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Revision 4

Fire Hazards Analysis for the Plutonium-Uranium Extraction Facility

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

P.O. Box 1600
Richland, Washington 99352

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CP-41822, Rev. 4

Fire Hazards Analysis for the Plutonium-Uranium Extraction Facility

Prepared by:

CH2M HILL Plateau Remediation Company
Richland, Washington

August 2017

Executive Summary

This Plutonium Uranium Extraction Facility (PUREX) Fire Hazards Analysis (FHA) covers surveillance and maintenance.

Revision 3 of this document focuses upon Tunnel 1 stabilization. Remaining sections of this FHA remain unchanged from Rev. 2.

Key Assumptions for PUREX are limited to Tunnel 1 stabilization activities being introduced with this revision. The Maximum Possible Fire Loss (MPFL) and the Maximum Credible Fire Loss (MCFL) have not been affected by the updates made in this revision

Revision 4 modifies the Tunnel 1 stabilization requirements.

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Terms

AC	Administrative Control
ALARA	as low as reasonably achievable
AMU	Aqueous Makeup
ASTM	American Society for Testing and Materials
BED	Building Emergency Director
BOS	Balance of Site
CFAST	Consolidated Model of Fire Growth and Smoke Transport
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
COR	Code of Record
CP	Central Plateau
CRD	Contractor Requirements Document
CW	collocated worker
D&D	decommissioning and demolition
DCF	dose conversion factor
DOE	U.S. Department of Energy
DR	damage ratio
DSA	Documented Safety Analysis
EAP	Emergency action plans
ECMP	east crane maintenance platform
Ecology	Washington State Department of Ecology
ERDF	Environmental Restoration Disposal Facility
FHA	Fire Hazards Analysis
FPE	fire protection engineer
FW	facility worker
HC	hazard category
HFD	Hanford Fire Department
HMS	Hanford Meteorological Station
HSEAS	Hanford Site Emergency Alerting System
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ICR	Interpretation/Clarification Request
ICRP	International Commission on Radiological Protection
ISMS	Integrated Environment, Safety, and Health Management System

LLW	low-level waste
MAR	material at risk
MCC	motor control center
MCFL	maximum credible fire loss
MLLW	mixed low-level waste
MOI	maximally-exposed offsite individual
MPFL	maximum possible fire loss
NDA	nondestructive assay
NFPA	National Fire Protection Association
NPH	natural phenomena hazard
P&O	Piping and Operating
PBS	polymeric barrier system
PCB	polychlorinated biphenyl
PMF	probable maximum flood
PMMA	polymethyl methacrylate
PPE	personal protective equipment
PR	product removal
PUREX	Plutonium-Uranium Extraction
QA	Quality Assurance
RFAR	Radio Fire Alarm Reporter
RL	Richland Operations Office
S&M	surveillance and maintenance
SAC	Specific Administrative Controls
SMP	Safety Management Programs
SNM	Special Nuclear Material
SCC	Structures, Systems, and Components
SWDB	steel waste disposal box
SWP	special work permit
TBP	tributyl phosphate
TED	total effective dose
TRU	Transuranic (waste)
TSR	Technical Safety Requirements
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.
UNH	uranyl nitrate hexahydrate
USQ	Unreviewed Safety Question
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

1.0 Introduction

1.1 Purpose

This Fire Hazards Analysis (FHA) addresses fire hazards and fire-related concerns in accordance with U.S. Department of Energy (DOE) Contractor Requirements Document (CRD) Order (O) 420.1C, *Facility Safety*, Attachment 2, Chapter II; Title 10, *Code of Federal Regulations* (CFR) Part 851, "Worker Safety and Health Program"; CRD O 420.1C (Supplemented, Rev. 0), *Facility Safety*; and the mandatory requirements of DOE-STD-1066-2012, *Fire Protection*, as defined by CRD O 420.1C, (Supplemented, Rev. 0).

This analysis is intended to comprehensively assess the risk from fire and ensure that there are no undue fire hazards to site personnel or to the public, that the potential for the occurrence of a fire is minimized, that process control and safety systems are not damaged by fire or related perils, and that property damage from fire and related perils does not exceed an acceptable level. The objectives of this FHA, based upon CRD O 420.1C, are:

- Minimize the likelihood of occurrence of a fire-related event.
- Minimize the consequence of a fire-related event affecting the public, workers, environment, property, and missions.
- Provide a level of safety protection consistent with the "highly protected risk" class of industrial risks, as defined in DOE-STD-1066-2012. The analyses presented in this FHA investigate various fire scenarios, and strategies are introduced to control the consequences of those accidents to limit losses.

1.2 Scope

This FHA addresses all buildings and structures located inside the Plutonium-Uranium Extraction (PUREX) exclusion zone. The scope includes the evaluation of building construction features, fire hazards, and the need for maintaining any fire protection systems throughout the plant's surveillance and maintenance (S&M) process lifecycle. The results are presented in terms of the fire hazards present, the potential extent of fire damage, and the impacts to employee and public safety.

To the extent possible, the FHA and the *Plutonium-Uranium Extraction Facility Documented Safety Analysis*, CP-14977, Rev. 10, have been interfaced to optimize resources and maintain reasonable consistency between the two documents and reflects the condition during the ongoing S&M mission, as well as anticipated decommissioning and demolition (D&D) and D&D preparation activities.

1.3 Approach

This FHA is based on and draws extensively from FHAs and other safety analysis documents previously developed for the facility. The previous FHAs and relevant safety analyses were reviewed to determine if fire scenarios remain applicable to current operations. Information

found in the previous FHAs and related documents was used to develop the required descriptions and analyses.

Hanford Site and building surveys were also conducted to ensure that assumptions and conclusions carried forward are still applicable, and any new deficiencies and concerns were noted and incorporated into this FHA. The surveys included site and building walkdowns; discussions with Fire Protection, Fire Department, and Nuclear Safety personnel; and review of drawings and site plans. Utilizing the surveys as well as information from previously-developed facility documents, the level of compliance with DOE fire protection and life safety requirements was determined. The 202-A Building canyon areas have not been accessed since the previous edition of this document, and conditions were assumed not to have changed.

Analyses were performed to establish candidate fire scenarios. The damage potential associated with these scenarios was evaluated, and the maximum possible fire loss values were determined. Where appropriate, quantitative analyses were performed to estimate the potential impact of plausible fire scenarios. The analyses involved review of the applicable requirements and modeling and analysis in order to quantify the potential impact of plausible fire scenarios on facility operations and fire safety.

Except for the 202-A Canyon Building, the fire areas were defined by the exterior walls of the buildings. This approach was taken to simplify the FHA and to yield more conservative results. The spatial separation between combustible materials inside of the 202-A Building was evaluated in lieu of taking full credit for the performance of interior firewalls. This conservative approach was used because new penetrations were made to achieve the desired confinement function of the building exhaust system.

A graded approach was used to evaluate the impact of a fire incident within each fire area. Fire modeling was performed to evaluate the worst-case fire scenario in the 202-A Building, the laboratory annex, and in the railroad storage tunnel areas. A qualitative analysis was performed for the balance of the fire areas. Where other analyses have thoroughly addressed the impact of fire and explosion, the conclusions of those analyses were summarized in this report instead of reanalyzing the hazards.

1.4 Facility Overview

The PUREX Facility was designed and operated to recover nuclear materials from irradiated fuel elements. Plutonium and uranium were recovered as acidic solutions plutonium nitrate and uranyl nitrate hexahydrate (UNH).

The construction of PUREX began in 1952, and the facility began operation in 1956. PUREX operations were halted in September 1972, and the facility was maintained in standby mode until 1978. Between 1978 and 1983, the plant went through a series of operational upgrades and start-up tests, and it began operating again in 1983. PUREX remained in full operation until 1988. The facility was shifted to standby mode again in 1990 and operations were fully shut down in 1992.

In December 1992, planning was initiated to transition PUREX from standby status to shutdown status. Efforts were concentrated on removing, reducing, and stabilizing the remaining radioactive and chemical materials. As part of the PUREX deactivation, the electricity, water,

fire protection, and steam utilities were disconnected and isolated. The only remaining utilities in the PUREX compound are a skid-mounted substation that supplies power for surveillance monitoring and control, surveillance lighting, exhaust fan motors, and the water supply for the remaining three fire hydrants. As part of the deactivation plan for the fire protection system, a request was submitted and approved by DOE-Richland Operations Office (RL) to have the property at the PUREX facility devalued. The buildings and contents were assigned a property value of zero in July 1996.

In the deactivated state, the PUREX Canyon Facility is in a low-maintenance, environmentally-stable condition, awaiting final D&D.

Tunnel No. 1 has experienced a partial collapse and is considered to be unstable. Tunnel No. 2 is under evaluation and might also be considered as unstable. This FHA revision adds controls for the stabilization of Tunnel No. 1. See Section 12.1.6 and 12.1.7 for further information.

1.5 Limitations

The conclusions and recommendations of this FHA are bounded by critical assumptions and other assumptions in the subsections below. Any activities that fall outside such constraints must be evaluated by a fire protection engineer (FPE).

2.0 Critical FHA Assumptions and Controls

2.1 Critical Assumptions

Critical assumptions in this FHA involve the control of combustible materials and conduct of operations.

2.1.1 Combustible Control Critical Assumptions

The basic tenet of the fire protection program is to introduce only those materials including combustible materials needed to accomplish the task. Materials should be removed as soon as is practical. When noncombustible materials are available to perform a task, those non-combustible materials should be the first choice, with combustible materials used only when the non-combustible materials are not available.

Basis: *The ALARA concept for introduction of combustible materials into the building is critical to maintaining the fire risk associated with these materials at a minimum.*

1. Work packages that introduce combustible materials, flammable or combustible liquids or ignition sources and hazards inside the PUREX Facility shall be reviewed by an FPE.

   Basis*: Controlling and limiting combustibles include planner's efforts to list expected combustibles, FPE review of all work packages, worker training to alert them of the need to minimize combustibles, a dedicated individual performing daily monitoring of combustibles, a formal surveillance to assure compliance and management's awareness and commitment to maintain a fire-safe workplace.*

2. Chemicals are managed in accordance with the Chemical Management Plan, which implements a process for obtaining inventory, tracking inventory, storage, and disposal.

   Basis: *Facility procedures require tracking chemicals brought into the facility. Identification of these chemicals is important as many chemicals require that controls be implemented to minimize fire hazards.*

2.1.2 Operational Critical Assumptions

1. Waste containers used for shipping radiological waste from the facility meet the requirements of the Site Transportation program.

   Basis: *Compliant containers assure that fire impacts to drums and crates will respond as analyzed within this FHA.*

2. Remaining inventory is limited to reacted forms of Pu with no expectation that remaining Pu holdup is pyrophoric.

   Basis: *Remaining Pu has been exposed to atmosphere for several years. Oxidation is expected to have been ongoing. This treatment is consistent with Nuclear Safety accident analysis assumptions.*

3. The Pre-Incident Plans are reviewed periodically, and the Hanford Fire Department (HFD) is notified of facility changes that may impact the plans.

   Basis: *HFD review is needed to assure the response personnel are aware of facility conditions.*

2.2 FHA Controls

2.2.1 Combustible Material Controls

Combustible materials and ignition sources were substantially reduced during the deactivation process at the PUREX Facility. The combustible loading that remains in the facility including the canyon, galleries laboratory annex, non-laboratory annex and the 202-A building is discussed in detail in Section 8.1.

The KBO&PR Project has adopted a set of standard recommendations that apply to all KBO&PR Facilities. The intent of the standard recommendation applicable to combustible materials is to provide a means to restrict and control the addition of new combustible materials while allowing current S&M activities to be conducted. The recommendation as stated in Section 24.2.2 is as follows.

Combustible Control

- Combustible material accumulations must be controlled to maintain the FHA assumptions. Allowed S&M activities shall be conducted such that generated combustible material and ignition sources associated with the activity are minimized and removed at the end of the defined work evolution.

2.2.2 Tunnel Stabilization Project Specific Combustible Controls

- A non-combustible, vegetation free, clear space shall be provided for equipment use during grouting and other activities.

Table 2-1. Combustible Loading Controls

Location/Area	Combustible Item	Control Limitation	Control Limit	Compliance Action(s)	FHA Section
202-A/PUREX Complex	Miscellaneous Combustible Materials	Quantity	Those needed to perform task/Protect FHA Key Assumptions	FPE review of Work Packages	2.1.1/8.0/ 24.2.2
202-A/PUREX Complex	Chemicals	ALARA	Those needed to perform task	Chemical Management Plan/FPE review of work package	2.1.1/2.1.2
202-A/PUREX Complex	Flammable Gas	Quantity	Per NFPA 1. Not to exceed MAQ.	Hanford Fire Marshal Permit	8.3.2
PUREX Complex Exterior	Natural Vegetation	Distance	30 feet from structures	Surveillance	11.5
PUREX Complex Waste Staging Area	Waste box	One box	Distance – 10 feet	Operation/Surveillance	12.7/24.2.2
PUREX Complex Waste Staging Area	Fueled Vehicles and fuel powered waste handling equipment	Fuel Supply	Attendance	Manned while in area/Removed at end of work evolution	24.2.2
202-A/PUREX Complex/Labs	Polyurethane Foam	Quantity	No further use	FPE Work Package Review	24.2.2

2.2.3 Operational Controls

Operational controls required by this FHA pertain to life safety and waste staging. These requirements are stated as recommendations in Section 24.2.1 and are implemented through 2CP-SUR-A 04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility*.

3.0 DOE Orders and Industry Codes and Standards

3.1 DOE Directives

This FHA addresses the requirements of DOE CRD O 420.1C, *Facility Safety* and Title 10, CFR 851, *Worker Safety and Health Program*. The FHA also addresses the mandatory requirements of DOE-STD-1066-2012, *Fire Protection*, as defined by CRD O 420.1C, Supplemented, Rev. 0, *Facility Safety*.

3.2 Mandatory Codes and Standards Applicable to Facility

The building code utilized for design during facility construction is referred to as the code of record (COR). The specialty codes and standards used for installation of various required fire protection systems in a facility are invoked by reference in the building COR and are also considered to be part of the COR. In many cases, more recent editions of the specialty codes and standards than those referenced in the building COR may have been utilized and are listed. This practice is acceptable and conservative, but the edition referenced in the building COR is the oldest edition permitted for use.

The facilities were constructed in the 1950s, and it is assumed that the Uniform Building Code (UBC) in some form was the COR for these buildings. The primary benefit of establishing the COR for a building is that fixed building components and systems (e.g., exit locations, stairs, hallways, fire suppression and detection systems) that were constructed or installed in compliance with the requirements of the applicable COR are not required to comply with subsequent updates of the codes unless specifically invoked by the newer version, such as by a retroactivity clause. The COR for a facility (or a portion thereof) are often revised when significant modifications occur. New construction/modification is regulated under the current revision (i.e., the 2015 Edition) of the International Building Code (IBC) per CRD O 420.1C (Supplemented, Rev. 0), Section B.1.a.

The COR concept shall not be applied to issues regulated by the fire or life safety codes or to inspection, testing, and maintenance activities for required fire protection systems. Instead, issues regulated by the fire code are regulated by the currently-adopted version of the fire code at Hanford and inspection, testing, and maintenance are performed in accordance with the currently-adopted code as defined by the authority having jurisdiction. Maintenance of required systems is performed in accordance with PRC-PRO-40425, *Fire Protection System Inspection, Testing and Maintenance*, PRC-PRO-FP-40404, *Fire Protection Program*. , Alternate Approaches: Variances, Exemptions and Equivalencies

DOE-Richland Operations Office approves equivalencies when the strict wording of the code cannot be met. The process for preparation and submittal of equivalencies, exemptions, and interpretation/clarification requests (ICRs) is outlined in PRC-PRO-FP-40424, *Equivalencies, Exemptions and Interpretation/Clarification Requests (ICRs)*. There are no exceptions or equivalencies applicable to the PUREX complex.

3.2.1 Emergency Response Time

The estimated response times to fires and emergency medical contacts cannot always meet the emergency response time and deployment objectives in NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, on the Hanford Site with the current number of fire stations and response personnel. Also, no single fire station on the Hanford Site can achieve a full first alarm assignment at a fire suppression incident or medical incident within the NFPA 1710 designated response time objectives. When accounting for Site facility design features; the reliability and prevalence of fire detection, alarm, and suppression systems; the effectiveness of existing fire prevention programs; the Site's low fire loss history; and the trained workforce, DOE has granted the equivalency for all areas of the Site.

4.0 Mission and Associated Hazards

4.1 Mission Description

The Hanford Site, located along the Columbia River in southeastern Washington State, is engaged in one of the world's largest and most complex environmental cleanup projects. The 586 mi^2 Hanford Site is federally owned and under DOE administrative control (see Figure 4-1).

The Site's near-term cleanup strategy has been defined with the implementation of the 2015 Vision. The Hanford Site Cleanup 2015 Vision is built on the underlying principles of protecting the Columbia River, cleaning up the River Corridor, and keeping groundwater contamination on the Central Plateau from moving toward the Columbia River.

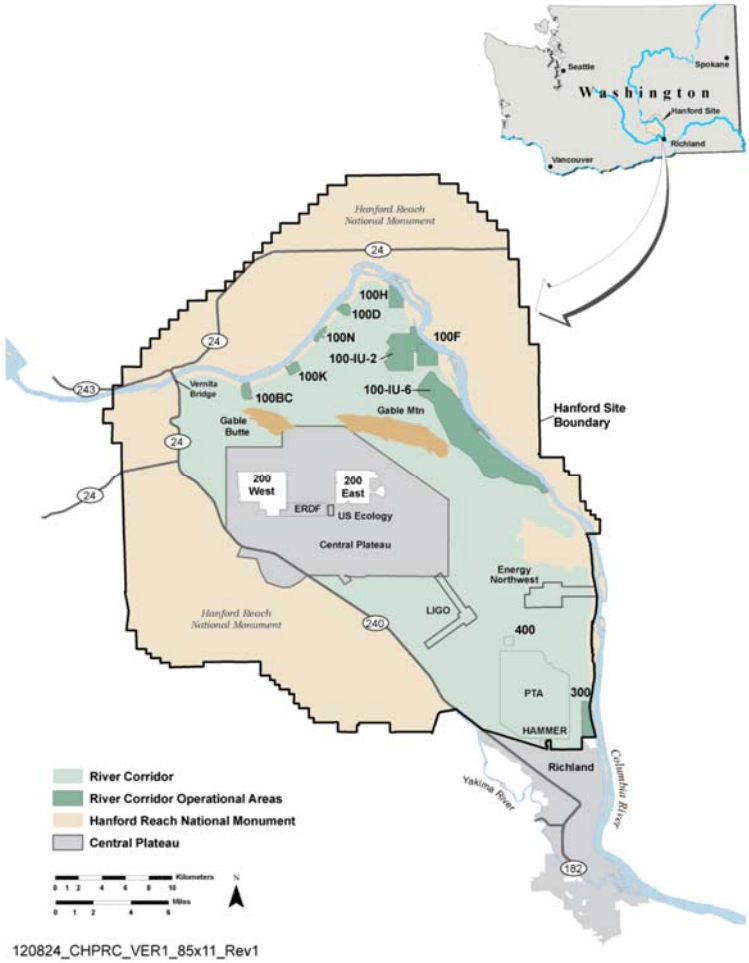


Figure 4-1. Hanford Site Map

4.2 Inherent Hazards

There are currently no operating processes within PUREX, as the facility is in shutdown mode. Inherent hazards include those in any shutdown facility including infestation of pests, the growth of mold, and dilapidated conditions. The presence of combustibles is strictly controlled, so the hazards associated with S&M or D&D activities are specific to the materials necessary for each job. Areas with high levels of radiation and contamination add additional risk to workers when present in the facility.

5.0 Occupancy Classification and Building Code Construction Requirements

5.1 Facility Overview

Over its life cycle, the PUREX Facility was designed and operated to recover plutonium, uranium, and neptunium from irradiated fuel elements received from the 100N Reactor and the single-pass reactors on the DOE Hanford Site. Plutonium was recovered as an acidic solution of plutonium nitrate or was converted to plutonium oxide in N cell. Various products were then transferred to the Plutonium Finishing Plant. Uranium was recovered as UNH, which was transferred for further processing to the Uranium Trioxide Plant. Neptunium was recovered and transferred to other Hanford Site facilities. The location of the PUREX Facility on the Hanford Site is illustrated in Figure 5-1.

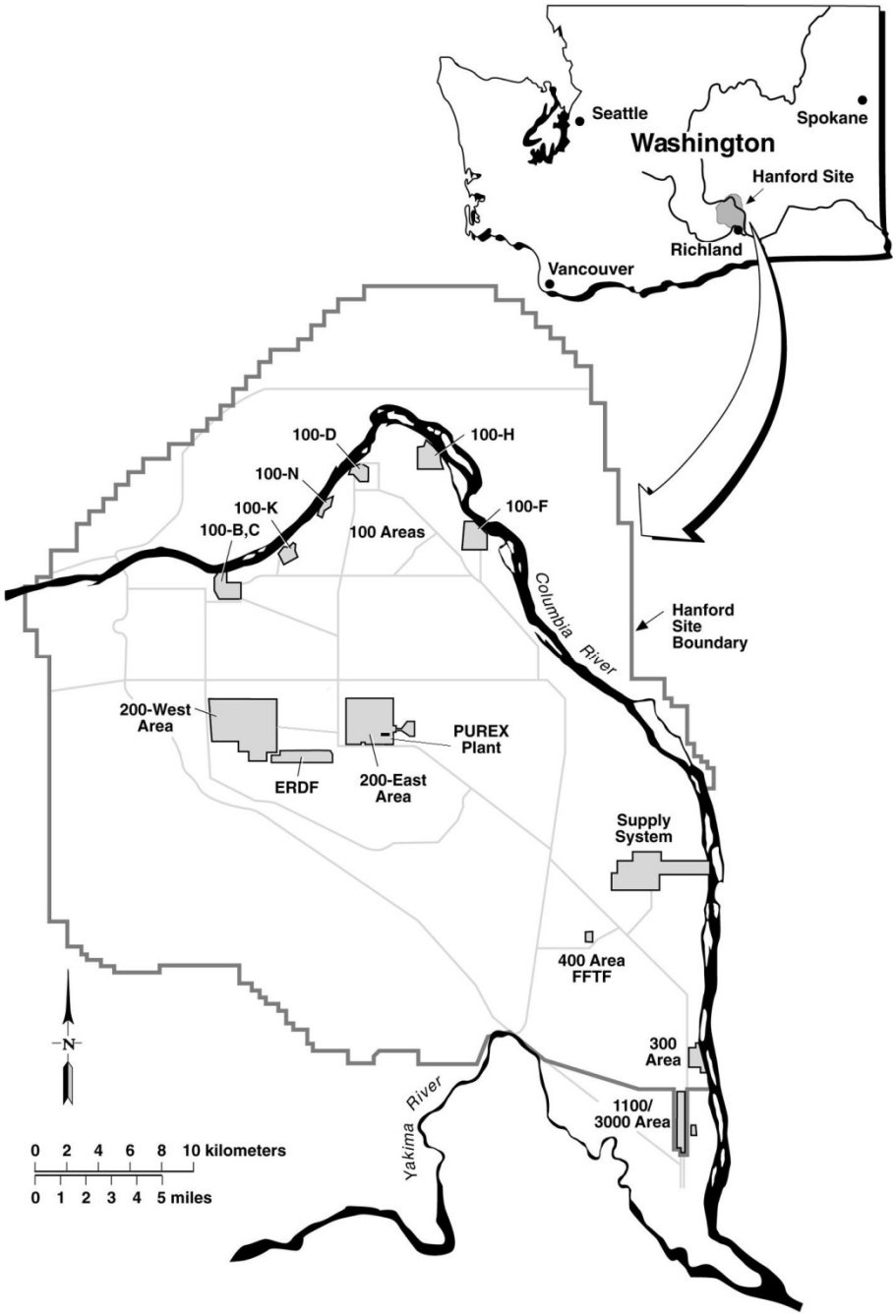
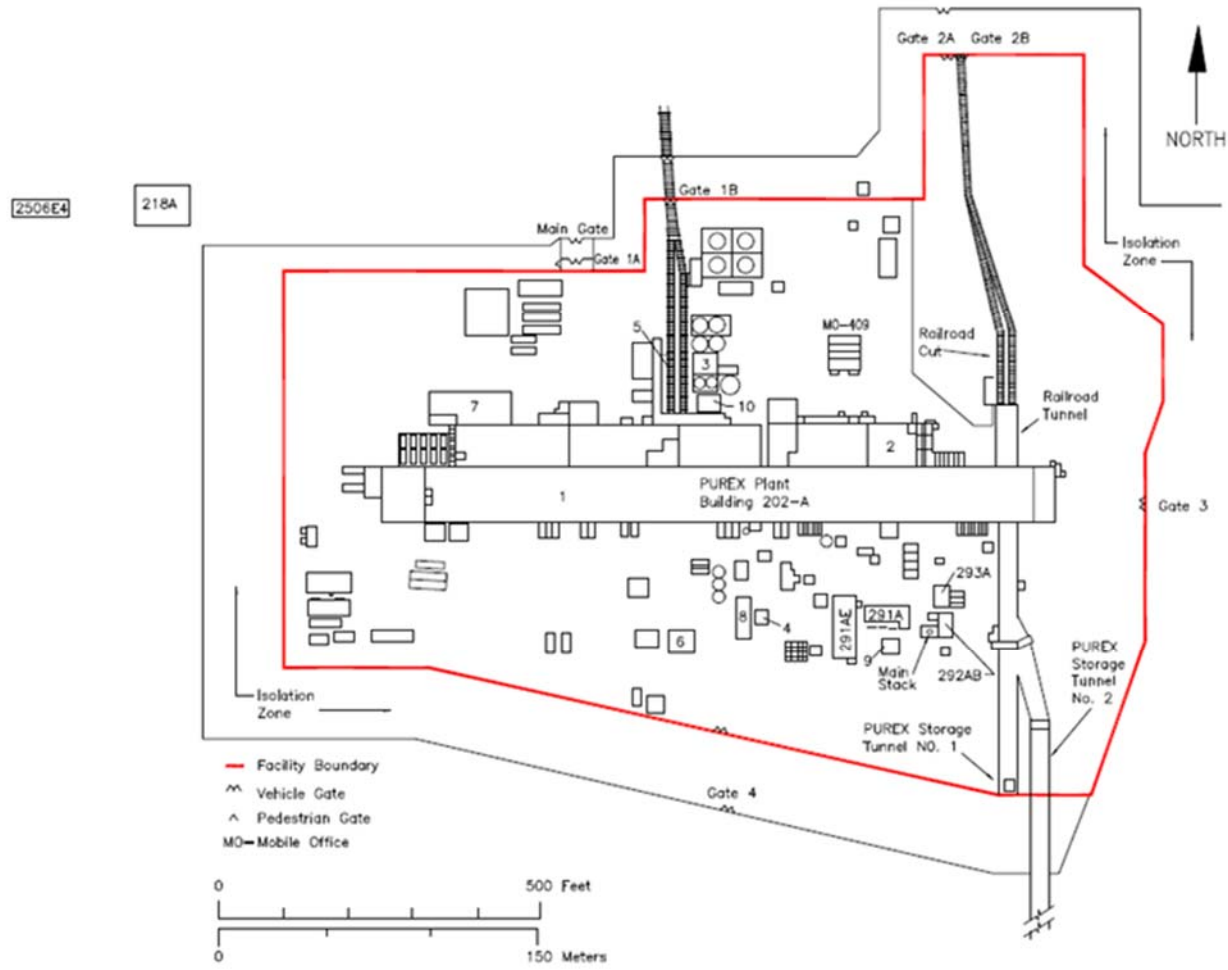


Figure 5-1. The PUREX Facility Location on the Hanford Site

Construction of the PUREX Facility began in 1952, and the facility began operating in 1956. The operation was shut down in September 1972. The facility was maintained in wet standby until 1978. During this period, major plant components, such as extraction columns and associated tanks, were periodically flushed with nitric acid solution. Pumps, column pulsers, jets, and other mechanical components were operated on a regular basis. Failed equipment was either upgraded or replaced. From 1978 to 1983, the plant progressed from wet standby through

cold start-up tests and resumed recovery operations in November 1983. The PUREX Facility was operational until 1988 when it was again shut down. The facility began transitioning into cold standby in October 1990, and was placed in cold standby in September 1992. In December 1992, planning was initiated to change the status of the PUREX Facility from cold standby to deactivation (or transition to shutdown). Deactivation was completed in 1998, and the facility has been in S&M mode since that time. The PUREX Facility, which consists of the Main Canyon Building (202-A), adjacent buildings, facilities, and PUREX Storage Tunnels 1 and 2, is illustrated in Figure 5-2. Figure 5-3 is an elevation view of the PUREX 202-A Building. Figure 5-4 illustrates plan views of the 202-A Building.



Legend

1. 202-A PUREX Facility Building
2. 204-A U cell
3. 211-A Building
4. 213-A reg. maintenance workshop
5. 214-A, B, C, D
6. 221-A pipefitter shop
7. 271-AB PUREX office/maintenance facility
8. 252-AB electrical substation
9. 217-A SAMCON unit
10. 252-AC surveillance lighting electrical substation

Note

Not all facilities are called out in this figure.

