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222-S Laboratory Documented Safety Analysis

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ACRONYMS

10 CFR	Title 10 *Code of Federal Regulations*
AC	Administrative Control
AIChE	American Institute of Chemical Engineers
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ATL	Advanced Technologies and Laboratories International, Inc.
ATS	Analytical Technical Services
BBI	Best Basis Inventory
CAM	continuous air monitor
CED	committed effective dose
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSU	Chemical Storage Unit
CW	collocated worker
CWC	Central Waste Complex
DBA	design basis accident
DBE	design basis earthquake
DE-Ci	dose equivalent curies
DEF	dose equivalent factor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSA	Documented Safety Analysis
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FHA	Fire Hazards Analysis
FRP	fiberglass reinforced pipe
HEPA	high-efficiency particulate air (filter)
HMS	Hanford Meteorological Station
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
ISMS	Integrated Environment, Safety, and Health Management System
LCO	Limiting Condition for Operation
LCS	Limiting Control Setting
LLW	low-level waste
MAR	material at risk
MCM	minimum critical mass
MOI	maximum offsite individual
NDA	nondestructive assay
NEC	National Electrical Code
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
OCC	occupational
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl

PFP	Plutonium Finishing Plant
PHA	Preliminary Hazards Analysis
PNNL	Pacific Northwest National Laboratory
PVC	polyvinyl chloride
QA	quality assurance
RAD	radiological
RCRA	Resource Conservation and Recovery Act
REDOX	reduction-oxidation (facility)
SAA	Satellite Accumulation Area
SARAH	*Hanford Safety Analysis and Risk Assessment Handbook*
SL	Safety Limit
SMP	Safety Management Program
SR	Surveillance Requirement
SSC	structures, systems, and components
TED	total effective dose
TEDF	Treated Effluent Disposal Facility
TPQ	Threshold Planning Quantity
TRU	transuranic (waste)
TSD	Treatment, Storage, and Disposal
TSR	Technical Safety Requirements
TWINS	Tank Waste Information Network System
UBC	Uniform Building Code
VCP	vitrified clay pipe
WDOE	Washington State Department of Ecology
WRPS	Washington River Protection Solutions, LLC

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EXECUTIVE SUMMARY

Facility Background and Mission

The 222-S Laboratory Complex, located in the 200 West Area of the Hanford Nuclear Reservation, provides analytical chemistry services for the Hanford Site projects, operations, and environmental cleanup activities. Laboratory personnel complete organic, inorganic, and radioisotope analysis of liquid and solid samples brought to the laboratory by the Hanford Site customers. Currently, the 222-S Laboratory long-term mission is to support the Hanford Site environmental cleanup and restoration activities.

Facility Overview

Between 1950 and 1951 the 222-S Laboratory was constructed adjacent to the plutonium reduction-oxidation (REDOX) facility in the 200 West Area on the Central Plateau of the Hanford Site. The laboratory and office space have been progressively enlarged and upgraded as the mission warranted. The 222-S Laboratory Complex consists of the 222-S Laboratory Building, which provides analytical chemistry services for the Hanford Site, and the auxiliary buildings that support the chemistry mission.

The Hanford Site is a 1,517 km^2 (586 mi^2) tract of semiarid land located within the Pasco Basin of the Columbia Plateau in southeastern Washington State. Facilities and activities at the Hanford Site are consolidated in operating areas scattered across the site and occupy approximately 6% of the total site area. The site is bounded on the north by the Saddle Mountains, on the east by the Columbia River, on the south by the Yakima River, and on the west by the Rattlesnake Hills.

The 222-S Laboratory and auxiliary buildings, located in the southwest portion of the 200 West Area of the Hanford site, are collectively a Hazard Category 3 nonreactor nuclear facility. 222-S Laboratory is exposed to a potential hazard from radioactive and toxicological release by the Plutonium Finishing Plant (PFP). The laboratory is within the emergency planning zone of the PFP and is connected to the Patrol Operations Center, which would communicate emergencies via the Site emergency notification system. The PFP is located approximately 3 km (1.9 mi) northwest of 222-S Laboratory. Previously, the mission of PFP was to produce weapons-grade plutonium metal. Currently, the mission is to place the remaining plutonium in a stabilized form (e.g., plutonium oxide) in preparation for the eventual decontamination and decommissioning of the facility. Other facilities in the 200 West Area with ongoing operations that have a potential for affecting 222-S Laboratory include the high-level radioactive waste storage tanks, Environmental Restoration Disposal Facility, Central Waste Complex (CWC), T Plant, and low-level burial grounds.

Policy that complies with applicable U.S. Department of Energy (DOE) Orders and the Code of Federal Regulations is established. The 222-S Laboratory has procedures as the means to comply with the Orders and regulations.

Facility Hazard Classification
Hazards that can contribute to the uncontrolled release of radioactive or hazardous materials (called hazardous conditions) are systematically and comprehensively identified through the Hazard Analysis process (Section 3.3). The identified set of potential uncontrolled releases is subject to a candidate selection process. This process identifies candidate representative accidents, which are the starting point for the Accident Analysis (Section 3.4). Results of the accident analysis and the hazard analysis are used to support the Control Decision Process (Section 3.3.2.3.2). This process identifies safety-related controls and classifies safety-related structures, systems, and components (SSCs). The controls are allocated to all hazardous conditions identified by the Hazard Analysis.

The 222-S Laboratory will be operated as a Hazard Category 3 nuclear facility by maintaining radioactive material inventories below Category 2 threshold quantities provided in DOE-STD-1027-92. Facility inventory limits are used to maintain the total inventory in the facility below the dose equivalent curies used to calculate the dose consequences identified in the accident analysis, which is below the Hazard Category 2 thresholds.

Safety Analysis Overview
Facility operations consistent with its mission to receive, analyze, store, report, and discharge radioactive materials is reviewed for the identification of all hazards and energy sources. A hazard is defined to be an energy source or harmful material (radioactive or hazardous). The following hazards were not considered for further detailed analysis in the hazard evaluation:

- Hazards routinely encountered and/or accepted by the public
- Hazards controlled by regulations and/or one or more national consensus standards
- General radiological hazards subject to Title 10, *Code of Federal Regulations* Part 835, “Occupational Radiation Protection” (10 CFR 835)
- Hazards likely to be found in homes, general retail outlets, and associated with open-road transportation subject to U.S. Department of Transportation regulation.

However, these types of industrial and radiological hazards are included in the evaluation of hazards.

From the Preliminary Hazards Analysis (PHA) a wide-ranging set of hazardous conditions is formulated that could lead to release of radioactive or hazardous materials from contained locations within the facility vessels and piping. Based on this, a list of candidate representative accidents is selected that can be considered to represent and bound all hazardous conditions. From this candidate list, accidents are defined and analysis performed to quantitatively determine safety impacts.

Six accident groups were identified using this approach. These groups are discussed along with the bounding hazardous condition for each group in Section 3.3.2.3.5. Chemical releases are provided for completeness but they are not considered part of the candidate representative accident selection.

- Fire/Explosion
- Storage Tank Failure/Leaks
- Container Handling Accidents
- Container Overpressure Accidents
- Confinement System Failure
- Natural Phenomena/External Events

A building-wide fire is selected as the bounding accident for the 222-S Laboratory. Such a fire can be started by a failure of a compressed cylinder of flammable gas or gas line in a laboratory room. The building-wide fire scenario is assumed to result from the spread of either a local fire or a local deflagration and resulting fire.

The expectation for Hazard Category 3 facilities, according to the direction presented in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH), is the establishment of an inventory limit based on quantification of unmitigated risk from bounding scenarios.

