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CP-18179
Revision 8

224-B Facility Documented Safety Analysis

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

ch2m SM

P.O. Box 1600
Richland, Washington 99352

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CP-18179
Revision 8
EDC#: ECR-15-001584

224-B Facility Documented Safety Analysis

Document Type: DSA Program/Project: CP S&M

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Date Published
December 2016

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APPROVED
By G. E. Bratton at 10:56 am, Dec 08, 2016

Release Approval

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Printed in the United States of America

Total pages: 93

CHPRC RECORD OF REVISION (ROR)	(1) Document Number CP-18179

(2) Title
224-B Facility Documented Safety Analysis

Change Control Record

(3) Revision	(4) Description of Change – Replace, Add, and Delete Pages ADD ROW	Authorized for Release (5) DA/TA	Date
0A	Per HNF-EDC-4-20992.	A.M. Horner 7/23/04	☒
1	Per HNF-EDC-4-23527.	A.M. Horner 9/19/05	☒
2	Release of Revision 2, HNF-EDC-08-28542.	E.N. Dodd III 6/8/06	☒
2A	EDC-07-32482, Page change to address the addition of reference RPP-RPT-27570 (Mackey 2006) with regard to the Seismic Scenario identified in Section 3.5.1.	E.N. Dodd III 1/30/07	☒
3	Update inventory values with respect to decay and Americium buildup, per PRC-EDC-09-41167.	E.N. Dodd III 5/28/09	☒
4	Revision issued to comply with a Condition of Approval to Safety Evaluation Report 09-SED-0081, which required revision and removal of the FHA from the DSA and publish it as a stand-alone document. FHA has been removed, revised as required and is issued as a separate document, CP-42689, 224-B Fire Hazard Analysis.	E.N. Dodd III 9/23/09	☒
5	2011 annual update per ECR-10-002137. The major change is the update of the Radidose accident analyses in Appendix D for Material Solubility Class of 2 and dose consequences in Chapter 3 consistent with the JCO documented in CHPRC-00870.	W.A. Dautell 8/3/11	☒
6	2012 Annual Update per ECR-12-000179. The major changes are deleting the building structure as a Design Feature and reclassifying it as Defense-in-Depth, Important to Safety; provide explicit description of the 224-B facility boundary; and providing an explicit TSR limit for TRU-waste storage.	E.T. Berg 2/15/12	☒
7	2012 Annual Update per ECR-13-00003. Minor corrections to the hazards table and adminstrative updates.	L.I. Covey 4/9/13	☒
8 RS	2016 Annual update per ECR-15-001584. Minor updates to the Hazards Analysis, clarified the addition of new radiological inventory is prohibited, clarified anticipated activities.	C.J. Francy 12/8/16	☒
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A-6004-786 (REV 2)

CP-18179, Rev. 8

224-B Facility Documented Safety Analysis

Prepared by:

CH2M HILL Plateau Remediation Company
Richland, Washington

December 2015

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Terms

AC	administrative control
ARF	airborne release fraction
CHPRC	CH2M HILL Plateau Remediation Company
CW	collocated worker
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
ERDF	Environmental Restoration Disposal Facility
FHA	Fire Hazard Analysis
HA	hazards analysis
HC	hazard category
ICRP	International Commission on Radiological Protection
ID	identification
KA	key attributes
LLW	low-level waste
NDA	nondestructive assay
NPH	natural phenomena hazard
MAR	material at risk
MOI	maximally-exposed offsite individual
MW	mixed waste
PHA	preliminary hazards analysis
QA	Quality Assurance
RF	respirable fractions
RL	U.S. Department of Energy, Richland Operations Office
RO/RO	Roll-on/Roll-off
S&MN	Surveillance & Maintenance
SAC	Specific Administrative Controls
SARAH	*Safety Analysis and Risk Assessment Handbook*
SMP	Safety Management Program
SSC	structures, systems, and components
TED	total effective dose
TRU	transuranic
TSR	technical safety requirements
USQ	unreviewed safety question

ES.1 Executive Summary

The 224-B Facility is a small canyon building located in the 200 East (200E) Area next to B Plant. The 224-B Facility was a plutonium concentration facility that was deactivated in the early 1950s. The building has not operated since and has been in surveillance and maintenance mode for the last several years. The Documented Safety Analysis (DSA) for the 224-B Facility is maintained in accordance with 10 CFR 830, *Nuclear Safety Management*, and as such, is updated on an annual basis, as necessary, to reflect any changes in the facility, the work, or the hazards as they are analyzed in the DSA.

The 2016 annual update to this DSA includes minor updates to reflect planned operations and current support programs. Chapter 2 and the Hazards Analysis in Appendix A were updated to allow borehole (well) drilling activities. Chapter 2 was also updated to reflect current practices in response to deteriorating containers and spills. Minor changes were made to the Technical Safety Requirements (TSRs) in Appendix C to make TSR Administrative Control (AC) violation recovery actions consistent with the actions in other Central Plateau Surveillance & Maintenance DSAs and to eliminate the general principles of operability since no Limiting Conditions of Operations exist for the facility. Other changes to the DSA were updates to support programs; a "Margin of Safety" section was added to Chapter 3 to support Unreviewed Safety Question Determinations; the Fire Protection Program discussion in Chapter 5 was updated to take exception to Key Attribute 11-5, as the facility does not have any fire protection systems; and references to the Safety Management Programs (SMPs) in Chapter 3 and Appendix A were updated to reflect the current SMP titles. A checklist was added to Appendix A that dispositions the energy designators identified in Table A-1. Minor clarifications and edits were made throughout the document.

1.0 Introduction

1.1 Summary

This document provides the Documented Safety Analysis (DSA) for the 224-B Facility using the guidance of U.S. Department of Energy, Richland Operations Office (RL) Letter, "Contract No. DE-AC06-96RL13200 – FHI, Nuclear Safety Expectations for Nuclear Facilities in Surveillance and Maintenance," 02-ABD-0091, 0202188 A, dated May 9, 2002. This DSA was developed in accordance with DOE-STD-1120-2005, *Integration of Environment, Safety, and Health Into Facility Disposition Activities*. The Fire Hazard Analysis (FHA) for the 224-B Facility is presented in CP-42689, *224-B Fire Hazard Analysis*.

1.2 Facility Overview

The 224-B Facility is a small canyon building located in the 200E Area next to B Plant. It contains five process cells separated from three levels of operating galleries by a 12-in. thick concrete wall. A sixth cell (F Cell) is outside the canyon walls. The 224-B Building is a deactivated plutonium concentration facility. The 224-B Building was constructed in the original Hanford Works project as part of the B Plant complex. Process solutions were transferred from the 221-B Canyon Building to the 224-B process cells for purification and plutonium concentration. Plutonium concentration operations were performed in conjunction with B Plant separations activities from approximately 1944 to 1952. The building's process components were deactivated shortly thereafter. The 224-B Building is presently in surveillance and maintenance (S&M) mode.

1.3 Organization Description

The U.S. Department of Energy (DOE) owns and has overall responsibility for the Hanford Site. CH2M HILL Plateau Remediation Company (CHPRC) is the prime contractor responsible for overall coordination and operation of the site facilities. The Central Plateau S&M Organization is responsible for S&M at the 224-B Facility.

1.4 Planned Facility Activities

There are currently no operating processes at the 224-B Facility, since it is in S&M mode. During the current building life cycle stage, planned activities will consist primarily of S&M and storage of incidental S&M supplies and materials related to S&M activities. A more detailed description is provided in Section 2.5, "Planned Operations."

1.5 Summary of Facility Hazard Categorization

Based on the building inventory and potential energy sources, the building is categorized as a Hazard Category (HC) 3 nuclear facility. Determination of the HC is presented in Section 3.3, "Hazard Categorization." For criticality considerations, the building is classified as a limited control facility. A limited control facility contains more than half a minimum critical mass, but

criticality is incredible due to the physical form and distribution of the fissionable material and controls are required to protect the physical form and distribution.

2.0 Facility Description

2.1 Introduction

This section provides the facility description of the 224-B Building. The facility description is based on historical documents, drawings, and observations made by CHPRC staff. No attempt has been made to verify the as-built condition of the building. The descriptions and illustrations are considered to be general information and are used for illustrative purposes only.

In addition to supplying an overall understanding of the facility, the facility description provides the basis for the assumptions made in the hazards and accident analyses (Chapter 3.0).

2.2 Facility Overview

The 224-B Building is a deactivated plutonium concentration facility. The 224-B Building was constructed in the original Hanford Works project as part of the B Plant complex. Process solutions were transferred from the 221-B Canyon Building to the 224-B process cells for purification and plutonium concentration. The facility was constructed in accordance with the design codes, standards, and regulations in place at the time of construction.

The B Plant complex is located in the northwest quadrant of the 200E Area of the Hanford Site. The 200E Area is located on a plateau at an elevation ranging from approximately 620 to 800 ft above mean sea level near the middle of the Hanford Site. Highway 240 is located 5.13 miles southwest of the B Plant complex and the Columbia River is 7.04 miles to the north-northwest. The distance to the nearest Hanford Site boundary is 10.33 miles to the southwest. The 224-B Building lies south of the 221-B Canyon Building and west of the 222-B Laboratory.

Plutonium concentration operations were performed in conjunction with B Plant separation activities from approximately 1944 to 1952. The facility's process components were deactivated shortly thereafter. Subsequent to the deactivation, occupancy of the building included plant support and plant forces personnel, pipe fabrication activities, and decommissioning staff. The decommissioning staff, preparing to start decommissioning in the mid-1980s, were the building's last occupants. The decommissioning staff moved out in the late 1980s, following the deferral of the decommissioning project.

The 224-B Building contains six process cells and an associated operating gallery, offices, and support areas. C Cell received product solutions from the 221-B Canyon Building, as well as wastes from the 224-B Building. Chemical processing of the crude product was performed in cells A, D, and E. B Cell was initially a standby cell but was also used to augment operations in D Cell. F Cell was the final concentration area. At one time, there were plans to convert the west half of F Cell into a process area designated as G Cell, however, this modification was never implemented. The area north of F Cell is known as the loadout area.

2.3 224-B Facility

The 224-B Facility consists of a single canyon-type building that is approximately 40 ft tall. The building is constructed of reinforced concrete and concrete block (Figure 2-1). The first and

second floors have approximate outside dimensions of 197 ft by 60 ft; the third floor is 145.5 ft by 60 ft. The outer walls that surround process cells A through E are 1-ft thick concrete. The building is divided into two main sections (along its length) by a 1-ft thick concrete wall. Offices, galleries, and F Cell are located on one side of the dividing wall and processing cells A through E are located on the other side. Figures 2-2 through 2-4 depict a plan of the three floors in the 224-B Building. The 224-B physical boundary is limited to the 224-B Building structure and any active containments or structures supporting 224-B Building entries that are within the B Plant fence.

2.3.1 Operating Gallery/Service Area

The first floor of the office and gallery portion of the building is 13 ft high and contains vacant offices, a restroom, a change room, a lunchroom, and a mechanical room. The mechanical room housed the air supply equipment and the motor control centers for the process equipment. A series of small lockers along the north wall was previously used for compressed gas cylinder storage, but these lockers are currently empty. A room at the west end of the building was used as a product (plutonium) loadout area (also known as the regulated workshop, truck bay, and maintenance shop). A 4-in. thick, 3 ft wide by 2.67 ft high stainless-steel slab tank (F-10 weigh tank) enclosed in a loadout hood (also known as the process hood) is located along the east wall of the loadout area.

A 1999 inspection of the loadout hood indicates that the loadout hood was decontaminated and stabilized (i.e., sprayed with a fixative). Exterior joints and doors were taped and sprayed. The stainless-steel frame, reinforced-glass viewing windows, piping, and connections to the ventilation header appeared to be intact. No significant dose rates were observed.

Following deactivation of the 224-B Building, the loadout area was converted to a regulated workshop. The loadout hood was isolated from the loadout area by a plywood enclosure. A large roll-up door was installed in an outside wall of the loadout area.

The 12 ft high second floor of the gallery side of the building is a pipe gallery for cells A through E and an operating gallery for F Cell. Aqueous makeup, steam and water piping, instrument and air tubing, and electrical conduit pass through the 1-ft thick concrete wall from the pipe gallery to cells A through E. The east side of F Cell is separated from the office area by a 1-ft thick concrete wall and the west side is separated from the loadout area by a metal partitioning wall. The piping passes through "windows" that were left in the wall when the wall structure was poured. Following installation of the piping, the "windows" were cemented over to seal the cells from the gallery.

A sample room for each cell, A through E, is located in the second-floor pipe gallery. This room also serves as an airlock to an operating deck in A, B, D, and E Cells. The west end of the second-floor gallery was the operating area for F Cell. This area contains panel boards and non-oil filled viewing windows into the cell. Pumps and aqueous makeup tanks for F Cell originally installed in this gallery have been removed. The piping into the cell has been blanked on the gallery side of the metal partitioning wall that isolates the cell. The second floor was modified for use as an office area and lunchroom. The wood-frame and drywall walls in the pipe gallery and F Cell operating gallery define these rooms.

The third-floor gallery was the operating gallery for cells A through E and contains deactivated aqueous makeup tanks, scales, pumps, and control panels for the five cells. Observational windows with movable shielded covers allowed viewing into the cells.

An elevator on the gallery side of the building serves all three floors. The four ton elevator has a 7 ft wide by 8 ft high opening and provides access to the building from a concrete loading platform.

2.3.2 Process Cells

The process cells are identified as cells A through E (F Cell is described later) and are located in the processing portion of the building. The process vessels (and the process cells) serve to provide a measure of confinement for the radioactive inventory. Five of the cells (A through E) are three-stories high (40 ft) and are separated from each other by 15 ft high, 8-in. thick concrete walls. The dimension of each cell is approximately 25 ft by 28 ft. Four of these cells (A, B, D, and E) are similar in equipment and configuration. The first floor of each cell contains two 9 ft diameter by 9 ft tall tanks and one 4.5 ft diameter by 7 ft tall tank. The B Cell has an additional 4.5 ft diameter by 7 ft tall tank. Some of the tanks are equipped with deactivated agitators. Cells A, B, D, and E also have a 10 ft by 12 ft operating deck/platform at the second-floor level. Access to the decks is through the vestibules in the second-floor pipe gallery. The vestibule doors are steel and are sealed with tape to minimize the potential of contamination spread from the cells into the gallery areas. A 40-in. centrifuge is located on each of the operating decks.

C Cell differs from the other cells in both structure and arrangement. Approximately half of the cell has a floor that is 19 ft below the first-floor level. Vessels in the deep cell include two 4.5 ft diameter by 7 ft tall tanks and one 9 ft diameter by 9 ft high tank. A 5.5 ft by 11 ft high pipe tunnel extends 34 ft from the deep cell beneath the first-floor offices to a pipe encasement. The piping in this tunnel and the encasement were used for transferring solutions between 221-B and 224-B Buildings. A single, 9 ft diameter by 9 ft high tank is on the first-floor level of C Cell.

In addition to the A, B, D, and E operating decks/platforms, access to the individual cells is through ground-level exterior doors. Sheet metal covers with neoprene gaskets and caulking have been placed over these doors to minimize air infiltration. Additionally, a 12 ft wide by 21 ft high equipment access door is located in the top portion of the outside wall of E Cell.

A manually operated, 8-ton bridge crane was installed over the cells. The rails run the length of cells A through E, allowing access to each of the cells. The internal rails of the bridge crane are aligned with external rails that pass through the equipment access door, allowing the crane to move equipment into and out of the building. The crane was operated from a walkway that extends around the outside of the cells at the second-floor level. The crane is without power and is now deactivated. A 6 ft high wall shields the walkway from the cells and access doors to the walkway are located at both ends of the A through E pipe gallery.

The 50.5 ft by 25 ft by 24 ft high F Cell is separated from the other cells by a concrete wall. Only process and waste piping interconnect F Cell with the other cells. One-quarter of F Cell is a 12.67 ft by 25 ft centrifuge deck that is elevated 7 ft above the remainder of the cell floor. Doors enter F Cell from the loadout area, the outside, and from the second-floor operating gallery.

Two 26-in. centrifuges are located on the elevated operating deck of F Cell. The first-floor level contains four vessels with dimensions of 4 ft diameter by 5 ft high. Additional equipment includes a small centrifuge that is 12 in. in diameter and two small vessels 1.5 ft diameter by 2 ft high. A scale and agitator motor from elsewhere in the building are being stored in F Cell.

2.3.3 Ventilation

The air balance in 224-B was achieved by air supply and building exhaust. Air was supplied through ducting to the first and third floors of the gallery and office side of the building (air leaked from here into cells A through E), to the F Cell operating gallery, and to the load-out room (air leaked from the latter two areas into F Cell). Cell exhaust was provided by roof ventilators. These roof ventilators (which were not filtered) have been capped and are no longer running. A small amount of air leaks into the vessels, which are tied into the B Plant main exhaust system (Figure 2-5) via stainless-steel subheaders connected to 6-in. diameter, below grade, clay pipes. These, in turn, connect to the 2 ft diameter clay header, laid along the south and west sides of 224-B, that leads to the B Plant main exhaust tunnel at Section 20 of the 221-B Canyon Building (WHC 1994).

In cells A through E, the flanged openings are covered with plywood to prevent animal intrusion. The F-10 weigh tank and loadout hood are also covered by plywood. Based on the existing configuration and conditions, there is no evidence that the tanks are sealed. Due to this fact, the potential for accumulation of hydrogen in the tanks is not considered a credible concern.

The current configuration has not resulted in a detectable release nor the spread of contamination to the office or gallery areas in the 224-B Building. This is likely because surface contamination (e.g., particulate deposition of particulate and residual process contaminants from process operations) has long since stabilized on the surfaces of the structures and components. No significant release of radioactivity is anticipated as long as the contaminated surface areas are not greatly disturbed.

2.3.4 Equipment and Floor Drains

Four sewer systems were used in the 224-B Building (Figure 2-6). Additionally, an internal cell drainage system collected drainage in a waste receiver tank in the deep pit portion of C Cell. The sanitary sewer systems are not currently in use, and rubber plugs have been used to seal the septic drain system.

A gutter along the east end of cells A through E drains in to a 6-in. pipe laid below the cell floors. A floor drain in the corner of cells A, B, D, and E operating decks drains in to the 6-in. line. The 6 in. drain line is sloped from each end of the cells toward C Cell. In C Cell, the drain line empties into Tank C-9 (originally it drained to the larger tank, Tank C-7). Drainage from the deep portion of C Cell collects in a sump with a transfer jet to Tank C-7.

The F Cell and the loadout room each drain to a sump. The sumps were equipped with transfer jets to allow transfer via a series of tanks to Tank C-8. Tank C-8 was equipped with a transfer jet to pump to the 241-B-361 Settling Tank. From the settling tank, liquids were sent to the 216-B-5 reverse well. All transfer jet routings are out of service and will not be reactivated.

A cooling water drain line is found in each of the cells. The drain lines connect to a header laid parallel to the south wall of the 224-B Building. Past the east end of the plant, the pipeline turns north and runs to B Plant where it connects to the 24-in. diameter, cooling water sewer. This low-risk effluent discharge line has been isolated by removing jumpers from the nozzles that routed cooling water to the cooling water headers. In addition, the cooling water was isolated from the buildings that discharged water to the cooling water systems. The effluent discharge lines to basins were plugged by pouring concrete in the valve pits. Sampling has not been performed to determine the contamination levels in the deactivated pipes and/or basins. Some residual contamination may exist in the cooling water sewers, but it is expected that the contamination levels are insignificant from a nuclear safety perspective. The 224-B Building sanitary sewer (i.e., toilets, sinks, and showers) drains to a pipeline that is routed around the west end of B Plant to a sanitary tile field on the north side of B Plant. The pipeline also serves a building to the north and a building to the east end of the 224-B Building. Discussion with long-time facility workers suggests that these pipelines have also been capped, but no documented evidence is available.

All floor drains on the first, second, and third floors of the office and gallery portion of the building have been grouted closed, except for the elevator pit drain. The elevator pit drains to a pipeline (via a french drain) on the north side of the building. This pipeline also receives waste from the 291-B stack area and is connected to drains in the nearby 222-B Building. The pipeline is also routed around the west end of B Plant and drains into the B Plant chemical sewer, which also serves a building to the east of the 224-B Building.

An additional pipeline shown in Figure 2-6 is a transfer line (which is still in place) to Cell 35 of B Plant.

2.3.5 Safety Support Systems

The 224-B Facility does not have active safety support systems such as fire protection, radiological monitoring, building emergency alarm, or notification systems.

2.4 Facility Operational History

Plutonium-bearing solution was transferred from the "tail" end of the 221-B Canyon Building to the 224-B Building C Cell via underground piping. The starting batch size was 330 gallons. Here the plutonium (Pu) solution from the 221 Building was oxidized with sodium bismuthate. Phosphoric acid was then added to produce a by-product precipitation, leaving the Pu in the solution. Centrifuging then separated the solution and precipitate. Nitric acid was added to dissolve the by-product cake, and it became waste. Next, the plutonium-bearing solution was oxidized with potassium permanganate ($KMnO_4$). Hydrogen fluoride and lanthanum salts were added, in what was known as the "crossover" step. A lanthanum fluoride precipitate was produced, leaving hexavalent Pu in the solution.

Impurities were precipitated in a by-product cake, as the fission products were carried with the lanthanum. This by-product cake contained all of the lanthanides (cerium, strontium, lanthanum, etc.) that the bismuth phosphate ($BiPO_4$) could not carry out of the stream. The cake was dissolved in nitric acid, neutralized with sodium hydroxide, and sent to tanks for settling. The plutonium solution was then reduced to plus four state by adding oxalic acid. Lanthanum salts

and hydrogen fluoride again were added, thus precipitating lanthanum fluoride that contained the Pu. The precipitate was separated by centrifugation and potassium hydroxide was added to metathesis the Pu lanthanum fluoride, forming a solid Pu lanthanum oxide. Any liquid was removed by centrifugation, and the solid Pu lanthanum oxide was then dissolved in nitric acid to form Pu nitrate. By this time, the original 330-gallon batch that had entered the building had been concentrated to eight gallons.

2.5 Planned Operations

There are currently no operating processes at the 224-B Facility, since it has been deactivated and is in S&M mode. During the current building life-cycle phase, planned activities will consist primarily of S&M and incidental storage of supplies and materials related to S&M activities and limited hazard reduction deactivation activities. Active building systems are limited to general utilities.

The scope of work includes S&M that maintains confinement of hazardous wastes and protects the worker. This work scope includes pre-approved activities such as asbestos abatement actions, surveillance of the facility, preventative maintenance of selected equipment, and incidental storage of necessary supplies and equipment. The work scope also includes activities that are anticipated but not defined by pre-approved procedures. Examples of anticipated activities without pre-approved procedures include replacement or upgrades of postings and barriers, container management, demand repairs to structures, systems, or components (SSCs), spill response, characterization, and response or investigation of non-typical surveillance reports. Characterization, sampling, and geophysical logging activities may include the insertion, setup, sampling, and (if needed) decommissioning of boreholes (wells). The boreholes (wells) are to be located and operated such that they do not compromise the function or integrity of any facility SSC or program credited with a safety function. Programmatic controls described in Chapter 5 are in place to ensure that S&M activities are within the safety basis and workers are protected.