Figure 5-2. The PUREX Fire Hazards Analysis Site Plan

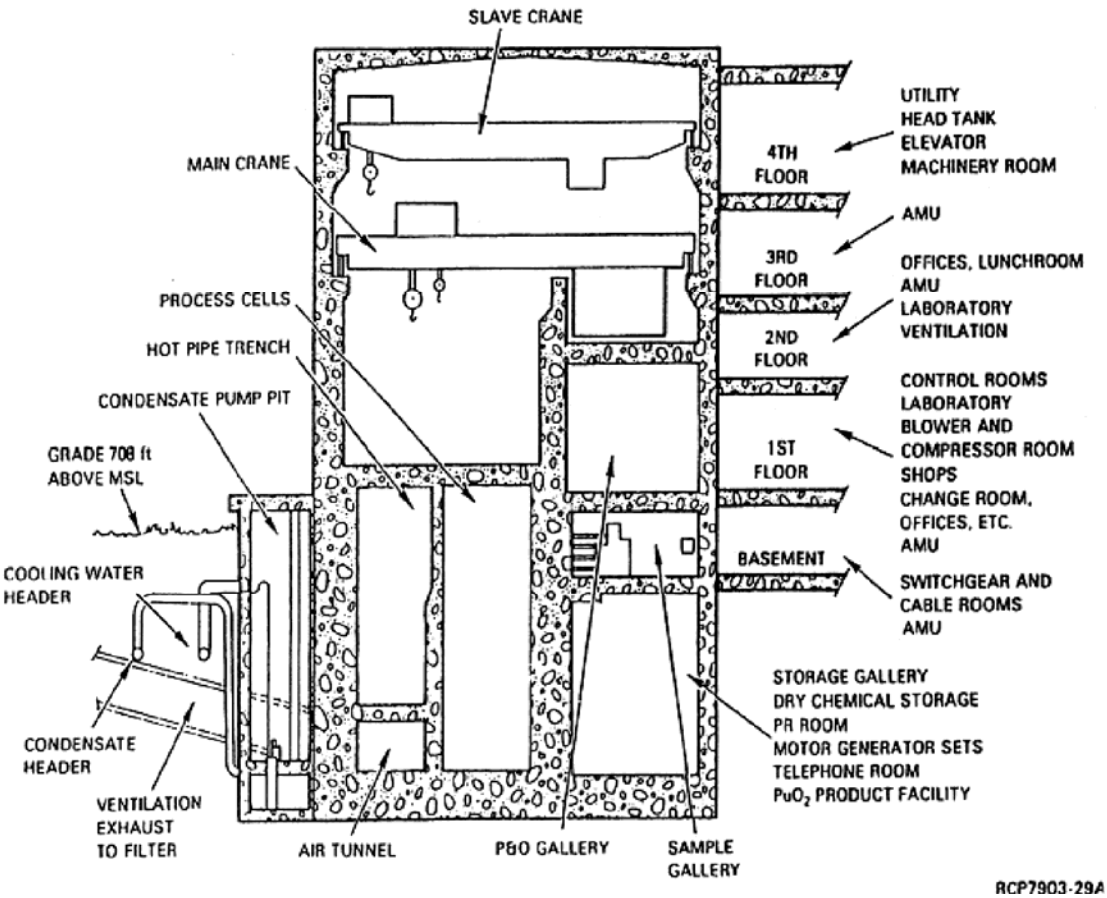


Figure 5-3. PUREX Facility Cross-Sectional Diagram

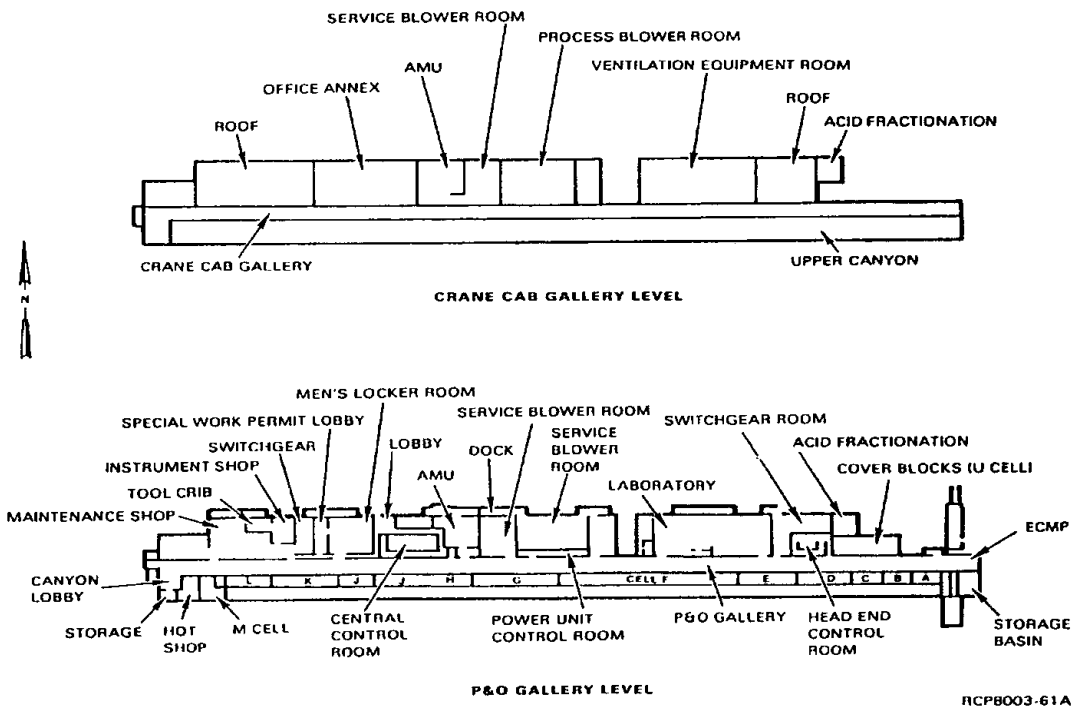


Figure 5-4. Plan Views – The PUREX 202-A Building

Since the facility was placed into S&M mode, a new roof was placed over the 202-A Canyon and aqueous makeup unit (AMU) areas (HNF-11698, *PUREX Roof Collapse Accident Analysis*). Conditions in the facility have been relatively stable since deactivation, with minor exceptions.

The PUREX Complex Buildings identified in Table 5-1, "Hazard Category 2 Buildings," are classified as Hazard Category 2 nuclear facilities.

Table 5-1. Hazard Category 2 Buildings

202-A	221A
204A	291AE
213A	291A
218-E-14 *	Deep Bed Filter 1 **
218-E-15 *	Deep Bed Filter 2 **

* These structures are the PUREX storage tunnels. They are inaccessible underground structures.

** The Deep Bed filter structures are underground and inaccessible. They were not included in the assessment, but are listed here as they are Hazard Category 2 Nuclear facilities inside the PUREX Complex nuclear boundary.

5.2 Building Occupancy Classification

Occupancy classifications of 202-A under the UBC, the facility's COR, would range from Business for the administrative areas to Hazardous for the radiological areas. Classifications of other areas could be Storage, Industrial, and possibly Assembly. In its current use and occupancy, the classifications would be H-4, Hazardous, in accordance with the IBC and Special

Purpose Industrial in accordance with National Fire Protection Association (NFPA). The facilities are unoccupied and are not used for storage purposes of any kind.

5.3 Building Construction Types

This section provides a brief description of the PUREX Facility's buildings and structures. Additional information on each building and how it was used during process operations can be found in the Documented Safety Analysis (DSA). Construction classification designations cited for buildings and structures are in accordance with the Uniform Building Code of 1994. Unless otherwise indicated, all structures are conservatively classified as construction Type II-N. A bracketed number or letter follows the building or structure number that corresponds to the PUREX Building list number shown in Figure 5-2, "PUREX Fire Hazards Analysis Site Plan."

5.4 Description of Construction

The structures cited in Table 5-2, "Negligible Fire Risk Buildings/Structures," present a negligible fire loss potential. Based upon the following factors, they have been screened from the analysis:

- The buildings and contents have a property record value of zero.
- The buildings are of non-combustible construction.
- Based on construction and configuration they do not pose an exposure hazard to the main facility structures or to each other.
- All combustibles have been removed or reduced as much as possible.
- Non critical electrical sources have been removed or reduced as much as possible. If electrical power is used for S&M activities, it is deactivated at the end of these activities.
- The buildings do not contain safety-class equipment.
- The buildings do not have fire protection features.
- The buildings do not contain fire protection features that are required to mitigate the consequences of design basis accidents.
- The buildings do not represent exposure hazards to structures that could generate a maximum possible fire loss (MPFL) of more than $5,000,000.

Table 5-2. Negligible Fire Risk Buildings/Structures.

203-A Storage Area	291-AG Building
203-A UNH Pump House/Control Room	291-AH Ammonia Off-Gas Sampler Building
204-A U cell	291-Al Instrument Shack
206-A Fractionator	291-AK Air Tunnel Enclosure
210-A Drum Storage	292-AA PR Stack Sample House
211-A Demineralize Building and Chemical Tank Farm	292-AB Main Stack Building
212-A Load Out	293-A Dissolver Off-Gas Building
213-A Regulated Maintenance Workshop	294-A Off-Gas Instrument Shack
214 Warehouse	295-A ASD (ammonia scrubber discharge)
221-A Maintenance Shop	295-AA SCD (steam condensate discharge)
225-EC CSL Building	295-AB PDD (process distillate discharge)
252-A Switch Gear/Transformer Station	
271-AB Annex	295-AC CSL (chemical sewer)
276-A R cell	295-AD CWL Sample Station
291-A Exhaust Plenum, Fans	295-AE PDD Diversion
291-A, No. 1, 2, and 3 Filter Area	2701-AB Badge House
2901-A Elevated Water Tank	2711-A Air Compressor Building
281-A Stand By Generators	2711-A-1 N cell air compressors
241-A-151 Shielded Valve Pit	2712-A Sample Vacuum Pumps
291-AB Sample Shack	2714-A Chemical Storage
291-AC Instrument Shack	PR Dock
291-AD Ammonia Off-Gas Building	

5.4.1 202-A Canyon Building

The 202-A Building is 306.32 m (1,005 ft) long by 36.27 m (119 ft) wide by 30.48 m (100 ft) tall, with approximately 12.19 m (40 ft) located below grade and 18.29 m (60 ft) located above grade. This was the primary processing building for PUREX operations.

The main structural components include the following:

- A thick-walled, heavily-shielded concrete canyon containing processing equipment.
- A section composed of three gallery levels parallel to and isolated from the canyon.
- A steel and transite annex to the north of the gallery section housing offices, the laboratory, and a number of building service areas.
- Reinforced-concrete railroad storage tunnels forming a “T” at the east end.

Both a vertical and horizontal cross-section of the 202-A Building are shown in Figure 5-3, "PUREX Facility Cross-Sectional Diagram," and Figure 5-4, "PUREX Facility Elevation Sectional Diagram."

The 202-A Canyon Building is of massive, reinforced–concrete, noncombustible construction with a construction classification at least equivalent to Type II (000), in accordance with NFPA 220, *Standard on Types of Building Construction*. The exterior walls, and interior partition walls that separate the major sections of the facility are reinforced concrete of varying thicknesses. The roof deck is concrete with an insulation board over the concrete with a built-up composition roof membrane. The composition roof of asphalt and gravel has been covered in its entirety with a structural standing seam metal roof system. The original composition roof remains under the new roof. The canyon area proper is a narrow structure that is 1,005 ft long, 30 ft 6 in. wide, and 104 ft high, with about 40 ft of this height below grade. The canyon is subdivided into a single row of 12 process cells paralleled on the south side by a hot (radioactive) pipe trench with an air tunnel connected to the cells running underneath the pipe trench. East of the canyon, a railroad spur enters the plant below grade through a tunnel. At the east end of the canyon is an inactive fuel storage basin. The east crane maintenance platform (ECMP) is in an extension that was added to the existing 202-A Building in 1957. The extension is 71 ft 3 in. tall, 36 ft. wide, and 61 ft. 4 in. deep. It is a reinforced-concrete and steel-beam structure. The three exterior sides are made of 5-cm (2-in.) thick asbestos cement board, which in turn is covered with 9-in. precast concrete panels above the 731 ft elevation and 4-in. precast concrete panels below the 731 ft elevation. Three interior 3 in. thick, steel-plate shielding doors separate the canyon from the ECMP. Below the 731 ft elevation, 10 in. of concrete from the original building separate these structures.

Fuel processing occurred in the main canyon cells, located at the center of the building. These cells are subdivided along the length of the building into a single row of 12 process cells (A through M). On one side of the process cells, a hot (radioactive) pipe trench was used to transfer process solutions between the operating cells. Located below the pipe trench is an air tunnel that connects to the process cells and pipe trench to route air flow to the 291-A #1, #2, and #3 filters outside of the PUREX Building. Figure 5-5, "PUREX Facility Air Flow Diagram," shows the ventilation system as it is currently configured.

The hot-pipe trench contains an array of pipe headers interconnecting the cells that permitted inter-cell transfers of radioactive solutions. Also, the pipe trench contains the piping for transfers to facilities outside the 202-A Building, which have been isolated. The air tunnel, which lies directly below the pipe trench, exhausts the ventilation air from the individual cells to the main ventilation exhaust filters and then to the main stack. The ventilation system is still in operation. A crane-way is located directly above the Piping and Operating (P&O) Gallery and runs nearly the length of the canyon for three, 40-ton capacity cranes. The P&O gallery is described in the following subsection 5.4.1.1.

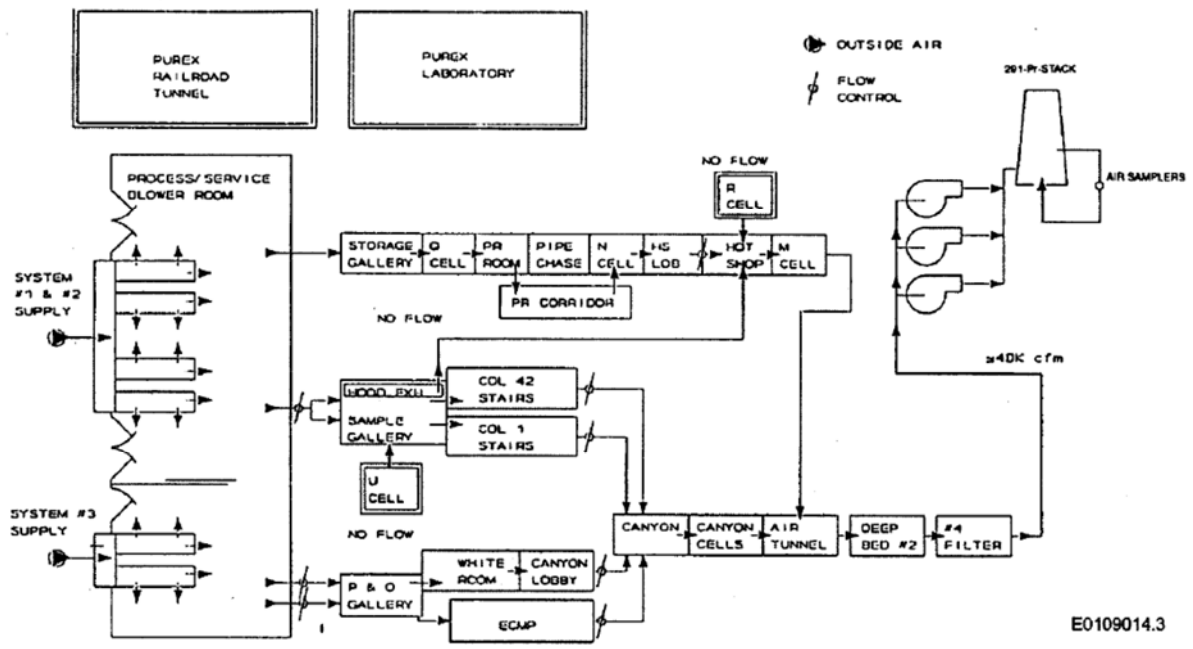


Figure 5-5. PUREX Facility Air Flow Diagram

Two annex buildings are connected to the north side of the canyon building, which supplied areas for offices, aqueous make-up tanks, ventilation control equipment, laboratory analysis, electrical feed distribution, and maintenance shops. The annex structures are separated from the canyon building by construction features having a fire-resistance rating of 2 hours.

Two railroad spurs connect the PUREX plant to the 200 East Area rail system. One of the railroad spurs provided access to the tank storage areas on the north side of PUREX. The other railroad spur enters the 202-A Building through a reinforced-concrete railroad tunnel at the northeast corner, approximately 4.6 m (15 ft) below grade (see Figure 5-2). The spur was used to deliver reactor fuels and equipment to the 202-A Building for processing. The rail tunnel extends through the PUREX Building to the south side, connecting the 202-A Building to two underground tunnels used for storing radioactively-contaminated equipment. A remotely-operated vertical door provided access to the tunnel on the north end, and access to the canyon from the tunnel was proved by a horizontal door controlled in the dispatcher's office. These doors were sealed during deactivation to support ventilation flow upgrades. Two personnel access doors to the tunnel were also sealed during deactivation.

5.4.1.1 202-A Galleries

Three stacked gallery levels paralleling the canyon on the north side of the structure contain service piping and process instrumentation, equipment for process samples, and storage space for equipment and dry chemicals. The upper P&O gallery contains deactivated instrument racks, electrical motor controls, steam and cooling water supply lines, and the piping and associated

valves for transferring nonradioactive solutions that served the in-cell equipment. It is separated from the canyon to the south by a 4-ft-thick reinforced concrete wall. A reinforced concrete ceiling approximately 2 ft thick separates it from the canyon crane-way above and an 18 in. thick concrete floor separates it from the Sample Gallery below. The P&O Gallery measures approximately 20 ft wide by 18 ft 6 in. high. The sample gallery is located below the P&O Gallery and contains the remote samplers that were used for obtaining process samples from the cell equipment. The sample gallery is 20 ft wide by 10 ft 3 in. high. Walls, ceiling and floor are all of reinforced concrete construction. Below the sample Gallery is the Storage Gallery. The west end of the storage gallery is a separate area that was used for the neptunium purification and load-out facility (in Q cell), the plutonium product removal (PR) room, and the plutonium oxide production facility (in N cell). An equipment maintenance and decontamination area (in M cell) and a low-level contaminated equipment maintenance shop, which was used for maintenance of equipment removed from the canyon, are located at this level, but were not part of the storage gallery proper. The walls, floors, and ceiling of the gallery areas vary from 1 to 2 ft thick.

Three glovebox areas were installed at the west end of the storage gallery that were used to process neptunium and plutonium. These glovebox areas were separated into three main areas, identified as Q cell, the PR room, and N cell. Each of these areas were isolated from the storage gallery and from each other with thick concrete walls and metal structures. The Q cell area contained gloveboxes, a control room, and aqueous make-up areas that were used for purification and loadout of neptunium product. The PR room contained several gloveboxes that were used to route or load out plutonium-nitrate product solutions. The N cell area contained control rooms and process gloveboxes that were used to convert plutonium-nitrate solutions to plutonium oxide powder. The gloveboxes in these areas are constructed of metal and have glass viewing windows. Some portions of the gloveboxes used plastic panels.

5.4.1.2 Laboratory Annex

The laboratory annex is an 18.3 m (60 ft) by 54.9 m (180 ft), two-story building located on the north center side of the 202-A Building. The first floor housed numerous laboratories, and the second floor housed heating, ventilation, and air conditioning (HVAC) equipment and concrete high-efficiency particulate air (HEPA) filter enclosures for hoods located in the laboratories below. The laboratory dock consists of three segments (No. 5, No. 6, and No. 7). Several small steel-on-steel frame, transite-on-steel frame, partially and fully-enclosed structures are located on the north side of the annex. The structures stored flammable gas manifolds, compressed gas cylinders, and regulated and nonregulated drums. The cylinders, drums, and associated equipment were removed during deactivation.

5.4.1.3 Service Annex

The service annex is adjacent to the galleries and consists of two separate areas. The larger main area contains the maintenance shops, offices, lunchroom, locker room, radiation zone entry lobby, ventilation air and supply room, a switchgear room, compressor room, central control room, and the AMU areas. The smaller laboratory area contains the analytical laboratory, the head-end control room, and a switchgear room.

5.4.2 203A

The 203A storage area is a 123 ft long by 103 ft wide by 6 ft high, reinforced-concrete, diked area surrounding storage tanks used for uranyl nitrate hexahydrate and other acidic solutions. The area is located to the north of the 202-A Building and the 211-A liquid chemical tank farm. The area is isolated from utilities and other structures that remained at the end of deactivation. Four 378,541 L (100,000 gal) capacity tanks are also located within individual diked sections, and three smaller capacity tanks are located within the diked area. All tanks are empty or flushed in accordance with approved endpoint criteria, with only a minimum heel remaining at the completion of the deactivation project. Adjacent to this diked area is the 203-A Building, which is a 47 ft by 16 ft by 12 ft high, reinforced-concrete structure used to house pumps and the control room for the 203A storage tanks. A rail car and truck loading/unloading station is located on the west side of this area. To the east of the 203A area is a 36 ft by 25 ft by 20 ft high metal building used to store empty metal drums.

5.4.3 204A

The 204A Building (U cell) is a 76 ft long by 20 ft wide by 35 ft high concrete structure (vault), built below grade, with removable concrete cover blocks extending above grade to form the building roof. U cell contains four large tanks, two (TK-U1 and TK-U2) of which were used for recovered nitric acid and laboratory waste collection. Currently, U cell is accessed through the 202-A sample gallery.

5.4.4 217-A SAMCON Unit

The 217-A Building is a small (approx. 10 ft by 10 ft) metal covered fiberboard building (non-combustible) that contains the surveillance and monitoring control system (SAMCON).

5.4.5 221A

The 221A Building (pipefitter shop) was used to support PUREX operations. The building is a single-story structure with approximate dimensions of 36 ft long by 25 ft wide by 20 ft high. The building is a stand-alone, slab-on-grade, one room, wood-frame structure with metal siding. A roll-up door provides equipment access on the east side of the building and a personnel door is located on the west side. No active utilities are provided in the deactivated building. The building is controlled as a radiological materials storage area and is used to support long term S&M activities of PUREX and provides space for the following:

- Interim storage and staging of miscellaneous radiological waste containers.
- Maintenance area for controlled equipment (ventilation equipment) that is associated with the PUREX Facility.
- Storage of non-contaminated equipment (filters) that is used for S&M of the PUREX Facility.
- Storage of laundered and used personal protective equipment (PPE).

An area north of the 221A Building and an area south of the deep-bed filters also serves as staging for low-level waste (LLW) awaiting disposal.

5.4.6 252-AB Electrical Substation

A new skid-mounted, 13.8/2.4-kV electrical unit substation was installed to supply the PUREX Facility exhaust ventilation and data acquisition systems. The new electrical unit substation is constructed of metal-covered fiber board and consists of an overhead 13.8-kV electrical line to the site; two 13.8/2.4-kV oil-filled, step-down transformers; two 2.4/480-kV oil-filled, step-down transformers; and switch gear that provided power to the exhaust fans, surveillance lighting, and monitoring and control systems.

5.4.7 271AB

The 271AB office/maintenance annex is a 105 ft long by 32 ft by 28 ft high, two-story building located on the north side and at the west end of the 202-A Building. The exterior walls are steel-on-steel frame with a built-up roof of steel decking on a steel frame. Interior walls are gypsum board with wood doors and carpeted floors. This annex contained operations offices and maintenance facilities.

5.4.8 276A

The 276A Building (R cell) is a 65 ft long by 23 ft wide by 35 ft high concrete structure (vault), built below grade, with removable concrete cover blocks forming the building roof. The concrete blocks extend above grade. R cell provided organic solvent decontamination and storage. Currently, R-cell is accessed through the 202-A sample gallery (R cell centrifuge platform) or through the PR corridor (R cell vault floor).

5.4.9 291-A Exhaust Plenum, Fans, and the Main Stack

The 291-A exhaust plenum and fan area consist of an underground air duct connected to the 291-AE No. 4 filter building discharge air duct, which is an above-grade segment that houses four ventilation fan units, three electric motor-driven and one steam-turbine drive (deactivated), and a segment that drops below grade and connects to the base of the 291-A-1 main stack. A 7.0 m (23 ft) long by 4.3 m (14 ft) wide by 4.3 m (14 ft) high reinforced-concrete building houses the deactivated steam-turbine drive that powered the backup exhaust ventilation fan (prior to deactivation). The walls and floor are reinforced concrete. The 2.4-kV motor-driven fans are located on the south side of the aboveground plenum segment (west of the steam-driven fan building).

The 291-A-1 main stack is reinforced concrete and rises 60.96 m (200 ft) above grade. The stack has a freestanding, 2.1 m (7 ft) inner-diameter, stainless-steel liner. The top of the stack is capped to cover the annulus between the stack and the liner.

5.4.10 291-A, No. 1, No. 2, and No. 3 Filter Areas and Exhaust Tunnels

A 2.4 m (8 ft) wide by 2.4 m (8 ft) high reinforced-concrete exhaust air duct connects the 202-A Building to three filter housings in the south yard area. The filter housings are constructed of concrete and are located below ground level. The No. 1 and No. 2 filters are constructed of concrete, metal, and fiberglass filter media. These filters operated in parallel to remove solids from PUREX process air before discharge to the atmosphere through the main stack. The overall

dimensions of the No. 1 and No. 2 filter housings are 25 m (82 ft) long by 16 m (52 ft) wide by 4 m (13 ft) deep. The No. 3 filter housing is 17 m (56 ft) long by 13 m (44 ft) wide by 4 m (13 ft) deep; however, the No. 3 filter housing was never put into service (isolated) and is void of filter media. During deactivation, the No. 1 filter was blanked and the No. 2 filter was routed (in accordance with normal flow design) into the No. 4 filter building.

The No. 1 and No. 2 deep-bed filters were designed to remove 99.9 percent of the particulate from the air stream. Each filter has two glass-fiber bed sections, a pre-filter, and a cleanup filter. In the No. 1 filter, the pre-filter is a 2.1 m (7 ft) deep bed, packed with 115-K fiberglass. In the No. 2 filter, the pre-filter bed consists of five layers, each packed with a different density of fiberglass. The airflow direction is downward through No. 1 filter and upward through the No. 2 pre-filters. The cleanup filter beds consist of 2.5 cm (1 in.) thick, deep-bed filter units with an upward airflow.

Fire screens were installed in the inlet duct of the No. 3 filter and in front of all filters (with the exception of the final HEPA bank). A water seal installed in the exit air duct was designed to stop airflow when filled with water. The seal was designed to be automatically filled by gravity discharge from an aboveground 37,855 L (10,000 gal) water storage tank (southeast of the 291-AJ instrument shack) if fire was detected by a sensing element in the filter area inlet duct or by a manually-operated switch located in the 291-AE No. 4 filter building. This system was shut down and isolated prior to the deactivation project.

The pre-filter media for the No. 1 and No. 2 filter primary beds is a glass product (115 L) that is no longer manufactured. This media is a Class 1 filter, Underwriter's Laboratory (UL) Standard 900. A Class I filter is one that, when clean, will not contribute fuel when attacked by flame and emits only negligible amounts of smoke. The secondary stage of the deep-bed filters are a Class II Filter, UL Standard 900. A Class II Filter, when clean, burns moderately when attacked by flame, or emits moderate amounts of smoke, or both.

5.4.11 291-AE No. 4 Filter Building

The 291-AE Building is a 37.5 m (123 ft) by 12.5 m (41 ft) by 5.2 m (17 ft) high reinforced-concrete building. The walls and floor are reinforced concrete. The roof is also reinforced concrete and has 10 removable concrete hatches, one over each filter unit. The building houses 10 modular filter units, each with upstream and downstream isolation valves. A typical modular filter unit consists of a stainless-steel housing and a 4-by-3 array of HEPA filters. The original design criteria for the HEPA filter system specified that coarse fire screens were to be installed upstream and downstream of the HEPA filters.

The fire screens were deemed unnecessary and were not installed because the airflow passes first through the Class I Filter then through the Class II Filter.

Two reinforced-concrete air ducts located below the building are parallel to each other and run north/south. The west duct is an inlet air duct that connects to the underground air duct from the No. 2 filters. The east duct is the discharge air duct from the HEPA filter units, connecting to the aboveground reinforced-concrete exhaust air plenum. A 7.3 m (24 ft) by 3.7 m (12 ft) by 2.7 m (9 ft) high metal structure is attached to the south side of the building, housing mechanical and electrical equipment and serving the entrance vestibule for the No. 4 filter building.

5.4.12 2701-AB Badge House

The 2701-AB Building is a 16.2 m (53 ft) by 8.2 m (27 ft) by 4.9 m (16 ft) high non-combustible structure. The building has a basement area that was used as the Hanford Site security command center. The walls are concrete block, and the floors are concrete and steel (around the security area). The building roof is reinforced concrete, with a built-up tar and gravel covering. All equipment has been removed from the building. The building is currently being used for staging supplies used during S&M activities.

5.4.13 252-AC Surveillance Lighting Electrical Substation

The 252-AC Building is a small, skid-mounted, metal-covered fiberboard building (non-combustible) that contains the transformer and switchgear for the surveillance lighting system.

5.4.14 PUREX Tunnel #1

General Electric designed and constructed Storage Tunnel 1 in 1956 as part of PUREX Facility construction. The storage tunnel is deactivated, with no access provided. All utilities and ventilation systems are isolated or removed. Water was removed from the water-fillable shielding door, the door was sealed, and the tunnel ventilation was deactivated (e.g., capped and de-energized). The layout of the PUREX Storage Tunnels is shown in Figure 5 2.

Storage Tunnel 1 consists of the following three areas: the water-fillable door, the storage area, and the ventilation shaft. The main portion of the storage tunnel is 109.1 m (358 ft) long and is composed of two sections. The inside dimensions of the storage tunnel, for both sections, are 6.7 m (22 ft) in height and 5.8 m (19 ft) wide. The east side of the first 31.4 m (103 ft) length of the storage tunnel closest to the PUREX Facility (northern part of storage tunnel) is composed of a 0.91-m (3-ft) thick reinforced-concrete wall, which allowed for the later construction of Storage Tunnel 2 without disturbing Storage Tunnel 1. The remaining 77 m (253 ft) portion of the east wall, the west wall, and the roof are all composed of 12 in x 14 in timbers. The same types of timbers are used in both sections.

All exterior surfaces of the timber structure are covered with mineral surfaced, asphalt-coated roofing felt (referred to as “90-pound roofing” in the specifications of the time). The entire structure is covered with earth fill to provide a minimum cover of 2.4 m (8 ft).

The vent shaft located at the south end of the storage tunnel provided a means of connecting a filter and fan to the storage area. The shaft has been sealed and capped to prevent the release of contamination.

The materials used in the storage tunnel and in the construction of the storage tunnel were controlled by the original drawings and specifications given in GE 1955, Specifications for Disposal Facility for Failed Equipment.

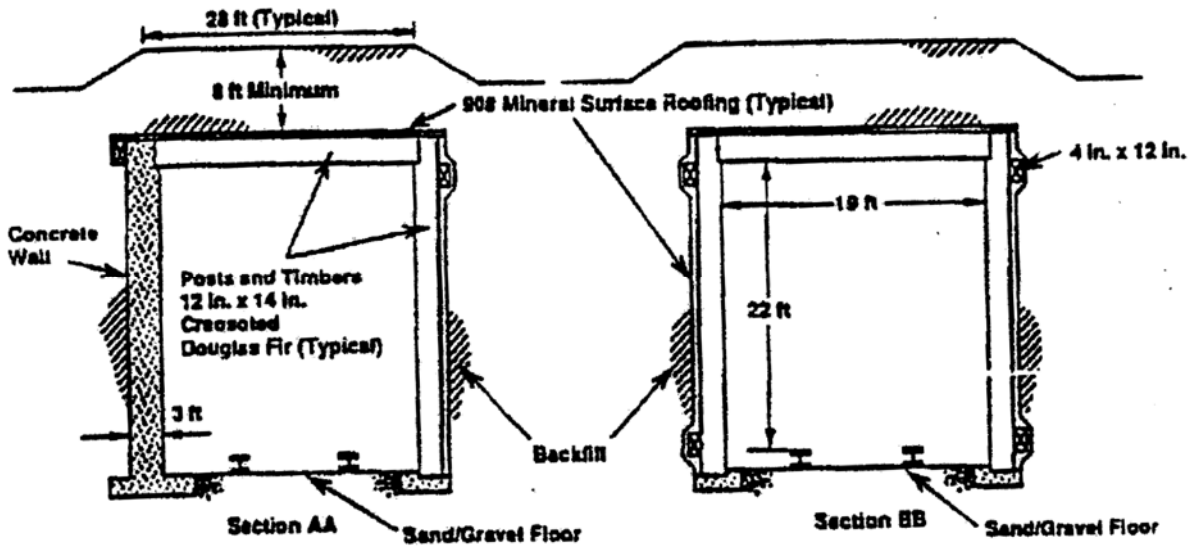


Figure 5-6. Sectional View of PUREX Storage Tunnel No. 1

The storage tunnels are used to store large pieces of deactivated high-radiation-level process equipment on railcars. The storage tunnels provided direct support to transition activities by accepting PUREX-plant waste material and failed or obsolete process equipment that was too radioactive or bulky for removal from the PUREX plant for storage. The PUREX storage tunnels could also accept waste generated from other sources on the Hanford Site on a case-by-case basis. Mixed waste has been stored in the PUREX storage tunnels on railcars since being placed into service. However, not all the material stored in the railcars contains mixed waste. A detailed description of tunnel contents is found in Appendix C of the PUREX DSA. The equipment is secured to railcars that have been modified by removing and replacing the wood beds with steel decking or wood decking encased with steel plating. A drip pan, filled with kitty litter, was attached to the railcars to catch any leaks or drips when concentrators were stored. All access into the tunnels is prohibited due to high radiation and contamination levels.

See Sections 12.1.6 and 12.1 7 regarding Tunnel Collapse and Stabilization.

5.4.15 PUREX Tunnel #2

Construction of Storage Tunnel 2 was started and completed in 1964. The storage tunnel is deactivated with no access provided. All utilities and ventilation systems are isolated or removed. Water was removed from the water-fillable shielding door, the door was sealed, and the tunnel ventilation was deactivated (e.g., capped and de-energized).