Organizations
Washington River Protection Solutions LLC (WRPS) is the prime contractor to DOE responsible for managing the 222-S Laboratory. The 222-S Laboratory organization has the responsibility for the operation of the laboratory including programs such as maintenance, waste management, occupational health and safety, radiological control, and process development. Advanced Technologies and Laboratories International, Inc. (ATL) has the responsibility for routine management of the analytical chemistry services at the 222-S Laboratory.

The 222-S Laboratory Documented Safety Analysis (DSA) was prepared by a team of operating and technical staff from the 222-S Laboratory, the Pacific Northwest National Laboratory (PNNL), and nuclear safety personnel of WRPS.

Safety Analysis Conclusions
The operation of the 222-S Laboratory will have no impact on members of the public, collocated workers, and environment, and minimal impact on operating personnel during normal operations. No safety-class or safety-significant SSCs were identified by the hazard and accident analysis. Adherence to the Technical Safety Requirements (TSR) ensures that the facility will be operated within the established risk guidelines.

Documented Safety Analysis Organization
The structure and content of this DSA parallels the format delineated in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*.

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1.0 SITE CHARACTERISTICS

1.1 Introduction

This chapter provides a summary of U.S. Department of Energy (DOE) Hanford Site Characteristics relative to the 222-S Laboratory as specified by DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chapter 2. Much of the information in this section is general for the Hanford Site; however, it has been tailored to reflect information relevant to the 222-S Laboratory operations and activities. This chapter conforms to the direction presented in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH).

The U.S. Army Corps of Engineers selected the Hanford Site in 1943 for the production of nuclear weapons material. Current activities on the Hanford Site focus on environmental restoration, waste management, and technology research. The Hanford Site utilizes access control points at the entrance roads for reasons of national security as well as health and safety considerations.

The natural characteristics of the Hanford Site have been researched continually and documented since the early 1940s. Information about local winds and diffusion estimates are based on measurements at the Hanford Meteorological Station (HMS). Data specific to the WRPS nuclear facilities include nearby industrial, transportation, and military facilities; subsurface hydrology; potential impacts of river flooding; and seismic hazards.

Between 1950 and 1951 the 222-S Laboratory was constructed adjacent to the plutonium reduction-oxidation (REDOX) facility in the 200 West Area on the Central Plateau of the Hanford Site. The laboratory and office space have been progressively enlarged and upgraded as the mission warranted. The 222-S Laboratory Complex consists of the 222-S Laboratory Building, which provides analytical chemistry services for the Hanford Site, and the auxiliary buildings that support the chemistry mission. The laboratory and support facilities are individually described in Chapter 2.0.

1.2 Requirements

The Hanford Site was designed, built, and operated using a range of different requirements since 1943. Current requirements for design, construction, and operation of Tank Operations Contractor (TOC) nuclear facilities are specified by Contract DE-AC27-08RV14800.

Current requirements for the evaluation of hazards are contained in DOE O 420.1B, *Facility Safety*, and Title 10 *Code of Federal Regulations* Part 830 (10 CFR 830) Subpart B, “Safety Basis Requirements.”

1.3 Site Description

This section describes the overall Hanford Site, the area boundaries, and presents demographic information for the area based on 1990 and 2000 census data. The site covers a large area so specific distances used in hazard categorization and accident analyses for facilities vary depending on the facility's location within the Hanford Site. Much of the current information is obtained from reference document PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*. The parameters specific to the 222-S Laboratory accident analysis are described here and in Chapter 2.0.

1.3.1 Geography

The Hanford Site is a 1517-km^2 (586 square mile) tract of semiarid land located within the Pasco Basin of the Columbia Plateau in southeastern Washington State. Facilities and activities at the Hanford Site are consolidated in operating areas scattered across the site and occupy approximately 6% of the total site area. The site is bounded on the north by the Saddle Mountains, on the east by the Columbia River, on the south by the Yakima River, and on the west by the Rattlesnake Hills. The Site extends into Benton, Franklin, Grant, and Adams Counties. State Highways 24, 240, and 243 pass through the Hanford Site. Figures 1-1 through 1-3 show the location of the Hanford Site within the state of Washington, a Hanford Site map, and a detailed map of the 200 West Area.

The Hanford Patrol controls access to the Hanford Site for DOE and only persons authorized by DOE are allowed to enter. Although the public may travel on the Columbia River and State Route 240, both of which allow passage in close proximity to the facilities inside the Site boundary, the Benton County Sheriff's Department in cooperation with the Hanford Patrol may restrict such travel; thus, these routes are not considered public.

The hazard and accident analysis for the 222-S Laboratory considers the closest Offsite Public to be 13.0 km (8.1 miles) directly west of the laboratory.

1.3.2 Demography

This section summarizes data on current regional and transient population. Only DOE authorized public, workers, contractors, and visitors are permitted within the site boundary. There are no residents within the Hanford Site boundary and the population distribution in the area surrounding the site is not uniform.

The larger communities nearest the site include Richland, Kennewick, Pasco, West Richland, Benton City, Prosser, Sunnyside, Grandview, and Mesa. The city of Richland is the closest of the large population centers to the 222-S Laboratory and is approximately 37.0 km (23 miles).

1.4 Environmental Description

This section summarizes the meteorological, hydrological, and geological information pertaining to the 222-S Laboratory and other facilities located on the Hanford Site.

1.4.1 Meteorology

The Hanford Site is located in a semiarid region of southeastern Washington State. The region's climate is greatly influenced by the Pacific Ocean, the Cascade Mountain Range to the west, and other mountain ranges located to the north and east. The Pacific Ocean moderates temperatures throughout the Pacific Northwest and the Cascade Range generates a rain shadow that limits rain and snowfall in the eastern half of Washington State. The Cascade Range also serves as a source of cold air drainage, which has a considerable effect on the wind regime on the Hanford Site.

Mountain ranges to the north and east of the region shield the area from the severe winter storms and frigid air masses that move southward across Canada.

Data for the Hanford Site are compiled at the HMS. The HMS is located on Hanford's 200 Central Plateau, just outside the northeast corner of 200 West Area and about 4 km (3 mi) west of the 200 East Area. Meteorological measurements have been made at the HMS since late 1944. Prior to the establishment of the HMS, local meteorological observations were made at the Old Hanford Townsite (1912 through late 1943) and in Richland (1943-1944). A climatological summary for Hanford is documented in PNNL-13469, *Climatological Data Summary 2000 with Historical Data*.

To accurately characterize meteorological differences across the Hanford Site, the HMS operates a network of automated monitoring stations. These stations, which currently number approximately 30, are located throughout the site and in neighboring areas (Figure 1-4). A 124-m (408 ft) instrumented meteorological tower operates at the HMS. A 60-m (197 ft) instrumented tower operates at each of the 100-N, 300, and 400 Area meteorology-monitoring sites, (Figure 1-5). Most of the other network stations use short-instrumented towers with heights of about 9.1 m (30 ft). Data are collected and processed at each monitoring site, and key information is transmitted to the HMS every 15 minutes. This monitoring network has been in full operation since the early 1980s.

Information concerning local winds and diffusion estimates are based on measurements at the HMS. Meteorological parameters measured in the area of the Hanford Site are documented in PNNL-11107, *Climatological Data Summary, 1995 with Historical Data*, and in PNNL-13469, *Hanford Site Climatological Data Summary 2000 with Historical Data*. In December 1944, the HMS and its 125-meter (410 ft) instrumented tower became operational. In 1982, the instruments on the tower were replaced with equipment that met applicable U.S. Nuclear Regulatory Commission requirements. Temperature, relative humidity, precipitation, atmospheric pressure, solar radiation, cloud cover, and visibility are measured or observed at regular intervals at the HMS.