General deactivation and decommissioning activities are not authorized by this DSA. Additional characterization of the 224-B Facility, such as the process cells and tanks within the process cells, will be required prior to performing deactivation and decommissioning activities. Limited removal of equipment is appropriate to repair equipment or address equipment or structural failure. Any hot work or introduction of combustible material, such as a greenhouse, within the facility will be reviewed and approved by fire protection personnel in accordance with site procedures. The addition of fissile material to the current facility inventory is not authorized.

The unreviewed safety question (USQ) process is a programmatic control used to aid in change management. Pre-approved procedures, when revised, are screened and evaluated as required under USQ requirements. Original and revised procedures and work packages are screened and evaluated as required under the USQ process. Non-typical surveillance reports, audits, and similar documents are reviewed to determine if they meet the criteria for safety evaluations under discovery requirements of the USQ process.

2.5.1 Routinely Surveyed Areas

Routine surveillances are implemented by approved procedures.

2.5.2 Surveillance and Maintenance of Barriers and Postings

Barriers and postings are used to prevent unwarranted access to hazardous areas and to inform personnel of conditions that exist at the facility. Barriers and postings consist of locks and tags, door locks, fencing, confined-space postings, and radiological-area postings. Barriers and postings are installed and inspected as part of the S&M activities, as specified in work instructions. Discrepant conditions regarding barriers or postings are identified on associated data/inspection sheets and corrected.

2.5.3 Identification and Removal of Asbestos

Asbestos-containing materials or presumed asbestos-containing materials are inspected before renovation or equipment removal/repair activities. If damaged friable asbestos is encountered, the actions to be taken will depend upon the scope and severity of the damage. Repair, encapsulation, or removal will be managed through the hazardous material control program requirements of the Safety Management Program (SMP).

2.5.4 Container Management

Normally, relatively small volumes of waste are accumulated during S&M activities. Risk reduction actions or other non-routine activities provide the need for conservative contingency plans. Designated areas may be used to accumulate waste before shipping. Waste staged for transport is placed in waste containers that comply with applicable shipping and disposal requirements. The addition of radiological material to the 224-B Facility inventory is not allowed under this DSA; this requirement does not apply to instrument check sources, calibration check sources, and contaminated tools or equipment. Transuranic (TRU)[1] waste staged for transport is placed in waste containers that comply with applicable shipping and disposal requirements.

Surveillance activities include inspecting existing containers, sampling, identifying, and labeling unlabeled containers. Containers are removed and transported to a permitted storage facility for treatment, storage, and/or disposal. Periodic container inspections are performed to identify container deterioration or signs of leakage. If a deteriorating or leaking container is found, the situation is evaluated and actions are taken based on the severity of the situation, e.g., the container may be monitored, repackaged, or moved to an appropriate treatment/disposal facility. Corrective action is taken, when applicable, to prevent recurrence. The activities are managed consistent with applicable requirements of the Hazardous Material Protection, Work Control, Fire Protection, and Radiation Protection programs.

2.5.5 Equipment Calibration, Testing, Maintenance and Repair

Calibration and testing may be conducted as required on equipment such as electrical components.

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[1] Waste materials contaminated with 100nCi/g of TRU materials having half-lives longer than 20 years.

Maintenance and repairs are performed as necessary to maintain equipment. Proposed changes will be evaluated individually to determine if these are within the bounds of the safety analysis as required by the work control and USQ programs.

2.5.6 Repair and Upgrades of Confinement Systems

Maintenance and repair will be performed to the confinement systems/structures as necessary to maintain confinement. Upgrades or physical changes to these systems may be undertaken if the changes provide equivalent or improved confinement. Proposed changes will be evaluated individually to determine if these are within the bounds of the safety analysis as required by the work control and USQ programs.

2.5.7 Repair and Upgrades of Structural Components

Structural components necessary to ensure confinement will be repaired or upgraded as needed to maintain control of hazardous wastes. Proposed changes will be evaluated individually to determine if these are within the bounds of the safety analysis as required by the work control and USQ programs.

2.5.8 Inspection for and Response to Spills

Periodic surveillances of the 224-B Facility are performed. During these activities, the surveillance team looks for indications of a spill of a hazardous material. If a spill is discovered, the affected area will be isolated to prevent personnel exposure; corrective measures will be determined; and the spilled material will be packaged and shipped to an appropriate disposal facility compliant with requirements of the Radioactive and Hazardous Waste Management Program.

2.5.9 Removal and Disposal of Hazardous Wastes

Any hazardous waste removed from the 224-B Facility may, after proper waste designation, be disposed of at the Environmental Restoration Disposal Facility (ERDF) or at another approved disposal facility, as appropriate. Wastes will be packaged and shipped to an appropriate disposal facility in compliance with requirements of the Radioactive and Hazardous Waste Management Program.

2.5.10 Nondestructive Assay Waste Characterization and Sampling

Nondestructive assay (NDA), waste characterization, and sampling may be performed in the 224-B Building. The activities will be performed in accordance with established programs and procedures and shall comply with special controls (e.g., criticality reviews) as established in this DSA. These activities may be performed to better identify and characterize radioactive material inventory and location, determine quantity and makeup of newly discovered material, or support planning for eventual disposition. The use of in situ destructive assay techniques are not authorized.

2.5.11 Removal of Equipment

Equipment (e.g., abandoned conduits and deactivated electrical equipment) may be removed from the 224-B Building to reduce the risks from known hazards and to redeploy obsolete equipment as spare and replacement equipment (e.g., switchgear and motor control centers). This equipment may contain surface contaminants. Removal activities will be performed in accordance with established programs and procedures.

2.5.12 Radiological Surveys

Radiological surveys are performed to support S&M activities and are performed in accordance with established programs and procedures.

2.5.13 General Inspections and Tours

General inspections and tours may be performed separately from S&M activities. Inspections and tours will be conducted in accordance with appropriate programs and procedures.

2.6 Active Systems

The 224-B Building is supplied only with electrical power. Steam, water, and compressed air have been deactivated and the water supply header has been cut and capped external to the building.

A new, separate 480-volt power distribution system was installed in the building. This system feeds existing electrical panels and systems to the lighting and elevator. Power to the supply fan has been disconnected.

A secondary system that powered the centrifuges and original exhaust system has been deactivated. The main disconnect switch for the 480-volt system is located in the mechanical room. The electrical system to the building is generally only energized for S&M of the operating gallery/service area. Portable lighting is provided for entry to the cells when necessary; however, power may be provided for other S&M activities, if required. The active electrical system is shown in Figure 2-7.

Major hazards associated with the electrical systems have been addressed by upgrading the incoming and first-floor electrical systems. The old control center in the mechanical room has been disconnected/deactivated, and the incoming utility supply wires have been removed. The 224-B FHA (CP-42689) concluded that there is no significant fire-loading hazard; electrical circuits are in conduit, electrical circuits are not normally energized, and there are insufficient combustibles to mobilize significant inventory inside pipes and vessels. Hazards associated with the electrical system are identified in the hazards discussion presented in Appendix A.

The facility does not have any active communication systems. Workers communicate through radios, pagers, or cellular phones in accordance with approved access control procedures.

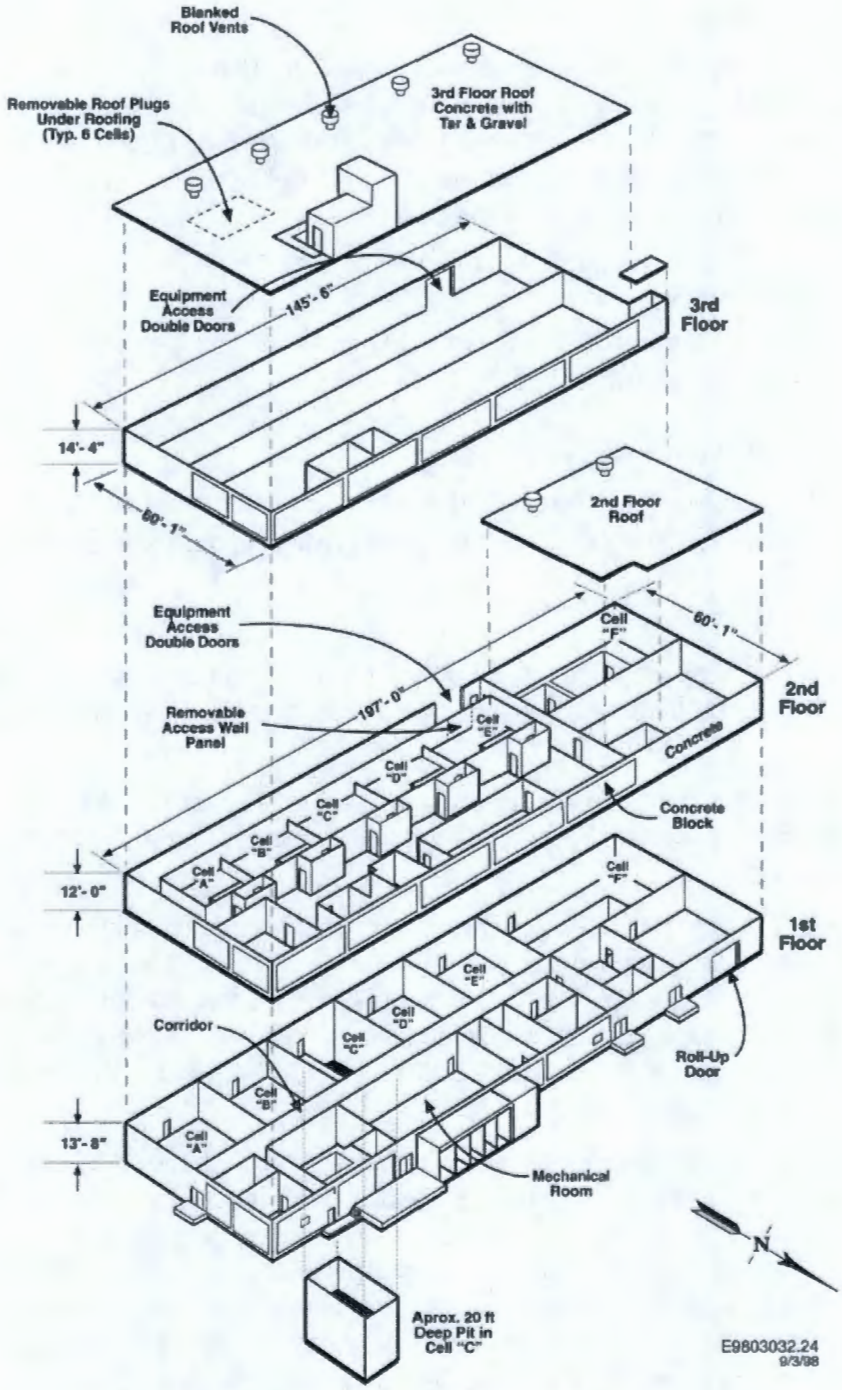


Figure 2-1. 224-B Building

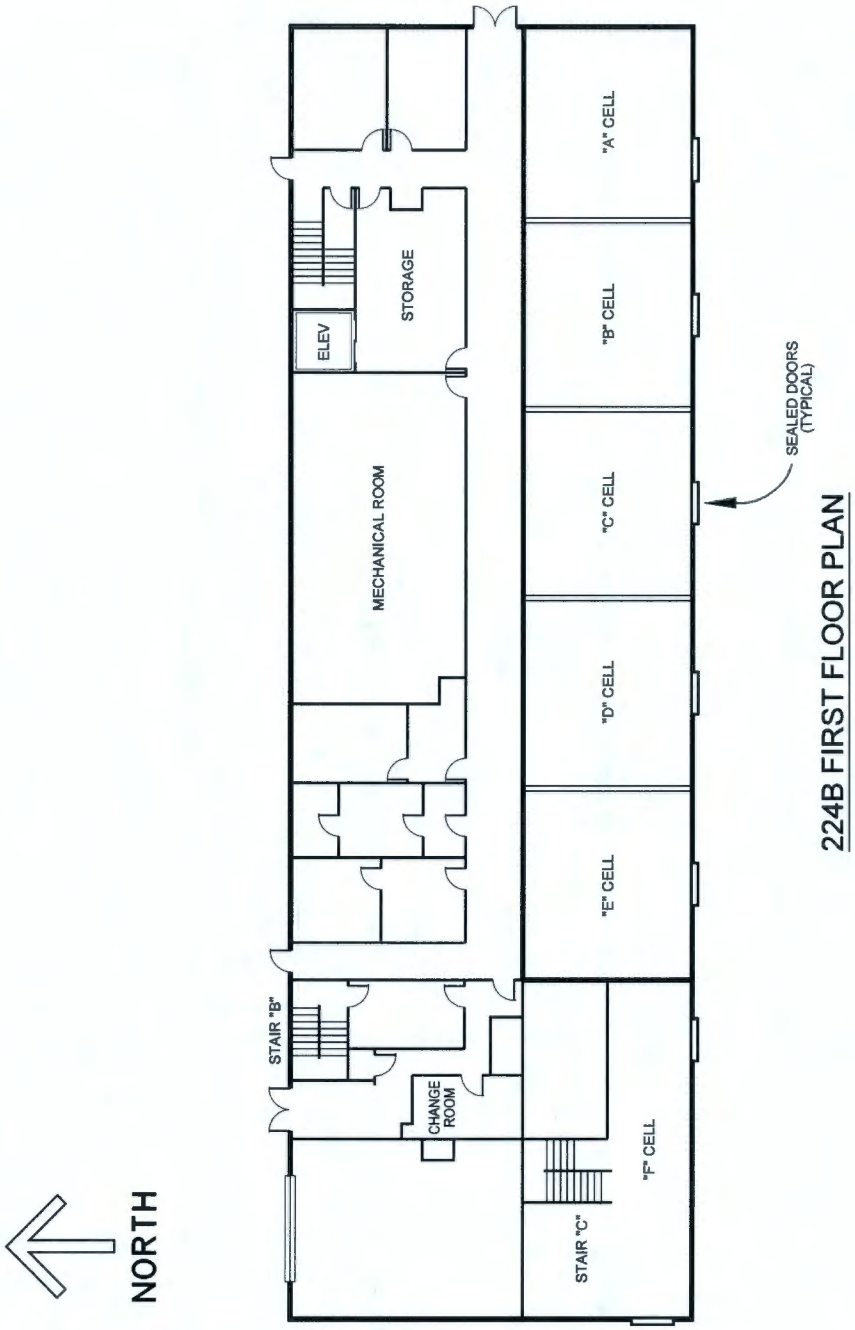


Figure 2-2. First Floor, 224-B Building

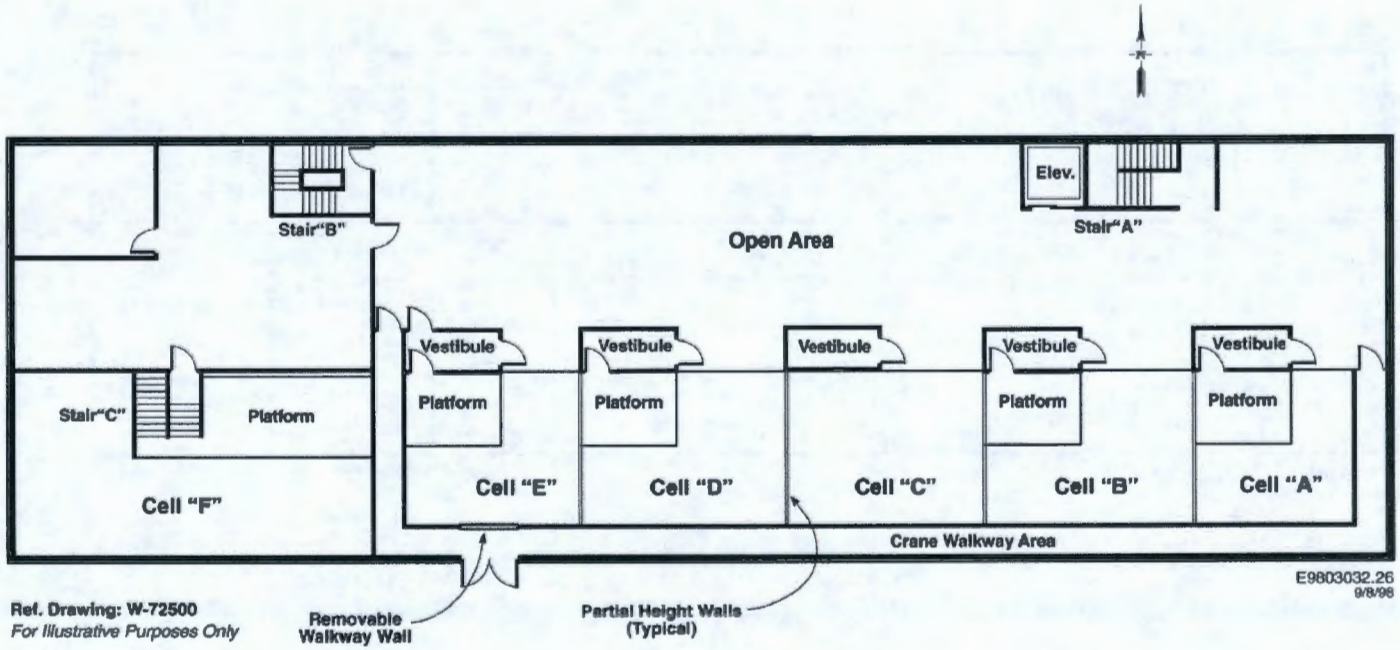


Figure 2-3. Second Floor, 224-B Building

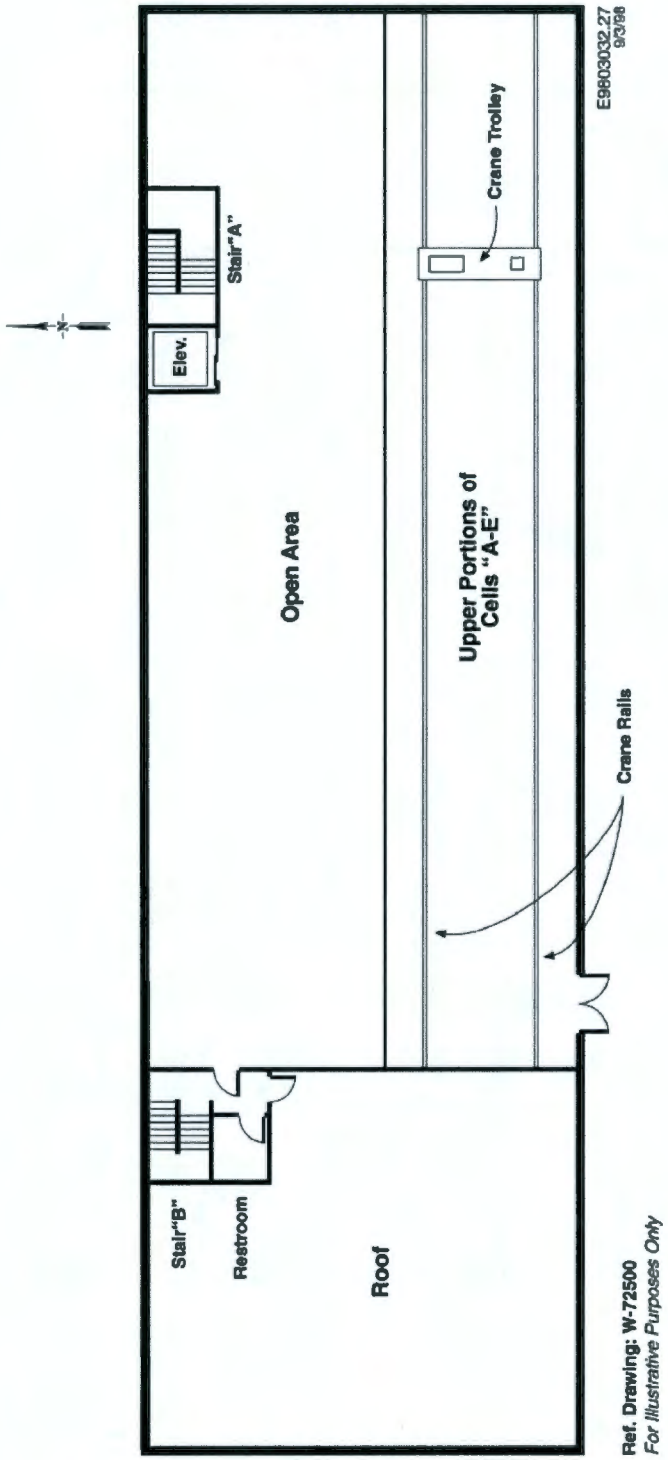
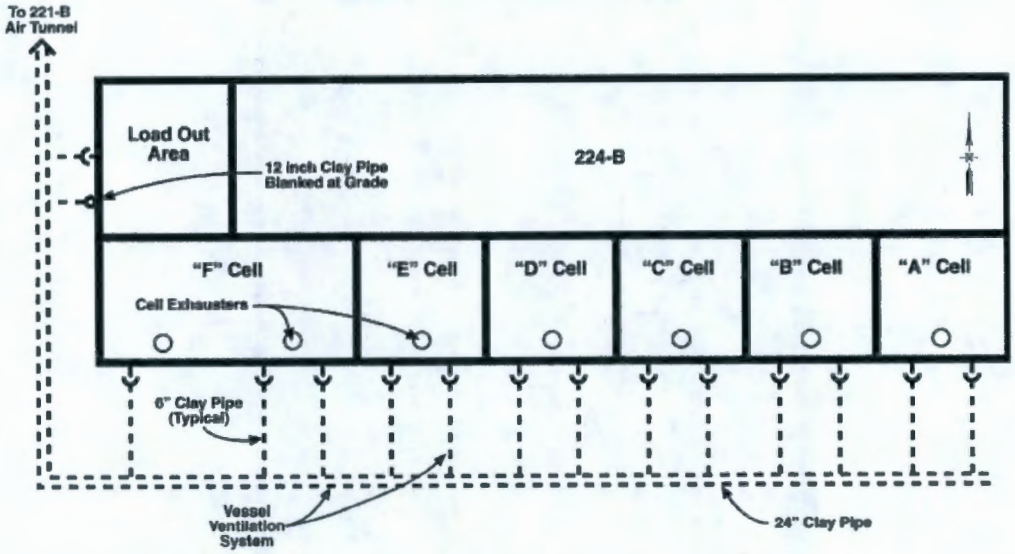
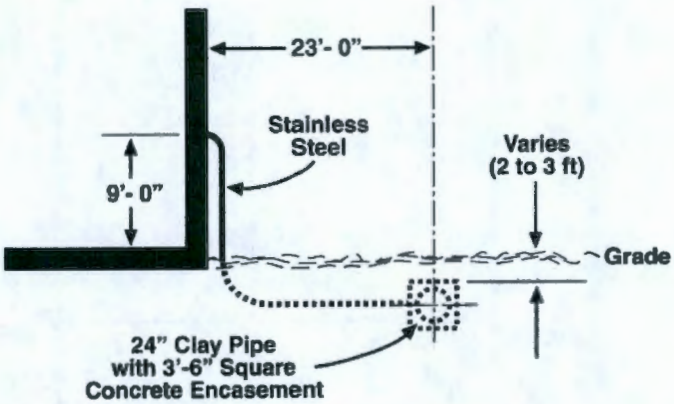