Storage Tunnel 2 consists of the following three areas: the water-fillable door, the storage area, and the ventilation shaft. The nominal inside dimensions of Storage Tunnel 2 are 514.5 m (1,688 ft) long, 10.4 m (34 ft) wide, and 7.9 m (26 ft) high. The storage area of Storage Tunnel 2 extends southward from the water-fillable door. This portion consists of a 10.4-m (34-ft) diameter steel semicircular-shaped roof of 0.5-cm (0.2-in.) thick steel plate. It is supported by internal I-beam wales that are attached to external reinforced-concrete arches. The interior and exterior surfaces of the steel roof are coated with a bituminous coating compound to inhibit corrosion. The entire storage area is covered with 2.4 m (8 ft) of earth fill to serve as radiation shielding.

The floor consists of railroad tracks laid on a gravel bed. The space between the railroad ties is filled to the top of the ties with gravel ballast. Stabilized earth was placed between the end of the ties and the walls. It is graded upward to the wall at a 67 percent slope. The tracks have a 1/10th of 1 percent slope to the south to prevent railcars from accidentally rolling out of the tunnel. The capacity of the tunnel is forty 12.8 m (42 ft) long modified railcars. At the present time, a total of 28 railcars have been placed in Tunnel No. 2. A sectional view of storage tunnel No. 2 is found in Figure 5-7, “Sectional View of PUREX Storage Tunnel No. 2.”

Commencing at the ends of the 2.4-m (8-ft) long ties, the earth floor is sloped upward on a 1 (vertical) to 1-1/2 (horizontal) grade on the east and west sides of the tunnel. The tracks are on a 0.1 percent downgrade slope to the south to ensure that the railcars remain in their storage position. A railcar bumper is located 2.4 m (8 ft) from the south end of the tracks to act as a stop. The nominal capacity of the storage area is forty 12.8-m (42-ft) long railcars; there are 28 rail cars in Storage Tunnel 2.

The ventilation shaft is located at the south end of Storage Tunnel 2. Storage Tunnel 2 does not provide for an inlet air supply. The ventilation shaft has been sealed and capped and fans abandoned in place.

Potential degradation of the PUREX Storage Tunnel 2 concrete due to gamma radiation was evaluated in 12-DWF&RS-NSL-015. Based on the dose calculations performed in CHPRC-1204181, the gamma radiation exposure to the storage tunnel structures was determined to be below the threshold of concern established in INEEL/EXT-04-02319. The source term in the storage tunnels is predominantly from fission products, most of which is gamma from 137Cs. The effects of neutron radiation were not evaluated.

Storage Tunnel 2 is deactivated with no access provided. All utilities and ventilation systems are isolated or removed.

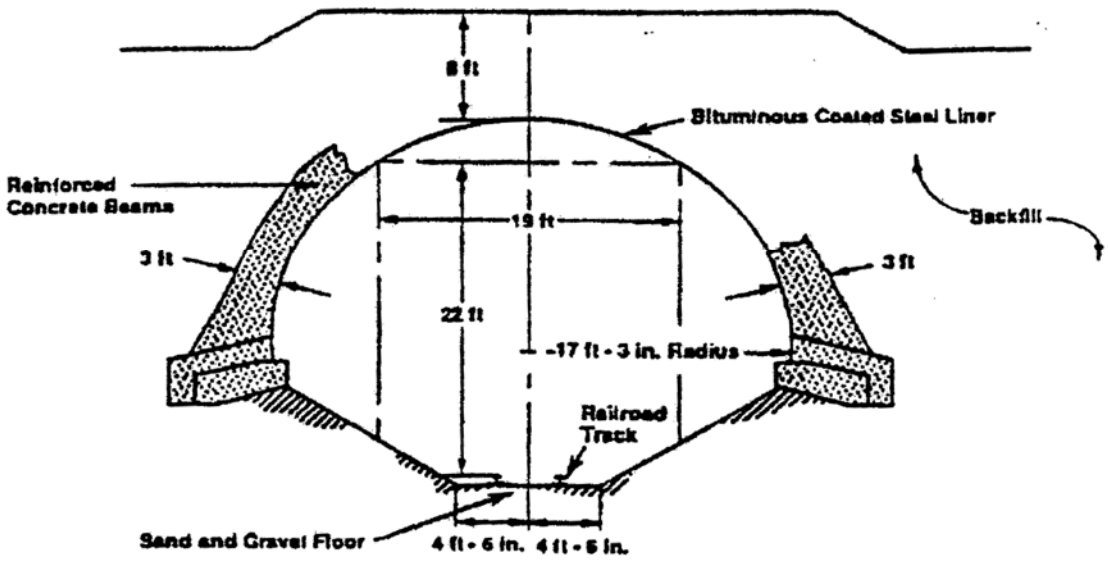


Figure 5-7. Sectional View of PUREX Storage Tunnel No. 2

6.0 Critical Process Equipment

Critical process equipment is defined as any equipment used to perform an important or key function for the facility's main mission or that has a replacement lead-time in excess of one year. The PUREX plant was shut down in 1992, and deactivation of the facility was completed in 1997. There is no critical process equipment in the facility.

7.0 High-Value Property

For the purposes of this analysis, high-value property has been defined as specific equipment with a replacement cost in excess of $5 million. The criteria for what is considered high-value property are not defined, but $5 million is selected based on this value being the threshold that the CRD requires for automatic fire suppression system protection.

There is no high-value property in the facility.

8.0 Fire Hazards

Burning fuel packages can impact a structure and the contents of a structure in a number of ways. Fire impacts that are of significance to the PUREX Complex include flashover, multiple fuel package ignition, waste drum and crate exposure, and structural failure. This section examines each of these impacts in terms of the fire exposure that causes them. Relevant controls that are in place or those that should be implemented are identified in the appropriate sections. Section 11 uses the information presented in this section to qualitatively assess the damage potential for various MPFL and MCFL scenarios.

Combustible materials and ignition sources were substantially reduced during the deactivation process at the PUREX Facility. The PUREX processing systems have been shut down, flushed, and drained. The steam supply to the plant has been isolated, and there are no hot-process pipes that could potentially serve as an ignition source within the facility structures. All canyon process equipment has been de-energized, hence, potential ignition sources such as arcing equipment and heat due to friction have been eliminated. The original electrical services to the 202-A Building and annexes were de-energized and isolated during facility deactivation.

Following deactivation, all buildings and structures that remain within the exclusion zone are unoccupied and are locked to prevent unauthorized entry. Access is controlled through K Basin Operations and Plateau Remediation (KBO&PR) Administrative Procedures. Electric power within the buildings was disconnected/de-energized, except for surveillance lighting (which is energized during surveillance activities only). The exceptions are the operating fan motor, stack sampling pumps, and data acquisition equipment in the 217-A, 291-A, and 292-AB Buildings.

The KBO&PR Project has adopted a set of standard recommendations that apply to all KBO&PR Facilities. These standard recommendations provide a means to restrict and control the addition of new combustible materials while allowing current S&M activities to be conducted.

Standard Recommendation 1: Combustible Control

- Combustible material accumulations must be controlled to maintain the FHA assumptions. Allowed S&M activities shall be conducted such that generated combustible material and ignition sources associated with the activity are minimized and removed at the end of the defined work evolution.

8.1 Combustible Loading

The following subsections present the main hazards that remain for each area of the facility discussed in Section 5.4 of this FHA.

8.1.1 202-A PUREX Main Building

The 202-A PUREX Building is sufficiently large, so the fire hazards discussion will be separated into the three main sections: annexes, galleries, and canyon. Each of these areas will be further broken down to address specific area fire hazards. The PUREX Building's annexes include the aqueous makeup area, office/control room, and ventilation, laboratory, and maintenance shop areas. In all of these annexes, most of the materials and equipment have been removed.

8.1.1.1 Laboratory Annex

The laboratory annex contains the main fire hazard for the annexes and the only contamination sources that are present in this portion of the facility. The main concern for the laboratory annex are the hoods that were decontaminated and coated with a contamination fixative polymeric barrier system (PBS) by the deactivating contractor, and then the hoods and ventilation ducts were isolated using expanded foam. The deactivation contractor used packaging foam (polyurethane) in parts of the laboratory to fix radioactivity and to fill void spaces in contaminated equipment. The foam was injected into contaminated exhaust ducts, exhaust plenums, utility chases behind the hoods, under some hood cabinet areas, and inside some of the hoods. The foam-filler material is contained within sheet metal or plate enclosures that are spatially separated. A few cases resulted in limited material being exposed to the room air, such as hand-holes in the front of the hood within Laboratory #1 and the decontamination room.

The quantity of cured polyurethane foam used in each laboratory varies in each area. The majority of the foam is inside the metal hood enclosures and ductwork, and in the hoods that have closed safety glass faceplates. A few individual hoods in Laboratories 1 and 4, as well as all of the hoods in the decontamination laboratory, are completely full of foam to the faceplates. Only about 5-10 ft^2 of the foam is exposed on the hand-holes in the faceplates of a few hoods in Laboratory 1 and the decontamination laboratory. Although the entire laboratory is considered one fire area, there are block walls with unprotected openings separating each of these areas. The following estimates of total polyurethane foam have been made for each laboratory area:

- Laboratory 1, Room 50 (Hoods 1-10)- 340 ft^3
- Laboratory 2, Room 51 (Hoods 11-18) -165 ft^3
- Laboratory 3, Room 53 (Hoods 19-26) -190 ft^3
- Decontamination Laboratory, Room 52 (Hoods 27-32)- 430 ft^3
- Laboratory 4, Room 58 (Hoods 33-38)- 185 ft^3
- Laboratory 5, Room 60 (Hoods 39-44)- 180 ft^3
- Laboratory 6, Room 66 (Hoods 45-54)- 210 ft^3

The total amount of polyurethane foam estimated in the laboratory annex is approximately 1,685 ft^3, with an estimated 515 ft^3 in the hoods, 620 ft^3 in the exhaust plenums and ducts, and 550 ft^3 in the utility chases behind the hoods and under the hood cabinet areas. The polyurethane foam is evaluated in Section 12.1.1. Other combustibles are very limited but would include minor amounts of wiring and insulation.

8.1.1.2 Non-Laboratory Annexes

Office areas, building services equipment, and maintenance shops are located in the remainder of the annex structures. These areas are free of radioactive materials. Combustible materials in the structure have been substantially reduced or eliminated. Upon completion of facility deactivation, the main concern in the non-laboratory annexes is residual materials in the form of minor combustible construction materials (telephone connector backboards, solid wood core doors and carpeting in the office annex, sanitary water-pipe insulation [urethane foam] to prevent pipe sweat, exposed telephone cables, and limited exposed electrical cables in east and west

switchgear rooms and in system panels in the main control room). The fire barrier between the annex areas and the canyon building provides adequate protection against fire propagation from one structure to another. Although this barrier is not being inspected, all work activities are planned and controlled by the KBO&PR S&M Administrative Procedures and Unreviewed Safety Question (USQ) process. Any changes to the barrier will be evaluated to ensure the integrity of the barrier.

8.1.1.3 Galleries

The P&O gallery contains the piping that was used to support the process canyon. All process piping in the P&O gallery was flushed and drained. The west end of the P&O gallery had been highly contaminated with plutonium nitrate during operations and was coated with several layers of paint (and was subsequently called the "white room"). Deactivation of this area added another coating of a contamination fixative in the form of a PBS. This PBS material is made by Bartlett Services, Inc., and has been tested for flame spread and smoke development using American Society for Testing and Materials (ASTM) E-84-00 tests. The PBS has a flame-spread index of 15 and a smoke development index of 30. This is rated as a Class A finish material and is used throughout the nuclear industry as a fire-safe fixative material.

The sample gallery contains the samplers used to monitor process streams, a glovebox used to load in and load out process solutions, and process support equipment. All process equipment and transfer lines in the sample gallery were drained. The sample gallery contains only minor amounts of combustibles in the form of insulation, wiring, residual greases in pumps and motors, and materials used to seal the individual samplers (tape and some minor amounts of expanding foam in cracks). The sample gallery samplers and general area had minor amounts of contamination on the outside of the samplers and should not present any real hazards. The main fire-loading concern for this area is a Plexiglas glovebox, approximately 0.9 m (3 ft) by 1.8 m (6 ft) by 1.8 m (6 ft) high, which was used to load/unload process solutions. This glovebox does not contain process materials and is contaminated to the same levels as the samplers.

The sample hoods in the sample gallery and the process hood in N-cell were sealed (as well as the sample hood ducts and other select ducts), which was done to prevent the migration of radioactive material in or from the hoods and ducts. The exhaust stacks for these systems were shut down as part of the deactivation process. A cross-tie duct was installed between the west hood exhaust duct and the hot shop supply ducting to permit potentially contaminated air to communicate with the slightly lower pressure zone of the hot shop.

The storage gallery was used during operation to store support equipment for the plant. During deactivation, all equipment was removed, and the storage gallery is presently empty. The main fire loading in this area is a single, 3 m (10 ft) by 3 m (10 ft) by 3 m (10 ft) high structure, constructed of wood and sheetrock. The storage gallery has some areas of contamination; however, these contaminated areas are isolated from combustible materials (wiring, insulation, etc.).

The PUREX Building contains three main glovebox rooms located at the west end of the storage gallery level: the PR room, Q-cell, and N-cell. All glovebox process solutions were removed and the vessels were flushed. As much combustible material as possible was removed from the gloveboxes. The gloveboxes are highly contaminated internally, and the initial deactivation step involved painting the internal surfaces with the Class A PBS material to affix the contamination

to the glovebox surfaces and remaining equipment. All outside glovebox solution and electrical connections were isolated and/or shut off. The gloveboxes ports previously used for gloves and bagouts were sealed by placing an aluminum pan over the port, taping the pan in place, and using a plastic cover taped in place to cover the pan and the port. Most of the gloveboxes are constructed of steel and glass; however, some gloveboxes use large Plexiglas (or similar) panels. Inlet HEPA filters remain installed but are blanked on the outside of the gloveboxes. Ventilation for the gloveboxes is routed to the process canyon using existing criticality drain lines. According to available information from the PUREX basis for interim operation for S&M (Dodd 1999), the PR room and N-cell contain significant quantities of plutonium. It is estimated that 1,199 g remain in the PR room and 1,643 g remain in N-cell. N-cell has a significant nuclear inventory but only a minor combustible inventory. The J cell has a large combustible inventory (oil in the pulsars) but only a minor nuclear inventory, therefore a fire in the N-cell would have less of a thermal impact on the filters than the postulated fire in J-cell detailed in Section 12.1.2.

8.1.1.4 5.1.4 Canyon

The PUREX canyon is isolated into four main areas: the air tunnel, the hot pipe trench, the canyon cells, and the canyon crane way and deck (Figure 5-3). The air tunnel and hot pipe trenches do not contain combustible materials. The canyon cells contain all of the process equipment used to convert the reactor fuels to product solutions. All of the canyon vessels have been drained and flushed to eliminate hazardous process materials (including the tributyl phosphate/normal paraffin hydrocarbon solvent). The canyon cells do, however, contain very high levels of contamination generated from process leaks that have dried up over time. The canyon cells are separated into 10 main processing cells that are isolated by concrete walls. The largest fire loading in a single process cell is located in the J cell, which contains two mechanical pulsers. The two pulsers each contain up to 120 gal of lubricant, are separated by at least 3 m (10 ft), and do not have any common process lines.

The PUREX craneway and canyon deck are located above the process cells and gallery areas. Removing all equipment and shutdown of the three gantry cranes deactivated the craneway and connected maintenance platforms. The main fire loading concern in the crane gallery is the lubricating greases and hydraulic fluids (approximately 10 gal) used in the cranes. The process cells and hot pipe trench are covered with thick, 0.9 m (3 ft) concrete blocks for shielding purposes. The top of these cover blocks is referred to as the canyon deck and was used to store failed canyon process equipment and connectors. During deactivation, as much equipment as possible was removed from the canyon deck and was placed into metal liner boxes or skips. These boxes or skips do not contain combustible materials. However, a single wood box, 1.2 m (4 ft) by 1.2 m (4 ft) by 2.4 m (8 ft), is stored on the canyon deck, which contained failed equipment. The equipment may contain no more than an estimated 10 gal of residual combustible hydraulic fluid. The box is over 200 ft from any other exposed combustible material.

At the east end of the PUREX Building is the rail tunnel that provided access to the plant and supported the transfer of material into the storage tunnels. The rail tunnel contains one railroad flatcar with a wood deck. The rail tunnel is isolated from the canyon by an overhead door and from the tunnels and environment by metal doors. All access to the tunnel was sealed during deactivation to prevent contamination migration.

8.1.1.5 218-E-14 and 218-E-15, No. 1and No. 2 Railroad Storage Tunnels

Access to the PUREX storage tunnels is prohibited because of high levels of radiation and contamination. The fire hazards noted are based upon the information provided by Hanford Site personnel, detailing the contents of both PUREX storage tunnels. Information on the potential fuel loads present in the PUREX storage tunnels is based on the Part B Permit (DOE/RL-90-24, Hanford Facility Dangerous Waste Permit Application, PUREX Storage Tunnels), and information provided by the facility staff.

Precise detail on the quantity, location, and many other physical conditions that exist in the tunnel could not be defined. The commodities and their arrangement in the PUREX storage tunnels can be detailed to some degree from site-provided documentation. Exact amounts of all materials and their precise locations relative to each other could not be determined. The PUREX storage tunnels have been isolated from normal human access for nearly 40 years. The documentation provided by Hanford Site personnel did not indicate any conditions in the PUREX storage tunnels that could be considered a relatively high fire hazard or fuel loading.

8.1.1.5.1 Storage Tunnel No. 1.

Tunnel No. 1 was filled to capacity between 1960 and 1965. Presently, the stagnant tunnel environment contains eight modified railcars filled with mixed waste and highly contaminated failed equipment such as irradiated machinery, machine components, and similar materials. In general, the mixed waste stored in Tunnel No. 1 is either attached to, contained within, or material removed from the PUREX plant and other onsite sources. The cited documentation indicates that additional hazardous wastes may be contained within Tunnel No. 1, but are not listed. These wastes could include oils from failed equipment, residual amounts of nitrates, other chemicals contained on or within failed equipment, and possibly asbestos or asbestos-containing material, most likely used as insulation for process tanks or lines (HNF-SD-CP-HIE-002).

The railcars were modified to accommodate the equipment and reduce degradation by removing the wood beds and replacing them with steel decking or wood decking encased with steel plate. The present information indicates a significant amount of radioactivity is present in the tunnel environment. The high-radiation levels indicate considerable exposure to the timber structure. The contents on each rail car are listed in Table 8-1, “Storage Tunnel No. 1 Contents.”

Table 8-1. Storage Tunnel No. 1 Contents

Burial Car No.	Burial Date	Contents	Initial Dose Rate
1 & 2	6/60	Solvent Extraction Separations Column Box of Misc. Jumpers	5 r/hr @ 60ft
3	7/60	E-F11,1WW Waste Concentrator	12.5 r/hr @ 100ft
4	12/60	G-E4 Centrifuge Two Concentrator Tube Bundles Box of Miscellaneous Jumpers	1.5 r/hr @ 150ft

Table 8-1. Storage Tunnel No. 1 Contents

Burial Car No.	Burial Date	Contents	Initial Dose Rate
5	1/61	E-H4,3WB Concentrator	150 mr/hr @ 50ft
6	4/61	E-F6, 2WW Waste Concentrator	5 r/hr @ 20ft
7	2/61	E-F11,1WW Waste Concentrator	25 r/hr @ 150ft
8	1/65	E-F6,1WW Waste Concentrator	Unrecorded

The amount of flammable/combustible materials in Tunnel No. 1 is not well defined within the documentation provided and more precise combustible/flammable material identification is not likely (given the high-radiation levels). Table 8-2, "Flammable/Combustible Fuel Stored in PUREX Tunnel No. 1," identifies the known flammable/combustible material stored within Tunnel No. 1.

Table 8-2. Flammable/Combustible Fuel Stored in PUREX Tunnel No. 1

Waste oil used in the journal of the rail cars.	See Appendix C of the DSA.
Some combustible materials other than wood may have been included with the stored items; the location and quantities are unknown.	See Appendix C of the DSA.
*Solvent extraction column (equipment pieces of PUREX plant) contains organic solvent. The organic solvent consists of 25% volume tributyl phosphate (TBP) with normal paraffin hydrocarbon (NPH) diluents. The NPH consists of a very pure mixture of n-dodecane to n- pentadecane.	Description of Potential PUREX Candidates for Decontamination and Decommissioning (WHC 1993).

*Comments by PUREX personnel. Based on equivalent design and pre-bunal flushing procedures, there were only traces/very small quantity of TBP/NPH. PUREX personnel have indicated that the quantity of TBP/NPH is relatively small, that is, <1 gallon.

8.1.1.5.2 Storage Tunnel No. 2.

At the present time, a total of 28 railcars have been placed in Tunnel No. 2. The first storage position was filled in December 1967 and the most recent waste emplacement occurred in June 1996.

Tunnel No. 2 contains both hazardous and non-hazardous radioactive wastes. A list of the known amounts of non-radiological materials stored in Tunnel No. 2 is shown in Table 8-3, "Storage Tunnel No. 2 Mixed Wastes." A total of 73,000 Ci of radiological inventory is present in Tunnel No. 2 from PUREX equipment and railroad tankers. The radioactive isotopes known to be present are H-3, Kr-85, Sr-90, Ru-106, Sb-125, Cs-134, Cs-137, Ce-144, Pm-147, Am-241, Pu-238, Pu-239, Pu-240, and Pu-241(HNF-SD-CP- HIE-002).

A list of the contents of Tunnel No.2 is also presented in *Plutonium Uranium Extraction (PUREX) End State Basis for Interim Operation (BIO) For Surveillance and Maintenance*, HNF-SD-CP-HIE-002.

Table 8-3. Storage Tunnel No. 2 Mixed Wastes

Contents	Quantity	
	Kg	(lb)
Absorbed oil	8.5	(18.7)
Ag (Silver)	740	(1631.0)
Ba (Barium)	3	(6.6)
Cd (Cadmium)	69	(152.0)
Cr (Chromium)	9	(19.8)
Hg (Mercury)	130	(286.0)
Pb (Lead)	9,734.00	(21,458.0)

Additional hazardous wastes located in the PUREX storage tunnels that are not listed include the following:

- Oils from failed equipment
- Residual amounts of nitrates
- Asbestos or asbestos-containing material used for insulation
- Other chemicals contained on or within failed equipment

Several documents identified the amount of hazardous materials contained within the Tunnel No. 2, but none of these documents provided information regarding the exact amount of flammable/combustible materials and their location. Table 8-4, "Flammable/Combustible Fuel Stored in PUREX Storage Tunnel No. 2," identifies the available information regarding the flammable/combustible materials present in Tunnel No. 2 along with the referenced source. No ignition sources were identified in the tunnel.

Table 8-4. Flammable/Combustible Fuel Stored in PUREX Tunnel No. 2

Fuel Load -Tunnel No. 2	Citation
Reactive or ignitable waste stored in the tunnel is silver nitrate. This material is dispersed on ceramic packing and is physically isolated from contact with any combustible material or ignition sources.	HNF-SD-EN-WAP-007, PUREX Storage Tunnels Waste Analysis Plan, p. 4
Absorbed oil = 8.5 kg (18.7 lb)	HNF-SD-EN-WAP-007, p. 12
Mineral oil stored in stainless steel containers received from Building 324. The oil leaking from the viewing windows of B cell was absorbed on rags and clay absorbent materials.	HNF-SD-EN-WAP-007, p. 9

8.1.2 291-A, No. 1, No. 2, and No. 3 Filter Areas and Exhaust Tunnels

The pre-filter media for the No. 1 and No. 2 filter primary beds are a glass product (115 L) that is no longer manufactured. This media is a Class I Filter, UL Standard 900. A Class I Filter is one that when clean, will not contribute fuel when attacked by flame and emits only negligible amounts of smoke. The secondary stage of the deep-bed filters is a Class II filter, UL Standard 900. A Class II filter is one that when clean, burns moderately when attacked by flame or emits moderate amounts of smoke or both. The No. 3 filter media was never installed and does not contain any combustibles.

The No. 1 and No. 2 filter primary beds are loaded with an approximate 100 to 200 g of Plutonium-239/240, approximately 20 to 200 Ci of Cs-137, 20 to 200 Ci of Sr-90, and approximately 0.2 Ci of Am-241.

8.1.3 291-AE No. 4 Filter Building

The 291-AE Building houses 10 modular filter units, each with upstream and downstream isolation valves. A typical modular filter unit consists of a stainless-steel housing and a 4 by 3 array of wood-framed paper HEPA filters.

8.1.4 291-A Exhaust Plenum, Fans, and the Main Stack

The fire-loading concerns in regard to the 291-A exhaust plenum, fans, and main stack involve small amounts of grease lubricants for the motors and wiring.

8.1.5 2701-AB Badge House

Fire-loading concerns for the 2701-AB Building involve insulation, wiring, and ceiling materials. This building is currently being used for staging S&M supplies such as clean PPE.

8.1.6 252-AB Electrical Substation

A new skid-mounted, 13.8/2.4-kV electrical unit substation was installed to supply the PUREX facility exhaust ventilation and data acquisition systems. Fire loading involves electrical cables and wiring; two 13.8/2.4-kV oil-filled, step-down transformers; two 2.4/480-kV oil-filled, step-down transformers; and switch gear that provided power to the exhaust fans, surveillance lighting, and monitoring and control systems.

8.1.7 217-A SAMCON Unit

The fire-loading concerns for the new monitoring station involve computer components, electrical monitoring equipment, insulation, and wiring.

8.1.8 252-AC Surveillance Lighting Electrical Substation

This skid-mounted substation supplies 750 kVA of electrical power to the dedicated surveillance lighting and strategically-located receptacles throughout the facility and contains switchgear, small transformers, panels, and electrical cables.

8.2 Ignition Sources

Steam service to the PUREX Facility was isolated; there are no hot-process pipes that could potentially serve as an ignition source within the facility structures.

8.3 Transient Combustible Loading

8.3.1 Ordinary Combustible Loading

The combustible loading program as described in this FHA limits the quantity various types of ordinary transient combustible materials within the facility. Combustible loading limitations are intended to protect the critical assumption provided in Section 2.1 and the combustible control related assumptions in Section 2.2. Table 2-1 lists the combustible loading controls identified in this FHA.

Transient ordinary combustible loading may consist of individual items such as wood, plastic, paper, etc., or be a combination of these such as an open waste crate or bags of trash.

8.3.2 Flammable and Combustible Liquids

Flammable and combustible liquids are defined by their piloted ignition temperature (NFPA 30, 2015). Flammable liquids have a flashpoint below 100°F (38°C) and combustible liquids have a flashpoint greater than or equal to 100°F (38°C). Once ignited, however, flammable and combustible liquids release the same amount of heat per unit volume (NFPA 30, 2015).

8.3.3 Flammable Gases

A Fire Marshal permit is required for the introduction of flammable gases into PUREX. Limited quantities of welding gases are permitted by this FHA and may be present depending on specific activities after an evaluation by the FPE that the activities are within the bounds of the FHA and do not challenge the conclusions reached in the FHA.

The generation of hydrogen gas from hydrogenous materials through radiolysis had been previously hypothesized, however no measurable levels of hydrogen generation have ever been observed. The potential risk of creating a flammable environment through hydrogen generation is now considered negligible.

8.4 Risk of Fire and Related Hazards

The MPFL event is discussed in Section 12.6. This scenario contains no fire-related hazards (direct flame impingement, hot gases, smoke mitigation, fire-fighting water damage, etc.) that require special or unique consideration.

8.5 Interior Finish Material

The interior finish of the 202-A Building is primarily concrete, concrete masonry units, and gypsum board. Some areas of the facility contain a drop ceiling. Ancillary structures are primarily concrete.

8.6 Chemical, Corrosive Agents, and Other Special Hazards

Although past facility operations have resulted in radiologically contaminated areas and equipment, the bulk of the chemical and hazardous material residue was flushed from piping and equipment during the deactivation process.

8.7 Process and Equipment Hazards (Special Hazards)

There are no active processes or equipment in the PUREX Facility.

9.0 Operations

Activities in the PUREX Facility include those that support the facility up to structural demolition. This section provides an overview of those activities in the PUREX Facility. Activities that impact the fire hazards of the facility are discussed in detail. Impacts to the facility fire hazards include the introduction of ignition sources and an increase in the fuel load. Guidance on best practice is provided where appropriate to reduce the risk or eliminate the impact of the activity to the overall fire hazards. Additionally, other methods may be implemented as necessary. PUREX Facility FPE review of work activities will address needed actions.

9.1 Normal Conditions

Facility activities have been grouped into four categories:

- General facility operations
- Hazardous material handling
- Radioactive waste generation and handling
- Decommissioning operations

9.1.1 General Facility Operations

General Facility Operations include activities needed to keep the facility safe, habitable, functional, or compliant with applicable requirements. They include surveillance, monitoring air flow, housekeeping, maintenance, and construction activities. Surveillance and monitoring activities present no unusual fire exposures. Surveillance activities include inspection of existing containers and sampling, identifying, and labeling unlabeled containers. Containers may be 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 container is repackaged or over-packed and moved to an appropriate disposal facility. Corrective action is taken to prevent recurrence. The activities are managed consistent with applicable requirements of the hazard material control, work control, fire protection, and radiological protection programs.

Housekeeping activities contribute to fire safety through the reduction of the available fuel loading throughout the facility.

Construction and maintenance activities may impact fire safety by obstructing egress routes, introducing combustibles and ignition sources, and modifying building features. An FPE reviews construction activities through work control processes. This review focuses on the activities' impact to facility operations and fire protection features. The review is an adequate control to ensure the maintenance of the fire protection posture of the facility.

9.2 Conditions under Special Situations

Hazardous materials handling and radioactive waste generation and handling may be necessary for some S&M and D&D activities.

9.2.1 Hazardous Materials Handling

Hazardous materials handling includes using, handling, removing, or storing hazardous chemicals and materials. Limited quantities of welding gases may be present depending on specific activities. Various amounts of hazardous material may be present within the PUREX Facility, as detailed in Section 10.2. These chemicals will be removed or managed in preparation for demolition activities. The chemicals needed for the decommissioning processes are brought into the facility and handled under controlled conditions and activities. These chemicals are managed in accordance with the Chemical Management Plan which implements a process for obtaining inventory, tracking inventory, storage, and disposal.

9.2.2 Radioactive Waste Generation and Handling

Radioactive waste and contaminated equipment handling activities consist of those associated with moving and storing radioactive waste containers and transferring contaminated equipment between work areas. Radioactive waste may be generated by general facility operations and by decommissioning activities. Radioactive aqueous and organic liquids will be generated if certain decommissioning activities such as hydrolancing, steam cleaning, and hydrolazing are performed. Radioactive liquids and sludge may be drained, pumped, or removed as required from piping and tanks. Radioactive waste forms are primarily metal, concrete, plastic, rubber, cloth and glass. These wastes are to be collected in approved containers, processed as necessary, and packaged into waste containers.

Waste containers used for shipping radiological waste from the facility meet the requirements of the Site Transportation program. The use of containers not constructed of metal (e.g., wood crates) is analyzed as needed within this FHA.

Waste may be transferred from the facilities through airlocks and openings. Airlocks are formed by a series of doors with intervening spaces arranged so that only one door is opened at a time. Confinement is thus maintained when moving objects from one area to another. The impact of any new wall openings will be assessed by the FPE through the work control process. Suitable construction materials will be provided to maintain required fire separation.

9.2.3 Decommissioning Operations

Decommissioning Operations may include disassembling size reducing SSCs and packaging them into waste containers as necessary. Production of MIX, TRU, and MIX TRU waste may be produced from work being done. Decommissioning activities generate free-release waste, radioactive waste, and non-radioactive hazardous waste. Specific planned activities include those which will facilitate future D&D of the PUREX Canyon, including canyon entry for maintenance, cleanup, and characterization. Activities outside the canyon and in the PUREX yard are also planned to facilitate access for canyon D&D.

