required 3. Airborne 4. Outdoor	1. Early leak detection.	1. Limited number of pits available for utilization. 2. Possible exposure to HLW (assumption)

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
NR	Proposed CW Task	Treatment of HLW, LAW	**Technology 11: Ceramic Waste Forms** Ceramics are achieved by high-temperature treatment and immobilize HLW and LAW by using nepheline, monazite, and corundum. (208: P.7)	MED: 11-75	1. Contact 2. PPE Required	1. Alternative to vitrification. 2. Yields similar volumes compared to vitrification. 3. Treats both HLW and LAW.	1. Requires the following facilities: retrieval and transfer systems, separations facilities, waste processing facilities, interim storage facilities for HLW and disposal facilities for LAW. 2. Potential new hazard: Plutonium High Fired Oxide (No supporting documentation found)
K Basins SNF	Demonstrated (Proposed) CW Task	Treatment and Transport of SNF	**Technology 12: Cold Vacuum Drying Process** The cold vacuum drying process removes water from multi-canister over packs (MCO's). The process consists of heating the MCO, draining the bulk water, vacuum drying residual water, heated recycle drying, and final verification of water removal. (223)	MED: 11-75	1. Contact 2. PPE Required	1. Safe limits of pressurization in the MCO during shipment 2. Safe shipment of fuel for the spent nuclear fuel program.	1. Demo revealed performance problems related to both equipment and problem design. 2. There is a possibility of worker exposure to LLRW and TRU waste types from MCO waste water.
K-Basin SNF	Demonstrated (Proposed) CW Task	Treatment of SNF	**Technology 13: Spent Fuel Sorter with Conan Manipulator Arm** A manipulator attached to an underwater sorting table in the K-Basins provides capabilities for separating inner and outer fuel elements for inspection and cleaning. (224)	LOW: <11	1. Limited Contact	1. Increased safety and reduced radiation exposures 2. Improved visibility 3. Improved quality of inspection 4. Lower cost through reduced reworking	1. Limitations were revealed during the demonstration. 2. Ergonomic problems were identified.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
K-Basins SNF	Demonstrated (Proposed) CW Task	Treatment of SNF	**Technology 14: Spent Fuel Cleaning Machine** An underwater fuel-cleaning machine with water jets offers thorough removal of sand and sludge from fuel elements (225)(213).	MED: 11-75	1. Contact 2. PPE Required	1. Reduced radiation exposure to workers 2. Reduced use of water 3. Effective removal of sludge and particles not visible with manual methods. 4. Greater reliability from automatic washing action 5. Enhanced process to dry the fuel 6. Improved final safety of eventual storage conditions.	N/A
NR	Proposed HW Task	Treatment Mixed Waste	**Technology 15: Calcination** The process of removing water and heating the waste to a temperature sufficiently elevated to decompose some of the chemical compounds such as hydroxides or nitrates. (208: Pp. 8-9)	MED: 11-75	NR	1. Output of a solid waste product that is not glass.	1. Potential new hazard: Plutonium High Fired Oxide (No supporting documentation found)
NR	Proposed HW Task	Treatment of Mixed Waste	**Technology 16: Pyrolysis** A pyrochemical technique that uses a high-temperature, chemically inert environment to break down and volatilize polymeric materials (plutonium-contaminated combustible residues consisting of paper, plastics, rags etc.). Tailored specifically for the glove box environment. (203: Pp. 44-46)	MED: 11-75	1. Contact 2. PPE Required / Glove box	1. Alternative to incineration. 2. Reduce current volumes of combustible wastes at DOE sites. 3. Performed in glove box to minimize exposure risk.	N/A