Prevailing wind directions near the surface on Hanford's Central Plateau are from the northwest in all months of the year (Figure 1-4). Winds from the northwest occur most frequently during the winter and summer. Winds from the southwest also have a high frequency of occurrence on the Central Plateau. During the spring and fall, there is an increase in the frequency of winds from the southwest and a corresponding decrease in winds from the northwest.

Stations that are relatively close together can exhibit significant differences in wind patterns. For example, the stations at Rattlesnake Springs and the 200 West Area are separated by about 5 km (3 mi), yet the wind patterns at the two stations are very different (see Figure 1-4). Care should be taken when assessing the appropriateness of the wind data used in estimating environmental impacts. When possible, wind data from the closest representative station should be used for assessing local dispersion conditions. The wind patterns measured at the #7 (West Area) and #19 (PFP) stations are very similar and are considered to be the most representative of wind patterns at the 222-S Laboratory.

1.4.2 Hydrology

The Hanford Site is situated within the Columbia River drainage basin. Two major rivers within the drainage basin, the Columbia and the Yakima, border the Hanford Site. Columbia River flow near the Hanford Site has been measured since 1917. These data show an average discharge of 3400 m^3/s (120,067 ft^3/s). Data gathered from the mouth of the Yakima River show an average discharge of 99 m^3/s (3496 ft^3/s).

The flow of the Columbia River adjacent to the Hanford Site is regulated by operation of the Priest Rapids Dam. The maximum historical flood recorded on the unregulated Columbia River occurred in 1894, causing a peak discharge at what is now the Hanford Site estimated at 21,000 m^3/s (741,594 ft^3/s). Under regulated conditions, the peak discharge below the Priest Rapids Dam for the 100-year flood is calculated to be 12,500 m^3/s (441,425 ft^3/s).

The most severe flood of the Yakima River was recorded in 1933 and had a peak discharge of 1900 m^3/s (67,097 ft^3/s). Floods of this size are expected about once every 170 years. The 100-year flood plain for the Yakima River indicates that floodwaters reach only the very southern portions of the Hanford Site and would not affect the 222-S Laboratory.

1.4.3 Geology

The Hanford Site lies within the Pasco Basin that is part of the Columbia Basin subprovince of the Columbia Intermontane Physiographic Province. The Pasco Basin comprises thick layers of basalt interspersed with layers of sedimentary material. Principal geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold formation, and the deposits informally referred to as the Hanford formation. Major topographic relief forms include several east-to-southeast trending ridges, which are the surface manifestations of anticlinal folding of the underlying basalt.

The Columbia River Basalt Group is composed of numerous basaltic lava flows. The rate of eruption of these lava flows slowed with time, allowing sediment to be deposited before the next basalt flow covered the landscape. These sediments now form water-bearing interbeds between many of the most recent basalt flows. Deposition of these sediments continued after eruption of the basalt flows ceased, creating the Ringold formation. This formation generally consists of an alternating sequence of sand and gravel main-channel river deposits and muddy overbank and lake deposits. In places, these layers are unconsolidated, while in others they are weakly to moderately cemented. The Ringold Formation was deposited some 8.5 to 3.9 million years ago. Deposition of the Ringold formation was followed by a period of nondeposition and erosion, which removed varying amounts of the sediment throughout the Pasco Basin. At the same time, the Plio-Pleistocene unit caliche and gravel and the wind blown sand and silt of the early "Palouse" soil were deposited in the western portion of the basin.

1.5 Natural Phenomena Threats

This section identifies the natural phenomena with potential for adverse impacts on the safe operation of 222-S. For each natural phenomenon, information is presented on frequency of occurrence, magnitude, and the design considerations that reduce impacts. The natural phenomena presented in this section are severe weather, floods, earthquakes, snow, rain, volcanic activity, and range fires.

Severe weather includes dust storms, high winds, thunderstorms, lightning strikes, and tornadoes. The most frequent severe weather phenomenon at the Hanford Site and the one with the greatest impact on normal operations is the dust storm. Dust storms occur when winds greater than 29 km/h (18 mph) re-suspend dust from various sources into the air. The HMS reports that dust storms occur at the Hanford Site with an average frequency of eight times a year. During these times, visibility is reduced to 9.7 km (6 miles) or less. Restricted visibility, blowing dust, and the potential to clog high-efficiency particulate air (HEPA) and other filters are the main hazards associated with these storms.

Extreme winds and the associated wind pressures on facilities and structures constitute the major severe weather hazard to safe operation of the facilities. The maximum-recorded peak wind gust at 15 m (49 ft) above ground level is 129 km/h (80 mph), which occurred in January 1972. Uniform design and evaluation guidelines based on these wind data have been developed for protection against extreme wind hazards at Hanford Site facilities and are used to determine the design criteria for new SSCs. The standard architectural-civil design criteria, DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, established the wind load design requirements.

The average year has 10 thunderstorm days. Thunderstorms are considered severe weather when accompanied by wind gusts greater than 90 km/h (56 mph) and/or hail with diameter equal to or greater than 1.9 cm (0.75 in.). Although very rare, severe weather thunderstorms have occurred at the Hanford Site. Other than the impact of rain, high wind speeds have the potential to adversely affect the facilities. The principal hazard associated with the thunderstorms is wild range fire due to lightning strikes.

Tornadoes are very rare in the vicinity of the Hanford Site. The DOE no longer requires design criteria to be established for tornadoes for nonreactor facilities on the Hanford Site.

Three scenarios for possible flooding on the Hanford Site are breach of Grand Coulee Dam, blockage of the Columbia River, and intense precipitation.

The maximum postulated flood scenario results from a hypothetical 50% breach of Grand Coulee Dam on the Columbia River, upstream from the Hanford Site. This scenario is calculated to result in an inundation of the Hanford Site with floodwaters to an elevation of about 148 m (486 ft) above mean sea level in the vicinity of B and C Reactors (Figure 1-6).

The elevation of the 222-S Laboratory is approximately 198 m (650 ft) above mean sea level. Floodwaters that rise to an elevation of only 148 m (486 ft) above sea level will not approach the laboratory.

The potential for massive landslides resulting in blockage along the Columbia River is judged to be bounded by the 50% breach of the Grand Coulee Dam case.

The location of the 222-S Laboratory near the top of the 200 Area plateau, in addition to the grading and drainage features that are provided, ensures that precipitation, even from a downpour as severe as 30 cm (12 in.) in 24 h, would infiltrate the ground or drain off toward the Columbia River without significant flooding. Adverse impacts from less severe local precipitation run-on and run-off are not expected. The laboratory is not sited in a wetlands or coastal high-hazard area.

The Columbia Plateau experiences seismic activities that are relatively shallow in nature and of low to moderate intensities. A seismic network installed on the Hanford Site in 1969 shows that the majority of seismic events have magnitudes of less than 3.5 and occur at depths of less than 4 km (2.5 mi). These are considered to be shallow micro earthquakes and may consist of as many as 100 events lasting from a few days to several months.

The largest known earthquake in the region occurred in 1936 near Milton Freewater, Oregon. The estimated surface-wave magnitude of this earthquake was 5.7 to 5.8. Other events occurred near Umatilla, Oregon, in 1893; near the Saddle Mountains in 1918; near Corfu, Washington, in 1973; and near College Place, Washington, in 1979. All of these events measured less than 4.5 in intensity.