9.3 Activity Impact on the Fire Hazards

Specific activities needed to accomplish deactivation, decommissioning and decontamination, and risk reduction activities can be grouped into four categories in this section based on their impact on the overall fire hazard and fire safety of the complex:

Activities that Introduce an Ignition Source

These activities involve the introduction of an ignition source. Ignition sources include an open flame, self-heating, and sparks that have high enough energy to ignite ordinary combustibles.

Activities that Increase the Fuel Load

These activities involve an increase in the combustible fuel load. This section considers only those activities that have the potential to introduce a substantial quantity of combustible materials.

Activities that Introduce an Ignition Source and Increase the Fuel Load

These activities involve the introduction of combustible materials and an ignition source. Ignition sources include open flames, self-heating, and spark. This section considers only those activities that have the potential to introduce a substantial quantity of combustible materials and where a credible means of igniting the combustibles exists.

Activities that have Minimal Impact on the Facility Fire Hazard

These are activities that do not introduce additional fuel loads or ignition sources.

As activities are proposed, all work packages where an increase in the fuel load or an introduction of ignition sources could occur, must be reviewed by an FPE. Necessary controls to mitigate the fire hazards associated with those specific activities will be addressed in detail as necessary.

10.0 Potential for a Toxic, Biological and/or Radiological Incident due to a Fire

10.1 Criticality, Radioactive Materials, and Contamination

The PUREX Facility is classified as a Limited Control Facility due to the amount of fissile material present. Everywhere within PUREX is firefighting Category A despite some areas with legacy Category C postings (Ref: WHC-SD-SQA-CSA-511, Rev 1). An objective of the deactivation project was to reduce the special nuclear material inventory and reclassify the PUREX Facility as a limited control facility, which has been accomplished. Thus, the remaining special nuclear material inventory will be in a form and distribution to ensure that critical mass cannot be exceeded.

Most of the buildings in the PUREX Facility contain only minor amounts of radioactive materials and contamination. The PUREX Canyon Building and other structures as described below contain significant amounts of radionuclides that could potentially be released as the result of a fire.

10.2 Hazardous Materials

One of the deactivation goals was to remove as much of the hazardous materials as possible. Some of the materials include asbestos, lead (paint and shielding material), mercury (switches and thermostats), and zinc (for galvanized piping).

Most of the ancillary structures at the PUREX Facility contain negligible amounts of low-level radioactive material in the form of fixed contamination on the structure or empty process equipment. Any possible release of the contamination following a fire incident would be inconsequential with respect to the health and safety of the public and the environment.

Six main structures contain significant levels of contamination. These buildings are the 202-A Building (i.e., analytical laboratory, canyon area, and glovebox areas), the 291-AD ammonia off-gas filter pit, the 294-A (dissolver filters), 241-A-151 shielded valve pit (waste transfer lines), 218-E-14 and 218-E-15 railroad storage tunnels, 291-A ventilation exhaust plenums and the #1 and #2 deep-bed filters. If released to the atmosphere, the contamination in these areas could impact the health and safety of the public, as well as contaminate a large area of the environment. The 291-AD ammonia off-gas filter pit, the 294-A (dissolver filters), 241-A-151 shielded valve pit, 291-A ventilation exhaust plenums, and the #1 and #2 deep-bed filters are concrete, below-ground structures, constructed of noncombustible materials and contain no ignition sources (Section 8.2). Release from these structures due to a fire is not considered credible.

Other hazardous materials are located in the 202-A Facility. The PUREX Building canyon cells contain solid cadmium for critical control and lead used for shielding, instrumentation, and equipment counterweights. The A, B, and C dissolver cells contain silver (deposited on the scrubber media inside process equipment) and mercury (used in temperature measurement). The N cell, Q cell, and PR room glove boxes used lead for shielding and also leaded-glass windows. In the storage gallery, lead bricks were used as shielding for an area with high dose rates. In the

sample gallery, lead was used as shielding material in the high-dose-rate samplers, and a lead glass window is on the tank D5 sample cave. The oil remaining in the canyon pulsers contains polychlorinated biphenyls (PCBs) at concentrations near the hazardous limit of 5 ppm.

The hazardous materials assumed to be in the storage tunnels are noted in Section 8.1.1.5.

10.3 Biological Hazards

No biological issues were identified relating to fire at the PUREX Facility.

11.0 Natural Hazards that may have an Impact on Fire Safety

Flooding, high winds, earthquakes, and range fires are natural hazards that could have an impact on fire safety. Natural hazards may impact the fire safety of a building by damaging the fire suppression systems, igniting fuel packages, and/or introducing additional fuel, as would be the case if a flammable gas line ruptured or a flammable liquid storage cabinet were damaged.

11.1 Earthquake

The bounding natural phenomena for the Hanford Site are seismic events.

Eastern Washington is a region of low-to-moderate seismicity. Hanford Site facilities are exposed to the possibility of moderate earthquake damage both from active seismic zones of Western Washington and those of Eastern Washington near Walla Walla. Seismic design parameters for the Hanford site, provided by the U.S. Coast and Geodetic Survey, are $S_s = 0.405$ g and $S_1 = 0.159$ g.

Seismic hazard risk analyses performed in 1981 for the PUREX Plant concluded that seismically- induced fire scenarios would only involve processes occurring during plant operation (WHC 1994).

The postulated conditions are no longer considered credible because of the shutdown of this facility and the removal (during the deactivation project) of many of the materials considered in these scenarios. Therefore, it is concluded there are no requirements that warrant survivability analysis of the postulated event. Impacts from earthquakes are limited to the limited utilities that remain at the PUREX Facility (e.g., electrical power, fire hydrants, and remote alarms).

11.2 Flood

The 200 Areas are situated on a plateau, and because of the elevation, the structures are not susceptible to catastrophic flooding even by the probable maximum flood (PMF) postulated by the U.S. Army Corps of Engineers. The PMF condition using this analysis is the dam-regulated PMF previously predicted by the U.S. Army Corps of Engineers. This projection was derived using extensive data and computer-modeling techniques and incorporates assumptions of conditions that are the most severe and are considered reasonably possible for the Columbia River Basin. Contributing factors of winter snow accumulation, spring melting, and runoff season rainstorms were maximized. However, the calculation shows that even under these circumstances, the 200 Areas would not be affected by a PMF. A hypothetical 50 percent breach in the Grand Coulee Dam would not elevate the flood level of the Columbia River above that required to cause damage to the 200 West Area.

The maximum 24-hour precipitation expected to occur once in 1,000 years is 6.8 cm (PNL-4622, *Climatological Summary for the Hanford Area*) and is not anticipated to have an impact on the facility through localized flooding.

11.3 Wind

The Hanford Meteorological Station (HMS) monitors wind speeds on the site in real time. Average wind speeds on site are about 7.5 mph, with the average in any given month ranging from 2.9 mph (November 1956) to 11.1 mph (April 1959 and April 1972). The peak wind gust recorded by the HMS is 80 mph (January 1972).

11.3.1 Tornadoes

The Pacific Northwest is one of the areas of the country with the lowest frequency of tornadoes. The entire State of Washington has an average tornado frequency of less than one per year. An analysis of the Hanford Site concludes that the probability of a tornado hitting any particular onsite facility is six in one million during any one year. Furthermore, DOE no longer requires non-reactor facilities at Hanford to be designed for tornado effects.

11.4 Lightning

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, places the Hanford Site within a lightning incidence zone where the yearly number of flashes to ground per square kilometer falls between 0.1 and 0.5. Evaluation of the risk of lightning attachment to a structure or object involves the determination of the equivalent collection area of the structure or object, the flash density for the area in which the structure is located, and the consequence of a strike. When justified by a risk assessment performed in accordance with NFPA 780, a lightning protection system must be installed.

The PUREX building is not equipped with lightening protection. All operations have ceased, and all concentrations of combustible materials, exposed to the potential of a direct or near lightning strike have been removed. Therefore, it is concluded that the expected plant configuration for the PUREX Facility does not warrant additional consideration or analysis because of fire-related risk associated with lightning.

11.5 Wildland Fire

Range fires of significant magnitude are considered anticipated events on the Hanford Site. Smaller fires occur routinely during the warmer months of June through August. The HFD's 2016 *Wildland Fire Management Plan* establishes an operational guide for managing the suppression of unwanted wildland fires as well as managing prescribed fires to achieve fuel management objectives. Two significant range fires occurring in 1984 and 2000 each ranged over several hundred square miles of Hanford Site land. The 2000 fire was halted at the west and south boundaries of the 200 West Area. In the event of a range fire, potential for site access restrictions and travel hazards for the Fire Department such as poor visibility should be anticipated.

Wind-blown vegetation is a constant problem across the Hanford Site. Surveillances of transient combustible materials are conducted, and when accumulations are found, the appropriate Hanford Site personnel are notified, and the accumulations are removed.

NFPA 1144, 2013, *Standard for Reducing Structure Ignition Hazards from Wildland Fire,* Section 5.1.3 requires the minimum separation from structures and adjacent lots or vegetation be

a minimum or 9 m (30 ft). The PUREX Facility maintains clear areas around all structures of at least 9 m (30 ft) from all lot lines and vegetation.

The ground within the double fencing and within the exclusion zone, which is maintained free of vegetation, acts as a firebreak between a range fire and any building or structure. Strategically located fire hydrants are left in place to provide external protection to the building against this exposure.

12.0 Damage Potential

Because the property at the PUREX plant has been assigned a value of zero, the only significant monetary cost that must be examined is the decontamination and disposal cost that would occur following a fire incident. Damage potential, in terms of fire loss, is defined as the dollar cost of restoring damaged property to its pre-fire condition. In accordance with the CRD, the items identified in DOE M 231.1-1A, Appendix F #8, must be considered when estimating the loss. This information is reproduced in Table 12-1, "Criteria for Loss Estimation."

Table 12-1. Criteria for Loss Estimation

Loss estimation includes the following:	
1.	Damage or loss of facilities, inventories, and associated equipment as a result of a fire or a fire suppression system actuation.
2.	All estimated or actual costs to restore DOE property to a reasonable approximation of pre-accident conditions. If an accident involves property that has been lost, completely destroyed, or contaminated to a degree precluding economically justifiable recovery, estimates shall be based on cost for actual replacement and installation of comparable equipment, devices, or materials (including nuclear materials) as well as clean-up and disposal cost for the damaged facility. Such costs should include credit for any salvage value associated with the loss.
3.	In the case of unused, obsolete, or excess building space, equipment, or materials that are not going to be replaced, the cost estimate of the market value at the time of the accident shall be used.
4.	Estimated costs for restoring to a reasonable degree to pre-accident condition, without improvement, all partially lost or damaged DOE property. Include replacement cost for all DOE-owned supplies and costs for decontamination operations where applicable.
5.	Estimated costs for reprocessing and reclaiming partially destroyed and damaged materials. Where applicable, costs for damage resulting from firefighting (e.g., water and smoke damage) should be included.
6.	All post-incident cleanup expenses both inside and outside the facility (e.g., cleanup of hazardous materials or radioactive contamination resulting from fires, or fire suppression system actuation).
7.	All costs for recharging fire suppression systems (gaseous, chemical, and foam agents) and decontamination or replacement of Fire Department equipment.
8.	Costs for damage caused by DOE operations to privately-owned property.
9.	Costs for restoration of land and land improvements (sidewalks, roads, etc.,) that were damaged as a result of an accident.
10.	Costs for outside specialists or organizations hired to mitigate losses and costs for non-standard labor hours (i.e., above the amount normally worked by the employee) for onsite personnel to restore the property to pre-accident condition.
11.	Any lost revenue experienced as a result of the accident. Examples include income-producing processes, such as power generating and transmission facilities or timber sales, whose loss would cause a reduction in payments to the Federal Government.
12.	Estimated damage losses to Government or private wetlands, grasslands, and forests as a result of a wild-land fire originating on DOE lands. Restoration costs should also be included along with actual costs to suppress the event.
13.	Labor hours expended by investigative and/or administrative personnel as a result of the incident.

Table 12-1. Criteria for Loss Estimation

Loss estimation includes the following:
14. Labor cost for personnel evacuated during a fire including any stand-down costs associated with: investigations, employee relocations, or restoration activities.
Loss estimation excludes the following:
1. Expenses resulting solely from loss of the use or occupancy of facilities affected by the fire, including lost production and research time, unless it becomes necessary to obtain special facilities (e.g., temporary structures) to maintain the facilities' use or occupancy.
2. All post-accident expenses paid by non-DOE sources (e.g., expenses covered by private insurance).
3. Expenses to bring property to modern standards.
4. Normal wear.
5. Damage to privately-owned property caused by other than DOE operations.
6. Labor hours for onsite firefighters during their normal work shifts.

The MPFL is defined in DOE-STD-1066-2012 as "the value of a building and its contents, excluding land value, within a fire area, unless a fire hazard analysis or a fire protection assessment demonstrates a lesser (or greater) loss potential. This assumes the failure of both automatic fire suppression systems and manual fire-fighting efforts."

When determining fire loss, the estimated damage to the facility and contents typically includes replacement cost, less salvage value, and typically excludes property scheduled for demolition; and decommissioned property not carried on books as a value. Fire loss typically includes the cost of decontamination and cleanup; the loss of production; the indirect costs of fire extinguishment (such as damaged Fire Department equipment); and, the effects on related areas.

The following subsections provide an estimate of the potential monetary liability to the government as a result of postulated fires in accordance with the above-stipulated loss limitations.

12.1 Analysis of Potential Fire Scenarios

This section provides further analysis of the DSA fire scenarios presented in Section 13 for the determination of damage potential.

12.1.1 202-A Laboratory Annex

The Sealed Air Corporation manufactured the INSTAPAK® polyurethane foam used to seal components in the analytical laboratory. The foam is a two-monomer polymer, with component "A" being a polymeric isocynate (polymethylene polyphenylisocyanate) and component "B" being polyurethane resin. When reacted, the foam has density of approximately 12.8 kg/m^3 (0.8 lb/ft^3). Thermal conductivity is 4.9E-03 kJ/s-m-°C (2.83E-03 Btu/hr-ft-°F), and the specific heat is 10.45E-02 kJ/kg-°C (0.025 Btu/lb-°F). The foam has an ignition temperature of about 427°C

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(800°F); thus, an incident radiative heat flux of about 25 kW/m^2 is required to ignite the material. A heat release rate of about 78 kW would be required to ignite the polyurethane from a 0.5 m distance; this highly-conservative heat release is based upon a point source radiative heat transfer model using a critical incident heat flux of 25 kW/m^2 and a radiative fraction of 1.0 for the energy released. There are no 78 kW or larger heat sources within 0.5 m of the polyurethane foam or any heat sources that can threaten the polyurethane foam as installed.

The quantity of cured polyurethane foam used in each laboratory varies in each area. The majority of the foam is inside the metal hood enclosures and ductwork, and in the hoods that have closed safety glass faceplates. Only about 5-10 ft^2 of the foam is exposed on the hand-holes in the faceplates of a few hoods in Laboratory 1 and the Decontamination Laboratory. Although the entire laboratory is considered one fire area, there are block walls with unprotected openings separating each of these areas. The following estimates of total polyurethane foam have been made for each laboratory area:

- Laboratory 1, Room 50 (Hoods 1-10)- 340 ft^3
- Laboratory 2, Room 51(Hoods 11-18) -165 ft^3
- Laboratory 3, Room 53 (Hoods 19-26) -190 ft^3
- Decontamination Laboratory, Room 52 (Hoods 27-32)- 430 ft^3
- Laboratory 4, Room 58 (Hoods 33-38)- 185 ft^3
- Laboratory 5, Room 60 (Hoods 39-44)- 180 ft^3
- Laboratory 6, Room 66 (Hoods 45-54)- 210 ft^3

The total amount of polyurethane foam estimated in the laboratory annex is approximately 1,685 ft^3, with an estimated 515 ft^3 in the hoods, 620 ft^3 in the exhaust plenums and ducts, and 550 ft^3 in the utility chases behind the hoods and under the hood cabinet areas.

The laboratories are uninhabited areas that require a radiological work permit for access. For as low as reasonably achievable (ALARA) reasons, no work is conducted in the laboratories, and there are no future plans to use the laboratory. Power to the laboratory hoods has been isolated. Area lighting is the only heat-producing equipment that currently exists in these areas. The area lighting is located more than 0.5 m away from the foamed ductwork. There is no functioning ventilation system for the laboratory, which is basically stagnant. All HVAC ducts have been plugged. The absence of any significant heat sources in the laboratories reduces the possibility of a fire incident originating inside of the analytical laboratories. Furthermore, there will be no other ignition sources within the laboratory. When surveillance is performed, a new lighting system is energized briefly in the laboratory change room areas and in the central corridor.

The north exterior wall of the canyon structure separates the laboratory from the canyon building galleries. Separation from the structures to the east and west of the laboratory is accomplished by > 150 mm thick (6 in.) concrete with no unsealed penetrations. In order to control the migration of contamination during S&M, gaps around fire doors that are not required for emergency egress have been sealed with weather stripping and/or tape. There are no significant combustible structures adjacent to the north side of the laboratory annex.

A review of end-point documentation including a video of the laboratory area that was recorded to document the final configuration of the labs concluded that the hoods in the decontamination room have been nearly completely filled to the glass faceplates with foam. There are a total of seven hoods located in the decontamination room. Six of the hoods are side by side. The seventh hood is located opposite these six hoods. The face of the hoods is the only portion of the hoods where the foam filling is or could be readily exposed to an ignition source. It is conceivable that if ignition of the foam on the face of one of the hoods were to occur, propagation to the adjacent hoods could take place by spreading across the lab faces since each is immediately adjacent to the next. If this were to occur, a worst-case scenario would be if the glass faceplates did not function to inhibit the fire spread from hood face to hood face. Therefore, it is conceivable that the polyurethane foam on the faces of all seven hoods could be burning at the same time, although this is extremely conservative. According to the original specifications for these hoods, the faceplate windows are 2-ply safety glass measuring 27.875 in. x 34.5 in. x 1/4 in. thick. These glass faceplate windows are held in place by a 14 gauge metal frame which encloses 1/2 in. of the glass on all sides. The surface of the exposed glass is approximately 26.875 in. x 33.5 in., for a total surface area of approximately 900 in^2 or 6.25 ft^2. This would equate to a total exposed surface area of 4.06 m^2 (43.8 ft^2).

The decontamination room is the area having the greatest amount of exposed foam, and therefore represents the bounding condition for a fire involving the polyurethane foam. The decontamination room measures approximately 5.18 m (17 ft) wide by 8.54 m (28 ft) deep and 3.81 (12.5 ft) high. The laboratory area, including the individual lab rooms, contains no vents and the ventilation system is isolated. A single 0.91 m (3 ft) wide by 2.13 m (7 ft) high door leads to the decontamination room. The floor of the labs is concrete, the walls are of concrete block, and the ceiling is concrete on steel.

A typical value for the heat of combustion for rigid polyurethane foam is 28,000 KJ/kg. A typical value for the mass loss rate is 0.025 kg/m^2-s. When polyurethane foam burns it generates copious amounts of smoke. The greater the amount of smoke generated, the less the combustion efficiency. A conservative value for combustion efficiency based on literature on this subject is 0.7. There are virtually no other combustible materials in the decontamination room that would contribute to the fire.

The estimated total quantities of radiological materials in the deactivated PUREX facility are listed in Table C-7 in the Appendix C of the DSA. Based on the information from the Appendix and assuming the same ratio of material exists in the laboratory annex, Table 12-2, "Estimated Inventory of Radiological Materials" provides the estimated inventory of radiological materials in the hoods of the laboratory annex.

Table 12-2. Estimated Inventory of Radiological Materials

Isotope	Estimated Quantity in the Lab Hoods
Sr-90 (Ci)	< 0.4 Ci
Cs-137 (Ci)	<0.6Ci
Pu-239 (g)	<0.1g
Pu-240 (g)	< 0.01g

Table 12-2. Estimated Inventory of Radiological Materials

Isotope	Estimated Quantity in the Lab Hoods
Am-241(g)	< 0.001g

12.1.1.1 Fire Loss and Deposition Cost Analysis, Laboratory Annex.

As part of this FHA, an estimate is required for the extent of ground contamination and possible cleanup costs associated with a severe fire in the PUREX laboratory annex. The combustible loading fire hazards assumptions for this analysis were taken from Section 8.1 and the estimated radiological material inventory identified in Table 12-2. The ground contamination model used here is described in detail in Himes (1994). A summary of the model as it applies to this analysis is given in the section on methodology.

12.1.1.2 Scenario Description

To determine the bounding deposition, the entire laboratory facility with its radiological inventory is considered at risk. This is considered conservative and bounding for purposes of determining the MPFL for the PUREX laboratory.

To determine the bounding fire severity within the PUREX laboratory complex, the multi-zone computer fire model, Consolidated Model of Fire Growth and Smoke Transport (CFAST), was used to estimate fire conditions in the compartment of fire origin. CFAST was developed by the National Institute of Standards and Technology for modeling steady and unsteady state burning rates in multiple compartment configurations. The initiating fire is user specified but is adjusted by CFAST based on the available fuel and oxygen supply.

For the laboratory annex building, there is no forced ventilation present in the building. All ducted vent paths have been sealed. Because there is no forced ventilation, the area of the door opening to the decontamination room will be used in conjunction with the equation below to determine the flow rate of air that will be available for combustion. The mass flow rate can be approximated by the following expression:

$$\dot{m}_{air} = 0.52 A_w h^{1/2} \text{ (kg/s)} \qquad \textbf{Eq. 11-1}$$

Where A_w is the effective area of ventilation (1.938 m^2) and h is the height of the ventilation opening (2.13 m). The mass flow rate for one door is then 1.471 kg/s. Using this result, it can be shown that the theoretical maximum fire size that can be sustained in the room based on an accepted value of 3,000 KJ of heat released for every 1 Kg of air consumed is 4,413 KW.

Several CFAST runs were developed for the PUREX laboratory in order to evaluate potential scenarios in the decontamination room. The decontamination room was chosen due the high inventory of rigid polyurethane foam in the room when compared to the other laboratory rooms. The ratio of foam volume to area was larger for this room than the other laboratory rooms. From the several CFAST runs, two were determined to be bounding based on fuel and building configuration. The CFAST runs were used to estimate the actual size fire that can be sustained using the theoretical value identified above as the starting point. One run modeled a fire with all openings to the PUREX Laboratory closed, including all doors leading to the outside. This is the current state of the conditions at the facility. CFAST predicts that this fire will not flashover

from the room or origin. The second run was modeled with one 0.91 m by 2.13 m door open to the outside. CFAST predicts that flashover will occur for this scenario. The estimated fire size per CFAST data for this fire is 4,059 kW versus 4,413 kW for the theoretical fire size. Therefore, a 4,059 kW fire will be used in the deposition calculation.

The ground contamination model assumes that the radioactive material is released in a range of particle sizes and is lofted to the equilibrium altitude of the thermal plume. As soon as the thermal plume reaches equilibrium height, the material is assumed to be released and to drift downwind to the ground while being dispersed horizontally and vertically. No credit is taken in the model for a stack or a closed structure. The effect of either a stack or structure would be to cool the plume and reduce its particulate load by internal fallout/plateout leading to a somewhat reduced ground contamination area. Since this facility is inside the 200 East Area, some portion of the falling material will deposit on hard surfaces such as streets, sidewalks, and building roof tops. Such hard surfaces are assumed to conservatively comprise 5 percent of the area within the plume. The rest of the area is assumed to be soil and gravel.

12.1.1.3 Source Term

The hoods and associated ductwork are the source of contamination in the PUREX laboratory. The tables previously listed in this section of the report present a breakdown of the inventory that is bounding for the various rooms and equipment. These tables form the basis for the deposition analysis contained below. The entire inventory of all hoods within the laboratory annex building is assumed to be available for release and is applied as input to the ground contamination model. Since under certain conditions, the fire in the decontamination room reached flashover; theoretically, the fire could spread throughout the entire laboratory complex and result in the entire inventory being released. The ground contamination model includes the effects of a release fraction, which is a function of particle size (and, therefore, fall velocity).

12.1.1.4 Methodology and Analysis Approach

The fire is normally specified in terms of a burn area to which the standard model area heat rate is applied. The standard heat rate per unit area in the facility fire ground contamination model (Hines 1994) is 9.48E+4 cal/m^2 (0.397 MW/m^2) based on a hot 50 percent wood – 50 percent plastic fire. The only function of the fire area in the facility fire ground contamination model is the determination of plume height as a function of fire heat rate. As discussed previously, CFAST predicts a peak heat release rate of 4,059 kW. This was input to the ground contamination model as an effective burn area of 10.2 m^2.

Formulas giving various parameters associated with the ground contamination contours have been previously developed and reported (Hines, 1994). Only the results applicable to this analysis will be given here for reference. The maximum downwind extent of contamination above a cleanup criterion C is given by:

$$x_L = \left(64.9 \frac{1}{C} A_F^{0.8407}\right)^{\frac{I}{m}} \qquad \textbf{Eq. 11-2}$$

where $m = 0.02940 \ln(A_F) + 3.248$, I is the inventory at risk, and A_F is the effective fire area in m^2. The maximum half-width of the contour (from the plume centerline) in meters is given by

$$y_W = 0.0461\sqrt{m}x_L^{0.9031} \qquad \textbf{Eq. 11-3}$$

y_W occurs at a downwind distance x_w given by

$$x_W = 0.575x_L \qquad \textbf{Eq. 11-4}$$

Finally, the area in m^2 contained within the contour defined by the contamination level C is given by

$$A_c = 0.0724\sqrt{m}x_L^{1.903} \qquad \textbf{Eq. 11-5}$$

These formulas are based on a tilted Gaussian plume model with a continuous particle size distribution. The particle size distribution derives from the cumulative release fraction developed in the basic ground contamination model. A cumulative release fraction is assumed of the form

$$F = 5.0E - 2v_g^{1.35} \qquad \textbf{Eq. 11-6}$$

where v_g is the gravitational drift velocity (m/s). This model fits the data (Sections 5.2.1.1 and 5.2.1.2 of DOE-HDBK-3010-94 [DOE 1994]) reasonably well when fitted to the points 1.0E-4 at 0.01 m/s and 5.0E-2 at 1.0 m/s. These two points correspond to particle sizes of about 10 µm and 100 µm, respectively, and represent average rather than bounding release fractions. Such a fit produces the numerical values 5.0E-2 and 1.35 appearing in the equation.

12.1.1.5 Cleanup Criteria

Accessible soil concentration limits for various isotopes are given in terms of pCi/g in Table 2-1 of DOE/RL-96-17 and Table 3-3 of DOE/RL-2001-11. For the case of an accident, however, the contamination will lie on the surface of the soil and is estimated in terms of Ci/m^2. The soil limit is normally converted to Ci/m^2 for accidents by assuming a minimum sample depth of 1 cm and a soil density of 1.6 g/cm^3. For a radionuclide mix, the sum of fractions rule applies. For this case the total inventory was given in terms of Ci of each isotope in the mix, which was converted to a sum of fractions as shown in Table 12-3, "Development of Cleanup Criterion for Soil."

Table 12-3. Development of Cleanup Criteria for Soil

Isotope	Inventory	Ci per Ci of Mix	200 East Area Soil Limit		Fraction of Limit per Ci of Mix
	(Ci)		*(pCi/g)*	*(Ci/m^2)*	*(m^2/Ci)*
Am-241	3.47E-03	3.43E-03	1.80E+02	2.88E-06	1.19E+03
Sr-90	4.00E-01	3.96E-01	2.80E+03	4.48E-05	7.25E+02
Pu-239	6.19E-03	6.12E-03	1.90E+02	3.04E-06	2.01E+03
Pu-240	2.27E-03	2.24E-03	1.90E+02	3.04E-06	7.38E+02
Cs-137	6.00E-01	5.93E-01	3.00E+01	4.8E-07	1.24E+06
TOTALS	1.01E+00	1.00E+00		Bounding	1.24E+06
Resulting Soil Cleanup Criterion (Ci/m^2)					8.07E-07

The reciprocal of the total sum of the fractions (Ci per Ci of mix / Ci per m^2) in the last column of Table 12-3 equals the Ci of mix per m^2, which produces a total sum of fractions equal to 1. The soil limit (C) for this mix is, therefore, Ci mix/m^2.

In applying cleanup standards for hard surfaces, the radionuclides are divided into several groups (transuranic [TRU], uranium, beta-gamma emitters, etc.) for which limits are applied separately. The lowest limit (and about the minimum detectable for alpha emitters in the field) for TRU residual removable hard surface contamination is 200 dpm/100 cm^2 (DOE 1990). The limit for a special group containing natural thorium, Th-232, Sr-90, Ra-232, Ra-224, U-232, 1-125, 1-126, 1-131, and 1-133 has the same limit of 200 dpm/100 cm^2. For beta-gamma emitters including mixed fission products containing Sr-90, the removable surface contamination limit is 1000 dpm/100 cm^2. Due to the presence of alpha emitters, the hard surface cleanup criterion for the PUREX laboratory is 200 dpm/100 cm^2. This results in a hard surface cleanup criterion (C) of 9.0E-09 Ci mix/m^2.

12.1.1.6 Modeling Results

The effective burn area of 10.2 m^2 produces m = 3.316. The releasable inventory is the sum of the isotopic inventory in the second column of Table 12-3, or 1.01E+00 Ci, for soil cleanup and hard surface cleanup. The resulting contamination areas characteristics for the two cleanup criteria are shown in Table 11-3 below. Each contamination cleanup area has a form very close to a long, narrow ellipse with a downwind length equal to x_L (Equation 11-2) and a maximum width equal to $2y_w$ (Equation 11-3) at a downwind distance x_w (Equation 11-4). For soil contamination, the total area inside the limit contour as given by Equation 11-5 is generally assumed to require cleanup. For hard surface cleanup, the affected area must be estimated by considering the amount of hard surface within the contour dimensions. The results are shown in Table 12-4, "Resulting Cleanup Area Contours."

Table 12-4. Resulting Cleanup Area Contours

Surface	Inventory (Ci)	Length xl(m)	Max Width At Location		Area Ac (m^2)
			$2y_w$ (m)	x_w (m)	
Soil	All	437.9	40.8	251.8	14,013
Hard	All	1,698.4	138.7	976.6	184,859

The cleanup concentration criterion for hard surfaces is much lower than that for soil; and, therefore, the affected area is much larger. Additionally, the cost of cleaning hard surfaces is much higher per unit area than that for scraping up contaminated soil and burying it. As the contamination areas are relatively small, the cleanup areas would be limited to land within and just outside of the 200 East Area.

Hard surface cleanup cost is estimated to be about \$38.20/m^2 based on a cleanup rate of 55 m^2/day at a cost of \$1,400/day with a 50 percent contingency factor in 1995 dollars (Benecke 1995) and then increased by 53 percent for inflation (DOE inflation values through 2016). The cleanup cost for soil is based on an incremental cost of \$5.49/m^2 derived from actual experience in cleaning up a large area of contaminated soil on the Hanford Site (Smith 1993), and again increased for inflation (since 1995). The cost of soil cleanup would be approximately \$122,000.

In addition, for hard surface cleanup, the ground fallout could contaminate about 184,859 m^2 in and just outside of the 200 East Area. Making a conservative assumption that 5 percent of this area is actual hard surface (roads, building roofs, etc.) leads to a hard surface cleanup area of about 9,243 m^2 with a cleanup cost of about $555,000 for a total of approximately $677,000. The 5 percent is conservative as the potential hard surface cleanup area is very great (with a very long plume), but there are minimal buildings and road surfaces in any plume direction.