Figure 2-4. Third Floor, 224-B Building





Ref. Drawings: W-75090
For Illustative Purposes Only

Figure 2-5. 224-B Building Process Vessel Vent Link to B Plant Exhaust System

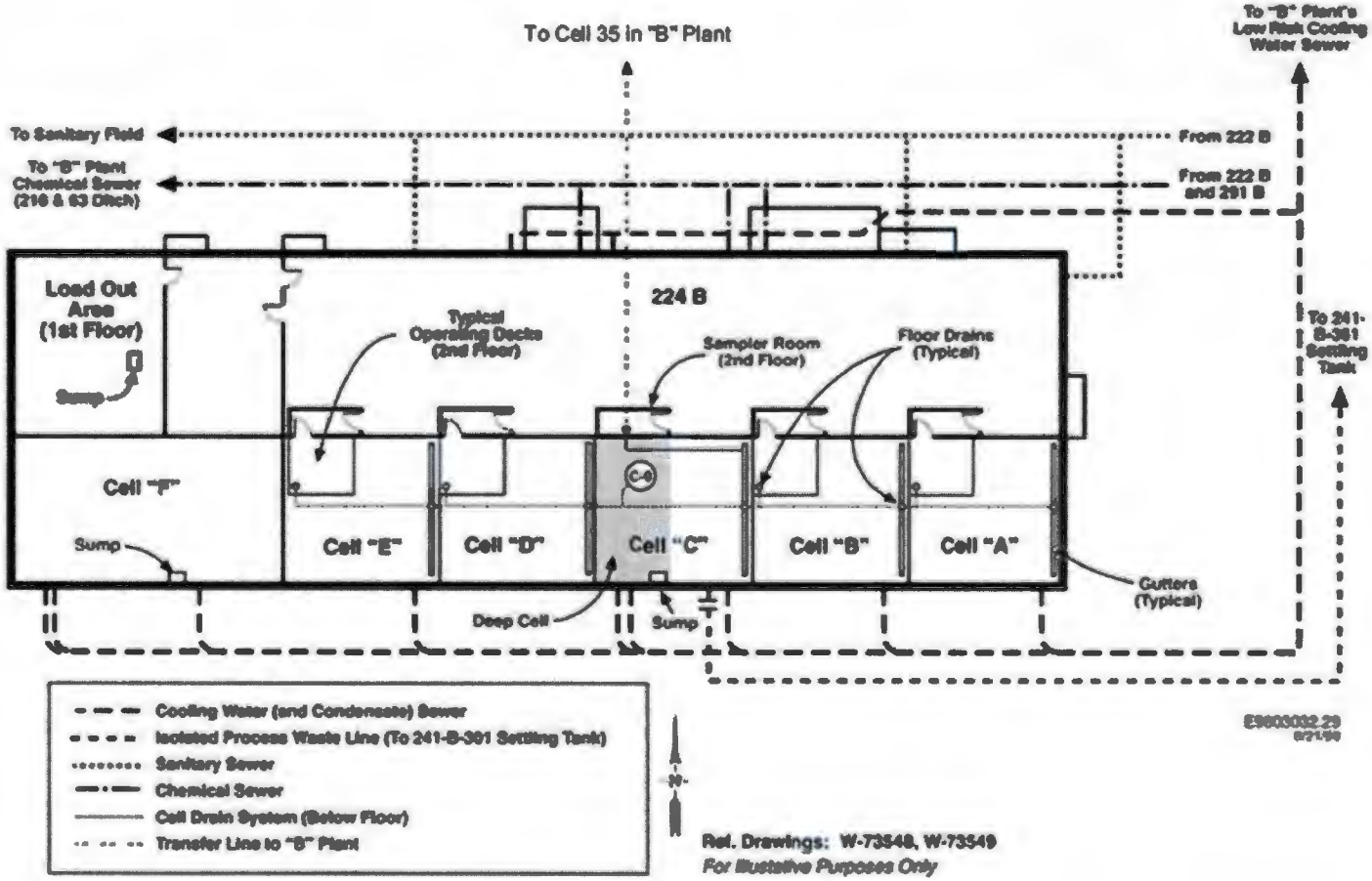


Figure 2-6. 224-B Drain and Sewer System

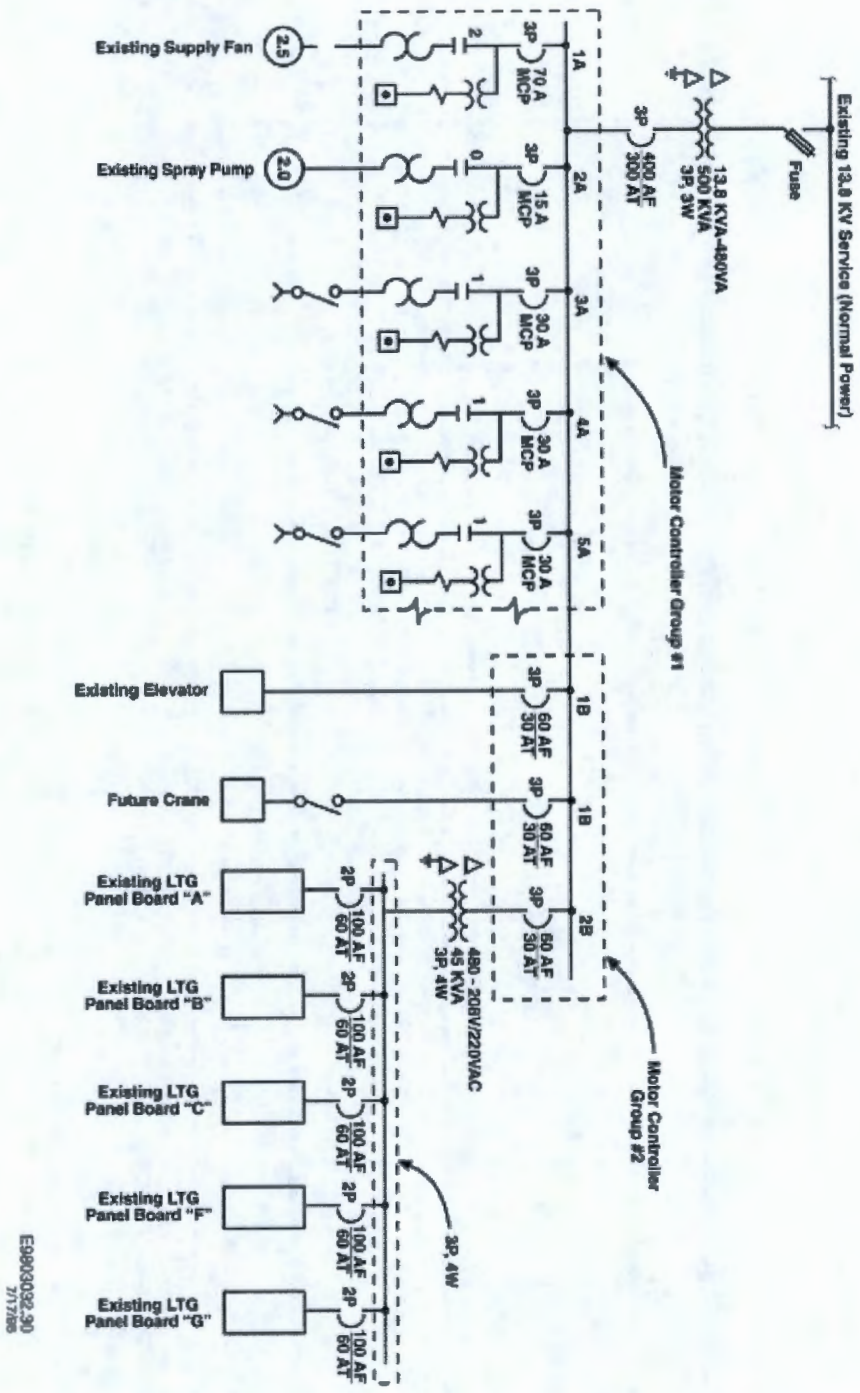


Figure 2-7. 224-B Building Electrical System

3.0 Hazards and Accident Analysis

3.1 Introduction

This chapter presents the results of the hazards analysis (HA) and the accident analysis performed for the 224-B Facility.

The HA was performed to evaluate the current S&M activities, as well as potential deactivation activities. The purpose of the HA was to systematically identify and evaluate the hazards associated with the current and potential deactivation activities at the 224-B Facility. The HA is intended to meet the guidance and/or requirements of the following documents:

- DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*
- DOE-STD-1120-2005, *Integration of Environment, Safety, and Health into Facility Disposition Activities.*

Completing the HA, analyzing the accidents, and developing this document consistent with the guidance and/or requirements of DOE-STD-1120-2005 provides for compliance with the expectations of Title 10, Code of Federal Regulations, Part 830 (10 CFR 830), *Nuclear Safety Management.*

3.2 Summary of Remaining Inventory

3.2.1 Radiological Material Inventory

In 1985, a characterization was performed at the 224-B Building in support of decontamination and decommissioning activities. The results of this effort are documented in SD-DD-TRP-002, *Radiological Characterization of the 224-B Hot Cells.* This DSA provides a bounding source term using SD-DD-TRP-002. This bounding source term is used for the accidents in Section 3.5. The source term generation is described in Appendix B.

The majority of the radionuclides are contained within the process cell areas. The quantities of radionuclides in other parts of the building are minimal and will not contribute significantly to the building inventory. Therefore, the cell inventory is taken as the inventory of the entire facility.

A general survey of the cells in the 224-B Building was performed using standard portable monitoring equipment. Results of the survey were recorded on hand-drawn maps. Based on the results of the general survey, a more thorough sampling and measurement campaign was conducted within the cells. Samples and smears were taken from exposed surfaces and included measurements of the radionuclide loading of the dust. Direct readings were also taken of the piping, tanks, and vessels. The sampling and measurement methods and equipment employed provide a conservative estimate of the radionuclide loading. A more detailed discussion of the methods and equipment is contained in SD-DD-TRP-002. The bounding inventory is presented in Appendix B and is used in the accident analysis and in determining the final HC.

3.2.2 Hazardous Chemical and Toxic Material Inventories

Past DSA references cited internal memos that are not readily retrievable, such as WHC internal memorandum 222-88-049, Management of Process Tanks and Lines in 224-B Building, dated March 22, 1988, which indicated that the 224-B Building process tanks and lines were previously drained and rinsed. Chemicals associated with operations at the 224-B Building may exist as residual deposition in tanks and piping (SD-WM-SAR-017, *Safety Analysis Report for the 224-B Plutonium Concentration Facility Decontamination and Decommissioning*).

Asbestos is a potential hazard associated with the 224-B Building, however, asbestos is not a hazard resulting in acute worker casualty and does not warrant detailed hazards analysis. Asbestos is present in friable and non-friable forms and is monitored and controlled as necessary.

3.3 Hazard Categorization

This section presents the results of the preliminary and final hazard categorizations performed in accordance with the guidance provided in DOE-STD-1027-92.

The sum of the inventory ratios for the 224-B Facility was found using the following equation:

$$\text{Sum of Ratios} = \sum_{i=1}^{j} \frac{\text{Inventory at Risk of Isotope}}{\text{Category 2 Threshold Quantity of Isotope}}$$

The preliminary hazards category was evaluated using the bounding source term as documented in Appendix B. This bounding source term indicates that the initial HC for the facility is HC 2 as shown in the following table.

Table 3-1. Preliminary Hazard Category with Bounding Source Term (Decayed to 2008)

Isotope	Radioactive Inventory (Ci)	Specific Activity Ci/g	Radioactive Inventory (g)	Hazard Category 2 Threshold (g)*	Ratio of Radioactive inventory to threshold values
^{238}Pu	2.69E+00	1.71E+01	1.57E-01	3.6E+00	4.36E-02
^{239}Pu	7.07E+01	6.21E-02	1.14E+03	9.00E+02	1.27E+00
^{240}Pu	1.69E+01	2.28E-01	7.41E+01	2.47E+02	3.00E-01
^{241}Pu	2.89E+01	1.03E+02	2.80E-01	2.80E+01	1.00E-02
^{242}Pu	1.44E-03	3.93E-03	3.66E-01	1.51E+04	2.42E-05
^{241}Am	1.31E+01	3.43E+00	3.82E+00	1.60E+01	2.38E-01
Total	1.32E+02		1.22E+03		1.86E+00

* *From* DOE-STD-1027 or LA-12846-MS, *Specific Activities and DOE-STD-1027-92 Hazard Category 2 Thresholds LANL Fact Sheet*, 1994.

The final hazard categorization was completed using the bounding source term (Appendix B). DOE-STD-1027-92 indicates that the default release fraction used for the hazard categorization standard is 1.0×10^{-3}. The contaminated equipment/waste handling fire presented in Section 3.5.5 uses a bounding release fraction for all of the 224-B accidents of 5.0E-04, which is 50 percent lower than the release fraction used in the hazard categorization document. Section 2.4.2 of HNF-8739, Revision 1, *Hanford Safety Analysis and Risk Assessment Handbook,* (SARAH) indicates that the threshold values may be adjusted corresponding to release fractions. The HC 2 threshold values for each isotope can therefore be doubled. The resulting sum of the activity ratios divided by the HC 2 threshold is then 0.93. While the 0.93 value is close to one, the conservative assumption that all of the material is modeled as packaged waste rather than fixed contamination to non-combustible surfaces (such as the inside of the tanks) supports concluding that the facility meets the requirements for a HC 3 facility.

3.4 Summary of Hazards Analysis Methods Used

The methodology and results of the 224-B Facility hazard analysis are presented in this section. The analysis was a structured, systematic examination of the facilities and operations described in Section 2.5. The hazard analysis consists of a hazard identification, classification, and evaluation.

3.4.1 Methodology

The 224-B HA was developed using an approved facility HA, the approved 224-T HA (since the 224-T Building was a sister facility for operations other than Transuranic Waste Storage and Assay Facility), and the guidance in the SARAH manual.

The 224-B Facility hazard evaluation consisted of completion of the hazards identification checklist in SARAH and a preliminary hazards analysis (PHA) developed using a "What if Checklist."

In the HA process, the team reviewed the facility conditions, the energies identified in the hazard identification checklist, and the planned activities to determine a set of hazardous conditions. The hazard analysis team assigned a preliminary likelihood, consequence, and risk category. These values are qualitatively assigned by the team and are used as a tool to identify the hazardous conditions that warrant additional analysis in the DSA. Tables 3-2, 3-3 and 3-4 reproduce hazard frequency, consequence categories, and risk bins, respectively, given in the SARAH manual.

Qualitative assessment of the likelihood and consequences used to determine the risk bin was performed using the values in the tables below. Any scenarios identified with a risk bin value of III or higher in overall risk are candidates for quantitative consequence analysis as design basis accidents.

Table 3-2. Frequency Categories Used in the Hazard Analysis

Estimated Annual Frequency	Description: Based on the initiating event(s) postulated
Anticipated: Above 10^{-2}/yr	The hazardous condition has occurred, or is likely to occur, during the lifetime of the building.
Unlikely: 10^{-4}/yr < to < 10^{-2}/yr	The hazardous condition is foreseeable, but unlikely to occur during the lifetime of the building.
Extremely Unlikely: 10^{-6}/yr < to < 10^{-4}/yr	The hazardous condition is perhaps possible, but extremely unlikely to occur during the lifetime of the building.
Beyond Extremely Unlikely: Below 10^{-6}/yr	The hazardous condition is considered too improbable to warrant further consideration.

Table 3-3. Safety Consequence Assessment Codes Used in the Hazards Analysis

Consequence	Maximum Offsite Individual (MOI)	Collocated Worker (CW)
High	>25 rem TED or >ERPG-2/TEEL-2	>100 rem TED or > ERPG-3/TEEL-3 at building boundary[1] or prompt death/serious injury to a facility worker.
Moderate	≥1 rem TED or >ERPG-1/TEEL-1	≥25 rem TED at building boundary[1] or >ERPG-2/TEEL-2 at building boundary, or significant radiological or chemical exposure to facility workers[2]
Low	<Moderate consequence	<Moderate consequence

[1] No less than 100 m (328 ft). For elevated releases, use point of highest dose.

[2] "Significant exposure" is one that is qualitatively judged to result in immediate, but reversible health effects.

ERPG = emergency response planning guideline

TED = total effective dose

TEEL = temporary emergency exposure limit

Table 3-4. Risk Bin Values

Consequences	Beyond Extremely Unlikely Below 10^{-6}/yr	Extremely Unlikely $10^{-4} - 10^{-6}$/yr	Unlikely $10^{-2} - 10^{-4}$/yr	Anticipated Above 10^{-2}/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	II*
Low Consequence	IV	IV	III	III

*Risk Bin designation taken from DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic Waste Facilities.*

The scenarios identified as candidates for quantitative consequence analysis are presented in Table 3-5, "Scenarios Selected for Quantitative Review." Table 3-5 identifies the relative risk

assigned based on the PHA and may change as a result of the final hazard analysis process. These have the highest potential consequences among all scenarios considered. The identification (ID) reflected is the hazard ID from the PHA table (Table A-2 of Appendix A).

Table 3-5. Scenarios Selected for Quantitative Review

ID	Hazardous Conditions	Preliminary Risk Bin Value
1	Failure of the building structure resulting from a seismic event	II
2	Failure/collapse of the building from a crane drop accident	I
4	Building fire involving all of the inventory	I
10	Equipment drop resulting in a release of material	I
12	Fire involving staged waste	I

3.5 Accident Analysis

In developing the accident analysis for the 224-B Facility, a straightforward approach could be taken due to the lack of operating systems and the limited scope of activities. The evaluation of the resulting scenarios and their potential consequences are presented in this section.

For each accident scenario, airborne release fractions (ARFs) and respirable fractions (RFs) were determined using recommendations in DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. The potential dose was then determined using the RADIDOSE program (version 3) for the Hanford Site. The default values for breathing rate and atmospheric dispersion coefficients in RADIDOSE were used in evaluating the dose consequences for onsite workers and the public, respectively. The released respirable radiological material is assumed to be in the form of a generally soluble material for each of the accidents modeled. The International Commission on Radiological Protection (ICRP) 68, *Dose Coefficients for Intakes of Radionuclides by Workers: A Replacement of ICRP Publication 61,* and ICRP 71, *Age Dependent Doses to Members of the Public from Intake of Radionuclides, Part 4, Inhalation Dose Coefficients,* dose conversion factors were used. The RADIDOSE analysis results are presented in Appendix D, *RADIDOSE Calculations*.

The CW receptor was evaluated at 328 ft (100 m). The nearest site boundary is 10.33 miles (16,630 m) to the southwest and was used as the minimum distance to the MOI. Distances were taken from Hanford Map, Version 2.0.

3.5.1 Seismic Scenario

A Uniform Building Code seismic demand is expected to result in some structural damage (cracking, spalling, and minor structural damage). A much more significant seismic event would be required to cause catastrophic failure of the building. For the analysis of the seismic scenario presented here, a total catastrophic failure of the building is modeled. Based on the Uniform Building Code, from the HA, and based on the seismic spectra discussed in *Development of PC2 Surface Spectra for Double-Shell Tank Facilities, DOE Hanford Site in Washington State*, RPP-RPT-27570 (Mackey 2006), a conservative frequency of "unlikely" is assumed for this scenario.

For this analysis, the seismic event assumes the total failure of the 224-B Building structure with a resulting ground level release of material. For this type of event, the entire building and the entire inventory are affected (see Table 3-1). The event is a short duration event, so an acute ground release without plume meander is used to model the potential consequences. There is no response or mitigating action associated with this scenario.

Section 4.4.3.3.2 of DOE-HDBK-3010-94 addresses releases based on observations with powder in a can, and the recommended bounding ARF and RF values provided are 1.0E-03 and 1.0E-01, respectively. The values are conservatively used to bound the form of the remaining materials. This is appropriate since the material is considered to be in the form of the fixed residuals remaining within the equipment following cleanout/flushing activities. These ARF and RF values were input into the RADIDOSE software to determine the dose consequences (Appendix D). The resulting dose consequences to the target receptor are presented in Table 3-6, "Seismic Event Consequences." With the unmitigated frequency of "unlikely," the corresponding risk bin value for the CW and MOI are also presented in this table.

Table 3-6. Seismic Event Dose Consequences

Receptor (Location)	TED (rem)	Risk Bin Values
CW (100 m)	1.33E+01	III
MOI (16.6 km)	8.19E-03	III

A fire was not included in the seismic event, since a fire is not expected during a building collapse of an inactive facility. The release fraction for a fire involving the entire building is discussed in Section 3.5.3 and is identified as 6.0E-05. This is smaller than the 1.0E-4 ARF x RF for the building collapse. Therefore, a fire in the seismic event would, at most, increase the dose consequences presented in Table 3-6 by 60 percent. From the values in Table 3-6 and the discussion below it is apparent that a 60 percent increase in the consequences would not change the conclusion that the consequences are low.

The following conservatisms were used in this analysis.

- The release was modeled based on powder rather than fixed material or thin film residuals within the equipment.

- The released respirable material is modeled as a generally soluble compound.
- The examined seismic event is assumed to catastrophically fail the building. The frequency of this event is conservatively considered "unlikely."
- No credit is taken for any damage ratio or leak path factor as part of the model.

The total effective dose (TED) for the CW is well below the risk guideline of 25 rem, which corresponds to a low consequence class. Similarly, the TED to the MOI is well below the 1 rem risk guidance, which corresponds to a low consequence class.

Given the conservatism identified in this model, the overall low consequences, and the overall low risk, no Safety Class or Safety Significant controls to reduce potential consequences to the target receptors were identified for this event. Further, since the building is not routinely occupied, no mitigation controls to protect building personnel, other than those implemented by the Emergency Preparedness Program, are warranted.

3.5.2 Roof Collapse (Crane Accident) Scenario

The use of a crane may be required at some point during the S&M phase to repair the roof structure or perform other tasks. As a result, drop of a crane load is a potential accident that warrants evaluation. Drop of a single crane load would most likely result in a single location failure of the roof and not a complete collapse of the building structure. However, for conservatism and ease of analysis, it is assumed that the entire building structure fails. The crane drop event is considered an "anticipated" event.