A seismic event is the most significant natural phenomenon affecting safety, because it has the greatest potential for resulting in common-cause failures. For most facilities, the primary seismic hazard is the earthquake ground motion. Other potentially adverse affects of earthquakes stem from fault displacement, liquefaction, seismically induced slope instability, and ground settlement; however, the geologic conditions favorable to these hazards are not present at Hanford or 200 W facilities.

For the high-hazard facility-use category, the design basis earthquake (DBE) is specified in the seismic guidelines as the maximum horizontal ground surface acceleration, with an annual probability of exceedance of 2.0E+04 (return period of 5000 years). This corresponds to a peak horizontal acceleration of 0.20g. For the moderate- and low-hazard facility-use categories, the seismic guidelines specify the DBE loading as the maximum horizontal ground surface acceleration with an annual probability of exceedance of 1.0E+03 (return period of 1000 years). This corresponds to a peak horizontal acceleration of 0.12g for the 200 West Area. Seismic design criteria are then applied to the facilities on the basis of the safety classifications of SSCs.

All new aboveground structures and components are designed to withstand snow loading in accordance with ANSI A58.1-1982, *Minimum Design Loads for Buildings and Other Structures*. The following criteria are used:

- Ground snow load-73 kg/m^2 (15 lb/ft^2), and
- Minimum roof load-98 kg/m^2 (20 lb/ft^2).

Because Hanford facilities are located in a semiarid region, the snow loading bound the rain loading.

The Hanford Site is in a region subject to ashfall from volcanic eruptions. The three major volcanic peaks closest to the Site are Mt. Adams, about 100 mi away; Mt. Rainier, about 110 mi away; and Mt. St. Helens, about 130 mi away. Important historical ashfalls affecting this location were from eruptions of Glacier Peak about 12,000 years ago, Mt. Mazama about 6000 years ago, and Mt. St. Helens about 8000 years ago. The most recent ashfall resulted from the May 18, 1980, eruption of Mt. St. Helens. Volcanic ash loading design criteria of 117.2 kg/m^2 (24 lb/ft^2) is applicable only to the design of safety-class SSCs.

The major factors that protect the 222-S Laboratory from hazards associated with range fires are (1) grading, maintenance, and continuous housekeeping to minimize combustible material; (2) fire breaks by the roadways; and (3) location close to the 200 Area Fire Station. (The fire station can respond to 200 West Area calls within 10 minutes.) The Hanford Fire Department has firefighting equipment on hand to deal with range fires and has experience protecting Hanford Site facilities from fire damage. For these reasons, adverse impacts in excess of the bounding accident scenarios are not anticipated.

The most severe range fire documented on the Hanford Site occurred in 1984. The fire burned approximately two-thirds of the total land area and threatened some Hanford Site facilities; however, because of the grading, maintenance, housekeeping, fire breaks, and the efforts of the Hanford Fire Department, facilities were protected, and there was no significant damage, project economic loss, or programmatic impact.

Another large range fire occurred in June and July 2000 and swept through the Hanford Site. It burned approximately 655 km^2 (250 mi^2).

Hazards from other natural phenomena (e.g., surge and seiche flooding, tsunami flooding, and ice flooding) were considered not credible or were determined to have no potential for impact.

1.6 External Human Generated Threats

The regional highway network traversing the Hanford Site (State Highways 24 and 240) has restricted access roadways. Commercial trucks that deliver gas, diesel fuel, and chemicals use these highways and Hanford Site roads. Because of the distance from these roads to the laboratory, the impact of a highway accident involving toxic and hazardous chemicals would be less severe than the bounding chemical or toxic material accident occurring in the 200 Areas.

The nearest airport to the Hanford site is the Richland Airport, a small general utility airport. Commercial air carriers use the Tri Cities Airport in Pasco, Washington, located southeast of Hanford facilities. The probability of a commercial aircraft adversely affecting the Hanford facilities is considered remote, given the relatively low volume of air traffic at the airport and the distance between the airports and Hanford facilities.

1.7 Nearby Facilities

No industrial refineries, oil storage facilities, or other major commercial facilities are located close to Hanford facilities. A vehicle refueling station is located adjacent to the 200 East Area approximately 5 km (3 mi) from 200 West Area. The nearest natural gas transmission pipeline is about 48 km (30 mi) away. The distance between these facilities and 222-S Laboratory makes any adverse impact to the laboratory from explosions or fire at these installations nonexistent.

The closest nearby facility which poses significant hazard to the 222-S Laboratory is the REDOX facility located approximately 100 m north of 222-S Laboratory. It is unoccupied and is scheduled for decontamination and decommissioning (D&D). The primary concern with the building, as reported in the REDOX documented safety analysis, is a roof collapse in a seismic event with a peak ground acceleration of greater than 0.03g. The radiological consequences resulting from the seismic event with the cover blocks installed, current configuration would result in a committed effective dose (CED) of 13 rem to the laboratory personnel in the 222-S Laboratory Building and up to 74 rem to personnel working between REDOX and the laboratory. The seismic analysis assumed that the coverblocks were in place, and they are designated as safety-significant Design Features and controlled through configuration management to ensure the cover blocks are not removed. If the cover blocks were not in place during a seismic event causing the roof to collapse, the CED to laboratory personnel is postulated to exceed 1000 rem.

The Plutonium Finishing Plant (PFP) is a nonreactor nuclear facility that poses a significant potential hazard to the 222-S Laboratory Complex from radioactive and toxicological material releases. The PFP is located approximately 3 km (1.9 mi) northeast of the 222-S Laboratory. Previously, the mission of PFP was to produce weapons-grade plutonium metal. Currently, the mission is to place the remaining plutonium in a stabilized form (e.g., plutonium oxide) in preparation for the eventual D&D of the facility. The 222-S Laboratory is within the emergency planning zone of the PFP and is connected to the Patrol Operations Center, which would communicate emergencies via the site emergency notification system. Other facilities in the 200 East and 200 West Areas with ongoing operations that have a potential for affecting the 222-S Laboratory Complex include the high-level radioactive waste storage tanks, Environmental Restoration Disposal Facility, 242 A Evaporator, Central Waste Complex (CWC), T Plant, low-level burial grounds, and Waste Encapsulation Storage Facility.

Emergency planning and response guidance for the 222-S Laboratory is contained within ATS-MP-1036, *Building Emergency Plan for the 222 S Laboratory Complex*. Neighboring facilities are notified of an event at 222-S Laboratory by activation of the sitewide "crash-phone" system or the Hanford Site emergency alerting system. Occupants of other facilities will respond in accordance with the respective organization emergency plans.

The only operating commercial nuclear power reactor in the Pacific Northwest is on the Hanford Site. The Energy Northwest Columbia Generating Station, a boiling water reactor with a design power level of 3323 MWt (thermal) and 1180 MWe (electrical), is located north of the 300 Area, east of the 400 Area and southeast of the 200 Areas. The operations of this reactor pose no significant risk to the 222-S Laboratory.

The southeastern boundary of the U.S. Army Yakima Training Range, used for military maneuvers and weapons training, is located 13 km (8 mi) from the 200 West Area. Live firing of weapons with explosive warheads is directed into an impact area within the center boundary; therefore, the U.S. Army states that no safety threat exists for people living adjacent to the Yakima Firing Center or for those living on the east bank of the Columbia River (DOA 1989, *Yakima Firing Center Proposed Land Acquisition*). Accordingly, the firing center is assumed to pose no threat to the 222-S Laboratory operations or personnel.

1.8 Validity of Existing Environmental Analyses

No significant discrepancies have been identified between the site characteristic assumptions made in this chapter and those made in the Hanford Environmental Impact Statements: DOE/EIS 0113, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes*; and DOE/EIS 0200-F, W*aste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*.