12.1.1.7 Laboratory Annex Conclusions

Using the various fire values for the foam material, combined with standard energy release rate equations and CFAST modeling with the laboratory doors open, it can be shown that the peak heat release rate occurring in the decontamination room with the foam on the faces of all seven hoods involved in a fire is approximately 4,059 kW, and flashover would be reached in about 680 seconds. With the laboratory doors closed, flashover would not occur due to oxygen starvation and the maximum fire size reaches 3,200 kW in about 270 seconds.

If flashover were to occur (which could happen according to the CFAST scenarios conducted if the air-lock doors to the laboratory area and the outside doors were open), the maximum loss anticipated from contamination clean up would be less than $500,000. Even with the quantities of polyurethane foam in the laboratory area, and considering the release of all radiological inventory within the laboratory hoods, the postulated fires would not result in a loss approaching DOE limits. The deactivation activities have also reduced the ignition sources available within this facility. As a result, no additional fire protection or detection is recommended for this area during the S&M of the facility.

12.1.2 202-A Canyon Building

As discussed in Section 8, the only noteworthy combustibles in the canyon building are the plastic materials in and around the sample gallery glove box, wood framing in the storage gallery, a plywood box on the canyon deck, and lubrication oil in the process cells.

The most significant fire hazard in the canyon building is the lubrication oil for the mechanical pulsers in the process cells. The largest fire loading in a single process cell is located in the J cell. That cell has two mechanical pulsers that each contain up to 454 L (120 gallons) of lubricant. A potential fire in the J cell represents a worst-case condition for all of the fuel packages in the canyon building. The pulsers are separated by at least 3 m (10 ft) and do not have common process lines. The J cell was selected for the bounding analysis because of the type of fire hazard and the location of the potential fire with respect to the HEPA filters located in the 291-AE Filter Building. Although the N cell has a larger radiological inventory than the J cell, the J cell fire is considered to be bounding. J cell has a far larger combustible inventory and is closer to the filters. If the J cell fire does not ignite the filters, the smaller fire possible in N cell will not have an impact on the filters; and any contamination within the facility will remain confined within the facility.

A fire hazard associated with a process cell is significant because the mass of lubrication oil (240 gal) is substantially larger than the masses of the combustibles in the galleries. A combustible liquid fire in the process cell would also develop faster and burn longer than the fuel packages in the gallery areas. Furthermore, combustion products from J cell would flow directly into the ventilation exhaust tunnel, whereas emissions from a fire in the galleries would be substantially

dispersed before entering the exhaust tunnel. Thus, a process cell fire represents the most severe threat to the exhaust system HEPA filters located in the 291-AE Building.

Fire modeling, with the aid of CFAST 2.0.1 software, was used to evaluate the impact of a combustible liquid fire in the J cell. Conservative input data such as high ambient temperature, high combustion efficiency, large fuel mass, high ventilation airflow, and smaller than actual compartment dimensions were used in the model. The data input and output associated with the CFAST models are documented in WHC-SD-WM-FHA-013, Rev. 0 (1995). The CFAST models can be found in CHPRC-03127, Rev 0, *J Cell Fire Model Input and Output*. The results of fire simulation demonstrate that the 291-AE Filter Building would not be exposed to temperatures above the design properties for the HEPA filters. Thus, a fire in the canyon building will not cause unacceptable property damage or impact the health and safety of the public and site personnel.

12.1.3 291-AE, No. 4 Filter Building

The 291-AE, No. 4 Filter Building is a 40 m by 13 m by 5.6 m (123 ft by 41 ft by 17 ft) high reinforced concrete building that houses 10 modular HEPA filter units. Each unit consists of a stainless-steel inlet duct connected to a totally enclosed HEPA, stainless steel, filter housing that discharges into a stainless steel exhaust duct. Each HEPA filter enclosure has an in-place testing assembly, a 4 by 3 array of HEPA filters, and an outlet valve. Each HEPA filter has a 610 mm by 610 mm by 290 mm (24 in. by 24 in. by 11.5 in.) high fire-retardant-treated, four-sided plywood box supporting the filter media. The HEPA filters are Class I filters in accordance with UL Standard 900. A stainless-steel building exhaust ventilation unit is located in the northeast corner of this building. The roughing filter media is exposed at the air inlet of this unit.

The 291-AE, No. 4 Filter Building remains operational following plant deactivation. There are no exposed combustible materials in the building, all entry points are locked, and the only intrinsic ignition source (i.e., electrical cables) has been de-energized except during the periodic surveillance inspections. As discussed above in Section 12.1.2, the filter building would not be exposed to temperatures above the design properties for the HEPA filters during a worst-case fire in the 202-A Building. Thus, the HEPA filters are not vulnerable to damage from postulated fire incidents in 202-A or 291-AE structures.

12.1.4 291-A Exhaust Plenum, Fans, and Main Stack

The exhaust unit is powered by one of the three electric-powered fans. A single exhaust fan supplies ventilation to the 202-A Building complex; the remaining two fans are available for use as backups. The three existing 2.4-kV electric-motor-driven exhaust fans are separated from each other by a minimum of approximately 10 ft so an electrical fire in one will not affect the other fan. All electrical cable is routed in metallic conduit. There are no exposed combustible materials adjacent to or near these fan units, and it is not expected that any such materials will be added. The MPFL would involve the loss of one 2.4-kV electric motor, caused by an electrically induced fire. The MPFL is < $1,000,000 which includes a new motor, installation, and cleanup. A fire in the exhaust motor would not cause a radiological release because the motor is located outside of the plenum. The loss of the ventilation exhaust fans also would not result in a significant radiological release.

12.1.5 Substation 252AB

Substation-252AB is a 13.8/2.4-kV electrical unit substation that was installed to supply power to the PUREX facility exhaust ventilation and data acquisition systems. The electrical unit substation consists of overhead 13.8- kV electrical lines to the site, each feeding 13.8/2.4-kV, oil-filled, step-down transformers and 2.4/480-kV, oil-filled, step-down transformers. These lines are cross-tied to supporting switchgear. The electrical feed supplies power to the following:

- Ventilation exhaust fans.
- Unit substation (252-AC) providing surveillance lighting in the 202-A Building and annex complex; all interior surveillance lighting is de-energized and isolated except during the routine surveillance inspections.
- Building power for the 291-AE No. 4 Filter Building, the 292-AB main stack building, and the 217-A SAMCON unit.

The worst-case fire scenario would be an electrically induced, oil-filled transformer fire. The design provides adequate fire barriers, containment, and spatial separation in the system to preclude loss of any operating system. Based on the project estimate for the substation, the MPFL would be <$1,000,000. No radiological release would occur; therefore, no associated radiological cleanup cost would be incurred.

12.1.6 218-E-14 and 218-E-15 Railroad Storage Tunnels, Tunnel Collapse

The fire scenario analysis previously provided in this Section has been moved to Appendix B.

On May 9, 2017, a portion of the PUREX Tunnel No. 1 (218-E-14) wood timber roof structure was observed to have collapsed into the tunnel resulting in a hole approximately 19 ft wide × 17 ft long. Actual time of the collapse and cause of the failure has not been determined. Potential factors contributing to the collapse are speculated to include heavy rainfall on May 4th and 5th, deterioration of tunnel wood timber structural support members due to prolonged exposure to high levels of radioactivity, and influence of low vibration sources near the site such as local thunderstorms or distant low-magnitude seismic activity. Due to the uncertainty in the condition and structural integrity of the remaining roof and wall timber supports, measures were taken to prevent additional roof loads or personnel from being placed over top of Tunnel No. 1 and within the roof load zone of influence until permanent stabilization measures can be taken.

Uncompacted soil and gravel fill were placed through the roof opening at the collapsed area to stabilize the tunnel support walls and to cap and seal off the tunnel interior space from further exposure to the atmosphere. A temporary protective cover over was installed over the full length of Tunnel No. 1 to reduce soil loading over the tunnel by minimizing or eliminating rainfall water infiltration into the 8-ft high soil berm over the tunnel timber roof structure. The protective cover consists of water resistant tarpaulin material which has an expected design life on the order of months.

Construction of Tunnel 1 was completed in 1956 as part of the PUREX Plant construction project. The storage tunnel consists of three sections, a water fillable door, a storage area, and a ventilation shaft. The water fillable door located at the north end of the tunnel is housed in a

concrete structure. The water fillable door is 24.5 ft in height, 22 ft wide and 7 ft in depth, constructed of ½ in. thick steel plate and hollow to permit filling with water for radiation shielding. The storage area, which is the main portion of Tunnel 1, extends from the water fillable door south 358 ft to the ventilation shaft and is 22 ft in height and 19 ft wide with a 1 percent grade downward slope from north to south. The roof and walls are constructed of 12" x 14" rough sawn creosote pressure treated Douglas-Fir wood timbers with the exception that the first 100 ft of the east wall was constructed with 3-ft thick reinforced concrete. Timber wall supports bear on a 1 ft thick by 3 ft wide continuous unreinforced concrete footing. The timber structure is covered with 90-lbs mineral surface roofing material. A minimum depth of 8-ft of uncompacted soil fill was placed over the top of tunnel. The tunnel floor consists of two railroad track rails supported by 7" x 9" rough sawn creosote pressure treated Douglas-Fir wood timber railroad ties that extend between the wall footings to brace and support the base of the tunnel walls. Railroad ties are laid on a gravel bed with spaces between ties filled with gravel ballast to the top of members.

The ventilation shaft is located at the south end of the tunnel. The shaft is approximately 5 ft by 5 ft in cross section and constructed of reinforced concrete. The ventilation shaft protrudes approximately 1 ft above grade and capped with a single stage high efficiency particulate air filter, an exhaust fan, and a stack at 20-ft in height. The ventilation system is not in operation. The tunnel was filled to its capacity in 1965 with eight rail cars, each of 40 ft to 42 ft in length, containing radioactive process equipment. Tunnel 1 remains in the aforementioned state while the structural evaluation and recommended resolutions for Tunnel 1 is completed.

Tunnel 2 (218-E-15) is under a structural evaluation and based upon that analysis Tunnel 2 might also be unstable.

12.1.7 Tunnel Stabilization

An engineered cementitious grout will be used to stabilize Tunnel 1. The stabilization process will limit further collapse of the tunnel. This approach will allow relatively easy implementation in a short period of time while acting as a built-in shielding from contamination. Grout can be tailored to specific compressive strengths, and can be engineered for flow characteristics to access small spaces, and tailored cure times.

Based upon the structural analysis of Tunnel 2, it may also be stabilized in a method similar to Tunnel 1.

Combustible liquids and solids may be present within the inventory of the tunnel. For example silver nitrate solids are described as present in Tunnel 2. However, none of the chemicals identified is water reactive or known to be reactive with the grout constituents during curing.

12.1.8 Waste Staging Area Fire

The staged waste storage area will be utilized for staged waste containers. The fire described here corresponds with Section 3.4.6 of the DSA.

Waste from S&M, waste removal, and contingency activities will generate contaminated waste. These wastes will result in various waste packages staged for transport and disposal.

<u>Scenario Development</u>: For this event the following is assumed:

- A fire is assumed to occur that involves the staged waste.
- TRU and TRU-mixed wastes will be staged in steel waste disposal boxes (SWDBs).
- A fire involving 10 combustible waste boxes at the waste staging area is considered the MPFL.

Source Term: The inventory is estimated to represent the maximum TRU inventory that will be located in the staging area. The staged waste consists of waste associated with contamination control (i.e., step-off waste, contaminated tools or consumables, PPE, etc.). The analysis in Section 3.4.2.2 of the DSA assumes that the packaged waste contains an inventory equivalent to 100 grams of 239 Pu and a proportional amount of other isotopes based on the A cell composition.

The estimated cleanup costs for a staged waste area fire involving both 1 and 10 waste boxes and all estimated inventory on the pad is calculated as follows:

- Fuel for the PUREX Facility staged waste storage area MPFL fire consists of 10 boxes, 4 ft by 4 ft by 8 ft made of ¾-in. plywood that contain staged waste
- The total surface area of the boxes is 1,280 ft^2 (119 m^2)
- The mass loss rate for wood (M") is 2.86E- 2 lb/m^2s
- The heat of combustion for wood (h_c) is 8,000 BTU/lb
- The peak heat release rate for one sheet of plywood can be calculated

$q'' = (M'')(h_c)(A) = (2.86E\text{-}2\ lb/m^2s)(8{,}000\ BTU/lb)(3\ m^2) = 686\ BTU/s$

where

Total (q″) = 686 BTU/s (4) (10) = 27,440 BTU/s (29 MW).

Using this calculation, 1 box will equate to a fire of 2.9 MW. This value will be used to calculate the MCFL in Section 12.7.

The results of using the Himes model (Himes 1994) to estimate cleanup costs associated with the MPFL fire are shown in Figures 12-5 and 12-6.

Building PUREX Document 100 g assumed in 10 boxes Engineer SC Wallace Date 18 June, 2009

Inputs			Instructions
Fire Size	29	(MW)	Any Number greater than 0
Hard Surface in Plume	1	(%)	Enter % as whole number (5, 10, etc.) OR total square meters (20000, etc.)
Hanford Site Area	200	(Location)	100, 200, etc. USE DROP DOWN BOX
Inflation Multiplier	35	(%)	Enter % as whole number (5, 10, etc.) - based on 1995 dollars
Inventory Reduction	1.00E+00	(Fraction of mix)	Use Cautiously! The model already utilizes an equivalent release fraction of 1E-04. Apply for mat'l in pipes, tanks, etc.

Isotope Breakdown (for Soil Cleanup and Hard Surface Designation)

Isotope (use drop down box)	Original Inventory (Ci)	Modified Inventory (using MAR RF) (Ci)	Ci per Ci of Mix	Soil Limit for the 200 Area (pCi/g)	Soil Limit for the 200 Area (Ci/m²)	Fraction of Limit per Ci of Mix (m2/Ci)	Hard Surface Cleanup Criteria dpm/100 cm²	Hard Surface Cleanup Criterion (Ci/m²)	Comments
Pu-239	6.21E+00	6.21E+00	1.25E-02	4.3E+02	6.80E-06	1.84E+03	20	9.00E-10	
Pu-240	3.57E+00	3.57E+00	7.21E-03	4.3E+02	6.80E-06	1.06E+03	20	9.00E-10	
Am-241	1.03E+01	1.03E+01	2.08E-02	3.4E+02	5.36E-06	3.88E+03	20	9.00E-10	
Sr-90	2.12E+02	2.12E+02	4.28E-01	2.4E+03	3.86E-05	1.11E+04	1,000	4.50E-08	
Cs-137	2.61E+02	2.61E+02	5.27E-01	2.3E+01	3.74E-07	1.41E+06	1,000	4.50E-08	
Pu-238	2.39E+00	2.39E+00	4.82E-03	3.7E+01	5.98E-07	8.06E+03	20	9.00E-10	
Total	4.95E+02	4.95E+02	1.00E+00		1.43E+06				
			Resulting Soil Cleanup Criterion (Ci/m²)		6.98E-07				

Cleanup Contours

Surface	Inventory (Ci)	Cleanup Criterion (Ci/m²)	Length X_L (m)	Max. Width $2y_w$ (m)	At Location x_w (m)	Area A_D (m²)	
Soil	4.95E+02	6.98E-07	4,214	318	2,423	1,050,925	
Hard-20 dpm/100 cm²	2.25E+01	9.00E-10	12,103	824	6,959	7,826,594	<<<Bounding Hard Surface Values
Hard-200 dpm/100 cm²	0.00E+00	9.00E-09	0	0	0	0	
Hard-1,000 dpm/100 cm²	4.73E+02	4.50E-08	9,366	654	5,385	4,804,787	
Hard-10,000 dpm/100 cm²	0.00E+00	4.50E-07	0	0	0	0	

	Unit Cleanup Cost	Cleanup Area	Cleanup Costs
Soil Cleanup	$7.58 /m²	1,050,925 m²	$7,962,015
Hard Surface Cleanup	52.72 /m²	78,266 m²	$4,125,867
Total			$12,087,882

Version 1 - 04/09/2003

Figure 12-1. Staged Waste Pad Fire Estimated Cleanup Costs for a Fire Involving Ten Waste Boxes and Estimated Inventory on the Pad

The entire inventory is assumed to be available for release and is applied as input to the ground contamination model.

The ground contamination model assumes that the radioactive material is attached to the flying ash from the fire, which is released in a range of particle sizes and is lofted to the equilibrium altitude of the thermal plume. As soon as the thermal plume reaches equilibrium height, the material is assumed to be released and to drift downwind to the ground while being dispersed horizontally and vertically. The ground contamination model includes the effects of a release fraction which is a function of particle size (and therefore fall velocity) and the effects of particle size during the dispersion of the material on the way to the ground. The contamination contours are approximately elliptical and are characterized by a length downwind from the source, a maximum width that occurs at a location slightly more than halfway down the length of the contour, and an area within the contour. As expected, the larger particles fall closest to the source while the finer particles tend to be carried farther downwind before hitting the ground.

Accessible soil concentration limits for various isotopes are given in terms of pCi/g in Table 2-1 of DOE/RL-96-17 and Table 3-3 of DOE/RL-2001-11. For the case of an accident, however, the contamination will lie on the surface of the soil and is estimated in terms of Ci/m^2. The soil limit is normally converted to Ci/m^2 for accidents by assuming a minimum sample depth of 1 cm and a soil density of 1.6 g/cm^3. For a radionuclide mix, the sum-of-fractions rule applies when formulating a cleanup criterion for soil. That is, the total of the ratios of each isotope concentration to its respective limit is equal to 1.

In applying cleanup standards for hard surfaces, the radionuclides are divided into several groups (TRU, uranium, beta-gamma emitters, etc.) for which limits are applied separately. The lowest limit (and about the minimum detectable for alpha emitters in the field) for TRU residual removable hard surface contamination is 20 dpm/100 cm^2 (DOE 1990).

The resulting contamination area characteristics for the two cleanup criteria are shown above in the associated table for each fire. Each contamination cleanup area has a form very close to a long, narrow ellipse with a downwind length equal to x_L and a maximum width equal to $2y_w$ at a downwind distance x_w. For soil contamination, the total area inside the limit contour is generally assumed to require cleanup. For hard surface cleanup, the affected area must be estimated by considering the amount of hard surface within the contour dimensions.

The cleanup concentration criterion for hard surfaces is much lower than that for soil; and therefore, the affected area is much larger. Additionally, the cost of cleaning hard surfaces is much higher per unit area than that for scraping up contaminated soil and burying it.

Hard-surface cleanup cost is estimated to be about \$38.20/m^2 based on a cleanup rate of 55m^2/day at a cost of \$1,400/day with a 50 percent contingency factor (Benecke 1995). The cleanup cost for soil is based on an incremental cost of \$5.49/m^2 derived from actual experience in cleaning up a large area of contaminated soil on the Hanford Site (Smith 1993). These figures are for onsite cleanup and the cleanup cost values used have been adjusted for inflation. The 2008 values shown in Figure 12-5 and Figure 12-6 when the Himes model was run have been increased by 38 percent.

Table 12-10 summarizes cleanup costs for the staged waste area MPFL as well as showing cost of a fire in one box on the staged waste pad. The 2016 loss estimate values in the table have been increased by an 11 percent inflation adjustment over 2008 values. By implementing recommendations in Section 24, this fire can be restricted to one box and cleanup costs will be significantly reduced.

Table 12-5. Cleanup Costs for MPFL Scenario – 10 Box Staged Waste Fire

Property and/or Equipment at Risk	DOE M231.1 App. F Ref.	Specific Item	Loss Estimate	Comment
Cost for damage or loss of facilities, inventories, etc.	9.a.(1)	Use of building and contents	$0	The plume from the fire could impact nearby facilities and result in loss of use of those facilities until cleanup operations are completed. However, per DOE M 231.1, App. F, 9.b.(1), the loss estimation can exclude any expense solely associated with loss of use or occupancy of a facility.
Cost to restore property to pre-fire condition or market value of property and equipment	9.a.(2) 9.a.(3) 9.a.(4) 9.a.(5)	Building and contents	$0	The building is in an S&M and decontamination mode awaiting demolition. No market value is assigned as the building would have no anticipated private industry use.
Post-fire cleanup costs (deposition cleanup)	9.a.(6)	Soil and hard surfaces	**$13,400,000**	Soil and hard surface contamination cleanup
Cost of recharging fire suppression systems	9.a.(7)	Sprinklers	$0	No anticipated cost
Cost for damage to privately owned property	9.a.(8)	Vehicles, etc.	$1,650,000	With southeast winds, it is assumed that 100 cars are contaminated at nearby facilities within the plume. The cost of decontamination or replacement is $16,500 per car.
Cost for restoration of land and land improvements, investigations, and stand-down	9.a.(9) 9.a.(12) 9.a.(13) 9.a.(14)	Varies	See comment	This is covered by the post-fire cleanup cost estimate.
Labor costs to mitigate losses and non-standard work hours	9.a.(10)	Specialists, decontamin-ation activities	$480,000	Assume 8 workers for 16 hr/day for 30 days (6 weeks) at $125/hr for special decontamination activities to restore work at nearby facilities.
Cost of lost revenue and production	9.a.(11)	Lost production operations	$0	The PUREX Facility is not in production mode.
TOTAL			**$15,530,000**	

12.2 Analysis of Worst-Case Automatic Fire Protection System Malfunction

All automatic fire protection systems have been deactivated. See Section 14 for more information.

12.3 Failure of Safety Systems Impact on Function

There are no safety-class or safety-significant systems, structures, and components (SSCs) identified in Section 4.1.1 of the DSA at the PUREX facility.

12.4 Radiological Dispersal Potential within Facility

The confinement ventilation system is located remotely from the bounding case fire in Storage Tunnel No. 1. Because of the long distances and arduous path that smoke and heat would be required to take to get to the filter system, damage to the system is not considered likely. Loss of ventilation is considered anticipated in the hazard analysis with a consequence of low.

12.5 Off-site Impact

The building structure does serve, to some extent, as a confinement barrier. As a result, the building structure is identified as defense-in-depth equipment. The USQ program and the engineering program are both key elements of applicable contractor SMPs that ensure configuration control of the confinement features.

The 202-A Building (analytical laboratory, canyon area, and glovebox areas) and the 218-E-14 and 218-E-15 railroad storage tunnels do have the potential to release contamination to the environment as the result of a fire and are further analyzed in Section 12.1.

12.6 Maximum Possible Fire Loss (MPFL)

The PUREX Complex buildings and their contents have all been devalued. The costs within the MPFL calculations are for contamination cleanup associated with the accident scenarios.

12.6.1 MPFL Scenario

The MPFL scenarios are represented by a fire in Storage Tunnel 1, as detailed in Section 12.1.6, and a staged waste area fire, detailed in Section 12.1.7. The MPFL for storage Tunnel 1 was estimated at $17,072,000. The estimated MPFL for the staged waste area fire is $15,530,000.

12.7 Maximum Credible Fire Loss

The MCFL is typically defined as the property damage that would be expected from a fire assuming the following:

- All installed fire protection systems functioned as designed.
- The effect of emergency response is omitted except for post-fire actions such as salvage work, and restoring operation.

Maximum credible fire loss estimates are based upon the operation of the installed fire protection systems. Because the PUREX Facility has no fire protection system, the MPFL and the MCFL are the same. In the case of the waste staging area at PUREX, combustible controls are in place to limit the fire to one fuel package. Section 24.2.1, Recommendation 3, 2nd bullet recommends a 10 ft separation between combustible waste storage boxes. This recommendation is implemented through 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX*

Facility. Since the separation distance requirement functions to limit fire spread from one box to adjacent boxes, a one box fire could be viewed as an MCFL event though not per the strict definition of an MCFL event. A one box fire is the most likely fire scenario on the waste storage pad. The FHA evaluates a one box staging area fire as the MCFL event.

Building PUREX (202 Document 10 grams in one waste box Engineer SC Wallace Date 18 June, 2 008

Inputs

			Instructions
Fire Size	2.9	(MW)	Any Number greater than 0
Hard Surface in Plume	1	(%)	Enter % as whole number (5, 10, etc.) OR total square meters (20000, etc.)
Hanford Site Area	200	(Location)	100, 200, etc. USE DROP DOWN BOX
Inflation Multiplier	38	(%)	Enter % as whole number (5, 10, etc.) - based on 1995 dollars
Inventory Reduction	1.00E+00	(Fraction of mix)	Use Cautiously! The model already utilizes an equivalent release fraction of 1E-04. Apply for mat'l in pipes, tanks, etc.

Isotope Breakdown (for Soil Cleanup and Hard Surface Designation)

Isotope (use drop down box)	Original Inventory (Ci)	Modified Inventory (using MAR RF) (Ci)	Ci per Ci of Mix	Soil Limit for the 200 Area (pCi/g)	Soil Limit for the 200 Area (Ci/m²)	Fraction of Limit per Ci of Mix (m2/Ci)	Hard Surface Cleanup Criteria dpm/100 cm²	Hard Surface Cleanup Criterion (Ci/m²)	Comments
Pu-238	6.21E-01	6.21E-01	1.25E-02	4.3E+02	6.80E-06	1.84E+03	20	9.00E-10	
Pu-240	3.57E-01	3.57E-01	7.21E-03	4.3E+02	6.80E-06	1.06E+03	20	9.00E-10	
Am-241	1.03E+00	1.03E+00	2.08E-02	3.4E+02	5.36E-06	3.88E+03	20	9.00E-10	
Sr-90	2.12E+01	2.12E+01	4.28E-01	2.4E+03	3.86E-05	1.11E+04	1,000	4.50E-08	
Cs-137	2.61E+01	2.61E+01	5.27E-01	2.3E+01	3.74E-07	1.41E+06	1,000	4.50E-08	
Pu-239	2.39E-01	2.39E-01	4.82E-03	3.7E+01	5.98E-07	8.06E+03	20	9.00E-10	
Total	4.95E+01	4.95E+01	1.00E+00			1.43E+06			
			Resulting Soil Cleanup Criterion (Ci/m²)			6.98E-07			

Cleanup Contours

Surface	Inventory (Ci)	Cleanup Criterion (Ci/m²)	Length X_L (m)	Max. Width $2y_w$ (m)	At Location x_w (m)	Area A_w (m²)	
Soil	4.95E+01	6.98E-07	1,387	115	798	125,603	
Hard-20 dpm/100 cm²	2.25E+00	9.00E-10	4,072	305	2,341	974,860	<<<Bounding Hard Surface Values
Hard-200 dpm/100 cm²	0.00E+00	9.00E-09	0	0	0	0	
Hard-1,000 dpm/100 cm²	4.73E+01	4.50E-08	3,134	241	1,802	592,401	
Hard-10,000 dpm/100 cm²	0.00E+00	4.50E-07	0	0	0	0	

	Unit Cleanup Cost	Cleanup Area	Cleanup Costs
Soil Cleanup	$7.58 /m²	125,603 m²	$951,590
Hard Surface Cleanup	52.72 /m²	9,747 m²	$513,802
Total			$1,465,392

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Figure 12-2. Staged Waste Pad Fire Estimated Cleanup Costs for a Fire Involving One Waste Box and Estimated Inventory on the Pad

Table 12-6. Cleanup Costs for MCFL Scenario – One Waste Box Staged Waste Fire

Property and/or Equipment at Risk	DOE M231.1 App. F Ref.	Specific Item	Loss Estimate	Comment
Cost for damage or loss of facilities, inventories, etc.	9.a.(1)	Use of building and contents	$0	The plume from the fire could impact nearby facilities and result in loss of use of those facilities until cleanup operations are completed. However, per DOE M 231.1, App. F, 9.b.(1), the loss estimation can exclude any expense solely associated with loss of use or occupancy of a facility.
Cost to restore property to pre-fire condition or market value of property and equipment	9.a.(2) 9.a.(3) 9.a.(4) 9.a.(5)	Building and contents	$0	The building is in an S&M and decontamination mode awaiting demolition. No market value is assigned as the building would have no anticipated private industry use.
Post-fire cleanup costs (deposition cleanup)	9.a.(6)	Soil and hard surfaces	$1,626,000	Soil and hard surface contamination cleanup.
Cost of recharging fire suppression systems	9.a.(7)	Sprinklers	$0	No anticipated cost.
Cost for damage to privately owned property	9.a.(8)	Vehicles, etc.	$1,650,000	With southeast winds, it is assumed that 100 cars are contaminated at nearby facilities within the plume. The cost of decontamination or replacement is $16,500 per car.
Cost for restoration of land and land improvements, investigations, and stand-down	9.a.(9) 9.a.(12) 9.a.(13) 9.a.(14)	Varies	See comment	This is covered by the post-fire cleanup cost estimate.
Labor costs to mitigate losses and non-standard work hours	9.a.(10)	Specialists, decontamin-ation activities	$480,000	Assume 8 workers for 16 hr/day for 30 days (6 weeks) at $125/hr for special decontamination activities to restore work at nearby facilities.
Cost of lost revenue and production	9.a.(11)	Lost production operations	$0	The PUREX Facility is not in production mode.
TOTAL			**$3,756,000**	

12.8 Recovery Potential

The ability of the 202-A exhaust system HEPA filters to survive the anticipated fire incidents has been demonstrated in Section 12.1. Fire damage to the HEPA filter is not expected as a result of the postulated fire events.

Only one of the existing, electrical, motor-driven exhaust fans is needed to provide sufficient negative pressure to ensure that air flow will be from the clean areas in the 202-A Building to radioactive contaminated areas and exhausted, via the ducts and HEPA filters, through the main stack.

The potential for toxic, biological, or radiation incidents caused by a fire is considered negligible for all buildings except Storage Tunnel No. 1 and the laboratory annex in the PUREX complex.

The fire in Storage Tunnel No. 1 could result in a structural failure and contamination spread beyond the tunnel perimeter. The area of contamination would be a function of the quantity of contamination material and the activity of the material. The damage resulting from a pool fire in the tunnel area includes ground contamination resulting from the airborne release of radionuclides. Radionuclide contamination could potentially be dispersed to the atmosphere from a fire involving the flammable/combustible liquid. Cleanup costs from the uniform dispersal of mixed waste are conservatively estimated to be $17,072,000.

The laboratory hood exhaust ducts, which have surface contamination, have been sealed with closed cell expand-in-place polyurethane foam. Possible fires involving the foam in the laboratory hoods have been reviewed with details provided in Section 12.1.1. Even if flashover were to occur, the resultant cleanup costs would be well below DOE limits.

For all other areas of the PUREX complex, there are no appreciable quantities of special nuclear material, radioactive materials, or hazardous or dangerous material in a form or location that would threaten Hanford personnel, the public, or the environment as a result of fire. Considerable surface contamination exists in the cells, the canyon, and the air ducts; however, release of the surface contamination from this area is not likely. As discussed throughout Section 8.1, the combustible materials have been substantially reduced within the buildings and structures. Loss of ventilation is anticipated to be an abnormal event. However unlikely, a fire coincidental with a loss of ventilation could result in negligible to minor amounts of leakage. Because of the limited combustibles that remain, the postulated fire events do not lead to catastrophic structural damage. The confinement features attributed to the PUREX structures are not predicted to be significantly influenced by the postulated fires.

The PUREX plant is shut down, and deactivation activities have been completed. Recovery from a fire incident would be limited to decontamination and stabilization. Because the facility does not have an identified future mission, programmatic delay is not a factor for consideration.

A recovery plan for the storage tunnels has not been developed. Factors that will impact the recovery plan include the extent of radiological release and associated air and ground contamination, as well as the extent of tunnel damage. Priority would be placed on limiting any further contamination that could result from the damaged tunnel structure. The pre-fire plan calls for no entry into the tunnels and the focus would be to have the cars and equipment buried to reduce the release of contamination spread. No efforts would be made to recover tunnel inventory or to restore the structure to its current state. Recovery efforts would involve remediation of the resulting surface contamination.