For this type of event, the entire building and inventory are affected (see Table 3-1). The event is a short duration event, so an acute ground release without plume meander is used to model the potential consequences. There is no response or mitigating action associated with this scenario.

Section 4.4.3.3.2 of DOE-HDBK-3010-94 addresses releases based on observations with powder in a can, and the recommended bounding ARF and RF values provided are 1.0E-03 and 1.0E-01, respectively. These values are conservatively used to bound the form of the remaining materials. This is appropriate since the material is considered to be in the form of fixed residuals remaining within the equipment following cleanout/flushing activities. These ARF and RF values were input into the RADIDOSE software to determine the dose consequences (Appendix D). The consequences are presented in Table 3-7, "Crane Drop Event Consequences." With the frequency of "anticipated," the corresponding risk bin values for the CW and the MOI are also presented in this table.

Table 3-7. Crane Drop Event Dose Consequences

Receptor (Location)	TED (rem)	Risk Bin Values
CW (100 m)	1.33E+01	III
MOI (16.6 km)	8.19E-03	III

The following conservatisms were used in this analysis.

- The release was modeled based on powder rather than fixed material or thin film residuals within the equipment.

- The released respirable material is modeled as a generally soluble compound.
- The "anticipated" crane drop event is assumed to fail the entire building structure.
- No credit is taken for damage ratio or any leak path factor as part of the model.

The TED for the CW is well below the risk guideline of 25 rem, which corresponds to a low consequence class. Similarly, the TED to the MOI is well below the 1 rem risk guidance, which corresponds to a low consequence class.

Since the unmitigated risk bin values for the CW and the MOI were both III and given the conservatism identified in this model, the overall low consequences, and the overall low risk, no Safety Significant or Safety Class controls are identified. The Operational Safety Program implements the requirements of DOE/RL-92-36, *Hanford Site Hoisting and Rigging Manual*, which serve to reduce the potential for a crane drop event; particularly one that could result in the catastrophic failure of the entire structure.

3.5.3 Building Fire Scenario

The bounding fire event is a fire that impacts the entire building and the entire inventory (see Table 3-1)[2]. Although some plume rise might be expected, the accident analysis is conservatively modeled as a ground level release. The event is a short duration event, so an acute ground release without plume meander is used to model the potential consequences. From the HA, the assigned frequency category for this scenario is "anticipated."

For a fire, Section 4.4.1.1 of DOE-HDBK-3010-94 identifies the ARF and RF as 6.0E-03 and 1.0E-02, respectively, for non-reactive compounds, plutonium oxide, or other powders. The material is contained within noncombustible tanks and equipment. These values were input into the RADIDOSE software to determine the dose consequences (Appendix D). The resulting dose consequences to the target receptors are presented in Table 3-8, "Building Fire Scenario Dose Consequences." With the assumed frequency of "anticipated," the corresponding Risk Bin values for the CW and the MOI are also presented.

Table 3-8. Building Fire Scenario Dose Consequences

Receptor (Location)	TED (rem)	Risk Bin Values
CW (100 m)	7.97E+00	III
MOI (16.6 km)	4.91E-03	III

The following conservatisms were used in this analysis.

- The release was modeled based on powder rather than fixed material or thin film residuals within the equipment.

[2] A building fire and a localized fire were postulated as potential hazards in the PHA and are identified in Table A-2 of Appendix A. However, the accident analysis shows that there is no change in the frequency and no additional control requirements for a fire impacting the entire building inventory. In light of these facts, the more conservative model of a complete building fire was chosen for evaluation.

- The released respirable material is modeled as a generally soluble compound.
- No credit is taken for any damage ratio or leak path factor as part of the model.

The unmitigated risk bin values for the CW and the MOI were both III. Given the conservatism identified in this model, the overall low consequences, and the overall low risk, no Safety Class or Safety Significant controls are warranted. However, the 224-B Building structure does serve, to some extent, as a confinement barrier. As a result, the 224-B Building structure is designated as defense-in-depth.

Due to the low risk, no additional fire scenarios for material within the facility are evaluated.

3.5.4 Contaminated Equipment Removal Scenario

For this analysis, the most contaminated single NDA location within the 224-B Building is assumed to be the contaminated equipment being removed. The 652 g inventory associated with the D-3 tank was chosen since it has the largest reported inventory for any single location within the facility. The assigned inventory values of the isotopic distribution for the D-3 tank are presented in Tables B4 and B5 of Appendix B.

In this scenario, the equipment is dropped, resulting in a ground-level release of material. The event is a short duration event, so an acute ground release without plume meander is used to model the potential consequences. There is no response or mitigating action associated with this scenario. From the HA, a conservative frequency of "anticipated" is assumed.

Section 4.4.3.3.2 of DOE-HDBK-3010-94 addresses releases based on observations with powder in a can, and the recommended bounding ARF and RF values provided are 1.0E-03 and 1.0E-01, respectively. These values are conservatively used to bound the form of the remaining materials. These ARF and RF values were input into the RADIDOSE software to determine the dose consequences (Appendix D). The resulting dose consequences to the target receptor are presented in Table 3-9, "Equipment Drop Scenario Dose Consequences." With the frequency of "anticipated," the corresponding risk bin values for the CW and the MOI are also presented in this table.

Table 3-9. Equipment Drop Scenario Dose Consequences

Receptor (Location)	TED (rem)	Risk Bin Values
CW (100 m)	7.09E+00	III
MOI (16.6 km)	4.37E-03	III

The following conservatisms were used in this analysis.

- The release was modeled based on powder rather than fixed material or thin film residuals within the equipment.
- The released respirable material is modeled as a generally soluble compound.

- A low energy drop is modeled as a more energetic seismic event debris impact.
- No credit is taken for any damage ratio or leak path factor as part of the model.

The TED for the CW is well below the risk guideline of 25 rem, which corresponds to a low consequence class. Similarly, the TED to the MOI is well below the 1 rem risk guidance, which corresponds to a low consequence class.

The unmitigated risk bin values for the CW and the MOI are both III. Given the conservatism identified in this model, the overall low consequences, and the overall low risk, the major risk is to the onsite worker involved in the work evolution at the time of the accident. The Operational Safety and Hazardous Material Protection SMPs serve to reduce the risk of this event to the onsite worker by implementing hoisting and rigging controls and job hazards analyses.

3.5.5 Contaminated Equipment/Waste-Handling Fire

S&M activities generate contaminated waste. Typically, the waste packages are limited to incidental low-level waste (LLW) associated with contamination control of S&M activities.

However, conditions may require risk-reduction activities for facility or personnel safety, which could lead to TRU waste from deactivated process components. This waste could generate waste packages staged for transport and disposal. For this analysis, a hypothetical waste drum is engulfed in a fire while being removed from the 224-B Building. The scenario assumes that the resulting fire burns with sufficient energy to result in releasing material in to the environment. The material at risk (MAR) inventory is assumed to be approximately 107 g, which includes 100 g of ^{239}Pu plus the corresponding gram quantities of other plutonium isotopes and americium based upon the isotopic distribution given in Table 3-1. A typical waste container is expected to consist primarily of step-off and contamination control waste and historically would be below 1 gram of ^{239}Pu. The use of 100 grams of ^{239}Pu and a proportional amount of other isotopes listed in Table 3-1 anticipates that the waste will include a contaminated component or piece of equipment. Because inventory values of this quantity would require a piece of contaminated equipment, it is reasonable to assume that no significant fraction of the MAR would be ejected from the drum and burn unconfined.

The following conservatisms were used in this analysis.

- The released respirable material is modeled as a generally soluble compound.
- The accident is conservatively modeled as a ground level release.
- The ARF and RF values were based on loosely agglomerated waste and are conservative as applied to packaged waste staged at the building.

The event is a short duration event. There is no response or mitigating action associated with this scenario. From the HA document, a conservative frequency of "anticipated" is assumed.

Section 5.2.1.1 of DOE-HDBK-3010 addresses releases for packaged waste in a fire and the recommended bounding ARF and RF values provided are 5.0E-4 and 1.0E+0, respectively. These bounding values were based on experiments on loosely agglomerated waste and, therefore, are conservative as applied to packaged waste staged at the building. These ARF and RF values were input into the RADIDOSE software to determine the dose consequences (Appendix D).

The resulting dose consequences to the target receptor are presented in Table 3-10, "Waste Handling Fire Dose Consequences." With the frequency of "anticipated," the corresponding risk bin values for the CW and the MOI are also presented in this table.

Table 3-10. Waste Handling Fire Dose Consequences

Receptor (Location)	TED (rem)	Risk Bin Values
CW (100 m)	5.82E+00	III
MOI (16.6 km)	3.59E-03	III

The TED for the CW is well below the risk guideline of 25 rem, which corresponds to a low consequence class. Similarly, the TED to the MOI is well below the 1 rem risk guidance, which corresponds to a low consequence class.

For the CW and the MOI, the unmitigated risk bin values are both III. Given the conservatism identified in this model and the overall low consequences, the risk of this event is adequately controlled by the SMPs.

3.6 Evaluation of Structures, Systems, and Components

From Section 3.5, "Accident Analysis," and Appendix A of this DSA, there is only one SSC associated with the 224-B Facility that warrants evaluation for Safety Significant or defense-in-depth designation. The SSC of interest is the building structure.

Since all accidents evaluated resulted in unmitigated risk bin values of III (see Table 3-11), the overall risk associated with the authorized activities at the 224-B Facility is low and the building structure does not warrant identification as a Safety Significant SSC nor a passive design feature. However, the 224-B Building structure is identified as providing a degree of confinement and hence, is considered defense-in-depth.

There are no Safety Significant SSCs related to worker safety for the 224-B Building. Consistent with the HA, accident analysis, and discussion in this section, there are contractor implemented SMPs applicable for the 224-B Facility that are addressed in the SMP AC in Appendix C, Section C.4.1.

Table 3-11. Final Risk Bin Determination for Analyzed Accidents

ID	Accident Analysis Section	Hazardous Conditions	Final Risk Bin Determination
1	3.5.1	Failure of the building structure resulting from a seismic event	III
2	3.5.2	Failure/collapse of the building from a crane drop accident	III
4	3.5.3	Building fire involving all of the inventory	III

Table 3-11. Final Risk Bin Determination for Analyzed Accidents

ID	Accident Analysis Section	Hazardous Conditions	Final Risk Bin Determination
10	3.5.4	Equipment drop resulting in a release of material	III
12	3.5.5	Fire involving staged waste	III

3.7 Margin of Safety

This section addresses margins of safety to facilitate USQ evaluations for changes affecting the 224-B Facility. Based on the guidance in DOE G 424.1-1B, Appendix A, and PRC-PRO-NS-062, the safety basis was reviewed to determine if there were instances of DOE-defined functional requirements for equipment that would provide a basis for the identification of margins of safety. There is no explicit margin of safety identified in this DSA. Margin of Safety must be an explicit function between a design or assumed failure point and its associated safety limit. This DSA does not contain safety limits nor does it have Safety Class SSCs that if failed, would result in a potential release greater than 25 rem to the MOI. As such, there are no explicit or implicit margins of safety associated with the 224-B Facility. The margin of safety question in USQ evaluations performed against this DSA shall be answered "No."

4.0 Hazard Controls

This chapter identifies the building features and control elements required for authorized activities at the 224-B Facility. It provides details about building equipment and features that are necessary to satisfy the current risk evaluation guidelines, provide defense-in-depth, and contribute to worker safety. The controls presented here are based on the results of the HA and accident analysis for S&M activities at the 224-B Facility, as described in Chapter 3.

4.1 Safety Structures, Systems, and Components

There are no Safety Class or Safety Significant SSCs required for S&M activities at the 224-B Building. This determination was based on the current criteria for selecting Safety Class systems as identified in PRC-PRO-NS-700, *Safety Basis Development,* and the guidance in DOE-02-ABD-0053, "Contract No. DE-AC06-96RL13200 – *Fluor Hanford Nuclear Safety Basis Strategy and Criteria.*" Specifically, any scenario with a risk bin value greater than III requires a Safety Class or Safety Significant SSC to reduce the risk bin value to III or less. Safety Class SSCs are identified to reduce risk to the MOI and Safety Significant SSCs are identified to reduce the risk to the CW. SSCs are evaluated for defense-in-depth designation if they are below the criteria for Safety Class and Safety Significant SSCs discussed above.

Table 4-1, "224-B Facility Scenario Summary Table," presents the potential consequences for the postulated accident scenarios. All of the unmitigated accident scenarios identified in Chapter 3 resulted in potential consequences that are less than 1 rem TED to the maximum offsite receptor and less than 25 rem TED to the CW at 100 m. The potential dose consequences are below the risk evaluation guidelines and result in a risk bin value of III for the unmitigated scenario in all cases to all receptors.

Table 4-1. 224-B Facility Scenario Summary Table

Scenario	Frequency	CWTED (rem)	MOI TED (rem)	Risk Bin Values
Seismic (3.5.1)	unlikely	1.33E+01	8.19E-03	III
Roof collapse (crane accident) (3.5.2)	anticipated	1.33E+01	8.19E-03	III
Building Fire (3.5.3)	anticipated	7.97E+00	4.91E-03	III
Contaminated equipment removal (3.5.4)	anticipated	7.09E+00	4.37E-03	III
Contaminated equipment/ Waste handling fire (3.5.5)	anticipated	5.82E+00	3.59E-03	III

4.2 Defense-In-Depth Equipment

Based on the discussion in the previous sections, the 224-B Building structure is designated as providing defense-in-depth. The hazards present a low risk to the CW and other receptors and the remaining systems have minimal impact to the accidents. As a result, no other equipment is designated as defense-in-depth for the 224-B Facility.

4.2.1 224-B Building Structure

An evaluation of the building structure safety designation is based on the consequences derived from the accident analyses in Chapter 3. Since none of the unmitigated accident analyses resulted in consequences greater than a risk bin III to the CW or MOI, no Safety Class or Safety Significant SSCs are warranted for these scenarios. While the 224-B Building structure is not credited for reducing the consequences to the CW or MOI, it does provide a safety function (a qualitative degree of confinement), as a passive SSC, that is effective against multiple hazards and some accident scenarios, which is one of the characteristics listed in PRC-PRO-NS-700, *Safety Basis Development*. Therefore, in accordance with PRC-PRO-NS-700, the 224-B Building structure is designated as a defense-in-depth feature.

Changes to defense-in-depth equipment are considered significant modifications. The USQ process required by 10 CFR 830 ensures that changes are appropriately analyzed and controlled so they do not adversely affect safe operation. The Initial Testing, In-Service Surveillance, and Maintenance SMP ensure that nuclear facility equipment degradation is appropriately identified and corrected.

4.3 Administrative Controls

From the HA and accident analysis processes, a number of programs were identified that are used to manage the risk associated with the planned activities at the 224-B Facility. However, none of these individual programs were identified as preventing or mitigating accident consequences requiring designation as an AC. To ensure continued safe management of the facility, two ACs are provided.

- AC C.4.1 "Safety Management Programs" is identified to ensure implementation and assessment of applicable SMPs.
- AC C.4.2 "Waste Inventory Control" is identified to ensure that containerized wastes staged at the facility are maintained within the inventories analyzed in the staged waste fire analysis (Section 3.5.5).

The two ACs are not classified as Specific Administrative Controls (SACs) because neither met the criteria described in DOE-STD-1186-2004, *Specific Administrative Controls*, Section 2.1, *Identification of SACs*. That is, the ACs are not needed to prevent or mitigate an accident scenario and the safety function would not be Safety Class or Safety Significant if the function were provided by an SSC since all accidents analyzed in Section 3.5 resulted in CW and MOI risk bin determinations of III without the application of controls.

4.4 Hazard Control Derivation Basis

Building features and controls serve to reduce the potential risk to the public and workers from uncontrolled releases of radiological materials. The 224-B Building structure is not credited for prevention or mitigation in the accident analyses of Section 3.5, however it is identified as providing defense-in-depth in Section 4.2. Key programmatic commitments in Chapters 3.0 and this Chapter are elements of the site SMPs, which are described in Chapter 5.0, "Safety Management Programs," and specified as a TSR in AC C.4.1, *Safety Management Programs (AC)*. The waste inventory assumptions used in the accident analysis are preserved through AC C.4.2, *Waste Inventory Control (AC)*, which limits staged TRU and/or TRU contaminated equipment waste to less than 8.92 DE-Ci. The limit of 8.92 DE-Ci is derived from the accident analysis of TRU contaminated equipment/TRU waste (Section 3.5.5), which contains 100 g of ^{239}Pu and a proportional amount of the other isotopes listed in Table 3-1. Table 4-2, below, shows the calculation of DE-Ci based on the isotopic distribution, mass ratios, and corresponding DE-Ci conversion factors.

Table 4-2. 224-B Isotope Mix

Isotope	Mass Ratio	Isotope grams with 100g ^{239}Pu	Ci	Ci to DE-Ci Conversion Factor[1]	DE-Ci
^{238}Pu	1.29E-04	1.38E-02	2.36E-01	9.2E-01	2.17E-01
^{239}Pu	9.34E-01	100	6.21E+00	1.0E00	6.21E+00
^{240}Pu	6.07E-02	6.5	1.48E+00	1.0E00	1.48E+00
^{241}Pu	2.30E-04	2.4E-02	2.53E+00	1.8E-02	4.55E-02
^{242}Pu	3.00E-04	3.2E-02	1.26E-04	9.6E-01	1.21E-04
^{241}Am	3.13E-03	3.4E-01	1.15E+00	8.4E-01	9.65E-01
Totals	**1.00**	**107 g**	**N/A**	**N/A**	**8.92 DE-Ci**

[1]. Conversion factors obtained from HNF-EP-0063, Rev 16.

4.5 Step-Out Criteria

No specific step-out criteria are defined for the planned S&M activities for the 224-B Facility. The DSA is applicable until a revised DSA authorizing removal and treatment of the applicable inventories is implemented. Completion of the associated inventory reduction activities will then allow the facility to be downgraded to less than HC 3.

5.0 Safety Management Programs

A summary of the key programmatic commitments is provided in this chapter. Additional detail regarding the requirements, drivers, and program descriptions may be found in HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*.

5.1 Prevention of Inadvertent Criticality

The bounding inventory for the 224-B Facility is approximately 1.22 kg (Table 3-1). This is more than double the minimum critical mass (530 g Pu) for an optimally water moderated and fully water reflected system and hence criticality is possible if an inventory approaching the bounding value actually exists in the facility and reconfiguration, moderation, and reflection could occur.

Based on the bounding values in Table B-7, the maximum value in any one cell is 679 g, in D Cell. The bulk of the material in D Cell is in Tank D-3 which contains approximately 650 g of Pu. The bounding inventory for D Cell is the only cell inventory in excess of a minimum critical mass. The neighboring cells, C Cell and E Cell, contain tens of grams of Pu that will not provide any meaningful interaction with the material in D Cell through the concrete separations between the cells.

Facility processing has long ceased. The scope of activities permitted under this safety basis document is limited to NDA and radiological swipes to support characterization, and surveillance and maintenance activities as described in Section 2.5. These activities will not result in transfer of residual Pu holdup in tank, piping, and vessels between the hot cells. Based on the quiescent state of the residual Pu, evaluation of the criticality potential is only required for D Cell.

Tank D-3 in D Cell contains the bulk of the material. Even if the additional material in the D Cell is assumed to be included as part of the tank inventory, the bounding residual Pu is 677 g. In order to support a criticality, this quantity would require concentration of the Pu into a small volume, with favorable geometry, optimal moderation, and full-water reflection.

Concentration of the Pu into a small volume would constitute concentrating the Pu into a spherical volume of approximately 17 liters. D-3 is 9 ft in diameter and 9 ft tall, which does not provide for concentration of the material in such a small volume. Even in the event of a seismic event that resulted in crushing the tank, the areal profile would be maintained and not result in concentration to that extent. A favorable geometry would require attaining a somewhat spherical shape. The tank bottom is not conducive to providing for such a geometry. The interstitial moderation required to support criticality will not be introduced as a result of NDA or taking radiological swipes. Although water moderation could be introduced by a leak, condensate, or some other unanticipated event, it is unlikely to result in a Pu solution approaching an optimal concentration. Near full reflection is required to support criticality. Human entry, as with S&M activities, into D Cell can increase reflection. Even if multiple people enter the cell and surround the tank, full reflection would not occur. Neutron leakage from the top and bottom of the tank would result in a configuration that would not approach full reflection. A seismic event resulting

in the collapse of the ceiling could possibly result in a configuration approaching full reflection; however, other conditions for criticality would not be met.

Based on the multiple configuration changes required to result in criticality, a criticality will not be achieved based on an S&M mission with limited characterization activities. The facility potentially contains greater than a minimum critical mass, however; the criticality is not credible based on form and distribution. The 224-B Facility meets the definition of a limited control facility.

The Hanford Site criticality program, documented in HNF-7098, *Criticality Safety Program*, is implemented through facility programs and procedures. The 224-B Facility is classified as a limited control facility. Requirements applicable to a limited control facility apply as described in HNF-11724.

Criticality safety activities are generally limited to maintenance of applicable postings and periodic inspection. The criticality safety program is described in Chapter 6.0 of HNF-11724. No exceptions are taken to the key attributes (KAs) pertaining to a limited control facility, as described in HNF-11724.

5.2 Radiation Protection

The radiological protection program implements applicable regulatory (10 CFR 835) and other contractual requirements. The program is based on functional or operational organizations implementing the necessary requirements. The radiological control program is described in Chapter 7.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.3 Hazardous Material Protection

The hazardous material control program is found in Chapter 8.0 of HNF-11724. No exceptions are taken to the key attributes as described in HNF-11724.

5.4 Radioactive and Hazardous Waste Management

The radioactive and hazardous waste management program is found in Chapter 9.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.5 Initial Testing, In-Service Surveillance, and Maintenance

The 224-B Building is currently in S&M mode with limited occupancy for S&M activities. The building is normally locked and access is controlled by approved procedures of the S&M organization. The scope of activities to be performed is summarized in Section 2.2. The initial testing and in-service S&M program is found in Chapter 10.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.6 Operational Safety

Operational safety includes application of the requirements of CRD O 422.1, *Conduct of Operations* and DOE/RL-92-36, *Hanford Site Hoisting and Rigging Manual.* The operational safety program is found in Chapter 11.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.7 Fire Protection

The fire hazards are identified and analyzed in Chapter 3 of this DSA and the 224-B FHA (CP-42689). Activities authorized by this DSA will be performed consistent with the requirements of the site fire protection program. Facility specific controls and recommendations are identified in the FHA. The fire protection program is described in a portion of Chapter 11.0 of HNF-11724. The KAs pertaining to fire protection, as described in HNF-11724, apply except for KA 11-5. There are no safety basis requirements for the deactivated facility fire suppression system. National Fire Protection Association inspection, testing, and maintenance requirements are not applicable to this deactivated system.