1.9 References

ANSI A58.1-1982, *Minimum Design Loads for Buildings and Other Structures*, American National Standards Institute, New York, New York.

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

10 CFR 830, Title 10, *Code of Federal Regulations*, Part 830, Subpart B, "Safety Basis Requirements," as amended.

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PNNL-13469, 2001, *Hanford Site Climatological Data Summary 2000 With Historical Data*, Pacific Northwest National Laboratory, Richland, Washington.

ATS-MP-1036, 2006, *Building Emergency Plan for the 222 S Laboratory Complex*, CH2M HILL Hanford Group, Inc., Richland, Washington.

FIGURE 1-1. THE HANFORD SITE IN WASHINGTON STATE.

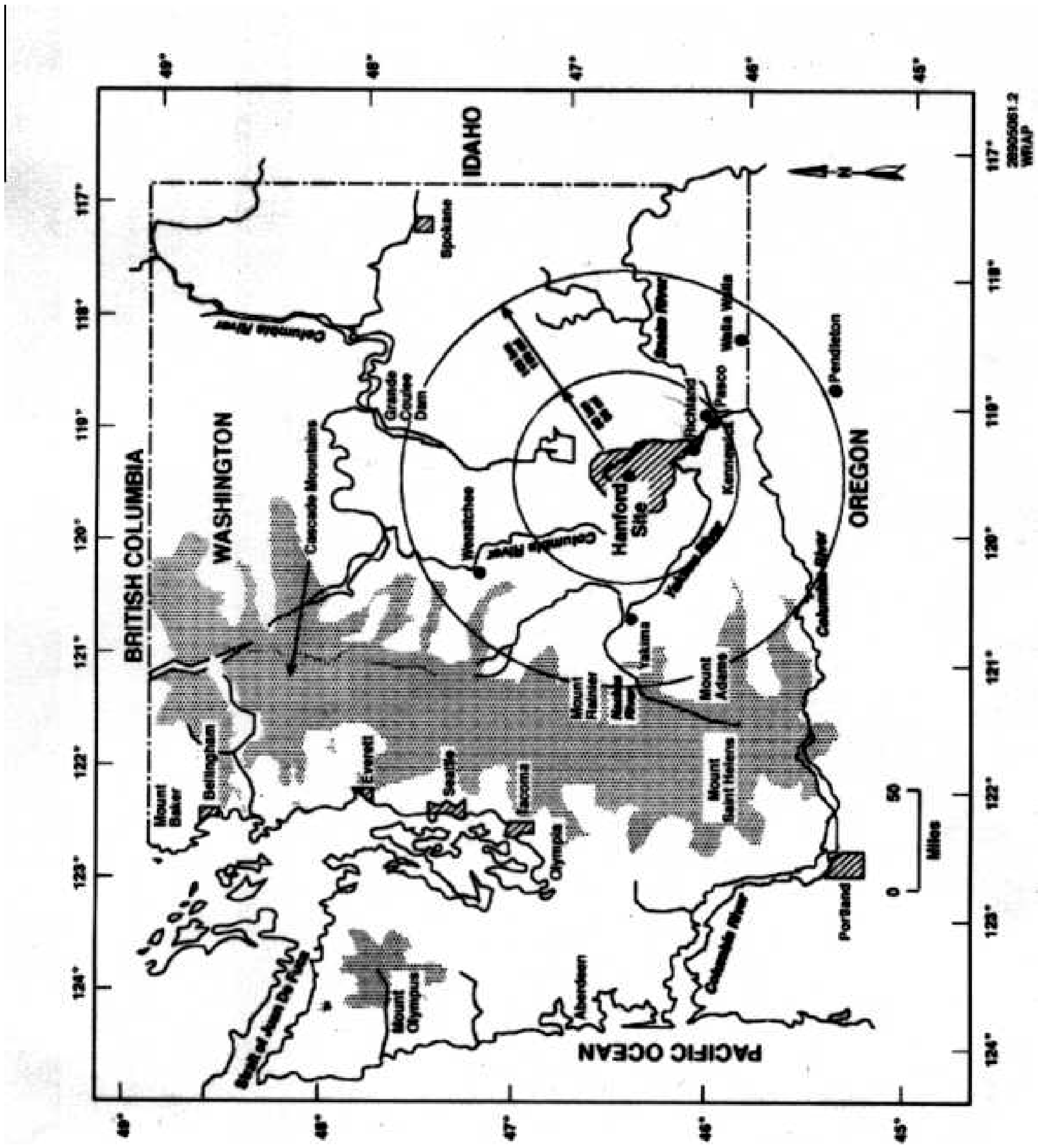


FIGURE 1-2. HANFORD SITE MAP.

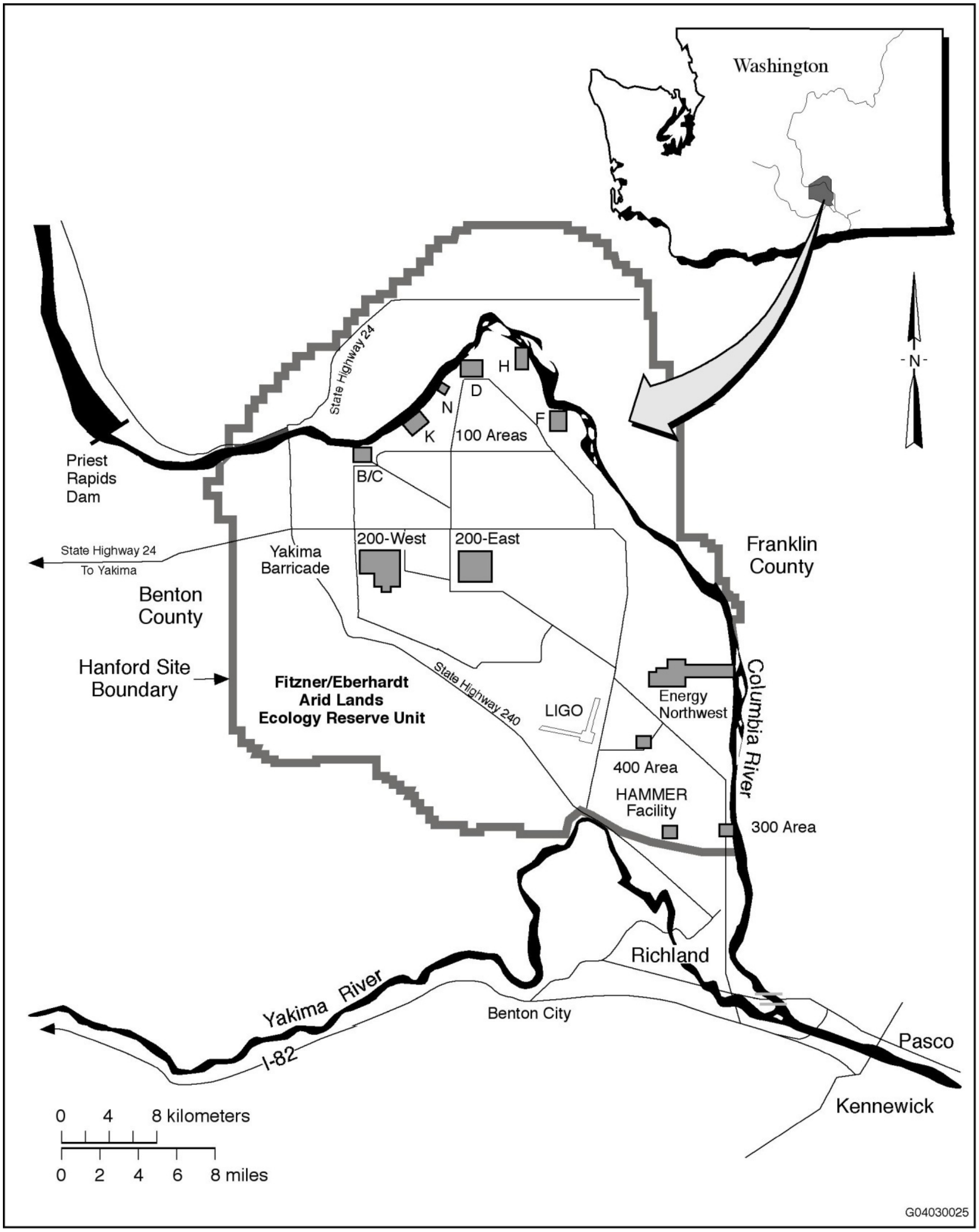


FIGURE 1-3. 200 WEST AREA.