13.0 DSA Design Basis Fire Scenario

The analysis in Section 12.6 is considered to be bounding, however it is recognized that new approaches and activities may occur that may be outside the bounds of this FHA. Any activities outside of the bounds of this FHA shall be evaluated and documented via Fire Protection Program requirements and incorporated into a revision to this document when its next revision is due or as conditions dictate. The DSA considered the fire scenarios described in the following subsections.

13.1 Aircraft Impact to the 202-A Building

The event considered a localized failure of the 202-A Building due to an aircraft impact. In accordance with DOE-STD-3014-2006, *Accident Analysis for Aircraft Crash into Hazardous Facilities*, an evaluation was performed to assess the frequency of an aircraft crash at the PUREX Facility. The details of the frequency analysis are documented in CP-56944, *CP S&M Aircraft Impact Frequency Analysis: PUREX*.

13.2 Staged Waste Fire

This operational event involves an outside fire affecting staged waste. S&M activities generate contaminated waste. Typically, the waste packages are limited to incidental LLW associated with contamination control of S&M activities. However, conditions may require risk-reduction activities that could lead to TRU waste from deactivated process components. This waste could generate waste packages staged for transport and disposal.

13.3 Fire in PUREX Storage Tunnel 1

In this analysis, a fire was postulated in PUREX Storage Tunnel 1. There are no active systems in the storage tunnels and the entrances are sealed, preventing personnel access.

13.4 N Cell Fire

This operational event involves a fire in N cell, as briefly discussed in Section 12.1.2 of this FHA.

14.0 Fire Protection Features

This section describes the deactivation history and the passive and active fire protection features remaining in the PUREX Facility.

14.1 Special Fire Protection Features

There are no special fire protection features.

14.2 Safety Class (SC) Fire Protection Features

An engineered safety feature is an SSC that prevents and/or mitigates the consequences of all potential accidents, including the design basis accidents. A Safety Class item provides protection of the offsite public and environment. In accordance with the PUREX DSA, CP-14977, Rev. 10, there are no safety-class SSCs identified for S&M or D&D activities at the PUREX Facility.

14.3 Safety Significant (SS) Fire Protection Features

In accordance with the PUREX DSA, there are no safety-significant SSCs identified for S&M activities at the PUREX Facility. The DSA identifies the PUREX Facility structures, which include the 202-A Building canyon walls, roof, and cover-blocks; deep-bed filters 1 and 2; and Storage Tunnels 1 and 2 as providing for defense-in-depth and are, therefore, considered Important to Safety (ITS).

14.4 Water Supply and Distribution System

Water for the 200 Area is drawn from the Columbia River at the 100-B Pumping Station and from two clean water wells. The water is pumped through a piping system known as the export water system. Pumps at the 100-D Pumping Station are tied into this system and serve as a backup.

Within the 200 East Area, export water is pumped to a reservoir at 282-E, which has a storage capacity of 3 million gallons. The water is pumped directly to plants in the 200 East Area as raw water for process, or it is pumped indirectly to the 282-E Building for conversion to sanitary water by chlorination and filtration. The other supply lines that extended around the PUREX Facility have been isolated and drained.

The water isolation was accomplished outside of the PUREX exclusion area, east of the junction that supplies a portion of 200 East Area tank farms with sanitary water. The PUREX sanitary water 2901-A high tank was shut down and permanently isolated. The purpose of the 2901-A water tank was to provide backup sanitary supply within the PUREX Facility. Fire protection water studies for the 200 East Area do not take credit for the availability of Tank 2901-A. Thus, the tank is not necessary for fire protection purposes within the PUREX Facility or for other structures in the 200 East Area.

Because the current raw water system supplying the PUREX facilities also provides water to a portion of the 200 East Area Tank Farm (specifically 241-A Tank Farm, 242-A Building, and

244-AR), the supply line through the PUREX exclusion area will be maintained. All of the lines from the main supply line (which currently supply facilities within the PUREX enclosure, with the exception of the previously mentioned fire hydrants) were capped or blanked.

14.4.1 Fire Hydrants

Water is available inside the PUREX fenced boundary for manual firefighting activities from the raw system. Fire hydrant S1A from the sanitary water system, also inside the fenced boundary, was available but was deactivated on September 28, 2011. Raw water hydrants R06A and R10A are located within the fenced boundary. The most recent flow tests of these hydrants are shown in Table 14-1. Due to unexpected difficulties during the test of hydrant R06A on October 26, 2015, the decision was made to perform a single-hydrant test in accordance with *Fire Systems Site-Wide Test procedure* FS0023 in lieu of the standard fire flow test.

Table 14-1. Hydrant Water Flow Test Results.

Test Hydrant	Static Pressure (psi)	Residual Pressure (psi)	Flowrate (gpm)	Flowrate (gpm) @ 20 psi	Flow Hydrant	Test Date
*R06A	118	92	583	1193	A-R-06A	10-26-2015
R10A	120	105	1137	3168	A-R-18E	12-14-2015

* Single hydrant test in accordance with Fire Systems Site-Wide Test procedure FS0023A.

14.5 Fire Suppression

Buildings at the PUREX Facility have been devalued; therefore, automatic suppression systems are no longer required for property protection. Prior to deactivation, many portions of the PUREX Building and annexes contained wet-pipe sprinkler systems. These systems have been deactivated and placed out of service. Deactivation of the wet pipe sprinkler systems occurred before any formal and proceduralized fire protection system deactivation process existed.

All special hazard suppression equipment was deactivated when the hazards were eliminated. These system deactivations were coordinated with the HFD Fire Marshal.

There is no restriction on the use of water for fire-fighting activities within the facility.

14.5.1 Manual Fire Suppression System

While all of the sprinkler systems within the PUREX Complex have been isolated and removed from service, the systems were configured in such a way that they could still be used during an emergency by HFD personnel utilizing the fire department connections on these systems to pump fire water into the sprinkler systems. There is no configuration control, maintenance, or testing of these systems; and they are not credited in the analysis. However, they may be of value during an emergency.

14.5.2 Portable Fire Extinguishers

The portable fire extinguishers have been removed from the PUREX Complex buildings.

14.6 Protective Signaling Systems

The detection and alarm systems are not required for mitigation of design basis accidents (no credit is taken for their operation). The 202-A Building has no fire detection and/or alarm system. After the building and office areas were considered unoccupied, the detection and alarm systems were not necessary for compliance with the Life Safety Code (NFPA 101).

14.6.1 Fire Detection Systems

The new 217-A SAMCON monitoring facility and the 252-AB electrical distribution facility are equipped with smoke detection and alarm systems. Each building contains smoke detectors, local alarms, pull boxes, and active radio fire alarm signal (RFAR) panels for immediate notification to the HFD. The factory-installed, automatic carbon dioxide suppression systems for both facilities were not placed in service. The carbon dioxide systems were specified by the deactivation contractor as part of the package for these pre-assembled units. A review of the code and/or regulatory basis determined that there was not a requirement for these systems. Because these systems are not required and there are a number of code-deficient details with the system that was installed, the HFD Fire Marshal's office recommended that the carbon dioxide systems not be placed in service. The carbon dioxide bottles were not installed.

14.6.2 Notification System

The PUREX facility is normally unoccupied, however means shall be provided for emergency notification (i.e., cell phone or radio) during periods of surveillance, work activities, or tours.

15.0 Fire Protection of Vital Safety Systems that have a Safety Function During or Following a Fire

No vital safety systems are present in the PUREX facility.

15.1 Confinement Ventilation Systems

The ventilation system for the 202-A Building was modified to support the S&M phase of the facility's lifecycle. At the completion of the deactivation project, the ventilation systems were either blanked or consolidated to flow to the 291-A Main PUREX Stack (Figure 5-5).

A negative pressure will continue to be maintained inside the 202-A Building process canyon with the exhaust through the 61 m (200 ft) stack. Airflow through the canyon galleries is routed to the canyon. Openings were made in existing gallery rooms and closed ventilation duct systems so that a cascade-type airflow supports the building exhaust ventilation system. The ventilation system changes do not adversely impact fire safety because the 202-A Structure is analyzed as a single fire area. The ventilation system will continue to flow air from clean areas to progressively more contaminated areas.

The supply fans for the 202-A and 271-AB annexes were shut down as part of the plant deactivation process. Building ventilation air enters through the existing ventilation annex supply ducts into the P&O gallery, sample gallery, and storage galleries. The supply fans were disconnected and controlling dampers were installed on the inlets. One of the 291-A exhaust stack 2.4-kV motor-driven fans operates to draw air through the 202-A Building. One additional backup motor driven fan may be used, should the first fan fail or otherwise be out of service. The air flows into the P&O gallery in the center of the building, flows through the white room at the west end of the P&O gallery and is routed to the canyon deck through the canyon lobby (Figure 5-5). The airflow into the sample gallery enters at the center of the gallery and is routed to the canyon crane way via the stairwell at the northeast end of the building. The airflow into the storage gallery enters the center of the gallery, cascades through the Q cell, PR room, and N cell glovebox rooms, into the hot shop, and is tied into the air tunnel. Wherever possible, the engineered ventilation path cascades through portions of the existing ductwork and through as much of the building as possible. New ductwork and control louvers were installed to provide control and to maintain airflow, preventing contamination movement into the clean areas of the plant.

The air flowing into the canyon from the P&O and sample galleries flows downward into the process cells in the spaces around the coverblocks on the canyon deck. The air then flows into the air tunnel through air holes in the walls at the bottom of each cell, where it combines with the sample gallery airflow. The air tunnel exhausts through an underground duct to the No. 2 deep-bed filter, the No. 4 filter building, and the fan. The tunnel then discharges through the 61 m (200 ft) main stack to the atmosphere. The No. 1 and No. 3 filter housings have been isolated and bypassed.

Loss of ventilation due to a fire or other incident will not jeopardize plant safety. The filter system fans are not safety class or safety significant because loss of the fans will not result in undue risk. The amount of radiological material in the building available for movement by wind

or natural convection draft is minimal. The possibility of radiological material release caused by the ventilation system shutdown is not a significant hazard (SAIC 1996).

The ventilation systems for the railroad storage tunnels, located in the 202-A Building are isolated and no longer in service. These tunnels are physically separated from all other PUREX Buildings. The ventilation system in the office and laboratory annexes, located on the north side of the canyon building, are isolated and no longer in service. The annex areas are separated from the canyon building by a 2-hr fire rated wall.

16.0 Life Safety Analysis

The Tunnel 1 stabilization project area is an Industrial Safety issue and does not fall within the scope of Life Safety.

The PUREX Facility was unoccupied in August 1996. All office equipment, shop equipment, and support equipment of value was removed from the buildings. PUREX is not open or accessible to the public. Workers are not assigned to a fixed space within the facility. The facility is classified as unoccupied in accordance with the Life Safety Code (NFPA 101). The S&M maintenance and tours do not constitute "occupancy" and are subject to the facility access control procedures.

Until the facility transitions to D&D activities, a reasonable and appropriate level of life safety features must be maintained at the facility. The Life Safety Code indicates that modifications to code requirements are permitted to allow alternative arrangements; however, in no case shall a modification provide less safety than would be provided by complying with the code provisions. Therefore, site-specific life safety requirements have been identified to account for the existing and future occupant loads, facility operations, and building fire hazards. A reasonable level of life safety can be provided at PUREX by implementing the appropriate requirements from NFPA 101, NFPA 241, and 29 *Code of Federal Regulations* (CFR) 1926. Based upon a review of the cited documents, the following life safety features will be maintained in the 202-A structure throughout the S&M lifecycle. These recommendations provide a reasonable and appropriate level of life safety for current operations.

Standard Recommendation: Safety/Egress

- Facility entry is limited to no more than ten people. If more than ten people are required to enter the facility, notify the HFD dispatch prior to entry and provide the number and location of the personnel to be present.
- Two independent and separate exits must be available for entry into facilities. If two separate exits are not available, obtain approval of the FPE prior to entry.
- A mechanism for two-way communications must be maintained for each separate party/group entering an S&M facility.
- Means shall be provided for emergency notification (i.e., cell phone or radio) during periods of surveillance, work activities, or tours.
- Each party/person entering an S&M facility will carry flashlights or other acceptable transportable lighting as a precaution for failure of general lighting or electrical service.
- The FPE, or delegate, shall conduct and document annual inspections of all facilities. These inspections will document that:
    - General combustible loading conditions are within allowable limitations and consistent with analyzed accidents; and
    - Egress requirements are maintained for allowed surveillance pathways.

The facility has been transitioned into an S&M mode and is in the process of transitioning into D&D activities. The facilities are entered infrequently for surveillance and some maintenance activities to assess integrity and degradation issues for unoccupied facilities and to ensure the continued safety of personnel entering for S&M activities by evaluating lighting, egress, ventilation, potential hazards of any kind, and assessing the operability of the remaining active fire alarm system components. The Safety/Egress recommendations identified in the FHA are implemented through Central Plateau S&M administrative and operational procedures. Technical Procedure 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility,* identifies the Annual surveillance requirements. This technical procedure also references procedure CPSM-PRO-OP-50768, (FSP-3647, OP-5), *Access Control for Surveillance & Maintenance Facilities*. These procedures implement the Safety/Egress requirements of the FHA including entry requirements of visitors. The procedure also identifies training requirements and common facility hazards.

The facility is normally locked and unoccupied and has been accessed only on a limited basis for tours and infrequent work activities. Access will be needed for decontamination and size-reduction activities, as discussed in Section 9.2.3, Decommissioning Operations. Prior to the performance of these activities, a life safety review of each work package will be performed by an FPE. The life safety review will ensure that adequate means of egress, lighting and notification of an emergency are provided for personnel inside the building.

16.1 Means of Egress

Table 16-1 identifies PUREX buildings and indicates compliance with exit requirements per NFPA 101, as evaluated for general routine S&M-type activities (e.g., surveillances, tours, inspections, pre-approved maintenance procedures, etc.). Activities, other than general routine S&M-type activities will be evaluated by the FPE and approved on a case-by-case basis.

Table 16-1. PUREX Facility Exit Requirements

BLDG	NAME	ACTIVE SYSTEMS	2 Exits Required	Meets Exit Requirements
202-A	202-A CANYON	POWER- LIGHTS	Yes	Yes
203A	ACID PUMP HOUSE		No	Yes
204A	ACID STORAGE VAULT, U CELL		Yes	Yes
206A	FRACTIONATOR BLDG		No	Yes
210A	DRUM STORAGE		No	Yes
211A	BULK COLD CHEM STORAGE		Yes	Yes
212A	FISSION PRODUCT LOADOUT		No	Yes
213A	FISSION PRODUCT LOAD IN		No	Yes
214A	PUREX FAC WAREHOUSE		No	Yes

Table 16-1. PUREX Facility Exit Requirements

BLDG	NAME	ACTIVE SYSTEMS	2 Exits Required	Meets Exit Requirements
217A	SAMCON SHACK (ACTIVE)	ELECT, AC, FIRE DETECT SYS	No	Yes
218-E-14	PUREX TUNNEL		Yes	PER
218-E-15	PUREX TUNNEL		Yes	PER
221A	STORAGE BLDG		No	Yes
225EC	TEDF INSTRU BLDG		No	Yes
252AB	EXH FAN SUBSTATION (ACTIVE)	ELECT, AC, FIRE DETECT SYS	No	Yes
252AC	SURV LTG SUBSTATION (ACTIVE)	ELECT, AC, FIRE DETECT SYS	Yes	Yes
2701AB	BADGE HOUSE	NONE	Yes	Yes
2711A	AIR COMP BLDG		No	Yes
2712A	PUMP HOUSE		No	Yes
2714A	CHEM WAREHOUSE		Yes	Yes
271AB	PUREX MAINT FAC		Yes	Yes
276A	COLD SOLVENT STORAGE BUILDING, R CELL (VAULT)		Yes	Yes
281A	EMERG GEN		Yes	Yes
291A	EXH AIR FILTER BLDG		Yes	Yes
291-A-1	MAIN STACK		No	N/A
291AB	EXH AIR SAMPLE SHACK		No	Yes
291AC	EXH AIR INSTR SHACK		No	Yes
291AD	AMMONIA OFF-GAS BLDG		No	Yes
291AE	#4 FILTER BLDG	POWER- LIGHTS	Yes	Yes*
291AG	SAMPLER STA 2	Power	No	Yes
291AH	AMMONIA OFF-GAS SMPLE STA		No	Yes
291AJ	SAMPLE STA 3		No	Yes
291AK	AIR TUNNEL ENCL		No	Yes
292AA	PR STACK SAMPLE HOUSE	POWER -LIGHTS, V ACUM PUMPS	No	Yes
292AB	GASEOUS EFFUENT MON BLDG	POWER- LIGHTS, VACUM PUMPS	No	Yes
293A	DISSOLVER OFF-GAS STA		Yes	Yes
294A	OFF-GAS INSTR SHACK		No	Yes
295A	ASD SAMPLE STA		No	Yes
295AA	SCD SAMPLE PUMP STA		No	Yes

Table 16-1. PUREX Facility Exit Requirements

BLDG	NAME	ACTIVE SYSTEMS	2 Exits Required	Meets Exit Requirements
295AB	PDD SAMPLE STA		No	Yes
295AC	CLS SAMPLE ST A		No	Yes
295AD	CWL SAMPLE STA		No	Yes
295AE	PDD MON BLDG		No	Yes

*Entry requires evaluation and approval by Fire Protection Engineer.
PER – Planned entry required

16.2 Emergency Lighting & Exit Signs

As decommissioning preparation work is planned, a life safety review of each work package will be performed by an FPE to ensure adequate lighting in the work area and egress pathways. Persons entering the building for surveillance are required to carry flashlights and a means for remote communication (e.g., cell phone or two-way radio).

17.0 Emergency Planning

Emergency Action Plans (EAPs) for the PUREX Facility are contained in the Building Emergency Plan for Central Plateau Surveillance and Maintenance, HNF-IP-0263-CP S&M, and the Facility Response Plan for the 218-E-14 and 218-E-15 Storage Tunnels, HNF-IP-0603-E-14/15. These plans identify the capabilities necessary to respond to emergency conditions, provides guidance and instructions for initiating emergency actions and serves as a basis for the training of personnel in emergency actions.

A fire or explosion hazard associated with the facilities within the PUREX complex is considered to be very low because of the small quantity of combustibles present and the lack of an ignition source.

Depending on the magnitude of a natural phenomenon event, fire, or explosion, damage to the storage tunnels is possible. The hazards could involve personnel and environmental exposure to mixed waste. In the event of such an occurrence, a recovery plan would be developed. Because of the potential for mixed waste to leach, water is not the preferred choice for fire control in the tunnels. Reduction of the air supply to the storage area by isolation with earth should permit the fire to self-extinguish. Heavy equipment and cranes would be called to the scene to cover areas of the tunnel that might collapse.

17.1 Facility Fire Training

CHPRC implements the DOE Emergency Management Plan through its Emergency Response 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.

17.1.1 Pre-Incident plans

In order to adequately plan and prepare for specific emergency incidents that could occur at the site facilities, the HFD conducts extensive pre-incident planning. The basic goal of pre-incident planning for industrial and special purpose sites and facilities, such as Hanford, is to provide emergency responders with as much helpful information as possible before any credible, postulated incident occurs. With appropriate and sufficient relevant information available in a pre-plan, response crews typically can evaluate the situation and mitigate the incident more safely, effectively, and efficiently.

17.2 Closure Status of Previous Findings and Recommendations

There were no previous fire protection assessment findings, recommendations or observations that remain open. The current PUREX FHA provides four recommendations. They pertain to the following topics: Combustible Control, Safety/Egress, Waste Staging, and Polyurethane Foam (Laboratory Annex). All recommendations are implemented through administrative control procedures.

18.0 Fire Department Response

The HFD is an established fire service organization within DOE. It is a department with a fully integrated fire protection program, linking the Fire and Emergency Response Services with the Fire Marshal, Fire Protection Engineering Support Services and Fire Protection System Inspection, Testing, and Maintenance Services. Mission Support Alliance, LLC (MSA) is responsible for managing and operating the HFD under contract with DOE-RL.

The DOE-RL CRD O 420.1C (Supplemented Rev. 0), stipulates that the HFD will provide fire suppression, rescue, emergency medical and ambulance services, and hazardous material response services, that are capable of addressing and terminating emergency situations, which could threaten the operations, employees, environment, or property on the Hanford Site. This is also emphasized in the applicable 10 CFR 851 requirements. The HFD is the designated incident command agency for mostly all Site emergencies and is the designated emergency response organization for all fires, rescue, and emergency medical responses on Site.

The Hanford Fire Department consists of three fire stations covering the 1,450 km^2 (560 mi^2) Hanford Site plus a former fire station in the 400 Area used for equipment storage only. These stations are strategically located across the Site to ensure minimum response time to all facilities. Each station is provided with an ambulance staffed by two emergency medical technicians/paramedics, a fully-equipped pumper truck with a minimum of four fighters (together termed an "engine company"), and for elevated structures beyond two stories, an aerial ladder vehicle.

The 200 Area Fire Station (Building 609A) is the closest fire station to the 202-S Building. This station provides fire protection, emergency medical services, and rescue services and is staffed by fire department response personnel on a 24-hr basis. The alarm is received initially at the central dispatch/communications center at the 200 Area Fire Station. Estimated response time to the 202-S Building from the time the alarm is received at the 200 Area Fire Station to the time the first piece of fire-fighting apparatus arrives on the scene of an incident at the 202-S Building is estimated at less than 10 minutes. The current HFD protocol in response to a fire call is to dispatch two engine-pumpers and an ambulance from the 200 Area Fire Station.

Due to the nature and extent of the various types of hazards on site, the HFD maintains special purpose vehicles capable of safe and effective response to large wildland/ground cover fires, HAZMAT and hazardous release calls, radiological type incidents, confined space, extrication, and other types of technical rescue calls, and multiple casualty incidents requiring advanced emergency medical protocols and hospital transportation in specially equipped ambulances. In the event of a structure fire, the first due vehicle is generally a pumper or quint (pumper with aerial ladder).

The nature of the incident (medical, hazardous materials, range fire, etc.) and what is housed in a particular station determines the type of apparatus selected by the crew. For calls involving hazardous materials, or for other types of non-fire calls, the appropriate vehicle (other than the aerial device/pumper) responds, in addition to the ambulance. For brush fires, type 3 and type 5 wildland apparatus, the pumper-tankers, and the water tender will respond.

18.1 Mutual Aid

The Hanford Fire Department participates in several formal mutual aid agreements with other fire departments and fire protection districts in surrounding jurisdictions which enable the HFD to augment its own fire and emergency medical resources in the event of a large fire or other emergency. Members of the agreements include, but not limited to, the Richland Fire Department; Kennewick Fire Department; Pasco Fire Department; Benton County Fire Protection Districts No. 1, 2, 3, 4, 5, and 6; Franklin County Fire Protection District No. 3; and Walla Walla County Fire Protection District No. 5.

18.2 Baseline Needs Assessment

The Hanford Fire Department Baseline Needs Assessment dated March 2014 (HNF-SP-1180, *Hanford Site Emergency Response Needs*) is current.

18.3 Apparatus Access to Facility

Roads and points of entry provide adequate fire apparatus access to PUREX structures. Fire Department access meets the requirements of NFPA 1.

19.0 Security and Safeguards Considerations Related to Fire Protection

The PUREX Facility does not have security features that could significantly delay a fire department response. The HFD access to the site is available through any of the four sets of double gates in the perimeter fencing. The four sets of gates in the existing double-row security fencing, which defines the exclusion zone, are padlocked. Access to the other buildings and structures within the exclusion zone are controlled by the existing door locking mechanisms. A key box, accessible only to the HFD, is located adjacent to the entrance gate and contains facility keys.

No security and safeguard considerations were identified that affect the conclusions resulting from this FHA.

20.0 Electrical Systems

Except for the following systems, all service and utility distribution systems for all of the buildings and structures within the exclusion zone have been isolated or removed:

- 291-A (electric motor driven exhaust fans)
- 292-AB (main stack monitoring building)
- 252-AB (electrical unit substation)
- 252-AC (electrical unit station)
- 202 Building (surveillance lighting)
- 217-A SAMCON building
- 291-AE fourth filter building

At the completion of the deactivation project, all electrical service to the 202-A Building and annexes was de-energized and isolated. All of the original plant power systems have been de-energized. Two electrical substations (252-AB and 252-AC) provide newly-installed power systems to the PUREX Facility for S&M. One substation (252-AB) supplies 1,500 kVA of electrical power to the operating canyon exhaust fan and 750 kVA of electrical power to the 292-AB stack monitoring building, the 291-AE No. 4 filter building, the 291-A-1 monitoring system, and the SAMCON instrument and control skid for surveillance and monitoring. The 252-AC station supplies 750 kVA of electrical power to dedicated surveillance lighting and strategically located receptacles throughout the facility. In addition, electric heat is provided to the 291-AE and 292-AB Buildings to protect instrumentation during cold weather.

Surveillance lighting and receptacles for the interior of the PUREX Facility are only activated for interior inspections via the substation (252-AC) located on the north side of the 202-A Building. All electrical lighting contact switches for the entire 202-A Facility have been located just inside the main entrance door to the building near 252-AC. The facility is isolated from electrical ignition sources between inspections.

20.1 Transformers

Substation-252AB is a 13.8/2.4-kV electrical unit substation that was installed to supply power to the PUREX facility exhaust ventilation and data acquisition systems. The electrical unit substation consists of overhead 13.8- kV electrical lines to the site each feeding 13.8/2.4-kV, oil-filled, step-down transformers and 2.4/480-kV, oil-filled, step-down transformers.

21.0 Exposure Fire Potential and the Potential for Fire Spread between Two Fire Areas

21.1 Exposure Fire Potential

A methodology for evaluating exposure hazards is outlined in NFPA 80A, *Recommended Practices for Protection of Buildings from Exterior Fire Exposures*. NFPA 80A recommends separation distances to protect a structure exposed to the radiative heat produced by a fire in an adjacent structure. More specifically, NFPA 80A is intended to provide recommendations for protecting combustibles within, and on the exterior of, an exposed building.

The DOE has devalued the buildings at the facility. The majority of the facility buildings no longer have any combustible contents. To be considered for a review against the NFPA 80A criteria, buildings have to have unprotected openings or walls that cannot withstand the anticipated exposure fire. In addition, only those structures with combustible contents located above ground need be considered for the exposure hazard review. Concrete or masonry walls with protected openings can be excluded from the consideration. Also, buildings void of radioactive materials and other hazardous materials need not be further considered for the review, as there are no potential decontamination costs associated with the structures. There were no structures identified that present an exposure hazard to or from adjacent facilities.

21.2 Fire Spread between Fire Areas

Several construction features of the facility function as fire barriers, these features are not routinely inspected but configuration control is maintained through the USQ Process and casual observations of these features are made annually during housekeeping and combustible loading walkdowns.

For this FHA, all buildings and structures are treated as separate fire areas. The exterior walls of the facility structures are used to define the fire area boundaries. The 202-A Canyon and laboratory annex structures are analyzed as separate fire areas, since there is a 2-hr firewall between them. The PUREX Building areas (process canyon, galleries, and annex buildings) are separated by fire barriers in the form of fire doors and fire dampers. Construction features having a fire resistance rating of at least 2 hrs separate buildings adjacent to the canyon structure. The railroad storage tunnels are physically separated from all other structures.

To control the migration of contamination during deactivation, gaps around the exterior wall fire doors that are not required for emergency egress are sealed with weather stripping or tape. The existing fire-damper-protected, ventilation openings between the galleries, two stairwells, and the 202-A Building canyon and cells remains open to support the confinement function of the 202-A Building exhaust system. Unprotected ventilation openings through the interior walls of the canyon structure will not adversely impact the fire safety of the building. As discussed in Section 4, the flowing air from non-contaminated areas progressively to more contaminated areas accomplishes the building confinement function. Section 12 demonstrates that a worst-case fire in the canyon building will not damage the exhaust system's HEPA filters.

22.0 Effect of Significant Fire Safety Deficiencies on Fire Risk

As there are no vital safety systems present in the PUREX facility, the only fire safety deficiencies involve operating outside of the controls and assumptions set forth in this document. Such scenarios do not warrant further investigation.

23.0 Environmental Impacts from a Fire

The building structure serves, to some extent, as a confinement barrier. As concluded by the fire scenarios in Section 12, any MAR released by a fire event would be contained within the building or carried through the normal ventilation path and either by plate out or filtration would be removed from the air exhausted through the stack.

23.1 Suppression System Runoff Considerations

During firefighting operations, most of the water used would be contained within the facility, but it is possible that some water would be lost out of the facility doors. Water running out of the doors would be absorbed into the ground immediately around the facility. The water run-off administrative controls for firefighting and the features inherent to the structure are concluded to be adequate.

24.0 Conclusion

This FHA was developed in accordance with the criteria contained in DOE O 420.1C, *Facility Safety*; Title 10 *Code of Federal Regulations* (CFR) 851, "Worker Safety and Health Program;" Contractor Requirement Document (CRD) O 420.1C, *Facility Safety*; and PRC-PRO-FP-40421, *Fire Protection Analyses*. Bases include previous FHAs and other safety basis documents as referenced herein. It is intended to address the major and credible fire hazards associated with facility activities. The fire hazard analyses were based on information obtained from a building visit, discussions with facility staff, and documentation/drawing reviews.

Findings included in this FHA bring the facility into compliance with the intent and objectives of the DOE Orders, Richland Operations Office Directive CRD O 420.1C, and mandatory codes and standards. Findings are significant issues that must addressed in the short term. If implementation of findings is not possible within 90 days of issue of this FHA, then development of an implementation plan addressing longer term implementation and identifying interim compensatory measures is required.

This section of the report consolidates all of the recommendations presented elsewhere in this FHA. The recommendations are provided to improve the level of safety and minimize the potential fire hazard. Should prioritization of recommendations be required, contact the FPE.

24.1 Findings

No findings were identified.

24.2 Recommendations

24.2.1 New Recommendations

None.

24.2.2 Existing Recommendations

The recommendations identified below are those that apply to ongoing S&M activities in the PUREX facility. They do not apply to deactivation, decommissioning, decontamination, and risk reduction activities, which are expected to follow the S&M phase.

Recommendation 1: Combustible Control

Combustible material accumulations must be controlled to maintain the FHA assumptions. Allowed S&M activities shall be conducted such that generated combustible material and ignition sources associated with the activity are minimized and removed at the end of the defined work evolution.

Status: Closed. Implemented through FSP-3647 (CPSM-PRO-50768), OP-5, *Access Control for CP S&M Facilities* and 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility*.

Recommendation 2: Safety/Egress

- Facility entry is limited to no more than ten people. If more than ten people are required to enter the facility, notify the HFD dispatch prior to entry and provide the number and location of the personnel to be present.
- Two independent and separate exits must be available for entry into facilities. If two separate exits are not available, obtain approval of the FPE prior to entry.
- A mechanism for two-way communications must be maintained for each separate party/group entering an S&M facility.
- Means shall be provided for emergency notification (i.e., cell phone or radio) during periods of surveillance, work activities, or tours.
- Each party/person entering an S&M facility will carry flashlights or other acceptable transportable lighting as a precaution for failure of general lighting or electrical service.
- The FPE, or delegate, shall conduct and document annual inspections of all facilities. These inspections will document that:
  - General combustible loading conditions are within allowable limitations and consistent with analyzed accidents; and
  - Egress requirements are maintained for allowed surveillance pathways.

Status: Closed. Implemented through FSP-3647 (CPSM-PRO-50768), OP-5, *Access Control for CP S&M Facilities*, and 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility*.

Recommendation 3: Stage Waste

- TRU-waste packaged in accordance with the Hanford Site Waste Acceptance Criteria shall be limited to 20.9 DE-Ci.
- A nominal separation of 10 ft shall be maintained between waste containers of combustible construction and TRU-waste containers.
- Vehicles and material-handling equipment powered by combustible or flammable fuels must be attended while operating within waste storage areas. Such equipment will be removed from the waste storage area at the end of the defined work evolution. Situations in which these requirements cannot be met require approval by facility management and the FPE.