5.8 Procedures and Training

The procedure development program employs a graded approach to ensure that work processes are controlled by approved instructions, procedures, design documents, technical standards, or other hazard controls adopted to meet regulatory or contractual requirements appropriate to the specific tasks to be performed. The training program provides employees, required to perform specified job requirements, with the training necessary to become qualified and maintain qualification. A description of the procedures development and training programs may be found in HNF-11724, Chapter 12.0. No exceptions are taken of the KAs as described in HNF-11724.

5.9 Human Factors

Chapter 13.0 of HNF-11724 has no application to the 224-B Facility as a facility in S&M awaiting final disposition.

5.10 Quality Assurance

CHPRC implements a Quality Assurance (QA) program meeting the requirements of 10 CFR 830, *Nuclear Safety Management,* Subpart A, "Quality Assurance Requirements," in accordance with PRC-MP-QA-599, *Quality Assurance Program.* The QA Program is described in Chapter 14.0 in HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.11 Emergency Preparedness Program

CHPRC implements the DOE Emergency Management Plan through its Emergency Preparedness Program. The implementing organization prepares and maintains hazard assessments and response plans for applicable facilities. Facility staff are trained and practice drills are used to ensure a timely and effective response should an emergency occur. While the S&M organization will perform drills annually, they will not be performed for every facility

annually. The Emergency Preparedness Program is described in Chapter 15.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

5.12 Management, Organization, and Institutional Safety Provisions

The details of management, organization, and institutional safety policies are summarized in Chapter 17.0 of HNF-11724. No exceptions are taken to the KAs as described in HNF-11724.

6.0 References

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

CP-42689, *224-B Fire Hazard Analysis*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

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DOE G 424.1-1B, 2010, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*, U.S. Department of Energy, Washington, D.C.

DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice No. 1, U.S. Department of Energy, Washington, D.C., 2000.

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DOE-STD-1120-2005, *Integration of Environment, Safety, and Health Into Facility Disposition Activities,* U.S. Department of Energy, Washington, D.C.

DOE-STD-1186-2004, *Specific Administrative Controls*, U.S. Department of Energy, Washington, D.C.

DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities,* U.S. Department of Energy, Washington, D.C.

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HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook*, Fluor Hanford, Richland, Washington, as amended.

HNF-7098, *Criticality Safety Program*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

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ICRP-71, *Age Dependent Doses to Members of the Public from Intake of Radionuclides, Part 4, Inhalation Dose Coefficients*, International Commission on Radiological Protection, Stockholm, Sweden, 1995.

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PRC-MP-QA-599, *Quality Assurance Program*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

PRC-PRO-NS-062, *Unreviewed Safety Question Process*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

PRC-PRO-NS-700, *Safety Basis Development*, CH2M HILL Plateau Remediation Company, Richland, Washington, as amended.

SD-DD-TRP-002, 1985, *Radiological Characterization of the 224-B Hot Cells*, Rockwell Hanford Operations, Richland, Washington.

SD-WM-SAR-017, 1985, *Safety Analysis Report for the 224-B Plutonium Concentration Facility Decontamination and Decommissioning*, Rev. 0, Rockwell Hanford Operations, Richland, Washington.

WHC-EP-0619, 1994, *Risk Management Study for the Hanford Site Facilities*, Vols. 1 through 4, Westinghouse Hanford Company, Richland, Washington.

Appendix A

Hazards Analysis Summary Data

Appendix A

A.1 Hazards Analysis Summary Data

Section 3.4 of this DSA provides a summary of the hazard analysis process used in the evaluation of the 224-B Building and planned activities. This appendix provides the completed hazard baseline checklist, the What If/Checklist used for the planned activities, and Table A-2, "Disposition of Energy Checklist Items."

The results are presented in Table A-3, "Hazards Analysis." As part of lessons learned, the consequences in the PHA were updated to reflect the quantitative accident analysis consequences in Section 3.5, *Accident Analysis*.

Following the presentation of the accident types considered, Table A-4, "Binning of Accidents," provides a summary of the selection of bounding and representative accidents and their bases.

The hazards analysis was reviewed in 2015 to ensure consistency and flow from the hazards analysis to the analyzed accidents in Chapter 3. The following disciplines reviewed and concurred with the revisions made to the hazards analysis and Chapter 3:

- Nuclear Safety – John Weidert
- Criticality Safety – Richard Stachowiak
- Fire Protection Engineering – Larry Anderlini
- Radiation Protection – Steve Tilton
- OS&IH – Garrett Knutson
- Facility Operations – Daniel Wieczorkowski
- Emergency Preparedness – Eric Kinnunen
- Engineering – Sam Wajeeh
- Environmental Protection – Daniel Turlington

Table A-1. Hazard Identification Checklist and Energy Designators

LOTE Low Thermal Energy	AE Acoustic Energy	BIO Biological
☒ 1 Cryogenic Systems	☐ 1 Equipment/Platform Vibration	☒ 1 Animal/Insect Hazard
☐ 1.1 Freeze Seal Equipment	☐ 2 Equipment Rooms	☒ 1.1 Dead Animals
☒ 1.2 Liquid N_2 in Dewars	☐ 2.1 Motor Rooms	☒ 1.2 Animal Droppings
☐ 1.3 Liquid N_2 in Tanks	☐ 2.2 Pump Rooms	☒ 1.3 Animal Bites
☐ 1.4 Liquid N_2 Production	☐ 2.3 Fan Rooms	☒ 1.4 Insect Bites
☐ 1.5 Other Cryogenic Systems	☐ 2.4 Compressor Rooms	☒ 1.5 Insect Stings
_____	☐ 2.5 Other Equipment Rooms	☐ 2 Plant Hazards
☐ 2 Low Ambient Temperatures	_____	☐ 2.1 Allergens
☐ 2.1 Loss of HVAC [system impacts]	☒ 3 Decontamination & Size Reduction Tools	☐ 2.2 Toxins
☐ 2.2 Loss of HVAC [worker impacts]	☒ 3.1 Cutting Devices	☒ 3 Disease Related Hazards
☐ 2.3 Freezers/Chillers	☒ 3.2 Decontamination Devices	☒ 3.1 Bacteria
☐ 2.4 Other Low Temperatures	☒ 3.3 Abrading Devices	☒ 3.2 Viruses
_____	☐ 3.4 Other AE Tools	☐ 3.3 Sewage
☐ 3 Other LOTE Hazards	_____	☐ 3.4 Blood/Body Fluids
_____	☐ 4 Other AE Hazards	☐ 3.5 Medical Waste
	_____	☐ 4 Other BIO Hazards
		_____

NPH Natural Phenomena	OTH Other	KE Kinetic Energy
☒ 1 Earthquakes	☒ 1 Inert/Low O_2 Atmosphere	☒ 1 Vehicle/Transport Devices in Motion
☒ 2 Natural Radiation	☒ 1.1 Dust [breathing]	☐ 1.1 Rail Cars/Trains
☒ 3 Lightning	☒ 1.2 N_2/He Atmosphere	☒ 1.2 Excavators/Backhoes
☒ 4 Solar/Heat Wave	☒ 1.3 Confined Spaces	☒ 1.3 Cranes/Crane Loads
☒ 5 Range Fire	☒ 1.3.1 Tanks	☒ 1.4 Trucks/Cars
☒ 6 Dust/Sand	☒ 1.3.2 Basins	☒ 1.5 Forklifts/Loaders
☒ 7 Fog	☒ 1.3.3 Manholes	☐ 1.6 Conveyors
☒ 8 Heavy Rain	☒ 1.3.4 Pits	☒ 1.7 Man-Powered Devices in Motion
☒ 8.1 Flooding [from rain]	☒ 1.4 Trench/Excavation Collapse	☒ 1.7.1 Hoists
☐ 8.2 Sediment Transport	☒ 1.5 Water in Confined Space	☒ 1.7.2 Carts/Dollies
☒ 9 Hail	☐ 1.6 Other Low O_2 Atmospheres	☐ 1.8 Other Device in Motion
☒ 10 Low Temperatures	_____	_____
☒ 11 Freeze	☒ 2 Inadequate Visibility	☒ 2 Loaded Transports in Motion
☒ 12 Heavy Snow	☒ 2.1 Respirator Fogging	☒ 2.1 Crane Loads [loaded]
☒ 13 High Winds	☒ 2.2 Dust [visibility]	☒ 2.2 Trucks [loaded]
☐ 14 Tornadoes	☐ 2.3 Glare	☒ 2.3 Forklifts [loaded]
☐ 15 Volcanoes	☐ 2.4 Other Impaired Visibility	☐ 2.4 Conveyors [loaded]
☒ 16 Volcanic Ash	_____	☒ 2.5 Loaded Man-Powered Transports in Motion
☐ 17 Other NPH	☒ 3 External/Offsite Event	☒ 2.5.1 Hoists [loaded]
_____	☒ 3.1 Aircraft Crash	☒ 2.5.2 Pallet Jacks [loaded]
	☐ 3.2 Offsite Transportation Accident	☒ 2.5.3 Carts/Dollies [loaded]
	☐ 3.3 Offsite Explosion	☒ 2.6 Other Transport in Motion
	☒ 3.4 Major Fire	Drilling vehicles
	☐ 3.5 Reservoir Failure	☒ 3 Decontamination & Size Reduction Tools
	☐ 3.6 Other External Event	☒ 3.1 Impact Tools
	_____	☒ 3.2 Projectile Tools
	☒ 4 Unknown Material	☐ 3.3 Other KE Tools
	☒ 5 Unknown Configuration	_____
	☐ 6 Other OTH Hazards	☐ 4 Relief Valve Blow-down
	_____	☐ 5 Other KE Hazards
		_____

Table A-1. Hazard Identification Checklist and Energy Designators

LOEE Loss of Electrical Energy	CM Chemical Materials	CE Chemical Energy
☐ 1 Loss of Powered Equipment	☒ 1 Toxins	☒ 1 Oxidizers
☐ 1.1 Motor Stoppage	☐ 1.1 Hepatotoxins [Carbon Tetrachloride]	☐ 1.1 Organic Peroxides
☐ 1.2 Pump Stoppage	☐ 1.2 Nephrotoxins [Chloroform]	☒ 1.2 Corrosives/Acids/Reagents/ Bleaches [in use]
☐ 1.3 Fan Stoppage in Areas with Differential Pressure	☒ 1.3 Neurotoxins [Mercury]	☒ 1.3 Residual Corrosives/Acids
☐ 1.3.1 Flow Reversal	☒ 1.4 Reproductive Toxins [Lead]	☐ 1.4 Battery Banks
☐ 1.3.2 Supply Fan Pressurization	☐ 1.5 Toxic Agents [Strychnine]	☒ 1.5 Other Oxidizers
☐ 1.3.3 Static Air Situation	☒ 1.6 Agents that Attack the Lungs [Asbestos, Beryllium]	_K permanganate___
☐ 1.4 Fan Stoppage in Ventilated Areas	☒ 1.6.1 Ceiling Tiles/Insulation	☐ 2 Reactives
☐ 1.4.1 Accumulation of Hazardous Vapors	☒ 1.7 Agents that Attack the Skin [Acetone]	☐ 2.1 Water Reactives [Sodium]
☐ 1.4.2 Accumulation of Asphyxiants	☒ 1.8 Agents that Attack the Eyes [Organic Solvents]	☐ 2.2 Shock Sensitive Chemicals [Nitrates]
☐ 1.4.3 Accumulation of Flammable Gases	☐ 1.9 Agents that Attack the Mucous Membranes [Ammonia]	☐ 2.3 Peroxides/ Superoxides/Ethers
☐ 1.5 Compressor Stoppage	☒ 1.10 Agents that Attack the Blood [Carbon Monoxide/ Cyanides]	☐ 2.4 Explosive Substances
☐ 1.5.1 Loss of Air [dry-pipe]	☒ 1.11 Carcinogens [Carbon Tetrachloride, PCBs]	☐ 2.4.1 Electric Squibs
☐ 1.5.2 Loss of Air [no inert]	☒ 1.12 Sensitizers [Beryllium/Epoxy Resins]	☐ 2.4.2 Dynamites/Caps/ Primer Cord
☐ 1.5.3 Reduced PPE Pressure	☒ 1.13 Irritants [Calcium Chloride]	☐ 2.4.3 Dusts [explosive]
☐ 1.6 Loss of Heaters	☒ 1.14 Pesticides/Insecticides	☐ 2.5 Other Reactives
☐ 1.6.1 System Freeze Impacts	☒ 1.15 Herbicides	_____
☐ 1.6.2 Worker Freeze Impacts	☐ 1.16 Other Toxins	☒ 3 Other Chemical Energy Hazards
☐ 1.7 Loss of Coolers/Chillers	_____	☒ 3.1 Corrosion/Oxidation [rust]
☐ 1.7.1 System Overheat Impacts	☐ 2 Asphyxiants	☒ 3.2 Bonding Agents
☐ 1.7.2 Worker Overheat Impacts	☒ 3 Miscellaneous Chemicals/Groups	☒ 3.2.1 Sealants/Fixatives
☐ 1.8 Misdirected Flow due to Loss of Valves/Dampers	☒ 3.1 Hazardous Wastes [RCRA, TSCA]	☒ 3.2.2 Epoxies/Adhesives
☐ 1.9 Loss Instrumentation	☒ 3.2 Creosote	☒ 3.3 Refrigerants/Coolants [Propylene Glycol]
☐ 1.10 Other Equipment Loss	☒ 3.3 Other Miscellaneous Chemicals	☒ 3.4 Water Treatment Products
_____	_____	☒ 3.5 Decontamination Chemicals
☒ 2 Inadequate Light/Illumination	☐ 4 Other CM Hazards	☒ 3.6 Miscellaneous Laboratory Chemicals
☒ 2.1 Operations Impacts	_____	☐ 3.7 Soil/Air/Water Reactions [Buried Materials]
☒ 2.2 Worker Impacts		☒ 4 Incompatible Wastes
☐ 3 Loss of Batteries/Direct Current Systems		☐ 5 High Temperature Wastes
☒ 4 Other LOEE Hazards		☐ 6 Other CE Hazards
LOEE For portable Equipment		_____

Table A-1. Hazard Identification Checklist and Energy Designators

ME Mechanical Energy	TP Thermal Potential Energy	EE Electrical Energy
☒ 1 Transverse [single direction] Motion Devices	☒ 1 Flammable Gases	☒ 1 High Voltage Equipment
☒ 1.1 Forklift Tines [puncture]	☒ 1.1 Natural Gas/Propane	☒ 1.1 Power Transmission Equipment
☐ 1.2 Piston Compressors [crush]	☒ 1.2 Welding/Cutting Gases	☒ 1.1.1 Wiring [high voltage]
☐ 1.3 Presses [crush]	☐ 1.3 Laboratory/Calibration Gases	☒ 1.1.2 Overhead Transmission Lines
☒ 1.4 Pinch Points [pinch]	☐ 1.3.1 Methane/Butane	☒ 1.1.3 Transformers [high voltage]
☒ 1.5 Sharp Edges/Objects [cut]	☐ 1.3.2 H_2 [lab]	☒ 1.1.4 Switchgear [high voltage]
☒ 1.6 Drills [puncture]	☒ 1.4 Process/Reaction Off-Gases	☐ 1.2 Capacitor Banks
☒ 1.7 Sanders/Brushes [wear]	☒ 1.4.1 H_2 [containers]	☐ 1.3 Lightning Grids
☒ 1.8 Shears/Pipe Cutters [shear]	☒ 1.4.2 H_2 [process]	☐ 1.4 Other High Voltage Hazards
☒ 1.9 Grinders [crush/pinch/shear]	☐ 1.4.3 Sewer Gas	
☐ 1.10 Other Transverse Motion	☐ 1.4.4 Carbon Monoxide	☒ 2 Low Voltage Equipment
	☐ 1.5 Other Flammable Gases	☒ 2.1 480/240/120 Volt Equipment
☒ 2 Reciprocating [back and forth] Motion Devices		☒ 2.1.1 Wiring [low voltage]
☒ 2.1 Vibration [wear]	☒ 2 Flammable/Combustible Liquids	☒ 2.1.2 Cable Runs
☒ 2.2 Saws [cut]	☒ 2.1 HEPA Test Aerosol Fluid	☒ 2.1.3 Overhead Wiring
☐ 2.3 Other Reciprocating Motion	☒ 2.2 Petroleum Based Products	☒ 2.1.4 Underground Wiring
	☒ 2.2.1 Gasoline	☒ 2.1.5 Transformers [low voltage]
☒ 3 Circular Motion Devices	☒ 2.2.2 Diesel Fuel	☒ 2.1.6 Switchgear [low voltage]
☒ 3.1 Belts/Hoist Cables [pull/wrap]	☒ 2.2.3 Oils [lube, coolant]	☒ 2.1.7 Service Outlets
☒ 3.2 Bearings/Shafts [wrap]	☒ 2.2.4 Grease	☒ 2.1.8 Other Electrical Equipment
☒ 3.3 Gears/Couplings [pull]	☒ 2.3 Vehicle/Equipment Fuel Tanks	
☒ 3.4 Diesel Generators/ Turbines [wrap]	☒ 2.3.1 Gasoline [tank]	☒ 2.2 Temporary Power Equipment
☒ 3.5 Pumps [wrap]	☒ 2.3.2 Diesel Fuel [tank]	☒ 2.2.1 Diesel Units
☒ 3.6 Fans [wrap]	☒ 2.4 Paint/Cleaning/ Decontamination Solvents	☐ 2.2.2 Battery Banks
☐ 3.7 Rotary Compressors [wrap]	☒ 2.5 Paints/Epoxies/Resins	☒ 2.2.3 12-32 VDC Systems
☐ 3.8 Centrifuges [wrap]	☐ 2.6 Other Flammable Liquids	☐ 2.2.4 Other Temporary Electrical
☒ 3.9 Drills/Rotary Sanders [wrap]		
☒ 3.10 Grinders [wrap]	☒ 3 Combustible Solids	☒ 2.3 Electrical Equipment [low voltage]
☐ 3.11 Other Circular Motion	☒ 3.1 Paper/Wood Products	☒ 2.3.1 Motors
	☒ 3.2 Cloth/Rags	☒ 2.3.2 Pumps
☐ 4 Other ME Hazards	☒ 3.3 Rubber	☒ 2.3.3 Fans
	☒ 3.4 Plastic Materials	☒ 2.3.4 Compressors
	☒ 3.4.1 Size Reduction Tents/ Permacons	☒ 2.3.5 Heaters
	☐ 3.4.2 Benelex/Lexan/HDPE	☐ 2.3.6 Valves/Dampers
	☒ 3.4.3 Rigid Liners/Poly-Liners/ Bagging Materials	☒ 2.3.7 Power Tools
	☐ 3.5 Other Combustible Solids	☐ 2.3.8 Instrumentation
		☐ 2.3.9 Other Electrical Use Equipment
		☐ 2.4 Grounding Grids
		☐ 2.5 Static Charge
		☐ 2.6 Other Low Voltage Hazards

Table A-1. Hazard Identification Checklist and Energy Designators

RE Radiant Energy	RM Radioactive Material	TE Thermal Energy
☒ 1 Direct Radiation Sources	☒ 1 Fissile Material [Metals/Oxides/Residues]	☐ 1 Chemical Reactions
☒ 1.1 Calibration Sources	☒ 1.1 Bag	☐ 2 Pyrophoric Material
☒ 1.2 Other Radioactive Material	☐ 1.2 Glovebox [exposed]	☐ 2.1 Plutonium/Uranium Metal
☒ 1.2.1 Fissile Material Storage/ Holdup	☐ 1.3 Can	☐ 2.2 Pyrophoric Chemicals
☐ 1.2.2 Actinide Solutions	☐ 1.4 Welded Can	☐ 2.3 Other Pyrophoric Material
☒ 1.2.3 Waste Containers	☒ 1.5 Drum	_____
☒ 1.2.4 Contamination	☒ 1.6 Overpack	☒ 3 Spontaneous Combustion Material
☐ 1.3 Other Direct Radiation Hazards	☐ 1.7 Type B Shipping Container	☒ 3.1 Petroleum Based Products
_____	☒ 1.8 Ducting [exposed]	☒ 3.2 Reactive Chemicals
☐ 2 Ionizing Radiation Devices	☒ 1.9 Plenum [exposed]	☒ 3.3 Nitric Acids/Organics
☐ 2.1 Radiography Equipment	☒ 1.10 Filter [exposed]	☒ 3.4 Paint/Cleaning/ Decontamination Solvents
☐ 2.2 X-Ray Machines	☐ 1.11 Cooler	☒ 4 Open Flame Sources
☐ 2.3 Electron Beams	☒ 1.12 Hood [exposed]	☒ 4.1 Cutting Torches
☐ 2.4 Ultra-Intense Lasers	☐ 1.13 Other Solid Fissile Material	☒ 4.2 Welding Torches
☐ 2.5 Accelerators	_____	☐ 4.3 Laboratory Burners
☐ 2.6 Other Ionizing Hazards	☒ 2 Actinide Solution	☐ 4.4 Other Open Flames
_____	☐ 2.1 Bottle	_____
☒ 3 Non-Ionizing Radiation Sources	☐ 2.2 Drum	☒ 5 Heating Devices/Systems
☐ 3.1 Electromagnetic Sources	☐ 2.3 Piping	☒ 5.1 Furnaces
☐ 3.1.1 Electromagnetic Communication Waves	☒ 2.4 Tank	☐ 5.2 Boilers
☐ 3.1.2 Radio-Frequency Generators	☐ 2.5 Other Liquid Fissile Material	☒ 5.3 Heaters
☐ 3.1.3 Microwave Frequencies	_____	☐ 5.4 Hot Plates
☐ 3.1.4 Electromagnetic Fields	☒ 3 Waste [LLW, LLM, TRU, TRM]	☐ 5.5 RTGs
☐ 3.1.5 Electric Furnaces	☒ 3.1 Bag	☐ 5.6 Other Heating Equipment
☐ 3.1.6 Computers	☐ 3.2 Glovebox [exposed]	_____
☒ 3.2 Welding/Cutting Devices	☒ 3.3 Drum	☐ 6 Radioactive Decay
☒ 3.2.1 Plasma Arc Magnetic Field	☒ 3.4 Metal Crate	☒ 7 High Temperature Items
☒ 3.2.2 Plasma Arc Infrared/Ultraviolet Light	☒ 3.5 Pipe Overpack Container	☐ 7.1 Lasers
☒ 3.2.3 Welding	☒ 3.6 Overpack	☐ 7.2 Incinerators/Fire Boxes
☐ 3.3 Low Power Lasers	☒ 3.7 Shipping Cask	☐ 7.3 Engine Exhaust Surfaces
☐ 3.4 Other Non-Ionizing Hazards	☒ 3.8 Ducting [exposed]	☐ 7.4 Steam Lines
_____	☒ 3.9 Plenum [exposed]	☐ 7.5 Electrical Equipment
☒ 4 Potential RE Sources	☒ 3.10 Filter [exposed]	☐ 7.5.1 Electrical Wiring
☒ 4.1 Critical Masses	☒ 3.11 Hood [exposed]	☒ 7.5.2 Portable Lamps/Lighting
☒ 4.1.1 Solid Fissile Material	☒ 3.12 Wooden Crate	☒ 7.6 Welding/Cutting/Grinding Surfaces
☐ 4.1.2 Liquid Fissile Material	☒ 3.13 Cargo Container	☒ 7.6.1 Plasma Arc Surfaces
☒ 4.1.3 Containerized Fissile Material	☒ 3.14 Other Waste Material	☒ 7.6.2 Welding Surfaces
☐ 4.2 Irradiated Equipment	_____	☒ 7.6.3 Grinder/Saw Surfaces
☐ 4.3 Other Potential RE Hazards	☒ 4 General Contamination	☒ 7.7 Friction Heated Surfaces
_____	☒ 4.1 Contaminated Soils	☒ 7.7.1 Belts [friction]
☐ 5 Other RE Hazards	☒ 4.2 Contaminated Water	☒ 7.7.2 Bearings [friction]
_____	☒ 4.3 Contaminated Oil/Antifreeze	☒ 7.7.3 Gears [friction]
	☒ 4.4 Other Contamination _Airborne Areas____	☒ 7.7.4 Power Tools [friction]
	☐ 5 Burial Grounds	☒ 7.7.5 Motors/Fans [friction]
	☐ 6 Other RM Hazards	☐ 7.8 Other High Temperature Items
	_____	_____
		☒ 8 High Ambient Temperature Areas
		☐ 8.1 Loss of Ventilation
		☐ 8.2 Areas Around Furnaces/Boilers
		☒ 8.3 Multiple Layers PPE
		☐ 9 Other TE Hazards
		_____