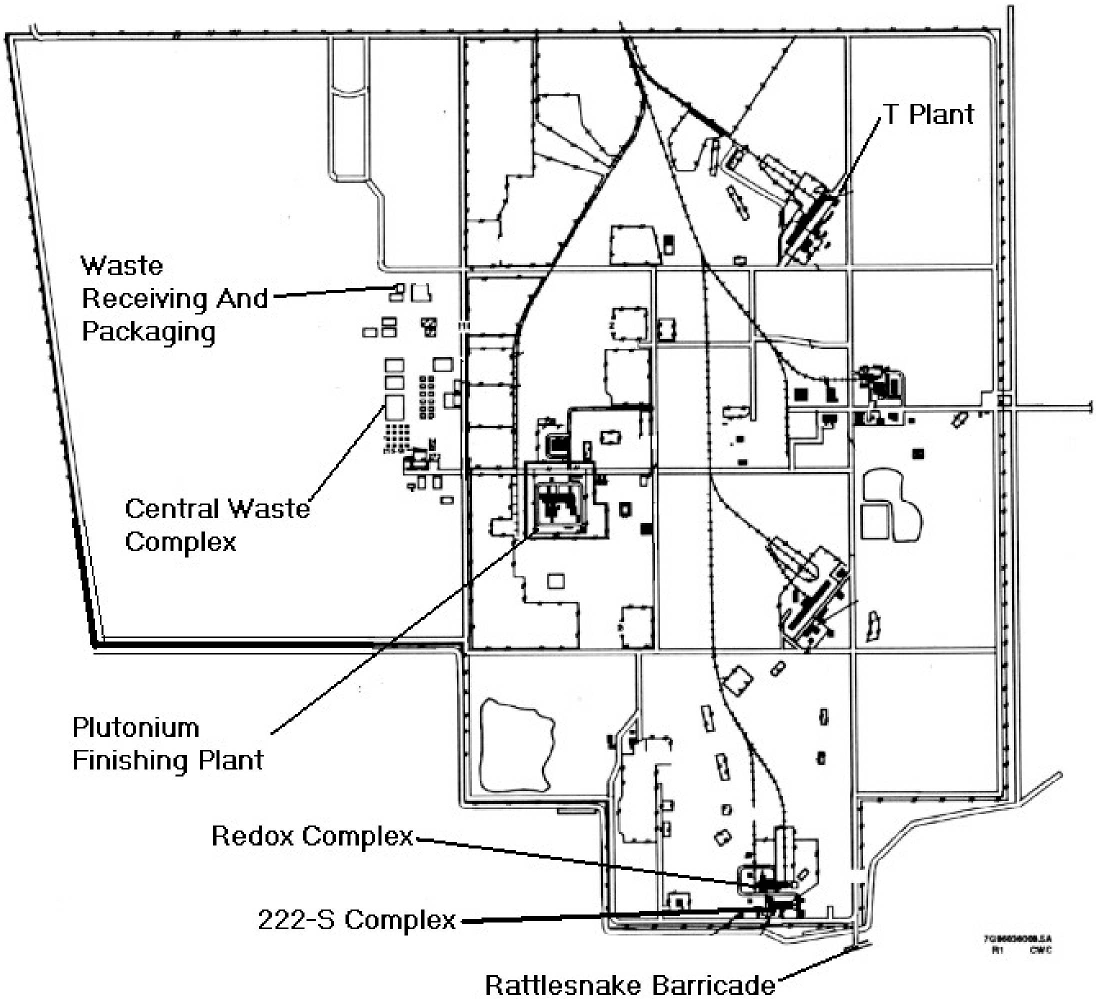


FIGURE 1-4. WIND ROSES AT THE 9.1-M (30 FT) LEVEL OF THE HANFORD METEOROLOGICAL MONITORING NETWORK, 1982 TO 2000.