Status: Closed. The second and third bullets of the recommendation are implemented through FSP-3647 (CPSM-PRO-50768), OP-5, *Access Control for CP S&M Facilities* and 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility*. The first bullet is a DSA Specific Administrative Control, implemented through FSP-3647 (CPSM-PRO-WM-50774), WM-2, *Waste Management*.

Recommendation 4: Polyurethane Foam

Do not allow the use of any additional polyurethane foam to stabilize contamination within process equipment. The routine surveillance of the facility should be reviewed and modified if

necessary to ensure that the existing foam containment in the laboratory annex ducts, hoods, and plenums remains in its current state and does not degrade to allow additional foam exposure.

Status: Closed. Implemented through FSP-3647 (CPSM-PRO-50768), OP-5, *Access Control for CP S&M Facilities*, and 2CP-SUR-A-04002 (CPSM-PRO-OP-50668), *Surveillance of PUREX Facility*.

24.2.3 D&D Preparation Activity Recommendations

D&D operations activities such as those detailed in Section 9.2.3, "Decommissioning Operations," will require the development of recommendations to address the increased fire risk that will be present during these activities.

24.3 Opportunities for Improvement

Opportunities for improvement are not requirements, but if the recommended improvements are made, it would reduce the risks of a fire and improve the overall level of safety in the facility. No opportunities for improvement have been identified.

25.0 References

ASTM E 119, 2015, *Standard Test Methods for Fire Tests of Building Construction and Materials,* American Society for Testing and Materials, West Conshohocken, Pennsylvania.

ASTM E 1354-16a, 2016, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

Benecke, M. W., 1995, *Justification to Remove 333 Building Fire Suppression System*, WHC-SD-NR-HIE-002, Westinghouse Hanford Company, Richland, Washington.

Butler, C. P.,1971, *Notes on Charring Rates in Wood*, Fire Research Note #896, Fire Research Station, Borehamwood, England.

CHPRC, 2015, *Crystal Reporting,* "Building and Contents Replacement Report Summary, CHPRC Hanford," CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00099, Rev. 0, 2009, *Standard Drum/Crate Fire Methodology*, Rocky Flats Environmental Technology Site, Golden, Colorado.

CHPRC-00100, Rev. 2, 2009*, Combustible Fuel Package Separation Distances*, Rocky Flats Environmental Technology Site, Golden, Colorado.

CP-14977, Rev. 10, 2017, *Plutonium-Uranium Extraction Facility Documented Safety Analysis*, CH2M HILL Plateau Remediation Company, Richland, Washington.

CRD O 420.1C, 2012, *Facility Safety* (Supplemented Rev. 0), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Dietenberger, et al., 1999, *Wood Handbook: Wood as an Engineering Material*, USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin.

Dodd, E. N., 1999, *Plutonium Uranium Extraction (PUREX) End State Basis for Interim Operation (BIO) For Surveillance and Maintenance*, HNF-SD-CP-ISB-004, Rev. 0, B&W Hanford Company, Richland, Washington.

DOE, 1987, Rev. 2, *U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Site*, U.S. Department of Energy, Washington, D.C.

DOE M 231.1-1A, Chg. 2, 2007, *Environment, Safety And Health Reporting Manual,* U.S. Department of Energy, Washington, D.C.

DOE O 420.1C, Chg. 1, 2015, *Facility Safety,* U.S. Department of Energy, Washington, D.C.

DOE-HDBK-3010-94, 1994, *DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, Volume 1 - Analysis of Experimental Data*, U.S. Department of Energy, Washington, D.C.

DOE-STD-1066-2012, 2012, *DOE Standard, Fire Protection,* U.S. Department of Energy, Washington, D.C.

DOE/RL-90-24, Rev. 4, 1997, *Hanford Facility Dangerous Waste Permit Application, PUREX Storage Tunnels* , U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-17, Rev. 6, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, U.S. Department of Energy, Richland Operations Office, Richland, Washington, October 2009.

DOE/RL-2001-11, Rev. 1, Draft C, *Final Feasibility Study for the Canyon Disposition Initiative (221-U Facility),* U. S. Department of Energy, Richland Operations Office, Richland, Washington, December 2003.

HNF-8599, Rev. 14, 2015, *Hanford Site 2015 Wildland Fire Management Plan*, Hanford Fire Department.

HNF-11724, Rev. 13, 2016, *CH2M HILL Plateau Remediation Company Safety Management Programs,* Fluor Hanford, Inc., Richland, Washington.

HNF-SP-1180, Rev. 4, 2014, *Hanford Site Emergency Response Needs,* Fluor Hanford, Inc., Richland, Washington.

McCaffrey, 1995, "Flame Height," Section 2- 1, The SFPE Handbook of Fire Protection Engineering, Second Edition, National Fire Protection Association, Quincy, Massachusetts.

NFPA, 1997, *Fire Protection Handbook*, Section 7, Chapter 4, "Structural Integrity during Fire," 18th Edition, National Fire Protection Association, Quincy, Massachusetts.

NFPA 30, 2015, *Flammable and Combustible Liquids Code*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 51B, 2014, *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work,* National Fire Protection Association, Quincy, Massachusetts.

NFPA 72, 2016, *National Fire Alarm Code,* National Fire Protection Association, Quincy, Massachusetts.

NFPA 101, 2015, *Life Safety Code,* National Fire Protection Association, Quincy, Massachusetts.

NFPA 220, 2015, *Standard on Types of Building Construction,* National Fire Protection Association, Quincy, Massachusetts.

NFPA 241, 2013, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* National Fire Protection Association, Quincy, Massachusetts.

NFPA 701, 2015, *Standard Methods of Fire Tests for Flame Propagation of Textiles of Films*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 780, 2014, *Standard for the Installation of Lightning Protection Systems*, National Fire Protection Association, Quincy, Massachusetts.

NFPA 801, 2014, Standard for Fire Protection for Facilities Handling Radioactive Materials, National Fire Protection Association, Quincy, Massachusetts.

NISTIR, 1997, *CFAST Zone Model 4985*, National Institute of Standards and Technology, Gaithersburg, Maryland.

PNL-4622, 1983, *Climatological Summary for the Hanford Area*, Pacific Northwest National Laboratory, Richland, Washington.

PRC-PRO-FP-40421, Rev. 0 Ch. 2, 2015, *Hot Work*, CH2M HILL Plateau Remediation Company, Richland, Washington.

PRC-STD-FP-40404, Rev. 1 Ch. 0, 2015, *Fire Protection Program*, CH2M HILL Plateau Remediation Company, Richland, Washington.

SFPE, 1995, *Society of Fire Protection Engineers Handbook,* 2nd Edition, Society of Fire Protection Engineers, Quincy, Massachusetts.

SFPE, 2002, *Society of Fire Protection Engineers Handbook,* 3rd Edition, Society of Fire Protection Engineers, Quincy, Massachusetts.

UL, 1917, *Fire Tests of Building Columns,* Underwriter's Laboratories, Inc., Chicago, Illinois.

UL 1709, 2011, *Rapid Rise Fire Tests of Protection Materials for Structural Steel,* Underwriter's Laboratories, Inc., Northbrook, Illinois.

U.S. Seismic Design Maps, Accessed January 5, 2016.

Appendix A

J Cell Fire Model Input and Output

Appendix A
J Cell Fire Model Input and Output

J Cell Fire Model Input and Output

1. The volume of lube oil involved in the fire is 908 (240 gallons) liters. This quantity is based upon the instantaneous release of the lube oil from two mechanical pulsers.

2. The entire inventory of the two pulsers is assumed to spill instantaneously. This input is considered to be conservative since the oil is in sealed casings without drains. This assumption also produces the largest spill area and highest available peak heat release rate. Based upon the entire surface area of J Cell, the spill area is assumed to be 152 m^2.

3. The combustible liquid was assumed to have burning characteristics similar to kerosene. Thus, the mass loss rate is 0.039 kg/m^2-s, the density is 820 kg/m^3, and the heat of combustion is 43200 kJ/kg.

4. The total canyon building airflow (18.9 m^3/s) is assumed to migrate through the J Cell. This assumption produces the highest possible peak heat release rate. Thus, the heat release (HRR) rate due to the available air forced through the J Cell is 66339 kW. This HRR is based upon the following equation.

$$\dot{Q}_c = \dot{m}_{air}\,\Delta H_c$$

where:

$\dot{Q}_c$ = HRR (kW)
m_{air} = mass flow rate of air into the compartment (18.9 m^3/s x 1.17 kg/m^3)
ΔH_c = heat of combustion per unit mass of air (3000 kJ/kg)

5. Assuming that the fire will grow as an "ultra fast t^2" fire, the growth rate constant is 0.1874 kW/s^2. The use of this assumption yields a peak heat release in the shortest amount of time. Thus, the growth time to reach 66339 kW would be 595 seconds. The growth time is based upon the following equation.

$$\dot{Q} = \alpha t^2$$

where:

$\dot{Q}$ = peak heat release rate
α = growth rate constant
t = time (s)

6. Based upon the following equation the mass of fuel consumed during the growth phase is 304 kg.

$$M_L = \alpha t^3/3\Delta H_c$$

where:

M_L = mass loss during the growth phase (kg)
α = growth rate constant (kW/s^2)
ΔH_c = heat of combustion (kJ/kg)

7. Based upon the following equation the burn time at the peak heat release rate is 287 seconds.

$$t_d = (M_T - M_L/Q_p)\Delta H_c$$

where:

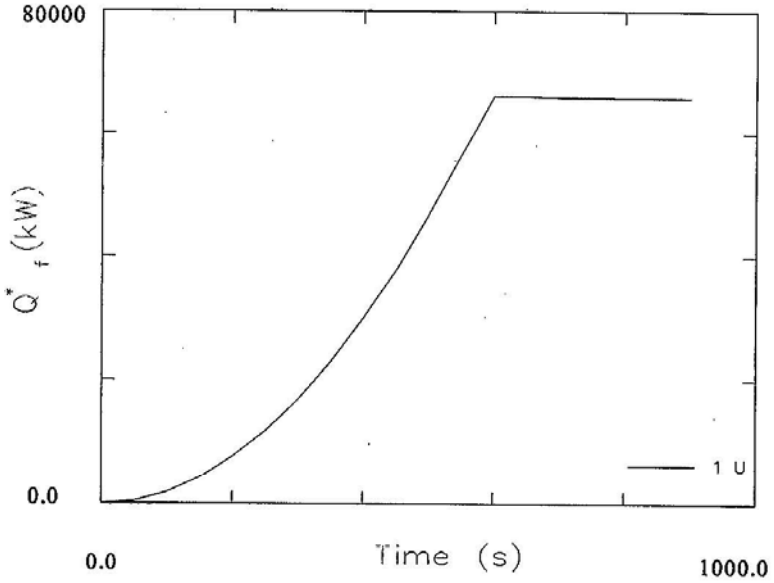
t_d = peak HRR burn time (s)
M_T = total fuel mass (kg)
M_L = mass loss during growth phase(kg)
ΔH_c = heat of combustion (kJ/kg)

$\dot{Q}$ = peak HRR

8. Using the previously discussed information the following fire specification was developed.

Time (s)	HRR (kW)	Mass Loss (g/s)
0	0	0
50	468.5	10.84491
100	1874	43.37963
150	4216.5	97.60416
200	7496	173.5185
250	11712.5	271.1227
300	16866	390.4167
350	22956.5	531.4005
400	29984	694.074
450	37948.5	878.4375
500	46850	1084.491
550	56688.5	1312.234
595	66344.28	1535.747
882	66344.28	1535.747

9. The following graph depicts the predicted heat release rate for the lube oil fire in J Cell.

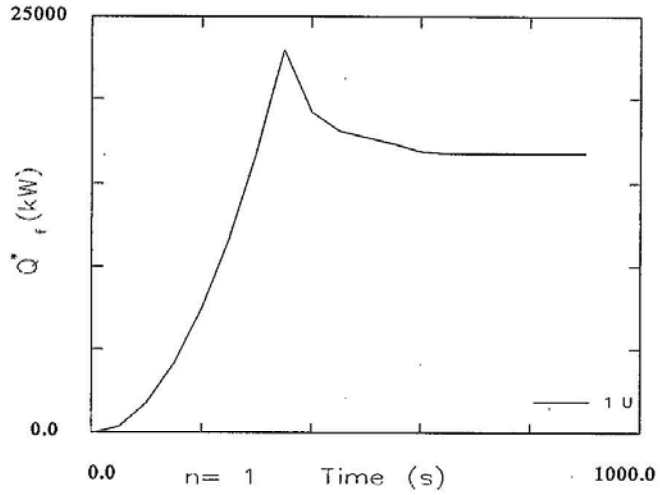

80000
0.0
Q^*_f (kW)
1 U
0.0
Time (s)
1000.0

10. The following is the CFAST data input for the J Cell fire.

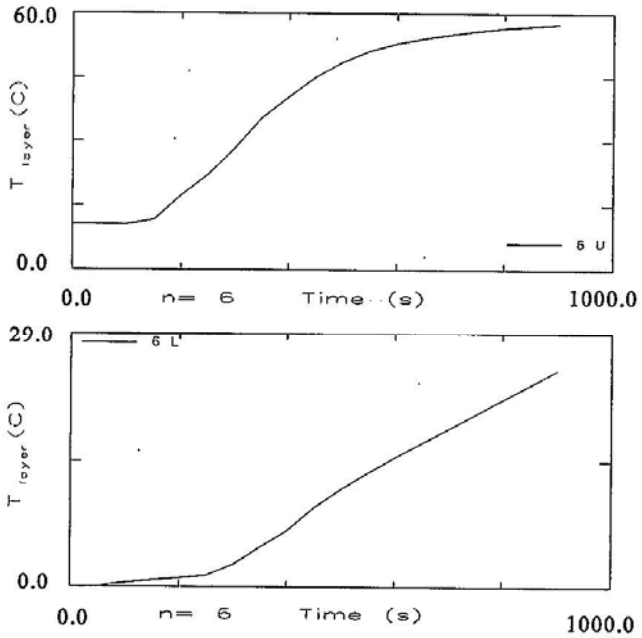
```
VERSN   2  PUREX J CELL FIRE
TIMES   900   50   50   50    0
TAMB  300. 101300.    0.
EAMB  316. 101300.    0.
HI/F    0.00  0.00  0.00  0.00  0.00  0.00
WIDTH   4.30  3.40 24.40 16.00 10.00 12.50
DEPTH  35.70 124.00  2.40 25.00  2.40 37.50
HEIGH  11.90  2.30  2.40  4.00  2.40  5.20
HVENT  1 2 1  8.900  2.130  1.830
HVENT  2 3 1  2.400  2.300  0.000
HVENT  3 4 1  2.400  2.400  0.000
HVENT  4 5 1  2.400  2.400  0.000
HVENT  5 6 1  2.400  2.400  0.000
CVENT  1 2 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
CVENT  2 3 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
CVENT  3 4 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
CVENT  4 5 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
CVENT  5 6 1  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
VVENT  7  1  1.00  2
MVOPN  6  1 H  1.20  1.00
MVOPN  7  4 H  1.20  1.00
MVDCT  1  2  1.00  1.00 .00100  0.00 1.0000  0.00 1.0000
MVDCT  3  4  1.00  1.00 .00100  0.00 1.0000  0.00 1.0000
MVFAN  2  3   100.00   300.00 0.232E+02 -0.440E-01
INELV  1  1.20  2  1.20  3  1.20  4  1.20
CEILI CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE
WALLS CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE
FLOOR CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE  CONCRETE
CHEMI   16.   0.  10.0   43200000.  300. 388. 0.150
LFBO  1
LFBT  2
FPOS  17.85  2.15  0.00
FTIME    50.  100.  150.  200.  250.  300.  350.  400.  450.  500.  550.  595.  882.
FMASS 0.0000 0.0108 0.0434 0.0976 0.1735 0.2712 0.3904 0.5314 0.6941 0.8784 1.0845 1.3122 1.5357
      1.5357
FHIGH   0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
FAREA 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00 152.00
      152.00
FQDOT  0.00     4.68E+05 1.87E+06 4.22E+06 7.50E+06 1.17E+07 1.69E+07 2.30E+07 3.00E+07
      3.79E+07 4.68E+07 5.67E+07 6.63E+07 6.63E+07
CJET OFF
HCR  0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333 0.333
```

11. The following CFAST generated graph depicts the heat release rate in J Cell throughout the fire simulation. The graph shows a peak HRR of 23000 kW at 350 seconds. The fire

then becomes constrained due to the fire compartment geometry and available air supply. At about 600 seconds a steady state HRR of 16800 kW is achieved and mainteaned for the remainder of the simulation.



12. The following CFAST generated graphs depict the upper and lower layer temperatures in the 4th Filter Cell throughout the fire simulation. The graphs show that the temperature in the HEPA filter building will peak at about 60 °C. This temperature is well below the continuous duty temperature (94 °C) recommended by the Filter Plenum Fire Protection Criteria contained in the *DOE Fire Protection Resource Manual.*



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Appendix B

Tunnel 1 Fire Scenario

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Appendix B
Tunnel 1 Fire Scenario

B.1 218-E-14 and 218-E-15 Railroad Storage Tunnels

The following scenario is maintained in this revision to the FHA to reflect condition prior to completion of grout stabilization. At the time that this work is complete, the material within the tunnel will be considered as encapsulated by the grout and will no longer contribute to a potential fire. Similarly, while small void spaces may exist in the final grout pour, they will be of insufficient size to provide sufficient oxygen for a sustained fire. The grout will also isolate any combustible fuels from potential external ignitions sources (all electrical power to the tunnel has been de-energized and there are no other credible internal ignition sources). While there are some combustible liquids and solids that may be present, no is considered to be water reactive, nor are there anticipated to be any sustained hazardous chemical reaction during or subsequent to curing of the final grout pour.

Access to the PUREX storage tunnels is prohibited unless performed in accordance with a work package and permit reviewed and approved by the cognizant FPE/DFM. High radiation levels and contamination make it impossible to enter the tunnels. Knowledge of the contents is limited, including kinds and quantities of combustible materials. It is assumed that the documentation, drawings, and plans that were provided and available are accurate. Changes to the contents or operations of either tunnel may require additional analysis to assess whether these changes impact the conclusions reached in this report. In keeping with sound engineering practice, conservative (worst-case) assumptions are made regarding fuel loading, fuel package burning rates, fire spread, and thermo-physical effects in the absence of technical information. In the event that such an analysis demonstrated minimal or no impact on the fire hazard potential, no further analysis is performed.

Several approaches were used for evaluating fire damage for the storage tunnels. This included searching literature identifying technical information relating to the problem, identifying ignition characteristics, and burning behavior of heavy timber materials under varying fire environment conditions. For Tunnel No. 1 this also includes identifying structural and load characteristics of heavy timber corresponding to the dimensions cited in the background information provided. This also involved determining the bounds for structural failure and determining the critical member dimensions necessary to sustain structural integrity for Tunnel No. 1.

A bounding fire scenario method has also been used. This method establishes a maximum quantity of combustible material that could potentially burn and an assessment of whether the consequences of such a fire would result in exceeding DOE loss criteria.

B.1.1 General Analysis Approach

As previously noted, the quantity, location, geometry, and arrangement of the fuel loads within the PUREX storage tunnels are not well defined. The ventilation characteristics of Tunnel No. 1 and Tunnel No. 2 are stagnant. The doors and HEPA exhaust stacks have been sealed and/or isolated. Known quantities of combustible materials are limited, and only minor amounts of solid and liquid waste appear to be present in the PUREX storage tunnels.

Fire scenarios considered to be bounding are selected and based on the available air in the PUREX storage tunnels, and equivalent mass of miscellaneous solid and liquid combustibles. The following plausible fire scenarios are included in this analysis:

- Maximum thermal insult analysis - bounding the thermal effects on the tunnel structure, maximum possible fire size based on the available oxygen in the PUREX storage tunnels.
- Evaluation of fires which may cause structural failure of Tunnel No. 1.
- Fire in Tunnel No. 2 - thermal exposure and response of structural beams and columns.

The impact of the fire scenarios was analyzed using fire dynamic principles or fire models (e.g., CFAST). The results of the analyses are used to predict the potential damage to the PUREX storage tunnels, including the structures. Structural failure could potentially lead to a loss of the tunnel integrity and release of combustion products and potentially radioactive material to the atmosphere. If the possibility for structural failure is demonstrated, further detailed analysis is not provided unless it may affect the conclusions of the report. Conversely, if a conservative analysis demonstrates that structural failure will not occur, less conservative approaches are not analyzed.

Various ventilation scenarios were modeled to represent possible configurations when a fire occurs in each of the PUREX storage tunnels. The two scenarios that are most representative to actual conditions are summarized below:

- Tunnel No. 1 - With leakage around the water-fillable door and through the tunnel structure, it is assumed that Tunnel No. 1 is not completely sealed.
- Tunnel No. 2 - With no leakage through the tunnel structure, it is assumed that Tunnel No. 2 is sealed.

Ventilation Scenario No. 1 is considered the best representation of actual conditions in Tunnel No. 1. In this case, fresh air is allowed to enter into the tunnel through the cracks and small openings. This condition is considered to be the worst-case scenario in terms of ventilation conditions. For this fire scenario, the flow areas of the vents are seen as characteristic of a tightly sealed door (Kiote and Milke 1992). The fire is modeled using small vents accounting for the cracks around the tunnel door and structure.

Ventilation Scenario No. 2 is considered to be representative of actual conditions in Tunnel No. 2. However, Tunnel No. 2 is not perfectly sealed and cracks around the structure and porosity of the tunnel structure will allow fresh air from the outside. This condition is evaluated to predict the thermal effects on the structure with the exhaust ventilation system deactivated.

Given that the postulated fires are ventilation controlled, they represent bounding cases with respect to the burning duration and the peak heat release rate. This heat release rate assumes complete combustion and unlimited oxygen. The data is used by CFAST as an input and CFAST will reduce this nominal heat release rate based on the availability of oxygen. Other input data includes the physical dimensions of the compartment, construction materials, physical properties of these materials, vent openings, ventilation systems, fire growth rates, and the position of the specified fire.

The fire modeling uses the total heat release rate, the average upper smoke layer temperature, and smoke layer interface height for a fire in both tunnels for each of the ventilation scenarios. Figures 12-1 through 12-4 provide the results of this information from the modeling for the scenarios for each of the storage tunnels. Although the maximum heat release rate was specified as 100 MW, the heat release rate does not exceed 19.5 MW in Tunnel No. 1 and 75 MW in Tunnel No. 2. This is because even with the large volume of the PUREX storage tunnels, the fire becomes ventilation limited.

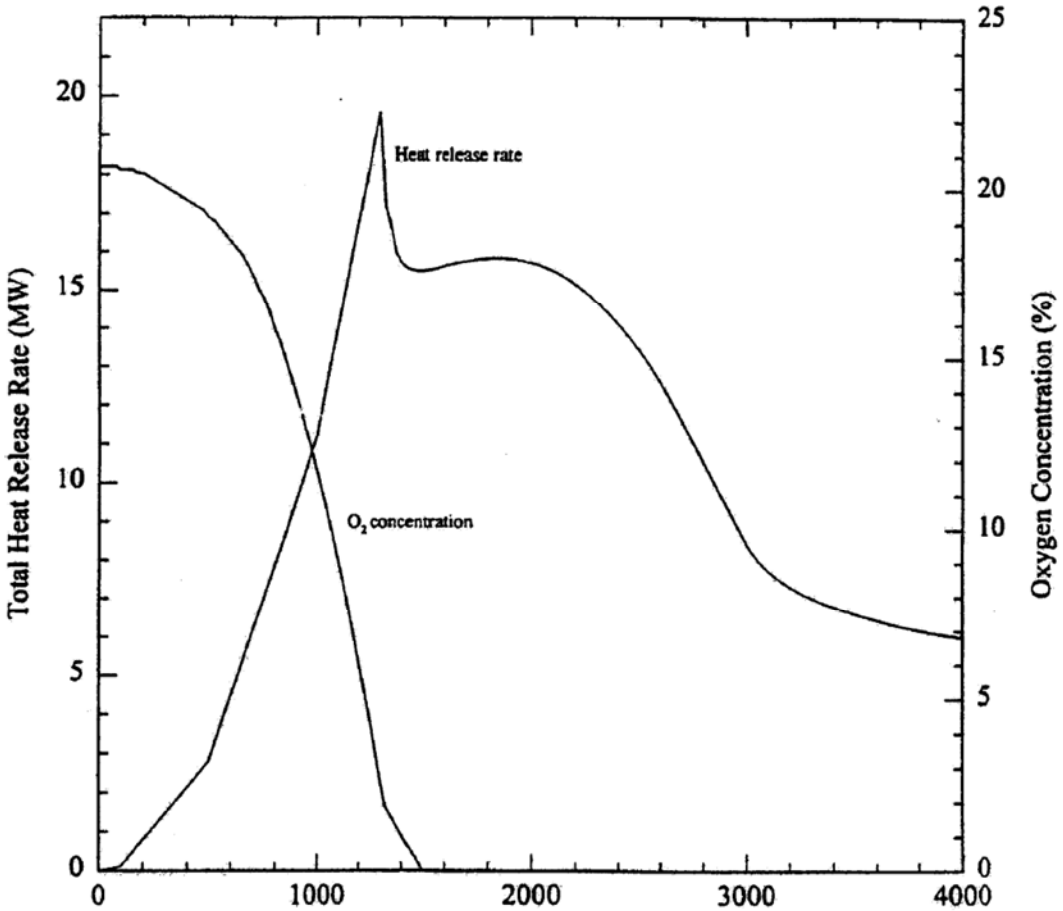

Figure B-1. Total Heat Release Rate and Oxygen Concentration of a Fire in Tunnel No. 1, Tunnel is not Properly Sealed

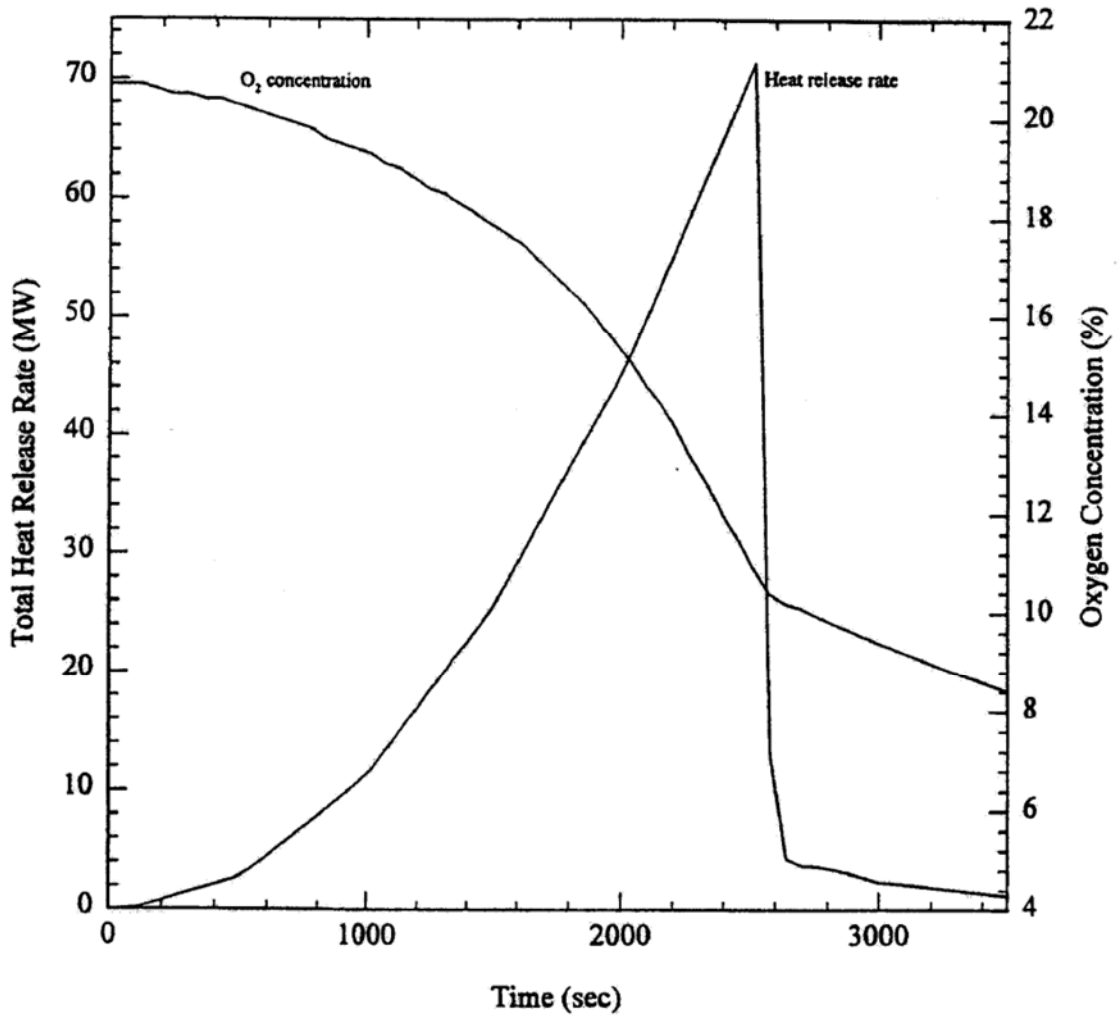

Figure B-2. Total Heat Release Rate and Oxygen Concentration of a Fire in Tunnel No. 2, Tunnel is Perfectly Sealed

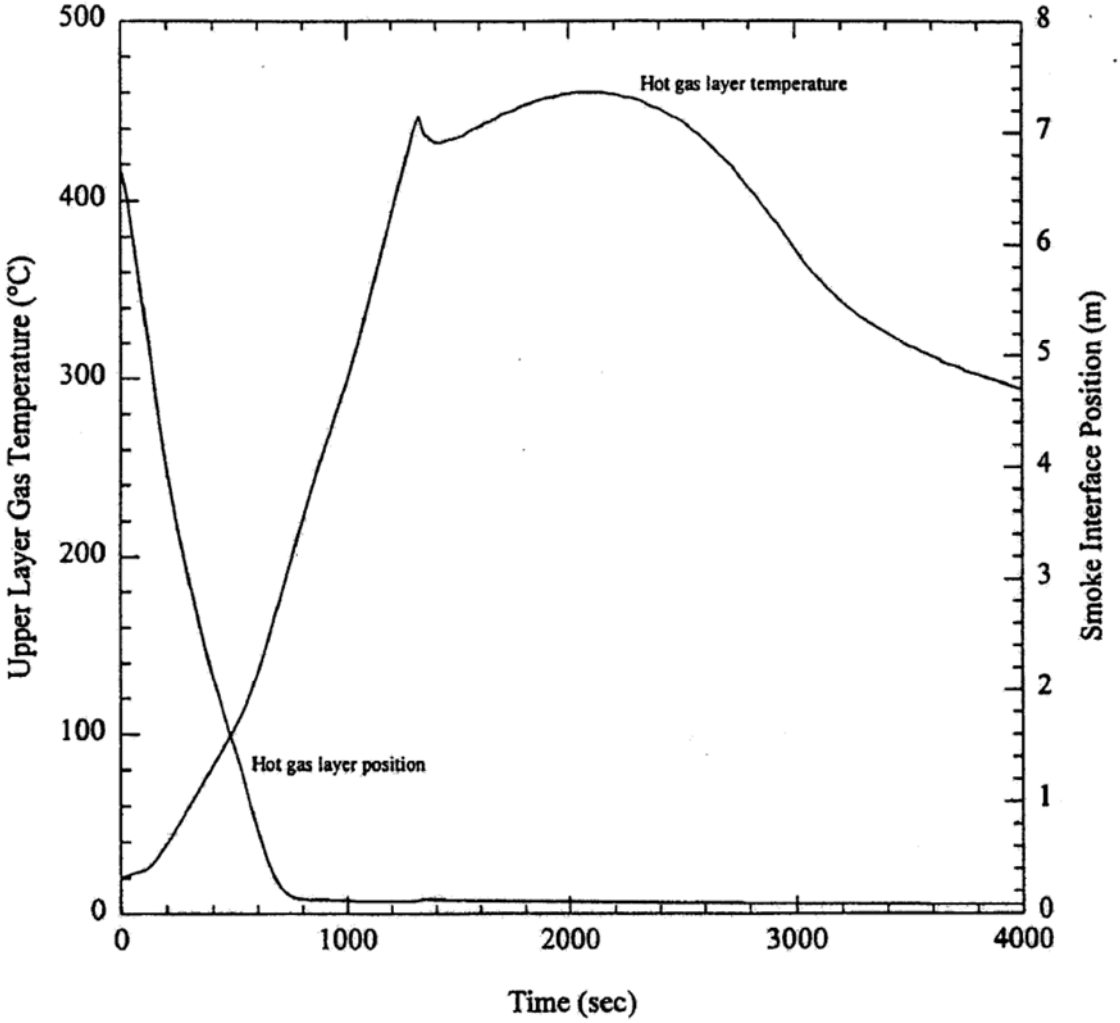

Figure B-3. Average Upper Smoke Layer Temperature and Smoke Layer Height of a Fire in Tunnel No. 1. Tunnel No. 1 is not Properly Sealed