Table A-1. Hazard Identification Checklist and Energy Designators

PE Potential Energy	PE Potential Energy (cont'd)	PE Potential Energy (cont'd)
☒ 1 Pressure-Related PE Hazards	☒ 2 Gravity-Related PE Hazards	☒ 3 Momentum-Related PE Hazards
☒ 1.1 Compressed Gases	☒ 2.1 Elevated Equipment/Structures	☒ 3.1 Moving Vehicle/Transport Devices
☒ 1.1.1 Breathing Air/Compressed Air/O_2	☒ 2.1.1 Cranes/Hoists	☐ 3.1.1 Rail Cars/Trains [in motion]
☒ 1.1.2 He/Argon/Specialty Gases	☒ 2.1.2 Ducting/Lights/Piping	☒ 3.1.2 Cranes [in motion]
☒ 1.1.3 Refrigerants/CO_2 Bottles	☒ 2.1.3 Rollup Doors	☒ 3.1.3 Trucks [in motion]
☒ 1.1.4 Other Bottled Gases	☒ 2.1.4 Elevators	☒ 3.1.4 Forklifts/Loaders [in motion]
☒ 1.1.5 Gas/Air Receivers/ Compressors	☒ 2.1.5 Roofs/Plenums	☐ 3.1.5 Other Moving Materials
☐ 1.1.6 Other Compressed Gas	☒ 2.1.6 Upper Floor Components	_____
_____	☒ 2.1.7 Tanks/Solutions in Elevated Equipment	☒ 3.2 Rotating Equipment
☒ 1.2 High Pressure Gas Systems	☐ 2.1.8 Steam/Natural Gas Lines	☒ 3.2.1 Bearings/Rollers/Shafts
☐ 1.2.1 Pressure Vessels	☒ 2.1.9 Power Lines/ Transformers	☒ 3.2.2 Gears/Couplings/Pivot Joints
☐ 1.2.2 Instrument/Plant Air	☐ 2.1.10 Other Elevated Equipment	☒ 3.2.3 Diesel Generators/Turbines
☐ 1.2.3 Chemical Reaction Vessels/ Autoclaves	_____	☒ 3.2.4 Pumps
☐ 1.2.4 Furnaces/Boilers	☒ 2.2 Elevated Hazardous Materials	☒ 3.2.5 Fans/Air Movers
☐ 1.2.5 Steam Header/Lines	☒ 2.2.1 Crane Loads	☐ 3.2.6 Rotary Compressors
☒ 1.2.6 Pneumatic Lines	☒ 2.2.2 Truck Loads	☐ 3.2.7 Centrifuges
☒ 1.2.7 Impact Tools	☒ 2.2.3 Forklift/Other Lifts Loads	☐ 3.2.8 Other Rotating Equipment
☒ 1.2.8 Sand/CO_2 Blasting Equipment	☐ 2.2.4 Conveyor Loads	_____
☐ 1.2.9 Other Pressurized Gas	☒ 2.2.5 Hoist Loads	☐ 3.3 Other Momentum PE Hazards
_____	☒ 2.2.6 Cart Loads	_____
☒ 1.3 High Pressure Liquid Systems	☒ 2.2.7 Hand Carried Loads	☐ 4 Other PE Hazards
☐ 1.3.1 Water Heaters	☐ 2.2.8 Stacked Hazardous Materials	_____
☒ 1.3.2 Excavators/Backhoes [hydraulics]	☐ 2.2.9 Other Elevated Materials	
☒ 1.3.3 Cranes [hydraulics]	_____	
☒ 1.3.4 Trucks/Cars [hydraulics]	☒ 2.3 Pits/Trenches/ Excavations	
☒ 1.3.5 Forklifts [hydraulics]	☒ 2.4 Elevated Work Surfaces	
☐ 1.3.6 Conveyors [hydraulics]	☒ 2.4.1 Roofs/Elevated Doors/Loading Docks	
☒ 1.3.7 Hydrolazing Equipment	☒ 2.4.2 Stairs/Elevators	
☒ 1.3.8 Tool Hydraulic Lines	☒ 2.4.3 Ladders/Fixed Ladders	
☐ 1.3.9 Solution Transfer Systems	☒ 2.4.4 Cherry-Pickers/Hysters	
☐ 1.3.10 Other Pressurized Liquids	☒ 2.4.5 Scaffolding/Scissor Jack Scaffolds	
_____	☒ 2.4.6 Other Elevated Surfaces __Cat Walk__	
☐ 1.4 Pressurized Systems/ Components	☐ 2.5 Other Gravity PE Hazards	
☐ 1.4.1 Coiled Springs	_____	
☐ 1.4.2 Stressed Members		
☐ 1.4.3 Torqued Bolts		
☐ 1.4.4 Gaskets/Seals/O'Rings		
☐ 1.4.5 Fire Suppression Systems		
☐ 1.4.6 Other Pressurized Systems		
_____		
☐ 1.5 Vacuum Systems		
☐ 1.6 Other Pressure PE Hazards		
_____		

A.2 Checklist for Surveillance and Maintenance/Deactivation

Surveillance and Maintenance:

Personnel Safety

- Lifting
- Slips/trips/falls
- Temperature extremes
- Biological hazards
- Radiological exposures
- Chemical exposures

Procedures

- Skipped steps
- Missed equipment
- Sequence error

Other Considerations

- External events
- Personnel error
- Equipment failure during S&M
- Unexpected conditions

Table A-2. Disposition of Energy Checklist Items

Hazards Checklist Item	Evaluation	SMP Disposition	HNF-11724 – Key Attribute
LOTE 1, 1.2	Liquid Nitrogen in dewars was identified as a possible hazard associated with NDA activities.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
AE (ALL)	Areas with operating equipment have acoustic energy considerations.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
BIO (ALL)	Biological hazards are an expected hazard, especially in non-occupied facilities in long term surveillance and maintenance.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
NPH 1, 12, 13, 16	Various NPHs that could result in failure of the building structure.	Initial Testing, In-Service Surveillance, and Maintenance HA ID 1, 3	Key Attribute 10-4
NPH 2, 3, 4, 5	Various NPHs that could result in a building fire.	Operational Safety HA IDs 4, 5, 12	Key Attribute 11-3, 11-4, 11-7
NPH 6, 7	Various NPHs that could contribute to a vehicle impact that could result in partial failure of the building structure.	Initial Testing, In-Service Surveillance, and Maintenance; Operational Safety HA ID 2	Key Attribute 10-4 and discussion in Section 11.3 on DOE/RL-92-36
NPH 8, 8.1, 9	NPH considerations for water intrusion.	Initial Testing, In-Service Surveillance, and Maintenance HA HA ID 8	Key Attribute 10-4
NPH 10, 11	NPH considerations for low/freezing temperatures.	Initial Testing, In-Service Surveillance, and Maintenance; Management, Organization, and Institutional Safety Provisions	Key Attribute 10-4, 17-10
NPH 1, 12, 13, 16	NPHs that could contribute to a loss of confinement.	Initial Testing, In-Service Surveillance, and Maintenance HA ID 3, 8	Key Attribute 10-4
OTH 1 (All)	Potential confined space (low oxygen) hazards identified at the facility.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
OTH 2 (All)	Potential visibility hazards identified at the facility.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
OTH 3, 3.1	External event of an aircraft impact to the facility.	HA ID 1a	No SMP can prevent an aircraft impact.
OTH 3.4	External event of a major fire impacting the facility.	Operational Safety HA ID 4, 5, 12	Key Attribute 11-3, 11-4, and 11-7

Table A-2. Disposition of Energy Checklist Items

Hazards Checklist Item	Evaluation	SMP Disposition	HNF-11724 – Key Attribute
OTH 4, 5	These items were checked by the HA team recognizing that the characterization information at the facility is not current and may be subject to change.	The hazard is dispositioned by use of conservative assumptions in modeling the accidents and by the identification of characterization activities as a primary authorized activity.	
KE 1 (All)	Vehicles in motion are an expected hazard for facilities in long-term S&M.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA IDs 2, 4, 5	Key Attribute 17-10; Key Attributes 11-3, 11-4, and 11-7; discussion in Section 11.3 of DOE/RL-92-36
KE 2 (All)	Vehicles in motion with loads.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA IDs 2, 4, 5	Key Attribute 17-10; Key Attributes 11-3, 11-4, 1-5, and 11-7; discussion in Section 11.3 on DOE/RL-92-36
KE 3 (All)	The tools are identified for use in decontamination and/or size reductions that may be performed under long-term S&M.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
LOEE 2 (All and 4)	Loss of electrical power including loss of portable equipment being used and worker lighting.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
CM (All)	From the facility history and conditions as well as past S&M activities performed by the HA team members these are the types of residual chemical materials that are expected within the facility. This addresses the potential for personnel exposure to the materials.	Management, Organization, and Institutional Safety Provisions HA ID 7	Key Attribute 17-10
CE (All)	From the facility history and conditions as well as past S&M activities performed by the HA team members these are the types of chemical energies that are expected within the facility.	Radioactive and Hazardous Waste Management; Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 7	Key Attribute 17-10; Key Attributes 11-3, 11-4, 11-5, and 11-7; Key Attributes 9-1, 9-3, and 9-6
ME (All)	Mechanical energy hazards associated with the current operating systems as well as the equipment associated with planned or authorized activities.	Radiation Protection; Hazardous Material Protection; Management, Organization, and Institutional Safety Provisions HA ID 10, 11	Key Attribute 17-10; Key Attributes 7-1 through 7-8; Key Attributes 8-5, 8-6 and 8-7

Table A-2. Disposition of Energy Checklist Items

Hazards Checklist Item	Evaluation	SMP Disposition	HNF-11724 – Key Attribute
TP (All)	Thermal potential energy hazards associated with the current facility conditions and equipment as well as those associated with planned or authorized activities.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 4, 5, 12	Key Attribute 17-10; Key Attributes 11-3, 11-4, and 11-7
EE (All)	Electrical energy hazards associated with the current operating systems as well as the equipment associated with planned or authorized activities.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 4, 5	Key Attribute 17-10.
RE 1 (All)	Radiant energies associated with residual inventory and authorized activities.	Radiation Protection HA ID 3, 4, 5, 6, 9, 10, 11, 12	Key Attributes 7-1 through 7-8
RE 3 (All)	Radiant energies associated with cutting and welding activities.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 11	Key Attribute 17-10; Key Attributes 11-3, 11-4, 11-5, and 11-7
RE 4 (All)	Radiant energies associated with residual inventory and authorized activities.	Prevention of Inadvertent Criticality HA ID 9	Key Attributes 6-1 through 6-6 – applicable based on the classification and activities at the facility
RM 1 (All)	Radioactive material associated with the residual inventory and the authorized activities.	Prevention of Inadvertent Criticality; Radiation Protection HA ID 1, 1a, 2 3, 4, 5, 6, 9, 10, 11, 12	Key Attributes 7-1 through 7-8; also Key Attributes 6-1 through 6-6 – applicable based on the classification and activities at the facility
RM 2 (All)	Radioactive material associated with residual inventory in tanks.	Radiation Protection; Management, Organization, and Institutional Safety Provisions HA ID 1, 1a, 2, 3, 4, 5, 6, 9, 10, 11,	Key Attributes 7-1 through 7-8; also Key Attribute 17-10
RM 3 (All)	Radioactive material associated with the residual inventory and the authorized activities as waste components.	Radiation Protection; Radioactive and Hazardous Waste Management; Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 1, 1a, 2, 3, 4, 5, 6, 9, 10, 11, 12	Key Attributes 9-1, 9-3 and 9-6; Key Attribute 17-10; Key Attributes 11-3, 11-4, and 11-7; Key Attributes 7-1 through 7-8
RM 4 (All)	Contaminated radioactive materials.	Radiation Protection; Management, Organization, and Institutional Safety Provisions HA ID 6, 11	Key Attribute 17-10; Key Attributes 7-1 through 7-8

Table A-2. Disposition of Energy Checklist Items

Hazards Checklist Item	Evaluation	SMP Disposition	HNF-11724 – Key Attribute
TE 3, 4, 5, 7 (All)	Thermal energy hazards associated with the inventory, authorized activities and systems. Sources considered hot enough to result in ignition.	Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 3, 4, 5, 11	Key Attribute 17-10; Key Attributes 11-3, 11-4, and 11-7
TE 8, 8.3	Thermal energy hazards to the worker related to temperature and multiple layers of PPE.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
PE 1 (All)	Pressurized systems potential energy hazards.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
PE 2.1(except 2.1.1), 2.3 , 2.4 (All)	Potential energy hazards associated with elevated working surfaces.	Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10
PE 2.1.1, 2.2	Potential energy hazards associated with crane work.	Initial Testing, In-Service Surveillance, and Maintenance; Operational Safety; Management, Organization, and Institutional Safety Provisions HA ID 2, 10	Key Attribute 17-10; Key Attribute 10-4; discussion in Section 11.3 on DOE/RL-92-36
PE 3 (All)	Momentum related potential energy hazards associated with current systems or possible equipment.	Initial Testing, In-Service Surveillance, and Maintenance; Operational Safety; Management, Organization, and Institutional Safety Provisions	Key Attribute 17-10; Key Attribute 10-4; discussion in Section 11.3 on DOE/RL-92-36; Key Attributes 11-3, 11-4.

Table A-2. Disposition of Energy Checklist Items

Hazards Checklist Item	Evaluation	SMP Disposition	HNF-11724 – Key Attribute

Notes:

DOE/RL-92-36, *Hanford Site Hoisting and Rigging Manual*

AE acoustic energy
BIO biological
CE chemical energy
CM chemical material
EE electrical energy
HA hazard analysis
HVAC heating, ventilation, and air conditioning
ID identification
KE kinetic energy
LOEE loss of electrical energy
LOTE low thermal energy
ME mechanical energy
NDA nondestructive assay
NPH natural phenomena hazard
OTH other
PE potential energy
PPE personal protective equipment
RE radiant energy
RM radioactive material
SMP Safety Management Program
TE thermal energy
TP thermal potential energy

Table A-3. Hazard Analysis

Hazard Summary				Event Rankings			Preventive and/or Mitigative Features			Worker Safety	
ID	**Hazards Condition**	**Contributing Events**	**Nature of Release**	**Likelihood**	**Consequence**	**Risk Bin**	**SSCs**	**Administrative**	**Remarks**	**Hazard Beyond Standard Industrial Hazard**	**Remarks**
1	Failure of the building structure	Seismic event; ash or snow load; high wind	Some portion of the facility radiological inventory released to the environment and/or exposure to personnel/receptors	Unlikely	Low	III	Building structure	Initial Testing, In-Service Surveillance, and Maintenance	Assumed that an "unlikely" seismic event; or snow/ash load results in catastrophic failure of the building.	Yes; analyzed in Section 3.5.1	Building structure provides no mitigation for FW, CW, or MOI. No additional controls beyond SMPs are required. Building is maintained; no specific SMP to prevent earthquake. The qualitative PHA identified the consequences as Moderate. However, after performing the quantitative accident analysis, the consequences were determined to be Low.
1a	Failure of the building structure	Aircraft Impact	Some portion of the facility radiological inventory released to the environment and/or exposure to personnel/receptors	Beyond Extremely Unlikely; less than 1E-06/yr based on analysis in HNF-8758, *Waste Encapsulation and Storage Facility Documented Safety Analysis*. WESF is larger than the 224-B facility and they are approximately the same distance from nearby airports; thus, the WESF analysis bounds the frequency for the 224-B Facility.	N/A	N/A	N/A	N/A		Not analyzed due to event likelihood	Building structure provides no mitigation for FW, CW, or MOI. No additional controls beyond SMPs are required.
2	Isolated failure of a portion of the building structure	Vehicle Impact; crane drop	Some portion of the facility radiological inventory released to the environment and/or exposure to personnel/receptors	Anticipated	Low	III	Building structure	Initial Testing, In-Service Surveillance, and Maintenance; Operational Safety	Auto does minimal damage. Includes fuel trucks and bottle trucks. Crane drop assumed to fail entire roof structure.	Yes; analyzed in Section 3.5.2	Building structure provides no mitigation for FW, CW, or MOI. No additional controls beyond SMPs are required. The qualitative PHA identified the consequences as Moderate. However, after performing the quantitative accident analysis, the consequences were determined to be Low.

Table A-3. Hazard Analysis

Hazard Summary				Event Rankings			Preventive and/or Mitigative Features			Worker Safety	
ID	Hazards Condition	Contributing Events	Nature of Release	Likelihood	Consequence	Risk Bin	SSCs	Administrative	Remarks	Hazard Beyond Standard Industrial Hazard	Remarks
3	Isolated failure; loss of confinement	Wear; aging; weather; Animal Intrusion	Portion of the facility inventory	Anticipated	Low	III	Building structure	Initial Testing, In-Service Surveillance, and Maintenance	Degradation does not represent a scenario with sufficient energy to result in a greater release.	No	Building structure provides no mitigation for FW, CW, or MOI. No additional controls beyond SMPs are required.
4	Building Fire	Ignition due to ongoing activities including vehicle impact; range fire	Entire facility inventory	Anticipated	Low	III	N/A	Operational Safety (Fire Protection) and fire department response	The entire building is assumed to burn. This is a conservative assumption	Yes; analyzed in Section 3.5.3	Risk to the facility worker is a standard industrial hazard since the dominant hazard is fire. No additional controls beyond SMPs are required. The qualitative PHA identified the consequences as Moderate. However, after performing the quantitative accident analysis, the consequences were determined to be Low.
5	Localized fire	Ignition due to ongoing activities including vehicle impacts; range fire	Portion of the facility inventory	Anticipated	Low	III	N/A	Operational Safety (Fire Protection) and fire department response	A portion of the building is burned but there is not sufficient energy to propagate to the entire building. This event is bounded by the building fire	Yes; bounded by analysis in Section 3.5.3	Risk to the facility worker is a standard industrial hazard since the dominant hazard is fire. No additional controls beyond SMPs are required.
6	Facility worker exposure radiological hazards	Facility worker enters radiological area without proper equipment. Personnel error in surveying and/or posting of the radiation areas. Exposure from errors in scabbling and other similar activities.	None to public	Anticipated	Low	III	N/A	Radiation Protection; Hazardous Material Protection	This could result in either an external or internal exposure to personnel. The event could occur in any of the radiation areas within the facility.	No	Radiation exposure is a hazard covered by SMPs. No additional controls beyond SMPs are required.

Table A-3. Hazard Analysis

Hazard Summary				Event Rankings			Preventive and/or Mitigative Features			Worker Safety	
ID	Hazards Condition	Contributing Events	Nature of Release	Likelihood	Consequence	Risk Bin	SSCs	Administrative	Remarks	Hazard Beyond Standard Industrial Hazard	Remarks
7	Facility worker exposure to toxic materials	Facility worker enters area containing toxicological materials without the proper equipment. Personnel error; inadequate characterization Exposure from errors in scabbling and other similar activities.	None to public	Anticipated	Low	III	N/A	Hazardous Material Protection	This could result in either an external or internal exposure to personnel. The event could occur in any of the facility areas with toxicological residual materials.	No	Exposure to toxic materials is a standard industrial hazard. No additional controls beyond SMPs are required.
8	Water intrusion/water spill	Water intrusion from natural sources (rain), and water lines.	Some release of contaminated water to the environment	Anticipated	Low	III	N/A	Initial Testing, In-Service Surveillance, and Maintenance	Low energy event with residual material does not result in a significant release to the environment.	No	No significant consequences. Radiation exposure is a hazard covered by SMPs. No additional controls beyond SMPs are required.
9	Criticality	Unauthorized movement of material	Release of fission products to environment/workers	Beyond Extremely Unlikely	High	III	N/A	Prevention of Inadvertent Criticality	The facility contains more than a minimum critical mass, but form and distribution are such that a criticality is not credible.	Not credible	Not a credible event.
10	Drop of equipment during removal; or waste container during handling	Personnel error; equipment failure.	Portion of the contamination on the equipment being removed	Anticipated	Low	III	N/A	Radiation Protection; Operational Safety; Hazardous Material Protection	Addresses the potential for equipment removal and accidents related to that event.	Yes; analyzed in Section 3.5.4	Risk to the facility worker is a standard industrial hazard since the dominant hazard is a load drop. No additional controls beyond SMPs are required. The qualitative PHA identified the consequences as Moderate. However, after performing the quantitative accident analysis, the consequences were determined to be Low.