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
T-Plant, LL Burial Ground WM	Deployed (Past/Present) HW Task	Treatment / Disposal of LLMW, TRU Mixed, HW	**Technology 17: Macro-encapsulation of Mixed -Waste Debris** Macro-encapsulation technology is an alternative means for treating and disposing of hazardous waste debris. Waste is size-reduced and packed into piping that is permanently welded then disposed of at a Low-Level Burial Ground. (226,227)	MED:11-75	1. Contact 2. PPE Required 3. Airborne 4. Indoor	1. Cost savings of greater than 50% compared to incineration 2. Treatment and disposal of waste, rather than storing it in RCRA-compliant buildings 3. A treatment option for non-combustible waste (unlike incineration) 4. Portability and waste volume reduction of approximately 75%.	1. Fire hazards are common to industrial extruder processes. 2. Molten polyethylene can cause severe burns. 3. Level B or C personnel protection is required.
Canister Storage Area WM	Deployment (Present) HW Task	Treatment of LLMW	**Technology 18: Mobile X-Ray System for Examination of LLW Burial Boxes** A mobile x-ray system inspects LLW (LLRW, LLMW) containers. With the imaging technology, compliance-mandated inspections are conducted remote and non-intrusively, providing reliable, recordable data on container contents. (228)	LOW: <11	1. Limited Contact 2. Remote	1. Cost savings 2. Time savings--<1 hour/box throughput (saves 15 hours/box) 3. Burial box integrity 4. Reliable, non-intrusive inspection 5. Enhanced worker safety from minimized handling and exposure.	N/A
WRAP Facility, 200 Area WM	Present HW Task	Treatment of Mixed Waste	**Technology 19: WRAP (Waste Receiving and Processing Facility)** Provides remote verification, characterization, treatment, and repackaging of radioactive solid wastes. (123)	HIGH: >75	1. Limited Contact 2. PPE required 3. Indoor	1. Most waste handling operations are done robotically to minimize worker exposure.	1. Worker exposure may occur during some transport and packaging procedures if process measures are not followed.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
Site Wide WM	Proposed HW Task	Treatment of Mixed Waste	**Technology 20: Cleanable Steel High Efficiency Particulate Air Filter** A cleanable stainless steel HEPA filter represents a near-term solution to the identified problems related to filter failure and waste disposal. (200: Pp. 36-38)	LOW: <11	1. Limited Contact	1. Significant cost savings 2. Increased reliability 3. Can with stand high temperatures, pressure and moisture conditions	1. Increased exposures to those workers cleaning the filter, however no documentation was found associated with this assumption.
PNNL WM/ER	Demonstrated (Proposed) HW Task	Treatment of HW	**Technology 21: Portable Acoustic Wave Sensor Systems for Volatile Organic Compounds (PAWS)** Consists of one or more surface acoustic wave (SAW) sensors utilizing sorbent coating to detect CHCs and VOCs. (202: Pp. 34-38)	LOW: <11	1. Limited Contact	1. Conducts continuous real-time monitoring 2. Cost savings 3. Small, portable, user friendly	N/A
Site Wide ER	Present HW Task	Treatment of Mixed Waste	**Technology 22: Resonant Sonic Drilling** Uses a combination of mechanically generated vibrations and rotary power to efficiently penetrate the soil. Drilling is used for characterization borings to determine location and extent of contamination. (198: Pp. 159-161, 238)	LOW: <11	1.Contact 2. PPE Required	1. Efficient 2. Drilling waste is minimized 3. Minimized exposure of wastes to personnel. 4. Contamination is minimized. 5. Able to reach inaccessible areas.	1. Like all drilling methods, produces noise levels that are considered dangerous to workers not wearing proper protection. 2. Level D personnel protection is used.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
100, 200 Areas TWRS, Site Wide De Projects	Deployed (Past/Present) De Task	Treatment of LLRW	**Technology 23: Aerosol Fog System for Fixing Radioactive Contamination** An aerosol fog system applies a sticky coating capture over the tank-farm work site and other areas to be decontaminated. The "coating-capture" fixes the radioactive contaminants so that workers can enter the area and perform routine maintenance and upgrade activities under enhanced ALARA conditions. (239)	LOW: <11	1. Limited Contact	1. Remote, in-situ application that reduces human exposure and enhances worker safety 2. Reduced time, effort and cost required for preventative radiation-protection 3. Minimized immediate decontamination activity required 4. 25% reduction in secondary waste 5. Effective capture protection that lasts for many weeks.	N/A
K-East Basin SNF	Deployed (Past/Present) De Task	LLRW Decon.	**Technology 24 : Decontamination of Piping Systems Using Hydro lasers** A mobile high-pressure pump unit delivers a high-pressure water jet to safely remove radioactive deposits in contaminated piping systems. (240)	LOW: <11	1. PPE Required	1. Effective removal of radioactive deposits in partially blocked piping 2. Increased safety and reduced worker exposure 3. Decontamination with less water and no acids 4. Cost savings	N/A
105-C ER	Demonstrated (Proposed) De Task	LLRW Decon.	**Technology 25: Concrete Grinder (Shaver/Spaller)** A hand-held concrete and coating removal tool that includes a 5" diamond grinding wheel and vacuum port for dust extraction suitable for flat surfaces. RAD decon for large areas or hot spots. (241, 242, 243)(213)	MED: 11-75	1. Contact 2. PPE Required 3. Airborne 4. Indoor/ Outdoor	1. Less vibration for the operator 2. Hand-held, Lightweight 3. Increased performance, efficient 4. Adaptable to existing HEPA vacuum systems for dust free operations	1. Workers must be careful to ensure that the vacuum hose stays connected properly and that a suitable vacuum level is maintained. 2. Not appropriate for use on very small concrete floors and slabs or those with a significant number of obstructions.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
105-C ER	Demonstrated (Proposed) De Task	Mixed Waste Decon.	**Technology 26: Lead "TechXtract" Chemical Decontamination** A sequential chemical extraction process for the removal of radionuclides, PCBs, and other hazardous organic and inorganic substances from solid materials such as concrete, brick and steel. (244)	LOW: <11 (2 De Workers, 1 RCT)	1. Contact 2. PPE Required	1. A very high percentage of cleaned material released. 2. A safe work place environment for decon. 3. Simple to deploy 4. Production rate is large scale.	1. The manual hoist system should be automated to decrease a risk of worker fatigue. 2. Brick holders should be adapted to process other types of metals. 3. Some skill required.
105-C ER	Demonstrated (Proposed) De Task	LLRW Decon.	**Technology 27: Reactor Stabilization** A dual coating system applied by a conventional paint spray pump and gun at the reactor front face. (245)	LOW: <11	1. PPE Required	1. Better contamination fixation and immediately adheres. 2. Dual coating of polymeric film over foam base provides complete coverage.	1. Application of improved coatings is more time consuming and labor intensive 2. Application of the improved technologies is simple but needs more specialized and trained personnel. 3. PPE required.
105-C ER	Demonstrated (Proposed) De Task	LLRW Decon.	**Technology 28: Self Contained Pipe Cutting Shear** The Lukas model LKE 70 is a self contained pipe cutting shear that does not require any hydraulic fluid lines. This shear has a built-in accumulator that uses approximately 1 pt of hydraulic fluid. (246)(213)	MED: 11-75	1. Contact 2. PPE Required 3. Airborne 4. Indoor/ Outdoor	1. Reduces the need for hydraulic fluid supply lines and/or an electric cord. 2. Reduces the chance of creating airborne contamination when compared to saws. 3. Reduces the chance of contamination release from internally contaminated pipes when compared to saws.	1. The tool had difficulty cutting a 3 inch pipe. 2. The tool seemed to have some difficulties in tight and congested areas. 3. PPE required.