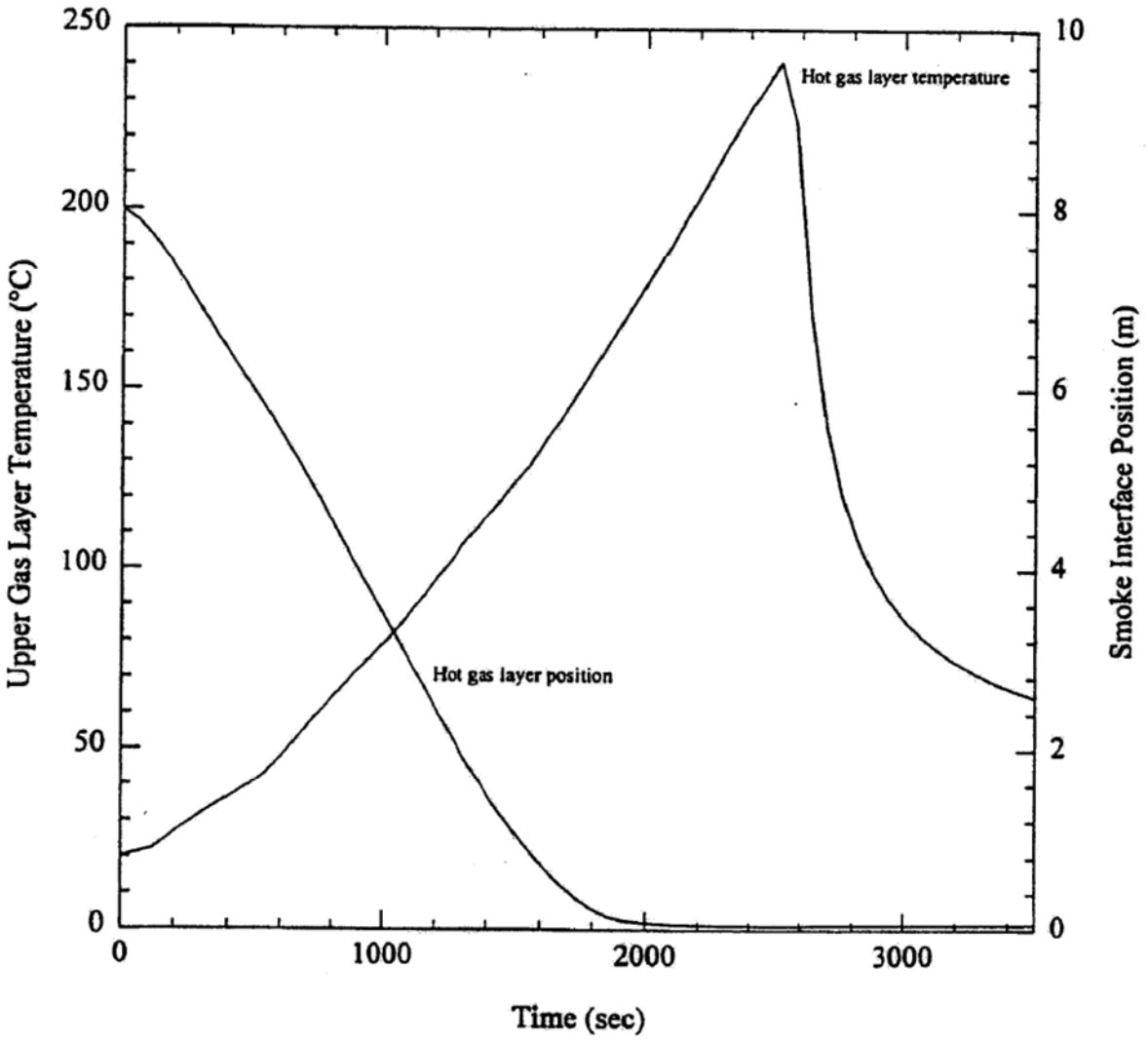

Figure 12-4. Average Upper Smoke Layer Temperature and Smoke Layer Height of a Fire in Tunnel No. 2. Tunnel No. 2 is Perfectly Sealed

B.1.2 Modeling Results

It is noted that the average temperatures by themselves will not have a significant impact on the structure and will not ignite wood timbers found in Tunnel No. 1. (For radiant ignition of wood, ignition temperature is reported at 600°C [1,112°F], Dietenberger, et al, Wood Handbook 1999).

The average temperature rise in Tunnel No. 2 is 214°C to 234°C (417°F to 453°F). These average temperatures are well below the critical failure temperature of steel. Typically, steel will begin to lose structural integrity at temperature of about 593°C (1,100°F), ASTM E119, *Standard Test for Fire Tests of Building Construction and Materials*. Therefore, structural failure is not predicted in the ventilation scenario.

The average upper gas layer temperatures during these scenarios are too low to cause flashover. Typically in compartment fires, the onset of flashover is associated with gas temperatures of 500 to 600°C (932 to 1112°F) (Walton and Thomas 1995). Flashover is a phenomenon that defines the point in a compartment fire where all the combustibles in the compartment are involved and flames appear to fill the entire volume. The predicted peak temperatures in the PUREX storage tunnels are well below the temperatures associated with flashover.

Further, the predicted temperatures produced during these scenarios are too low to cause structural damage within the PUREX storage tunnels. While the average upper layer gas temperatures are not sufficient to cause structural failure, a fire event that begins as a localized fire may cause structural failure due to flame impingement on the ceiling. Results from the CFAST simulation of the maximum heat release rate based on the ventilation in the PUREX storage tunnels are summarized in Table B-1, "Summary of the Fire Simulation Results for Maximum Thermal Insult to the Structure." Based on the actual fuels identified, this analysis is considered conservative. These analyses show that there is sufficient oxygen available in the PUREX storage tunnels, such that a significant fire can be sustained for some period of time. Based on this, a failure examination of potential fires and their impact on structural failure was performed.

Table B-1. Summary of Fire Simulation Results or Maximum Thermal Insult to the Structure

Tunnel Fire scenario	Maximum heat release rate, Q (MW)	Average upper gas layer temperature, T_g (°C)	Fire duration, t_d (sec)
Tunnel No. 1 is not perfectly sealed	19.5	460	1300
Tunnel No. 2 is perfectly sealed[1]	71	234	2500

[1] Although not perfectly sealed, this condition was evaluated to compare the potential effects on the structure.

B.1.3 Possible Ignition of Wood Timbers, Tunnel No. 1

Pyrolysis of wood can result from smoldering or flaming combustion. Smoldering combustion involves surface oxidation of a char layer, which provides sufficient heat necessary to cause further thermal degradation of the neighboring layer of combustible material. Successful propagation requires that volatiles be progressively driven out ahead of the zone of active combustion to expose fresh char, which will then begin to burn (Drysdale 1985). Flaming combustion or burning involves a relatively rapid pyrolytic reaction. Drysdale, 1985, reports that a thick slab of wood will not burn unless supported by radiation (i.e., flaming) or convection from another source (e.g., flames from a nearby fire or burning surface). Both modes of combustion were examined as potential causes of structural failure in Tunnel No. 1.

Through various analysis, it was concluded that a fire as small as 6 kW, which starts adjacent to a heavy timber tunnel column could cause ignition of the timber (example of 6 kW fire UL 1975

and ASTM E1354). While this represents an extrapolation of the heat flux data to smaller fires than were studied, suffice it to say that small fires can ignite the wood.

Smoldering combustion is a self-sustaining, propagating process (fueled by exothermic reactions) that is a non-flaming mode of combustion characterized by thermal degradation, charring, and evolution of volatile gases. The rate of smoldering propagation is directly related to the smoldering tendency of the material. The higher the smoldering tendency, the faster the propagation. Smoldering involves surface oxidation of the char, which provides the heat necessary to cause further thermal degradation of the neighboring layer of combustible material. Successful propagation requires that volatiles be progressively driven out, ahead of the zone of active combustion, to expose fresh char, which will then begin to burn.

Several studies have found that a thermally thick slab of wood will not sustain smoldering combustion unless external radiation is supplied. Flames or other smoldering surfaces could supply the required external radiation. Ohlemiller 1990 has observed that smoldering can be initiated by incident heat fluxes of 10 kW/m^2, though initiation times are 45 minutes or more. Butler 1971, *Notes on Charring Rates in Wood*, charring rate data shown in Drysdale 1985, show that sustained charring is possible at incident heat fluxes of about 12 kW/m^2. Since this was the lowest heat flux data presented, it cannot be assumed that sustained smoldering is not possible at lower heat fluxes.

The geometry which best supports sustained smoldering of wood is a crack or channel geometry in which radiative losses from smoldering surfaces are transferred to neighboring smoldering surfaces. In this geometry, the smoldering surfaces very efficiently provide the required radiation to one another. Since smoldering surfaces have surface temperatures in the 500 to 700°C (932° to 1292°F) range, this can provide radiative fluxes in the range of 20-50 kW/m^2. This is more than enough to sustain smoldering (Drysdale 1985 and Ohlemiller 1990).

Based on the available data, smoldering ignition within gaps between timbers can be expected to be self-sustaining and will ultimately result in sufficient charring of the timbers to cause structural failure. A 50-150 kW fire for a duration of 1 to 2 minutes appears to be sufficient to allow initiation of the smoldering. The effect of creosote preservative treatment on timber thermal properties is not considered to either increase or decrease ignitability. There is no data available in the literature that would indicate that Douglas fir treated with a preservative solution improved resistance to smoldering combustion. Freshly creosote-treated wood can be ignited and will burn readily, producing a dense smoke. However, after the timber has seasoned some months, the more volatile parts of the oil disappear from near the surface; and the creosoted wood usually is little, if any, easier to ignite than untreated wood (Wood Handbook 1999). Thus, creosote treatment is not considered to either increase or decrease ignitability of wood timbers.

If ignition of the timbers occurs as a result of exposure to a fire, flaming combustion will not be sustained unless supported by radiation or convection from another source (e.g., flames from nearby fire or burning surface) (Drysdale 1985). This is in agreement with Tewarson's and Pions' 1976 observation that thick wood cannot burn and sustain combustion in normal air without a substantial amount of external or radiative heat flux to the wood surface. In the case of thick Douglas-fir samples, Tewarson and Pion observed that heat flux transferred from a flame to the surface is just sufficient to match the heat flux lost by the surface.

The minimum quantity of fuel required to burn and result in structural failure can be predicted based on the timber-burning or charring rate, and the time required to burn through the timber to its critical dimension required to maintain structural integrity. Evaluations were made to determine:

- Critical structural dimensions of the wood timber.
- Time required to burn or char the timber to the point of structural failure.
- Minimum quantity of fuel (flammable/combustible liquid) required to sustain an exposure fire that results in structural failure.

Since the actual wood timber beam size is 30.5 cm by 35.6 cm (12 in. by 14 in.), it is concluded that if a fire consumes more than 7 cm (2.75 in.) of the beam's depth, then structural failure of the beam could occur. In a fire condition, the time to consume more than 7 cm (2.75 in.) of the wood timber depth is dependent upon its charring or burn-through rate. Since this analysis uses the UBC allowable stress in lieu of the failure stress, the results are thought to be conservative.

The time required to consume 7 cm (2.75 in.) or more of the wood timber was determined by using empirical equations, relating charring rate under ASTM E119 fire exposure to density and moisture content, are available for Douglas fir and other species of wood (Wood Handbook 1999). This approach yields a charring rate of 0.6 mm/min (0.024 in./min). This charring rate is consistent with the literature values. The char rate can be used to predict the time of timber beam failure. Utilizing the appropriate equations results in needing approximately 2 hrs to consume the 7 cm (2.75 in.) of the wooden timber to initiate beam failure and possible tunnel collapse.

Due to lack of information on the amount of flammable/combustible fuel stored in the tunnel, a large number of fire scenarios are possible based on the size and amount of the flammable/combustible liquid spill. With a fixed amount of fuel, large pools will burn with a high-heat release rate for a short duration and small pools will burn with a lower heat release rate for a longer duration. For this analysis, the scenario is bounded by calculating a pool fire size that will sustain combustion of the timbers in the tunnel for a period of time roughly corresponding to timber burn-through to the point of structural failure. For this analysis, it is assumed that a tributyl phosphate (TBP)-kerosene mixture is spilled over the tunnel floor surface, and is free to spread without being confined by the equipment and objects in the area.

Once ignited, a pool fire will spread rapidly over the surface of the liquid spill area. While the burning rate of a given fuel can be affected by its substrate (i.e., gravel and sand) in a spill, any absorption characteristics of the gravel and sand are conservatively neglected in this analysis. For purpose of evaluating the ability of the pool fire igniting the timbers, the worst-case scenario is the pool area, which can expose the timber beams in the tunnel.

The flammable/combustible liquid, when spilled, may form a pool of any shape and thickness, and may be controlled by the confinement of the facility and storage geometries. Since the location of the pool fire is not specified in the tunnel nor obvious per the tunnel arrangement, the worst-case spill must be determined. This is accomplished by assuming the timber is exposed to the pool fire such that failure will occur. The width of the tunnel is 5.9 m (19 ft), and if we assume the width of the railcar to be 2.4 m (8 ft), then a pool on either side of the railcar that is 1.7 m (5.6 ft) in diameter will cause direct flame exposure and ignition of the timber walls.

The flammable/combustible liquid fire results from a leak or ruptured vessel that spills the fuel at a rate required to sustain the pool area and combustion of wood timbers for a fixed time. Further, the fuel is assumed to spill on the soil surface of the tunnel. No slope or liquid flow is assumed on the tunnel soil surface.

For a steady state pool diameter of approximately 2 m, the fuel must spill at a rate of 9×10^{-5} m^3/sec. Assuming a charring rate of 0.06 cm/min (0.024 in./min) cited previously from observations of char on wooden beams and columns exposed to a standard fire test, the volume of fuel required to sustain the area of the fuel spill for a period of two hours is calculated to be 648 L (0.648 m^3 or 172 gal).

The material inventory in Tunnel No. 1 indicates the presence of flammable/combustible liquids. Thus, it is possible that ignition of the timbers in the tunnel could result from a flammable/ combustible liquid pool fire. Based on the material inventory information, an organic solvent TBP with NPH stored in a solvent extraction column is postulated as the potential fire. Since the exact inventory of combustible liquids could not be determined, it is conservatively assumed that Storage Tunnel No. 1 contains an inventory of combustible liquids that could be large enough to cause structural failure of the wooden beams and columns.

B.1.4 General Storage Tunnel Conclusions

Predicted peak temperatures produced by the scenarios are below the temperatures associated with flashover due to rapid oxygen depletion. Maximum thermal insult (medium fire growth rate) to the structures of Tunnel No. 1 and Tunnel No. 2 were evaluated based on available oxygen. Further, the predicted average upper layer temperatures produced during these scenarios are too small to cause structural damage within the PUREX storage tunnels. However, an initially localized fire may cause failure due to flame impingement in Storage Tunnel No. 1.

B.1.4.1 Storage Tunnel No. 1 Conclusions

A small flame can start ignition of the structural timbers in Tunnel No. 1. However, flaming combustion on the surface of the timber would not be sustained unless an external heat flux was supplied. There is no data available in the literature that would indicate Douglas fir treated with a preservative solution improves resistance to smoldering combustion. Therefore, creosote treatment is not considered to either increase or decrease ignitability of wood timbers.

Wood-charring rate can be used to predict structural failure of the timber in Tunnel No. 1 in the presence of a constant external heat flux. Based on the structural load calculations, structural failure due to charring could occur in approximately two hours. The volume of flammable/combustible liquid fuel required to burn and result in structural failure has been estimated to be 648 L (0.648 m^3 or 172 gal).

Smoldering combustion within gaps between timbers can be expected to be self-sustaining and will ultimately result in sufficient charring of the timbers to cause structural failure of Tunnel No. 1. A 6 kW fire exposing the area of a gap for a duration of 1 to 2 minutes appears to be sufficient to allow initiation of the smoldering (Examples of a 6 kW fire: (1) Approximately 227 grams [approximately ½ lb] cellulosic material. (2) Approximately 15.2 cm [approximately 6 in.] long by 0.6 cm [1/4 in.] diameter methane flame.).

The MPFL for Tunnel No. 1 exceeds the DOE criteria for installation of automatic fire suppression. However, the tunnels have been closed for nearly 40 years, there are no active systems associated with the tunnels to cause ignition, and entry is not allowed because of high radiation and contamination levels. The cost to install a suppression system or detection system and to maintain the system once installed would be very high. Installation of a suppression system is not recommended. There is no known correspondence from DOE in regard to accepting the lack of fire suppression in the PUREX Storage Tunnel No. 1.

B.1.4.2 Storage Tunnel No. 1 Damage Potential Estimates

Factors that will impact the recovery plan for Tunnel No. 1 include the extent of waste release and associated air and ground contamination and the extent of the structure damage. Priority would be placed on limiting any further release of contamination both onsite and offsite during emergency condition. This can be accomplished by providing an enclosure or a barrier to the damaged tunnel sections.

Recovery issues involve the remediation of the damaged structure and associated equipment, remediation of the resulting surface contamination, and safe storage of the mixed waste and failed process equipment.

Table B-2, "Cleanup Costs for MPFL Scenario – Storage Tunnel 1," provides a summary of the cost estimates for the candidate fire scenario for Tunnel No. 1 and incorporates the monetary losses associated with the structures that are damaged as result of the fire. Damage potential in terms of fire loss is defined as the dollar cost of restoring damaged property to its pre-fire condition.

DOE M 231.1B has been replaced. However, Appendix F from which Table B-2 was developed no longer exists. In accordance with CRD O 420.1C (Supplemented, Rev 0, Section B 7), CRD DOE O 231.1B (latest edition) is to be used when estimating fire loss. However, CRD O 231.1B does not have the criteria for determining fire loss. CRD O 231.1B requires the use of the Annual Fire Protection Program Summary Information Reporting Guide. The methodology based upon Appendix F is retained for reference in Revision 3.

Table B-2. Cleanup Costs for MPFL Scenario – Storage Tunnel 1

Property and/or Equipment at Risk	DOE M 231.1B, Appendix F	Specific Item	Loss Estimate	Comment
Cost for damage or loss of facilities, inventories, etc.	9..(1)	Use of building and contents	$0	The plume from the fire could impact PUREX Tunnels and result in loss of use of those facilities until cleanup operations are completed. However, per DOE M 231.1, App. F, 9.b.(1), the loss estimation can exclude any expense solely associated with loss of use or occupancy of a facility.

Table B-2. Cleanup Costs for MPFL Scenario – Storage Tunnel 1

Property and/or Equipment at Risk	DOE M 231.1B, Appendix F	Specific Item	Loss Estimate	Comment
Cost to restore property to pre-fire condition or market value of property and equipment	9.a.(2) 9.a.(3) 9.a.(4) 9.a.(5)	Building and contents	$0	The building is in an S&M and decontamination mode awaiting demolition. No market value is assigned as the building would have no anticipated private industry use.
Post-fire cleanup costs (deposition cleanup)	9.a.(6)	Soil and hard surfaces	$15,000,000	Soil and hard surface contamination cleanup
Cost of recharging fire suppression systems	9.a.(7)	Sprinklers	$0	No anticipated cost
Cost for damage to privately-owned property	9.a.(8)	Vehicles, etc.	$1,650,000	With southwest winds, it is assumed that 100 cars are contaminated at nearby facilities within the plume. The cost of decontamination or replacement is $16,500 per car.
Cost for restoration of land and land improvements, investigations, and stand-down	9.a.(9) 9.a.(12) 9.a.(13) 9.a.(14)	Varies	See comment	This is covered by the post-fire cleanup cost estimate.
Labor costs to mitigate losses and non-standard work hours	9.a.(10)	Specialists, decontamination activities	$422,000	Assume 8 workers for 16 hr/day for 30 days (6 weeks) at $125/hr for special decontamination activities to restore work outside of PUREX.
Cost of lost revenue and production	9.a.(11)	Lost production operations	$0	The PUREX Facility is not in production mode. However, an incident may impact access to and operation sat WRPS Tank Farms
TOTAL			**$17,072,000**	

This summary is based on a conservative fire size of 3 MW, 5 percent hard surface in the plume area, and a material at risk (MAR) release fraction of 1 percent. The actual form and distribution of the MAR is mostly film residue on the interior of piping and vessels after reported decontamination and flushing. Section 4.4.1 of DOE-HDBK-3010-94 states that a release fraction value of 0.01 is a reasonable and conservative value.

The cost to restore Tunnel No. 1 to operable condition is estimated to be < $20 million. This is a rough order of magnitude estimate provided by cognizant site personnel and is based on the detailed estimate performed by the Tank Waste Remediation System for a two-vault module

design to store high-level waste canisters (Harmsen and Zimmerman 1997). It should also be noted that based on the conditions of the tunnels, no efforts would be made to recover tunnel inventory or to restore the structure to its current state. Recovery efforts would involve remediation of the resulting surface contamination only.

The damage resulting from a flammable/combustible liquid pool fire in a storage tunnel includes an airborne release of radionuclides to the site or to the public. The following assesses the extent of contamination and maximum cleanup cost resulting from the fire scenario described in this report.

B.1.4.3 Potential Radiological Ground Contamination

The fire in Tunnel No. 1 could result in a structural failure and contamination spread beyond the tunnel perimeter. This does not take into account the fact that the tunnels are covered with 8 ft of earth over the structure. In the event of a tunnel collapse, this earth cover will collapse into the tunnel and reduce or eliminate the spread of contamination outside the tunnel. The area of contamination would be a function of the quantity of contamination material and the activity of the material. The damage resulting from a pool fire in the tunnel area includes ground contamination resulting from the airborne release of radionuclides. Radionuclide contamination could potentially be dispersed to the atmosphere from a fire involving the flammable/combustible liquid. Cleanup costs from the uniform dispersal of mixed waste are calculated using a method for estimating ground areas contaminated by a postulated fire in a facility containing radiological materials developed in Himes 1994. In the model, the dispersion of radioactively contaminated particles is calculated using classical plume equations. The model assumes no containment effect by a structure and is considered to be a conservative estimate of the actual dispersion.

The Himes 1994 model assumes a heat release rate per unit area of 400 kW/m^2, which is not consistent with this analysis. In this analysis, the heat release rate of the flammable/combustible liquid has been estimated as 1320 kW/m^2 for TBP-kerosene for Tunnel No. 1. The difference is accounted for by calculating the effective area of the fire. The effective area is determined by multiplying the fire area by the ratio of the unit heat release. The results of the calculation for the effective burning area are provided in Table B-3, “Effective Burning Area for Contamination Dispersion Calculations.” Damage of the storage tunnel will occur due to structural failure, the structural material (timber) will fall into the tunnel along with the soil that is on top of it and open a hole to the tunnel interior. Failure of the tunnel structure could potentially result in release of contaminated material in the environment. This could result in radiation exposure to the onsite and offsite personnel and environment.

Table B-3. Effective Burning Area for Contamination Dispersion Calculations

Location	Heat release rate flammable/ combustible liquid pool fire (kW/m^2)	Heat release rate Himes method (kW/m^2)	Pool fire burning area (m2)	Effective pool fire burning area A_f (m^2)
Tunnel No. 1	1320	400	2.27	7.50

The results of the model yield a maximum downwind extent of the contour corresponding to a minimum contamination level and the approximate contour corresponding to this minimum contamination. The maximum downwind extent, $x_l(m)$, is given by:

$$x_l = \left(64.9\frac{1}{C}A_F^{0.8407}\right)^{\frac{I}{m}} \qquad \textbf{Eq. B-1}$$

where I is the total radioactive inventory of the fuel load (Ci), C_{eq} is the equivalent radiological contamination limit (Ci/m^2), A_f is the effective burn area of the fire (m^2), and m is calculated from the following equation:

$$m = 0.02940 \ln A_f + 3.248 \qquad \textbf{Eq. B-2}$$

The area of the minimum contour level is given by:

$$A_c = 0.0724\sqrt{m}x_L^{1.903} \qquad \textbf{Eq. B-3}$$

where A_c is the radiological contamination area (m^2). The effective contamination limit, C_{eq} (Ci/m^2), is calculated from the following equation:

$$C_{eq} = \frac{100}{\sum\frac{P_i}{C_i}} \qquad \textbf{Eq. B-4}$$

where P_i is the percent curie activity of the ith radioactive isotope, and C_i is the contamination limit of the ith radioactive isotope.

The radioactive inventory breakdown and accessible soil concentration limit at the 200 East Area is listed in Table B-4, "Radionuclide Breakdown for Storage Tunnel No. 1 and Accessible Soil Concentration Limit." In considering the bounding ground contamination area that could result from pool fires, it can be assumed that all of the radionuclides released into the environment are spread over the maximum area in a concentration equal to the allowable soil concentration limit. This estimate is conservative and bounds the resulting cleanup costs. The ground contamination limit for each isotope (Ci/m^2) is based on accessible soil concentration limits.

Table B-4. Radionuclide Breakdown for Storage Tunnel No. 1 and Accessible Soil Concentration Limit

Radionuclide Isotope Breakdown Tunnel No. 1	Curie Inventory I (Ci)	Percent Composition Pi (%)	Minimum Soil Contamination Limit at 200 East Area Ci (Ci/m^2)
Cs-137	1.01E+04	34.4	4.80E-07
Sr-90	8.18E+03	27.9	4.48E-05
Pu-238	5.92E+01	0.2	3.36E-06
Pu-239	2.65E+02	0.9	3.04E-06
Pu-240	1.52E+02	0.5	3.04E-06
Pu-241	1.98E+03	6.7	l.GOE-04
Pu-242[1]	5.45E-02	<0.01	3.04E-06
Am-241	4.43E+02	1.5	2.88E-06
1-129	6.30E-03	<0.01	1.60E-04
Y-90[2]	8.18E+03	27.9	4.48E-05
Total	2.94E+04	100.0	1.35E-06

[1] Pu-242 entered as Pu-240.

[2] Y-90 entered as Sr-90.

Table B-5, “Results of Contamination Dispersion Model,” provides the results of Equations B-1 through B-4, the extent of the contamination and area of contamination based on a flammable/combustible liquid pool fire in the PUREX storage tunnels.

Table B-5. Results of Contamination Dispersion Model

Location	Effective Burning Area A_f (m^2)	Total Curie I (Ci)	Equivalent Minimum Soil Contamination Level C_{eq} (Ci/m^2) Eq.(4-4)	Extent of Contamination X_l (m) Eq.(4-1)	Area of Contamination A_c (m^2) Eq.(4-2)
Tunnel No. 1	7.50	2,940	1.35E-06	4311	1,086,461

Estimates of soil cleanup costs for the flammable/combustible liquid pool fires can be determined using cost values of soil contamination cleanup referenced in Himes 1994, which cites a soil cleanup unit value of \$5.49/m^2 (\$0.51/ft^2) and then increased by 38 percent for inflation. Due to the prevailing wind direction, virtually all of the contaminated area would involve the soil with a 5 percent hard surface cleanup considered.

The replacement of an estimated 100 private vehicles has also been included. Using this methodology results in a cleanup cost for the Tunnel No. 1 fire of approximately \$15,500,000. This represents the MPFL.

Informal studies have investigated the cost of installing fire suppression systems in the Tunnel No. 1, which resulted in cost prohibitive estimates. It is therefore accepted that due to the absence of ignition hazards, the installation of a fire suppression system is not warranted. There is no known correspondence from DOE in regard to accepting the lack of fire suppression in the PUREX Storage Tunnel No. 1.

B.1.4.4 Storage Tunnel No. 2 Conclusions

Collapse of Tunnel No. 2 would require 424 L (112 gal) of fuel. The total combustible material inventory for Tunnel No. 2 does not approach a level that is equivalent to 424 L (112 gal) of kerosene. Neither Tunnel No. 2 nor its contents have any monetary value. Since the analyzed bounding fire scenario does not result in a breach of the tunnel, there can be no MPFL associated with Tunnel No. 2 because no environmental cleanup would be required and no remediation from the fire event would be needed. Storage Tunnel No. 2 Conclusions

Collapse of Tunnel No. 2 would require 424 L (112 gal) of fuel. The total combustible material inventory for Tunnel No. 2 does not approach a level that is equivalent to 424 L (112 gal) of kerosene. Neither Tunnel No. 2 nor its contents have any monetary value. Since the analyzed bounding fire scenario does not result in a breach of the tunnel, there can be no MPFL associated with Tunnel No. 2 because no environmental cleanup would be required and no remediation from the fire event would be needed.

Appendix C

Peer Review Checklist

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CHPRC REVIEW CHECKLIST

Document Reviewed:
CP-41822, Rev 2 Fire Hazards Analysis for the Plutonium-Uranium Extraction Facility

Scope of Review:
Peer review of Fire Hazards analysis

Yes	No	N/A		
☒	☐	☐	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐		Problem completely defined.
☒	☐	☐		Accident scenarios developed in a clear and logical manner.
☒	☐	☐		Necessary assumptions explicitly stated and supported.
☐	☐	☒		Computer codes and data files documented.
☒	☐	☐		Data used in calculations explicitly stated in document.
☒	☐	☐		Data checked for consistency with original source information as applicable.
☐	☐	☒		Mathematical derivation checked including dimensional consistency of results.
☒	☐	☐		Models appropriate and used within range of validity or use outside range of established validity justified.
☐	☐	☒		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐		Software input correct and consistent with document reviewed.
☒	☐	☐		Software output consistent with input and with results reported in document reviewed.
☒	☐	☐		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐		Safety margins consistent with good engineering practices.
☒	☐	☐		Conclusions consistent with analytical results and applicable limits.
☒	☐	☐		Results and conclusions address all points required in the problem statement.
☒	☐	☐	*	Format consistent with appropriate NRC Regulatory Guide or other standards.
☐	☐	☒		Review calculations, comments, and/or notes are attached.
☐	☐	☒		For calculations in which codes/spreadsheets (e.g., RADIDOSE, GENII, etc) are used, is the latest revision used? Is the User Authorized?
☒	☐	☐		Hazard controls established are appropriate for the hazards including selection using the appropriate hierarchy (e.g., engineered over administrative).
☒	☐	☐		The preventive or mitigative credit assigned to hazard controls are appropriate, and the basis is documented.
☒	☐	☐		**Document approved.**

Thomas V. Kraft — 02/22/2017

Reviewer (Printed Name and Signature) — Date

*Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

A-6004-797 (REV 4)