Table A-3. Hazard Analysis

Hazard Summary				Event Rankings			Preventive and/or Mitigative Features			Worker Safety	
ID	Hazards Condition	Contributing Events	Nature of Release	Likelihood	Consequence	Risk Bin	SSCs	Administrative	Remarks	Hazard Beyond Standard Industrial Hazard	Remarks
11	Decontaminate and/or stabilize contaminated areas using both passive (wiping, cleaning, vacuuming, applying fixatives, etc.) and aggressive (scabbling, grinding, etc.) techniques.	Radiological and/or chemical material spread due to the nature of the process.	Fraction of facility inventory, specifically the impacted material.	Anticipated	Low	III	Building Structure	Radiation Program; Hazardous Material Protection	The team considered the application of the vigorous decontamination methods for contamination areas not to large inventories within vessels.	No	No significant consequences. Radiation exposure and contamination are hazards covered by SMPs. No additional controls beyond SMPs are required.
12	Fire impacting staged waste either internal or external to the facility	Personnel error; range fire. incompatible wastes; vehicle impact.	Some portion of the contamination within the waste.	Anticipated	Low	III	N/A	Operational Safety; Hazardous Material Protection		Yes; analyzed in Section 3.5.5	Risk to the facility worker is a standard industrial hazard since the dominant hazard is fire. No additional controls beyond SMPs are required. The qualitative PHA identified the consequences as Moderate. However, after performing the quantitative accident analysis, the consequences were determined to be Low.
13	Hazardous event at 221-B Facility affecting 224-B Facility	Seismic or impact event at 221-B Facility that causes a force of air through the transfer pipes connecting 221-B Facility and 224-B Facility	Portion of the contamination within the transfer pipes is released and creates a localized release of contamination in C Cell	Unlikely	Low	III	Building Structure	Initial Testing, In-Service Surveillance, and Maintenance		No	No significant consequences. Radiation exposure and contamination are hazards covered by SMPs. It is extremely unlikely that a FW would be Cell C at the time of this release.
14	Fire at 221-B Facility that potentially affects 224-B Facility	Personnel error; range fire	Portion of the 221-B Facility inventory is ignited. Based on the pipe configuration, it is not expected that a fire in 221-B would propagate through the several meters of underground pipe to the 224-B Facility; there is a low source of oxygen and combustibles.	Extremely Unlikely due to pipe configurations	Low	IV	Building Structure	Initial Testing, In-Service Surveillance, and Maintenance Operational Safety (Fire Protection) Program	Facility and pipe configuration does not support fire propagation from 221-B to 224-B.	No.	Fire would not propagate to 224-B from pipes connected to 221-B, thus no hazard to the FW in the 224-B Facility.

Table A-3. Hazard Analysis

Hazard Summary				Event Rankings			Preventive and/or Mitigative Features			Worker Safety	
ID	Hazards Condition	Contributing Events	Nature of Release	Likelihood	Consequence	Risk Bin	SSCs	Administrative	Remarks	Hazard Beyond Standard Industrial Hazard	Remarks

Note: Specific energy initiators are identified in the HID.

FW = facility worker

MW = mixed waste

ERDF = Environmental Restoration Disposal Facility

A.3 Hazard Identification Discussions

1. The event considered here is the catastrophic failure of the building structure due to natural phenomena events such as seismic, ash/snow loading, or high winds.
    a. The event considered here is the failure of the building structure due to an aircraft impact.
2. The event considered here is the failure of a portion of the building structure as a result of vehicle impact or drop of a crane load onto the building. For conservatism, the crane drop is assumed to result in total collapse of the building structure. This is an extremely conservative assumption made to make the consequence analysis more straightforward and less subject to engineering judgment decisions.
3. The event considered here is the failure of a portion of the building structure failing as a result of degradation over the extended surveillance and maintenance period. This is considered a low-energy event with minimal material release.
4. The event evaluated here is the burning of the entire building structure. This represents a scenario where a fire spreads due to high combustible loading within the building.
5. The event considered here is a localized fire. The combustible loading is considered to be insufficient to propagate to the entire building and the event is bounded by Item 4 above.
6. This event considers the potential for personnel working within the building to be exposed to radiation hazards.
7. This event considers the potential for building workers to be exposed to toxic material residuals during activities.
8. The event considered here is a water spill within the building as part of activities. The water is released in a contaminated area and contaminated water is released to the environment outside the building.
9. The event considered here is criticality. Since the building is a limited control facility, based on the form and distribution of the material, criticality is not considered a credible scenario.
10. The event considered here is the removal of TRU contaminated equipment and/or waste, and the equipment is dropped resulting in a release to the environment.
11. The event considered here is the decontamination of facility areas with aggressive techniques such as scabbling and grinding.
12. The event considered here is a fire involving the staged waste either within the building or external to the building.
13. This event considers the impact of a seismic or impact event at the 221-B Facility on the 224-B Facility due to the transfer pipe connection between the two facilities.

14. This event considers the impact of a fire event at the 221-B Facility on the 224-B Facility due to the transfer pipe connection between the two facilities.

Table A-4. Binning of Accidents

Accident ID	Representative and Bounding Event	Basis	Consequence Analysis in DSA
Impact/Seismic			
1	Seismic Event	This is the bounding seismic event since it involves the entire building inventory.	3.5.1
1a	Aircraft Impact	This event considers the failure of the building structure due to aircraft impact. As a result of the event likelihood, the event is not identified for consequence analysis.	No
2	Crane Drop Event	The release is the same for this event as the seismic event; however, the initiator is more frequent and very different. As a result this is included as a separate event.	3.5.2
3	Isolated failure; loss of confinement	The release is bounded by either ID-1 or 2 events since this is a lower energy event. The frequency is the same as the crane drop (ID-2) so the ID-2 is a more appropriate representative event.	No
10	Drop of equipment/waste during handling	This event was evaluated separately to ensure that any different release mechanisms versus the seismic event are captured.	3.5.4
13	Seismic/Impact Event at 221-B Facility	This event evaluates what impact a seismic or impact event at the 221-B Facility would have on the 224-B Facility due to the transfer pipe connection between these facilities	No
Fires			
4	Building fire	This is the bounding fire for the building inventory.	3.5.3
5	Localized fire	This event is bounded by the building fire.	No
12	Fire of staged waste	This event was evaluated separately to ensure that any different release mechanisms versus the other fire events are captured.	3.5.5
14	Fire at 221-B Facility	This event evaluated what impact a fire at the 221-B Facility would have on the 224-B Facility due to the transfer pipe connection between these facilities	No
Miscellaneous			
6	Facility worker exposure to radiation	This is a worker-level hazard. The energy is not sufficient to result in a release to the environment. As a personnel receptor event, it is used to evaluate controls/programs to ensure the safety of the worker.	No

Table A-4. Binning of Accidents

Accident ID	Representative and Bounding Event	Basis	Consequence Analysis in DSA
7	Facility worker exposure to toxic materials	This is a worker-level hazard. The energy is not sufficient to result in a release to the environment. As a personnel receptor event, it is used to evaluate controls/programs to ensure the safety of the worker.	No
8	Water intrusion/spill	This is a low-energy event. The potential release to the environment is bounded by the building fire event. No analysis of the water event is performed.	No
9	Criticality	This event is too low a probability to evaluate.	No
11	Decontaminate or stabilize	This is a worker-level hazard. The energy is not sufficient to result in a release to the environment. As a personnel receptor event, it is used to evaluate controls/programs to ensure the safety of the worker.	No

Table A-5. Correlation of Hazardous Energy and Material Sources to Accidents/Accident Types

Accident	Hazardous Energy Sources
Seismic/NPH	NPH
Fire	Electrical, Thermal, Friction, Pyrophoric Material, Open Flame, Flammables, Combustibles, Chemical Reaction, Vehicles in Motion
Equipment Drop	Cranes, Vehicles in Motion, Potential Energy
Crane Drop	Cranes, Vehicles in Motion, Potential Energy
Other/Worker Hazards[3]	Other Hazards, Acoustic Energy, Low Thermal Energy, Biological, Loss of Electrical Energy, Chemical Materials, Radioactive Materials, Potential Energy

NPH natural phenomena hazard

[3] It is recognized that all of the hazard types covered in the hazards identification checklist do impact the facility worker. This category contains those hazards that were identified by the HA team with impacts limited to the facility worker versus the other receptors and accidents. These hazards are addressed by the SMPs.

Appendix B

Hazards Analysis Summary Data

Appendix B
Inventory Development for 224-B Facility

B.1 Purpose

The inventory used in the safety basis is based on the material reported in the 1985 characterization report (SD-DD-TRP-002, *Radiological Characterization of the 224-B Hot Cells*). This appendix evaluates the data provided in the characterization report and develops the bounding inventory to be used to update the dose consequence analyses.

B.2 Data

Per Table 4.2 of SD-DD-TRP-002, the maximum upper limit of non-TRU radiological inventory (Cs-137, Sr-90 and Co-60) is 59 Ci. An analysis of the estimated inhalation dose contribution from these isotopes concluded that the increase would be less than 0.02% of the dose from the plutonium and americium estimated to be present. As such, this inventory was not included in the inventory estimate used in the accident analyses. The key data regarding the inventory of the 224-B hot cells are found in Tables 4.1 and 4.3 of the characterization report. Tables B-1 and B-2 below reproduce the data presented in Tables 4.3 and 4.1 of SD-DD-TRP-002.

Table B-1 presents the data for the tanks and centrifuges as presented in Table 4.3 of SD-DD-TRP-002. The centrifuges are all reported using the value of the E cell centrifuge as the basis. The corresponding standard deviation is reported as 284 percent of the mean value. A summary of the inventory for the tanks and centrifuges of each cell is incorporated into Table B-2.

Table B-1. Summary of Tank/Centrifuge 241-Am Inventory (Ci – 1985 Data)

Location	Component							Totals
Cell A	Tank A-1 3.0E-03	Tank A-3 3.0E-03	Tank A-4 1.0E-03	Centrifuge* 3.4E-02				4.1E-02
Cell B	Tank B-1 1.2E-02	Tank B-3 1.2E-02	Tank B-4 6.0E-03	Tank B-6 6.0E-03	Centrifuge* 3.4E-02			7.0E-02
Cell C	Tank C-4 2.9E-02	Tank C-7 3.8E-02	Tank C-8 8.3E-02	Tank C-9 2.9E-02				1.8E-01
Cell D	Tank D-1 2.8E-02	Tank D-3 3.44E+00	Tank D-4 1.0E-02	Centrifuge* 3.4E-02				3.5E+00
Cell E	Tank E-1 1.0E-03	Tank E-3 1.0E-03	Tank E-4 1.4E-2	Centrifuge* 3.4E-02				5.0EE-02
Cell F	Tank F-1 6.1E-2	Tank F-7 6.1E-02	Tank F-8 6.08E-01	Tank F-9 4.68E-01	F-2 Centrifuge* 3.4E-02	F-22 Centrifuge* 3.4E-02	2 Small Centrifuges* 3.0E-02	1.3E+00

*SD-DD-TRP-002 identifies that these are all estimated from the E-cell centrifuge. The reported standard deviation is 284%. No other standard deviations are provided for the tank data in Table 4.3 of the characterization report.

Table B-2 presents the summary data for ^{241}Am for each cell and is taken from Table 4.1 of SD-DD-TRP-002. The characterization report addresses each of the locations and/or inventory types such as dust, samplers, etc., and how the inventory data was determined. This information is not reproduced here. Instead, the mean and standard deviation values (percentages in parentheses) reported are used to determine a bounding inventory for the facility.

Table B-2. Summary of ^{241}Am Inventory (Ci – 1985 Data)

Category	Cell A	Cell B	Cell C	Cell D Except D-3	Tank D-3	Cell E	Cell F
Dust: Floor, Walls and Equipment	6.4E-04 (191%)	4.6E-04 (77%)	4.3E-04 (106%)	1.6E-04 (247%)		8.1E-05 (131%)	8.4E-05 (169%)
Gutter/Sump Samplers	2.2E-05 (103%)	2.2E-05 (103%)	3.8E-05 (103%)	2.2E-05 (103%)		2.2E-05 (103%)	4.4E-05 (103%)
Tanks, Centrifuges	4.1E-02 (96%)	7.02E-02 (96%)	1.8E-01 (96%)	7.2E-02 (96%)[1]	3.44E+00 (39%)[2]	5.0E-02 (96%)	1.3E+00 (96%)
Piping	1.7E-02 (99%)	1.7E-02 (99%)	2.1E-02 (99%)	1.7E-02 (99%)		1.7E-02 (99%)	2.1E-02 (99%)
C Pit Walls			2.9E-04 (106%)[3]				
Loadout Hood							6.8E-04 (169%)[3]

[1] The report identifies 86%; however, this value includes the D-3 tank which for calculation purposes is separated in Table B2. For conservatism, the 96% value reported for all other tanks is used.

[2] Tank D-3 is separated to facilitate the calculation process since it was evaluated by a second NDA. In this case, the data as presented in the second NDA is reproduced. This corresponds roughly to a standard deviation (σ) percentage of 39% of the mean.

[3] The report did not indicate standard deviation (σ) percentage for these locations. In order to be conservative, the highest standard deviation reported for the respective cell was used.

B.3 Evaluation

In order to determine a bounding inventory, the measured ^{241}Am inventory values presented in Table B2 were used with their reported standard deviation values (σ values). For the analysis, the "1.96 σ" values were added to the measured values. This sum represents the upper limit of the 95 percent confidence interval of the measurements. The cell summary measured value and standard deviation percentages were provided by the NDA analysts and are bounded by the individual location data and standard deviations reported.

Using the mean value for a cell or tank, the bounding value is determined by:

where:

σ = standard deviation (percent of mean) as reported in SD-DD-TRP-002

Using this equation, the bounding values of ^{241}Am for each cell or location were determined. The 1985 mean and bounding inventory values for ^{241}Am are presented in Table B-3.

Table B-3. Mean and Bounding Inventory for ^{241}Am (1985 Data)

Location	Mean (Ci)	Mean (g)	Bounding (Ci)	Bounding (g)
Cell A	5.87E-02	1.71E-02	1.71E-01	4.99E-02
Cell B	8.75E-02	2.55E-02	2.53E-01	7.37E-02
Cell C	2.02E-01	5.88E-02	5.83E-01	1.70E-01
Cell D[1]	8.92E-02	2.60E-02	2.58E-01	7.53E-02
Tank D-3	3.44E+00	1.00E+00	6.07E+00	1.77E+00
Cell E	6.71E-02	1.95E-02	1.94E-01	5.66E-02
Cell F	1.32E+00	3.85E-01	3.81E+00	1.11E+00
Totals	**5.27E+00**	**1.53E+00**	**1.13E+01**	**3.30E+00**

[1] Does not include Tank D-3.

A calculation of the plutonium inventory expected to be present was performed based on the calculated ^{241}Am bounding values. The analysis assumed that the plutonium came from weapons-grade fuel (6 percent ^{240}Pu). The analysis starts with 180-day cooled fuel isotopic distributions dated from 1952 (the last year of processing in 224-B). Table B-4 presents the assumed isotopic weight distribution values.

Table B-4. Plutonium Isotopic Distribution

Isotope	Distribution
^{238}Pu	0.020%
^{239}Pu	93.500%
^{240}Pu	6.110%
^{241}Pu	0.340%
^{242}Pu	0.030%

The 1985 decay corrected isotopic weight distribution values were calculated and are presented in Table B-5.

Table B-5. Isotopic Distribution (1985)

Isotope	Distribution
^{238}Pu	0.013%
^{239}Pu	93.531%
^{240}Pu	6.086%

^{241}Pu	0.023%
^{242}Pu	0.030%
^{241}Am	0.318%

The 1985 estimated plutonium isotopic inventory was calculated for each cell location using the distribution numbers of Table B-5 and the bounding ^{241}Am values of Table B-3. The 1985 estimated isotopic inventory is presented in Table B-6.

Table B-6. 224-B Facility Inventory in 1985 (grams)

Isotopes	Cell A	Cell B	Cell C	Cell D	Tank D-3	Cell E	Cell F	Total
^{238}Pu	2.84E-03	4.20E-03	9.67E-03	4.29E-03	1.01E-01	3.22E-03	6.32E-02	1.88E-01
^{239}Pu	1.72E+01	2.54E+01	5.86E+01	2.60E+01	6.10E+02	1.95E+01	3.83E+02	1.14E+03
^{240}Pu	1.12E+00	1.66E+00	3.82E+00	1.69E+00	3.98E+01	1.27E+00	2.50E+01	7.43E+01
^{241}Pu	1.28E-02	1.89E-02	4.36E-02	1.93E-02	4.54E-01	1.45E-02	2.85E-01	8.48E-01
^{242}Pu	5.53E-03	8.17E-03	1.88E-02	8.35E-03	1.96E-01	6.28E-03	1.23E-01	3.66E-01
^{241}Am	4.99E-02	7.37E-02	1.70E-01	7.53E-02	1.77E+00	5.66E-02	1.11E+00	3.30E+00
							Total	**1.22E+03**

This inventory estimate was further refined by decay correcting each isotope to 2008 values.[4]

While the total plutonium inventory will slowly decrease over time, the inventory of ^{241}Am will increase to a maximum due to its production as the decay daughter of ^{241}Pu. This is of significance since ^{241}Am is a significant contributor to inhalation dose. The ^{241}Am inventory as a function of time is given by the equation:

$$A(t) = \frac{\lambda_P}{\lambda_A - \lambda_P} \times P_0\left(e^{-\lambda_P t} - e^{-\lambda_A t}\right) + A_0\, e^{-\lambda_A t}$$

where:

$A(t)$ = the mass in grams of ^{241}Am at time t
A_0 = the initial mass in grams of ^{241}Am (assumed to be 0.0)
P_0 = the initial mass in grams of ^{241}Pu
λ_P = half-life constant (ln(2)/half-life) of ^{241}Pu = 0.048 yr^{-1}
λ_A = half-life constant (ln(2)/half-life) of ^{241}Am = 0.0016 yr^{-1}
e = the exponential function

[4] It is noted that the approach for estimating the plutonium inventory differs from the one that was used in SD-DD-TRP-002. This secondary approach was used since SD-DD-TRP-002 did not estimate plutonium isotopes other than Pu-239. The other plutonium isotopes expected to be present contribute significantly to accident inhalation dose. This approach is conservative since the final inventory estimate bounds both the mean and bounding estimates described in SD-DD-TRP-002.

For ^{241}Pu (half-life = 14.4 yrs) and ^{241}Am (half-life = 432.2 yrs) this maximum occurs at 73.1 years. A graphical representation of the in-growth of ^{241}Am from the decay of 1 gram of ^{241}Pu is presented in Figure B-1.

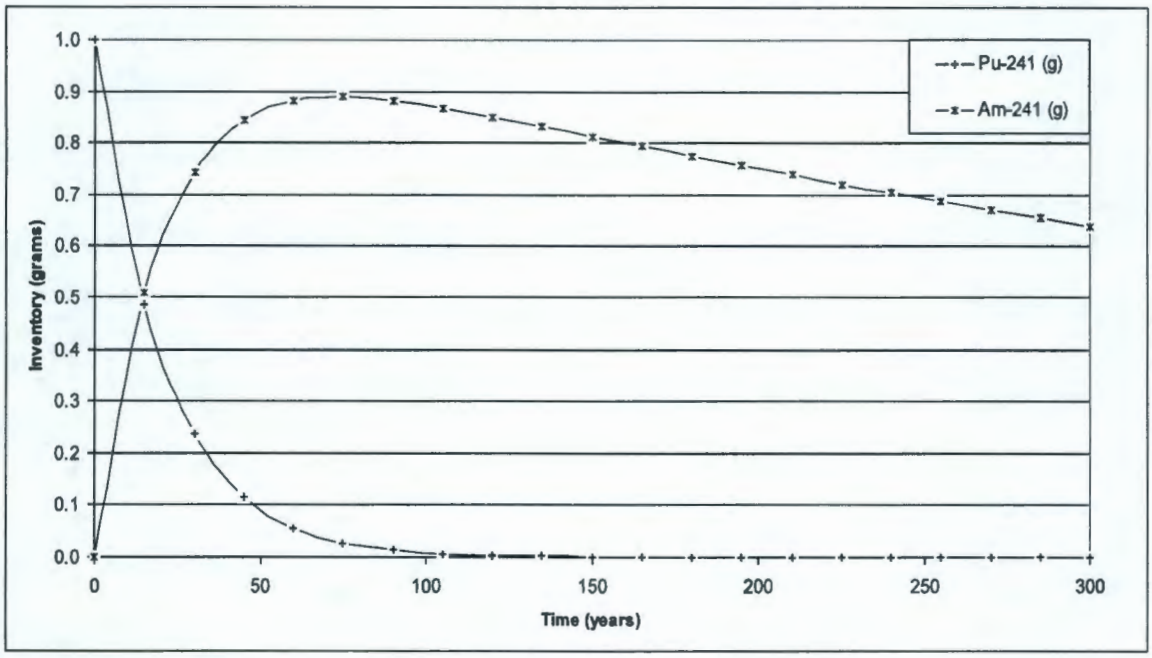

Figure B-1. Production and Decay of ^{241}Am from the Decay of 1 gram of ^{241}Pu

Recognizing that the increase in ^{241}Am, over time, could result in greater accident dose consequences, ^{241}Am will be estimated at its maximum value (73.1 yrs) to provide a bounding value for the year 2008 and beyond. This results in an approximately 16 percent increase in ^{241}Am inventory above the value estimated to be present in 1985. Further refinements to the inventory estimate, based upon the SD-DD-TRP-002 data, are deemed to be unnecessary since the plutonium dose contribution will decrease over time and ^{241}Am dose contribution has been bounded.

Tables B-7 and B-8 present the calculated bounding inventory values decay corrected in grams and curies.

Table B-7. Bounding 224-B Facility Inventory (grams)[1]

Isotopes	Cell A	Cell B	Cell C	Cell D[2]	Tank D-3	Cell E	Cell F	Total
^{238}Pu	2.37E-03	3.50E-03	8.06E-03	3.57E-03	8.40E-02	2.69E-03	5.27E-02	**1.57E-01**
^{239}Pu	1.72E+01	2.54E+01	5.86E+01	2.60E+01	6.10E+02	1.95E+01	3.83E+02	**1.14E+03**
^{240}Pu	1.12E+00	1.65E+00	3.81E+00	1.69E+00	3.97E+01	1.27E+00	2.49E+01	**7.41E+01**

^{241}Pu	4.23E-03	6.25E-03	1.44E-02	6.39E-03	1.50E-01	4.80E-03	9.42E-02	**2.80E-01**
^{242}Pu	5.53E-03	8.17E-03	1.88E-02	8.35E-03	1.96E-01	6.28E-03	1.23E-01	**3.66E-01**
^{241}Am	5.76E-02	8.51E-02	1.96E-01	8.70E-02	2.04E+00	6.54E-02	1.28E+00	**3.82E+00**
Total	**1.84E+01**	**2.72E+01**	**6.26E+01**	**2.78E+01**	**6.52E+02**	**2.09E+01**	**4.09E+02**	**1.22E+03**

[1] Plutonium isotopes decay corrected to 2008 values; ^{241}Am calculated at maximum value.