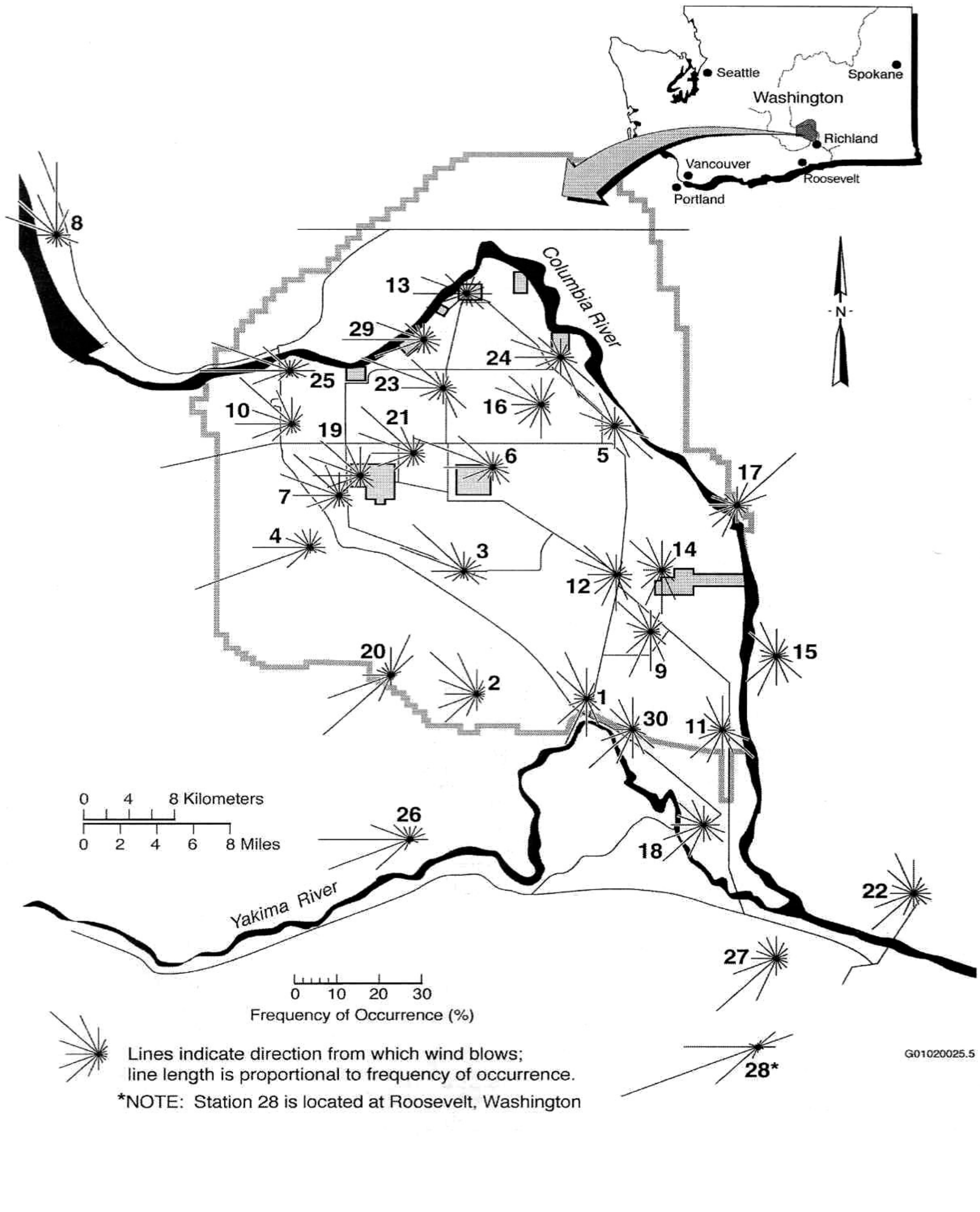


FIGURE 1-5. WIND ROSES AT THE 60-M (197 FT) LEVEL OF THE HANFORD METEOROLOGICAL MONITORING NETWORK, 1986 TO 2000.

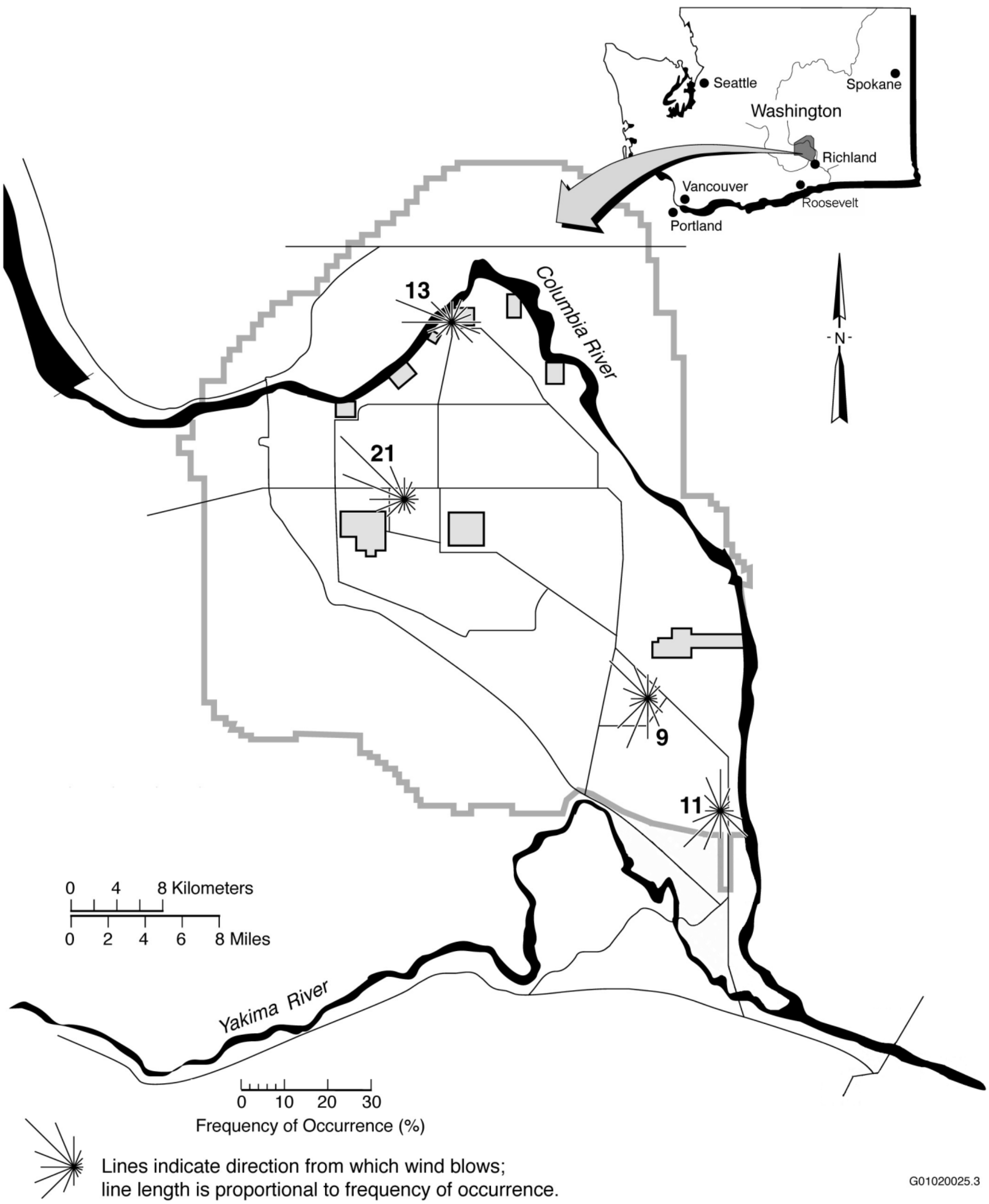
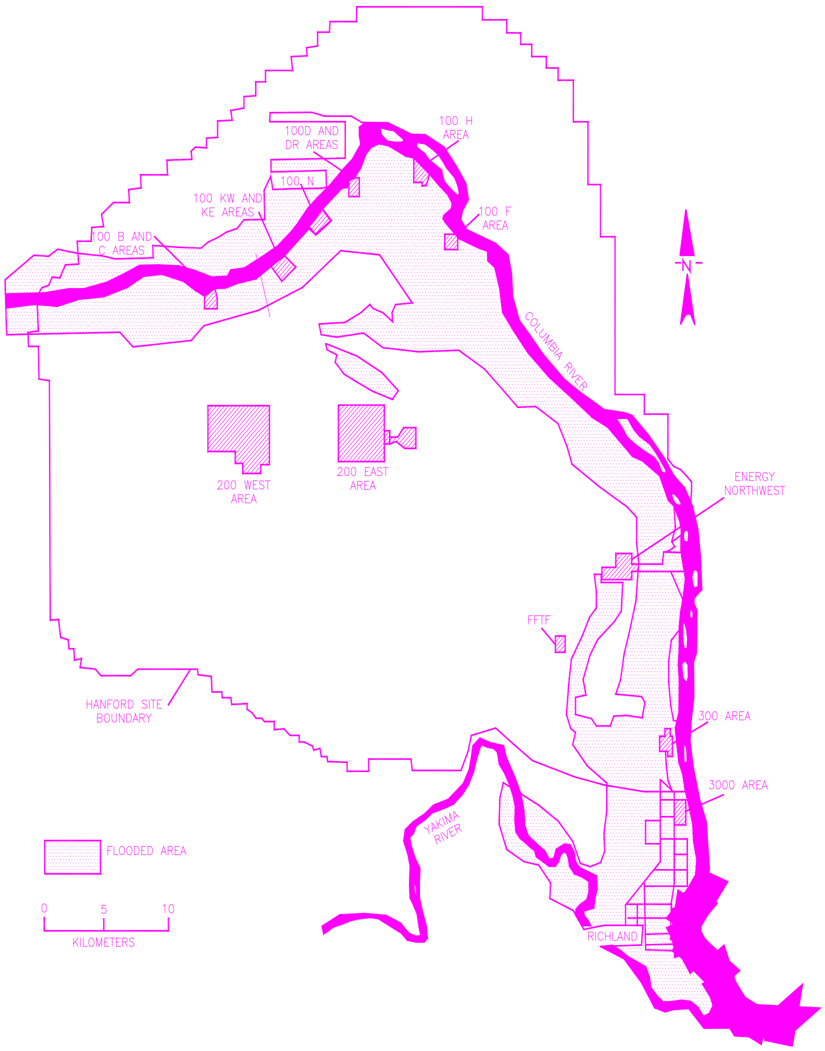


FIGURE 1-6. WORST-CASE HYPOTHETICAL FLOOD OF THE COLUMBIA RIVER.