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
105-C ER	Demonstrated (Proposed) De Task	Mixed Waste and LLRW Decon.	**Technology 29: High-Speed Clamshell Pipe Cutter** A light-weight, split frame pipe lathe for severing and/or beveling in-line pipe. (247)(213)	MED: 11-75	1. Contact 2. PPE required 3. Airborne 4. Indoor/ Outdoor	1. Easy use for two persons in confined areas 2. No Welder qualification required 3. Short cutting times 4. No flame, smoke, or applied heating involved 5. Control cutting remotely	1. May require prior surface treatment to ease use.
400 Area	Present De Task	Treatment of HW	**Technology 30: Asbestos Conversion System** Thermally converts the asbestos in asbestos containing material (ACM) into a totally nonhazardous substance. (199: Pp. 126-127, 248)(213)	MED: 11-75	1. Contact 2. PPE Required 3. Airborne 4. Indoor	1. Substantial volume reduction 2. Eliminate the asbestos portion of the waste stream 3. Cost savings	1. Uses extremely hot furnace for conversion.
Site Wide	Past / Present Di Task	LLRW, TRU Dismantle-ment	**Technology 31: Hydraulic Shears/Concrete Breakers/Concrete Pulverizers** Large scale equipment used for demolition activities so that material can be recycled. (249: P. 22, 238)	HIGH: >75	1. Contact 2. PPE Required 3. Airborne 4. Outdoor	1. Safer areas after demolition 2. Materials from old structures can be recycled after demolition.	1. Generation of secondary wastes. 2. Requires manual intervention and operation. 3. No minimized exposure to workers (PPE Required)
105-C ER	Demonstrated (Proposed) Di Task	Mixed, LLRW Dismantle-ment	**Technology 32: Dust Suppression System** A water-based dust suppression system for controlling concrete dust generated by a demolition ram. (250)	LOW: <11	1. Contact 2. PPE Required 3. Airborne 4. Outdoor	1. Reduce the risk of spreading contamination 2. Efficient dust suppression at point of dust generation 3. Labor reduction 4. Reduce water consumption	N/A