[2] Does not include Tank D-3

Table B-8. Bounding 224-B Facility Inventory (Curies)[1]

Isotopes	Cell A	Cell B	Cell C	Cell D[2]	Tank D-3	Cell E	Cell F	Total
^{238}Pu	4.06E-02	5.99E-02	1.38E-01	6.12E-02	1.44E+00	4.61E-02	9.03E-01	**2.69E+00**
^{239}Pu	1.07E+00	1.58E+00	3.63E+00	1.61E+00	3.79E+01	1.21E+00	2.38E+01	**7.07E+01**
^{240}Pu	2.55E-01	3.77E-01	8.68E-01	3.85E-01	9.04E+00	2.90E-01	5.68E+00	**1.69E+01**
^{241}Pu	4.36E-01	6.44E-01	1.48E+00	6.58E-01	1.54E+01	4.95E-01	9.70E+00	**2.89E+01**
^{242}Pu	2.17E-05	3.21E-05	7.39E-05	3.28E-05	7.70E-04	2.47E-05	4.83E-04	**1.44E-03**
^{241}Am	1.98E-01	2.92E-01	6.73E-01	2.99E-01	7.01E+00	2.25E-01	4.40E+00	**1.31E+01**
Total	**2.00E+00**	**2.95E+00**	**6.80E+00**	**3.01E+00**	**7.08E+01**	**2.27E+00**	**4.44E+01**	**1.32E+02**

[1] Plutonium isotopes decay corrected to 2008 values; ^{241}Am calculated at maximum value.

[2] Does not include Tank D-3.

Appendix C

Technical Safety Requirements for 224-B Facility Surveillance and Maintenance

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Appendix C
Technical Safety Requirements for 224-B Facility Surveillance and Maintenance

C.1 Use and Applications

This section contains basic information and instructions for using and applying the technical safety requirements (TSRs) and complies with 10 CFR 830 Subpart B requirements. See Chapter 5.0 for the project-specific implementation commitments regarding the TSRs.

C.1.1 Definitions

NOTE: Defined terms in this list appear in uppercase type throughout these TSRs.

Term	Definition
ACTION(S)	An ACTION statement describes the action or actions to be taken in the event a TSR element is not met. ACTION statements should be broken down whenever possible into separate statements describing a single deviated condition requiring operator action.
ACTIVITY	An ACTIVITY is the term representing the collection of tasks or steps commonly associated with a process.
ADMINISTRATIVE CONTROLS (ACs)	Provisions relating to organization and management, procedures, record keeping, assessment, and reporting necessary to ensure safe operation of a facility.
DESIGN FEATURE	DESIGN FEATURES of the facility specified in the TSRs that, if altered or modified, would have a significant effect on safety operation.
IMMEDIATE/ IMMEDIATELY	Term used as a completion time for ACTION Statements when a step is to be initiated as soon as possibly achievable after discovery without creating a less stable condition and continuously and aggressively pursued until complete.
LIMITING CONDITION FOR OPERATION (LCO)	The lowest functional capability or performance levels of essential safety-related hardware.
LIMITING CONTROL SETTING (LCS)	Setting on safety systems that controls process variables to prevent exceeding the SAFETY LIMITS.

Term	Definition
NORMAL OPERATIONS	See Section C1.2, "OPERATIONAL MODES."
OPERABLE/ INOPERABLE/ OPERABILITY	A system, subsystem, train, component, or device SHALL be OPERABLE or have OPERABILITY when it is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication, or other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its function(s) are also capable of performing their related support function(s). See Section C1.6, "General Principles of OPERABILITY."
OPERATING LIMITS	LIMITING CONTROL SETTINGS and LIMITING CONDITIONS FOR OPERATION.
OPERATIONAL MODES	OPERATIONAL MODES for the 224-B Building are NORMAL OPERATIONS. See Section C1.2, "OPERATIONAL MODES."
SAFETY LIMITS	Limits on process variables associated with those physical barriers that are necessary for the intended facility function and are found to be required to guard against the uncontrolled release of radioactive and other hazardous materials.
SHALL	Denotes a mandatory requirement that must be complied with to maintain the requirements, assumptions, or conditions of the facility safety basis.
SURVEILLANCE REQUIREMENTS (SR)	Requirements related to testing, calibration, or inspection to ensure OPERABILITY of safety-related equipment and required support systems, or to ensure that operations are within the specified LCO.
VIOLATION	See Section C1.5, "TSR VIOLATION."

C.1.2 Operational Modes

The operational conditions and modes that apply to the 224-B Building and its operations are defined as follows:

Term	Definition
NORMAL OPERATIONS	S&M ACTIVITIES are performed. The radioactive material inventory meets or exceeds the HC 3 threshold as defined in DOE-STD-1027-92.

C.1.3 Alternate Emergency Actions

Emergency actions may be taken in special circumstances. In an emergency, if a situation develops that is not addressed by the TSRs, staff members are expected to use their training, expertise, and applicable emergency response procedures to take actions to correct or mitigate the situation. Also, staff may take actions that depart from a requirement in the TSRs provided that the following are true:

- An emergency situation exists.
- These actions are needed IMMEDIATELY to protect the public health and safety.
- No action consistent with the TSR can provide adequate or equivalent protection.

Such actions SHALL be approved, at a minimum, by the facility manager, or the 224-B Building emergency director. If emergency actions are taken, verbal notifications SHALL be made to the U.S. Department of Energy, Richland Operations Office (RL) facility representative within 2 hours and by written reports to DOE Headquarters within 24 hours.

C.1.4 AC Element Not Met

Deficiencies in a program or procedure non-compliances that indicate a programmatic breakdown significant enough to render the safety analysis invalid, or failure to comply with an SMP key attribute. Isolated discrepancies in a program or procedure do not, by themselves, constitute a TSR AC VIOLATION.

If an AC element is discovered not to have been performed or not have been followed, this would not necessarily result in a TSR AC VIOLATION. If failure to meet an AC element does not result in a TSR AC VIOLATION based on any one of the criteria listed in Table C-1, then this would be reported as a noncompliance with a hazard control (occurrence reporting severity category SC3). If the failure to meet an AC element results from any one of the criteria listed in Table C-1, then this constitutes a TSR AC VIOLATION and the steps in Section C.1.5, "TSR AC VIOLATION," SHALL be completed.

Table C-1. Criteria Constituting TSR AC VIOLATIONS

• A required program has not been established.
• The program has been established but the facility has not attempted to implement the program.
• Time frames or actions specified upon failure to meet an AC element are not met.
• Failure to comply with the program requirements specified in this document results in multiple recurrences of a specific key element not being met indicating a programmatic breakdown.

C.1.5 TSR AC Violation

The following ACTIONS SHALL be taken in the event that a TSR AC VIOLATION occurs:

1. Terminate affected ACTIVITY(ies) IMMEDIATELY except as necessary to achieve a safe configuration.
2. Take the following reporting actions:
   a. Make appropriate entries documenting the failure to meet the AC element(s) in the facility record, indicating any operational areas affected and restrictions imposed. Maintain the status of restrictions and operational areas affected in the facility as recovery progresses.
   b. Notify RL in accordance with DOE occurrence reporting requirements.
   c. Prepare an Occurrence Report and implement the corrective action management process, as required.
3. Restore administrative element within 10 working days.
4. If the AC element(s) cannot be restored within 10 working days, notify RL Facility Representative within the 10 working days, develop a facility-approved recovery plan, and initiate ACTIONS of the recovery plan within the 10 working days.
5. Affected ACTIVITY(ies) may be resumed at any time when the relevant AC element(s) have been restored OR as specified by the recovery plan.

C.1.6 General Principles of OPERABILITY

No LCOs exist for the 224-B Facility. Therefore, principles of OPERABILITY are not required.

C.2 Safety Limits

There are no SAFETY LIMITS for the 224-B Building.

C.3 OPERATING LIMITS and Surveillance Requirements

As stated in Chapter 5.0 of the 224-B DSA, there are no LCOs or LCSs applicable to 224-B Building operations. As such, there are no surveillance requirements.

C.4 Administrative Controls

This section presents the ACs for the 224-B Facility. The ACs are provisions relating to organization and management, procedures, record keeping, assessment, and reporting necessary to ensure the safe operation of the facility.

C.4.1 Safety Management Programs (AC)

C.4.1.1 Applicability

Safety management program (SMP) applicability will be established, implemented, and maintained to ensure that the overall safety function of an SMP is maintained through implementation of all applicable key attributes of the SMP identified in HNF-11724, as modified by Chapter 5 of the 224-B DSA.

C.4.1.2 Administrative Requirements

The following SMPs, as described in HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Programs*, latest revision, SHALL be established, implemented, and maintained, unless otherwise noted in Chapter 5 of the 224-B DSA.

a. Program Key Element

- Criticality Prevention* - as applicable per HNF-7098, *Criticality Safety Program* (Chapter 6)
- Radiation Protection* (Chapter 7)
- Hazardous Material Protection* (Chapter 8)
- Radioactive and Hazardous Waste Management* (Chapter 9)
- Initial Testing, Surveillance, and Maintenance (Chapter 10)
- Operational Safety* (Conduct of Operations/Fire Protection/Hoisting and Rigging) (Chapter 11)
- Procedures and Training (Chapter 12)
- Quality Assurance* (Chapter 14)
- Emergency Preparedness* (Chapter 15)
- Management, Organization, and Institutional Safety Provisions (Chapter 17)

Note: Program key element c, listed below, only applies to those SMPs identified above by an asterisk (*).

b. 224-B Facility management SHALL ensure the overall safety function of an SMP (identified above) is maintained through the implementation of all applicable program key elements identified in HNF-11724, as modified in Chapter 5 of the 224-B DSA. They will also ensure that facility level assessments are performed as required by the continuous improvement process of the ISMS on those SMPs identified in Part a, above.

c. For those SMPs identified above by an asterisk (*), 224-B Facility management SHALL ensure the data from the facility-level ISMS assessments will be provided to the appropriate program manager for tracking and trending, and corrective action management required by PRC-PRO-QA-052, *Issues Management*, or successor document.

C.4.1.3 Responsibility

Facility management is responsible to ensure that the applicable commitments of the SMPs are implemented and that the continuous improvement commitment of the ISMS is maintained.

C.4.1.4 Recovery

See Section C.1.4, "AC Element Not Met."

C.4.1.5 Basis

These SMPs provide significant contributions to worker safety and are an integral part of safe S&M operations at the 224-B Facility.

C.4.2 Waste Inventory Control (AC)

C.4.2.1 Applicability

This AC applies to the staged TRU wastes that may be generated as removed contaminated equipment. This AC is applicable only to externally staged waste at the 224-B Facility. The limit of 8.92 DE-Ci, as shown in Table C-2, required by C.4.2.2, applies to TRU waste and contaminated equipment removed from the 224-B Building. This TSR remains applicable until the facility is recategorized as less than HC 3.

C.4.2.2 Requirement

This requirement limits the total externally staged TRU waste and TRU contaminated equipment removed from the 224-B Building to less than 8.92 DE-Ci, which preserves the assumptions used in the analysis performed in DSA Section 3.5.5, *Contaminated Equipment/Waste-Handling Fire.*

C.4.2.3 Responsibilities

Facility management is required to ensure that the radiological inventories are managed as required in the requirements of C.4.2.2 above. Inventory control records SHALL be maintained according to quality requirements that are contractually applicable. Anticipated TRU waste will require characterization and/or NDA prior to removal, staging, and disposition.

C.4.2.4 Recovery

See Section C.1.4, "AC Element Not Met."

C.4.2.5 Basis

The Contaminated Equipment/Waste-Handling Fire accident analysis within the DSA (Section 3.5.5) assumes a radiological inventory and configuration that define the analyzed dose consequences for staged TRU waste and TRU contaminated equipment external to the 224-B Building. This TSR provides AC to ensure that the applicable MAR inventory assumption of 8.92 DE-Ci in the DSA is maintained. Table C-2 converts the accident analysis MAR assumption to DE-Ci, which simplifies the analysis for maintaining radiological inventories.

Table C-2. 224-B Isotope Mix

Isotope	Mass Ratio	Isotope grams with 100g ^{239}Pu	Ci	Ci to DE-Ci Conversion Factor[1]	DE-Ci
^{238}Pu	1.29E-04	1.38E-02	2.36E-01	9.2E-01	2.17E-01
^{239}Pu	9.34E-01	100	6.21E+00	1.0E00	6.21E+00
^{240}Pu	6.07E-02	6.5	1.48E+00	1.0E00	1.48E+00
^{241}Pu	2.30E-04	2.4E-02	2.53E+00	1.8E-02	4.55E-02
^{242}Pu	3.00E-04	3.2E-02	1.26E-04	9.6E-01	1.21E-04
^{241}Am	3.13E-03	3.4E-01	1.15E+00	8.4E-01	9.65E-01
Totals	**1.00**	**107 g**	**N/A**	**N/A**	**8.92 DE-Ci**

[1]. Conversion factors obtained from HNF-EP-0063, Rev 16.

This TSR does not limit the accumulation of LLW/MW. An unmanageable volume of LLW/MW (as characterized in the waste profile WPPRCIFSM001, Rev. 0) is necessary to exceed the MAR limit of 8.92 DE-Ci. For perspective, two Environmental Restoration Disposal Facility (ERDF) Roll-On/Roll-Off (RO/RO) Containers have a total volume of 44.80 m^3 (1582 ft^3) with a maximum total net weight of 100,000 lb and equate to 0.4 DE-Ci based on the general LLW profile described in WPPRCIFSM001, Rev. 0. Therefore, in order to reach the MAR limit of 8.92 DE-Ci, over 40 ERDF RO/RO Containers filled with LLW/MW would need to be staged outside the facility, which is impractical during S&M operations.

C.5 Design Features

No DESIGN FEATURES are identified for the 224-B Facility. The 224-B Building structure is not identified as SC or SS and no credit is taken for reduction of accident consequences in the accident analyses performed in Section 3.5. However, the 224-B Building structure is identified as providing defense-in-depth and all changes or modifications to the 224-B Facility are subjected to the USQ process.

Appendix D

RADIDOSE Calculations

Appendix D

RADIDOSE Version 3.0 (5-18-2005)			
Input Parameter	**User Input**	**Default**	**Description (based on user input)**
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	1.22E+03		gram
Damage Ratio:		1	
Airborne Release Fraction:		1.00E-03	ARF from SARAH Table 3-4 (ARF page)
Respirable Fraction:		0.1	RF from SARAH Table 3-4 (ARF page)
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	8260		meters
Distance or X/Q for Offsite Public:	16630		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Seismic Event - All inventory at risk; DR = 1.0

Dose Results for the Postulated Accident:

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	1.22E-01	gram		
Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	Duration 0.5 h
Distance:	100 m	8,260 m	16,630 m	
X/Q:	3.28E-02	3.20E-05	1.32E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.90E+06	1.55E+07	1.55E+07	rem/gram
Total Dose:	**1.33E+01**	**1.98E-02**	**8.19E-03**	**rem**
Consequence:	Low	na	Low	

Material source amounts are listed on the "UnitDF" page.

Nuclide	Grams per gram	Specific Activity, Ci/g	Curies per gram
Pu-238	1.30E-04	1.71E+01	2.23E-03
Pu-239	9.35E-01	6.21E-02	5.80E-02
Pu-240	6.09E-02	2.28E-01	1.39E-02
Pu-241	2.30E-04	1.03E+02	2.37E-02
Pu-242	3.00E-04	3.93E-03	1.18E-06
Am-241	3.18E-03	3.43E+00	1.09E-02

Figure D-1. Seismic Scenario (Section 3.5.1)

RADIDOSE Version 3.0 (5-18-2005)			
Input Parameter	**User Input**	**Default**	**Description (based on user input)**
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	1.22E+03		gram
Damage Ratio:		1	
Airborne Release Fraction:		1.00E-03	ARF from SARAH Table 3-4 (ARF page)
Respirable Fraction:		0.1	RF from SARAH Table 3-4 (ARF page)
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	8260		meters
Distance or X/Q for Offsite Public:	16630		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

Roof Collapse - All inventory at risk; DR = 1.0

Dose Results for the Postulated Accident:

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	1.22E-01 gram			
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	**Duration 0.5 h**
Distance:	100 m	8,260 m	16,630 m	
X/Q:	3.28E-02	3.20E-05	1.32E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.90E+06	1.55E+07	1.55E+07	rem/gram
Total Dose:	**1.33E+01**	**1.98E-02**	**8.19E-03**	**rem**
Consequence:	Low	na	Low	

Material source amounts ar listed on the "UnitDF" page.

Nuclide	Grams per gram	Specific Activity, Ci/g	Curies per gram
Pu-238	1.30E-04	1.71E+01	2.23E-03
Pu-239	9.35E-01	6.21E-02	5.80E-02
Pu-240	6.09E-02	2.28E-01	1.39E-02
Pu-241	2.30E-04	1.03E+02	2.37E-02
Pu-242	3.00E-04	3.93E-03	1.18E-06
Am-241	3.18E-03	3.43E+00	1.09E-02

Figure D-2. Roof Collapse (Crane Accident) Scenario (Section 3.5.2)

RADIDOSE Version 3.0 (5-18-2005)			
Input Parameter	**User Input**	**Default**	**Description (based on user input)**
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	1.22E+03		gram
Damage Ratio:		1	
Airborne Release Fraction:		6.00E-03	ARF from SARAH Table 3-4 (ARF page)
Respirable Fraction:		0.01	RF from SARAH Table 3-4 (ARF page)
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	8260		meters
Distance or X/Q for Offsite Public:	16630		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

224-B Building Fire-All inventory at risk; DR = 1.0

Dose Results for the Postulated Accident:

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	7.32E-02	gram		
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	Duration 0.5 h
Distance:	100 m	8,260 m	16,630 m	
X/Q:	3.28E-02	3.20E-05	1.32E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.90E+06	1.55E+07	1.55E+07	rem/gram
Total Dose:	**7.97E+00**	**1.19E-02**	**4.91E-03**	**rem**
Consequence:	Low	na	Low	

Material source amounts ar listed on the "UnitDF" page.

Nuclide	Grams per gram	Specific Activity, Ci/g	Curies per gram
Pu-238	1.30E-04	1.71E+01	2.23E-03
Pu-239	9.35E-01	6.21E-02	5.80E-02
Pu-240	6.09E-02	2.28E-01	1.39E-02
Pu-241	2.30E-04	1.03E+02	2.37E-02
Pu-242	3.00E-04	3.93E-03	1.18E-06
Am-241	3.18E-03	3.43E+00	1.09E-02

Figure D-3. Building Fire Scenario (Section 3.5.3)

RADIDOSE Version 3.0 (5-18-2005)			
Input Parameter	**User Input**	**Default**	**Description (based on user input)**
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	3		Non-combustible Contaminated Solids
Accident Type (1-6):	2		External Impact
Quantity at Risk (MAR):	6.52E+02		gram
Damage Ratio:		1	
Airborne Release Fraction:		1.00E-03	ARF from SARAH Table 3-4 (ARF page)
Respirable Fraction:		0.1	RF from SARAH Table 3-4 (ARF page)
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	8260		meters
Distance or X/Q for Offsite Public:	16630		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours
Description of Accident Scenario:		Edit using function key F2. Carriage returns are not allowed.	
224-B Contaminated Equipment Removal Drop - Inventory at risk is contents of D-3 Tank; DR = 1.0			

Dose Results for the Postulated Accident:

User-defined mixture ("InSource" page)				
Non-combustible Contaminated Solids				
Point Source At Ground Level				**200 Area**
Total Respirable Release:	6.52E-02 gram			
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release Duration 0.5 h
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	
Distance:	100 m	8,260 m	16,630 m	
X/Q:	3.28E-02	3.20E-05	1.32E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.90E+06	1.55E+07	1.55E+07	rem/gram
Total Dose:	**7.09E+00**	**1.06E-02**	**4.37E-03**	**rem**
Consequence:	Low	na	Low	

Material source amounts ar listed on the "UnitDF" page.

Nuclide	Grams per gram	Specific Activity, Ci/g	Curies per gram
Pu-238	1.30E-04	1.71E+01	2.23E-03
Pu-239	9.35E-01	6.21E-02	5.80E-02
Pu-240	6.09E-02	2.28E-01	1.39E-02
Pu-241	2.30E-04	1.03E+02	2.37E-02
Pu-242	3.00E-04	3.93E-03	1.18E-06
Am-241	3.18E-03	3.43E+00	1.09E-02

Figure D-4. Contaminated Equipment Removal Scenario (Section 3.5.4)

RADIDOSE Version 3.0 (5-18-2005)			
Input Parameter	**User Input**	**Default**	**Description (based on user input)**
Facility/Material (1-14):	13		User-defined mixture ("InSource" page)
Form of Material (1-10):	1		Packaged Waste (bags, drums, boxes)
Accident Type (1-6):	1		Fire
Quantity at Risk (MAR):	1.07E+02		gram
Damage Ratio:		1	
Airborne Release Fraction:		5.00E-04	ARF from SARAH Table 3-4 (ARF page)
Respirable Fraction:		1	RF from SARAH Table 3-4 (ARF page)
Leak Path Factor:		1	LPF (applies to particulate only)
HEPA Filter Factor:	1		DF = 1 (applies to particulate only)
Collocated Worker Dose Factor:		3	ICRP 68, 5 µm AMAD
Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
Material Solubility Class:	2		compounds are generally soluble
Hanford Processing Area (1-4):		2	200 Area
Distance or X/Q for Collocated Worker:		100	meters
Distance or X/Q for Onsite Public:	8260		meters
Distance or X/Q for Offsite Public:	16630		meters
Emission Source Type (1-4):	1		Point source at ground level
Release Duration (0 to 8760 h):		0.5	hours

Description of Accident Scenario: Edit using function key F2. Carriage returns are not allowed.

224-B Waste Staging Area Fire - MAR assumed is approximately 107 g, which includes 100 g of Pu-239 and corresponding quantities of other plutonium isotopes and americium based on the isotopic distribution provided in Table 3-1; DR = 1.

Dose Results for the Postulated Accident:

User-defined mixture ("InSource" page)				
Packaged Waste (bags, drums, boxes)				
Point Source At Ground Level				200 Area
Total Respirable Release:	5.35E-02	gram		
Dose Factors:	ICRP 68, 5µm	ICRP 72 for Adult		Release
Receptor:	**Collocated Worker**	**Onsite Public**	**Offsite Public**	Duration 0.5 h
Distance:	100 m	8,260 m	16,630 m	
X/Q:	3.28E-02	3.20E-05	1.32E-05	s/m3
Breathing Rate:	3.35E-04	3.29E-04	3.29E-04	m3/s
Unit DCF:	9.90E+06	1.55E+07	1.55E+07	rem/gram
Total Dose:	**5.82E+00**	**8.70E-03**	**3.59E-03**	**rem**
Consequence:	Low	na	Low	

Material source amounts ar listed on the "UnitDF" page.

Nuclide	Grams per gram	Specific Activity, Ci/g	Curies per gram
Pu-238	1.30E-04	1.71E+01	2.23E-03
Pu-239	9.35E-01	6.21E-02	5.80E-02
Pu-240	6.09E-02	2.28E-01	1.39E-02
Pu-241	2.30E-04	1.03E+02	2.37E-02
Pu-242	3.00E-04	3.93E-03	1.18E-06
Am-241	3.18E-03	3.43E+00	1.09E-02

Figure D-5. Contaminated Equipment/Waste Handling Fire (Section 3.5.5)