Table 13.3 (Continued): Past, Present and Future Remediation Worker Technologies at the Hanford Site as of December 1998

Facility: Hanford, Area and Project	Category (HW, D&D, CWTask and Past, Present, Proposed)	Tech. Title	Technology and Brief Description	# Workers per Tech.	Descriptive Exposure Potential	Advantages	Disadvantages
105-C ER	Demonstrated (Proposed) Di Task	LLRW Dismantle-ment	**Technology 33: Liquid Nitrogen-Cooled Diamond Wire Concrete Cutter** Cuts through reinforced concrete walls and structures (walls and floors) and does not require wire cooling with water. (251)	LOW: <11	1. Contact (Possible *Liquid Nitrogen exposure) 2. PPE Required 3. Absorption 4. Airborne	1. Relatively easy to set up 2. Short setup time 3. No multiple steps 4. No cooling water for the saw, so no secondary liquid waste	1. Liquid Nitrogen can cause frost injuries and asphyxiation 2. Generation of large amount of dust 3. Need large HEPA filtration system 4. Wire overheating

14.0 Works Cited/References Overview

This following section presents the references cited within this document. The references are numbered according to appearance in the document, however, each reference kept the same 'Text Number' throughout the report. For example, if a reference was first assigned the number '12' and was cited again later in the document, the reference would remain '12'.

Page numbers used from a particular reference are presented next to the 'Text Number' within the document. For example, if page 3 of reference number 12 was cited within the text it would appear as '(12: P. 3)'. If multiple pages were cited, it would appear as '(12: Pp. 3-5)' within the text.

A total of 523 references were used in the compilation of this report. 262 references were cited in the document. All 523 references are kept within a Microsoft Access database for sorting and functionality. 'Table1' within the database is the primary table containing all references except Point of Contact (POC) conversations. Conversations are kept within the table called 'conversations'. The third table labeled 'Contacts (Outlook)' within the database contains POC information including name, address, phone number, e-mail address, etc.

All references within the database were assigned a 'reference tracking number'. This number was used for filing hard copy references. All hard copy references accompanied the final report released to NIOSH. The references database also accompanied this report.

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