2.0 FACILITY DESCRIPTION

This chapter describes the facility, its designed mission, and processes to support assumptions used in the hazard and accident analysis. These descriptions focus on all facility features necessary to understand the hazard and accident analysis, not just the safety systems, structures and components (SSCs). This chapter complies with 10 CFR 830 Subpart B, “Safety Basis Requirements,” and provides information consistent with the guidance provided in Chapter 2.0, *Facility Description*, of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. Also, the content of this chapter follows the direction provided in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH).

2.1 Introduction

The 222-S Laboratory is located on the southern edge of the 200 West Area in the Hanford Site adjacent to the plutonium reduction-oxidation (REDOX) facility. In accordance with the direction presented in 10 CFR 830, the 222-S Laboratory is a Hazard Category 3 nonreactor nuclear facility as specified in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. The magnitude of the worst-case accident for a DOE nuclear facility categorized as Hazard Category 3, such as the 222-S Laboratory, has the potential for only local significant consequences (10 CFR 830 Subpart B, “Safety Basis Management,” Appendix A, Table 1).

2.1.1 Objective

The objective of this chapter is to provide the discussion consistent with the graded approach for a Hazard Category 3 nonreactor nuclear facility that supports the assumptions used in the hazard and accident analysis provided in Chapter 3.0. The discussion includes the requirements for the 222-S Laboratory, a facility overview, facility structure, process description, confinement systems, safety support systems, utility distribution systems, and auxiliary systems and support facilities as they are relevant to current and future operations in relation to the hazards and accident analyses.

2.1.2 Scope

The scope of this chapter includes the process, structures, and operations of the 222-S Laboratory Complex and auxiliary buildings. The auxiliary buildings are used for ventilation and electrical services, bulk material storage, and handling and transferring wastes to an onsite waste handling facility or offsite facilities. The buildings and equipment or systems descriptions are provided in sufficient detail to identify potential accident initiators and allow for the selection of accident mitigative or preventive barriers. A complete listing of the buildings included in the scope of the DSA is shown in the following.

- 222-S Laboratory Building
- 222-S Laboratory Building Annex
- 222-SA Standards Laboratory
- 222-SB Filter Building
- 222-SC Filter Building

- 222-SE Filter Building
- 2716-S Storage Building
- 227-S Conditioned Storage Building
- 212-S Gas Storage Dock
- HS-0065 Chemical Storage Unit
- Waste Handling Facilities (includes 207-SL retention Basin, 225-WB, 218-W-7 Dry Waste Burial Ground, 219-S Waste Handling Facility, 222-SD Solid Waste Handling/Storage System, Bone Yard) and 222-S Laboratory Dangerous and Mixed Waste Storage Areas (HS-0082 and HS-0083)
- Administrative and office buildings (includes 2704-S and 2713-S Buildings and trailers/modular offices used for administrative support of the laboratory), Connex boxes

2.2 Requirements

The codes, standards, regulations, and DOE Orders used to establish the safety basis for the 222-S Laboratory Complex are contained in Contract DE-AC27-08RV14800.
Title 10 CFR 830 identifies DOE-STD-3009-94 as the "safe harbor" methodology for the preparation of the safety basis for a Hazard Category 3 nuclear facility such as the 222-S Laboratory. This chapter was prepared in accordance with the requirements of Chapter 2 of DOE-STD-3009-94. Additional guidance for the DSA process is provided in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH).

2.3 Facility Overview

The 222-S Laboratory's overview is a discussion of the facility configuration and the historical, current, and projected future basic processes. The 222-S Laboratory and auxiliary buildings, located in the 200 West Area of the Hanford Nuclear Reservation, Figure 2-1, are collectively a Hazard Category 3 nonreactor nuclear facility that provides analytical chemistry services for the Hanford Site.

Normally, samples are logged into tracking programs as they enter the laboratory. The requested sample analysis may be determined on samples as received, or samples may be diluted prior to analysis. After sample analysis and final results are reported, the liquid waste from the sample is generally transferred to the 219-S Waste Handling Facility for treatment and storage until transferred to tank farms. Radioactive solid waste is packaged and stored in such areas as the 222-S Laboratory Solid Waste Handling/Storage System and Bone Yard until transfer to a Hanford Disposal Site. Mixed waste is accumulated in Satellite Accumulation Areas (SAA) and transferred to 90-Day Accumulation Areas or a Treatment, Storage, and Disposal (TSD) unit until it is transferred out of the facility.

In the individual laboratory rooms, radioactive materials are processed within open-face or arm-ported hoods where inlet-air velocities are maintained to prevent contamination of the laboratory room or personnel within the room.

Other than the radioassay of contained sources in the basement counting room, laboratory technical functions (e.g., analysis of samples) are performed in the first-floor laboratory rooms (Figure 2-2). The size, shape, equipment layout, and work assignments vary from room to room.

However, some general observations can be made that characterize these rooms and the work that is performed in them.

The laboratory work, such as wet chemical analyses, is performed in fume hoods. The laboratory rooms have several hoods, most arranged in rows along the laboratory walls. Ventilation exhaust airflows from the corridors and rooms through the hoods and into the ventilation exhaust air system. The face velocity is high enough to prevent the flow of airborne radioactivity or noxious fumes from the hoods into the laboratory rooms. Many hoods are dedicated to specific activities that are posted on the outside wall of the hoods. Most of the hoods are provided with vacuum and electricity. One or more of the following gases may be available (piped) to the hoods: propane, methane, hydrogen, nitrous oxide, argon, nitrogen, and oxygen. Many of these laboratory rooms have center-island work benches that are provided with water sinks, drains, and storage cupboards. These benches are used for less hazardous work such as weighing reagents and cleaning glassware. The laboratory rooms are equipped, as needed, with standard laboratory equipment such as glassware, balances, reagents in small-quantity containers, clamps, and stands. Bricks are available in the laboratory rooms so small shielded enclosures can be constructed for temporary storage and shielding of small quantities of radioactive materials or shielding for survey equipment.

Normally, highly radioactive material, such as waste tank samples, are subsampled to smaller sample sizes to lower dose rate levels before laboratory processing. These operations are typically performed in hot cells that are equipped for handling larger, more cumbersome, containers of radioactive material. Where analytical techniques allow, samples are diluted to further reduce dose rates.

Other than those systems needed for ensuring radiological safety, the 222-S Laboratory activities are similar to those routinely encountered in many industrial chemical laboratories. The radiological safety systems are considered to be conventional in the nuclear industry.

No laboratory activities are foreseen that cannot be safely terminated either abruptly or within a very short time (a few minutes). Normally, during primary ventilation shutdowns, a minimum amount of ventilation is needed to mitigate the release of airborne radioactive particulates to the laboratory environment. The direct-drive diesel fan is designed to automatically provide this backup ventilation capacity.

Most radioactive materials handled in the laboratory are samples to be analyzed in support of Hanford Site operations (e.g., environmental restoration, waste management, and environmental concerns). In addition, some radioactive materials are used for preparing analytical standards and, on occasion, for bench-scale process testing.

The spectrum of radioactive materials handled in the laboratory is very broad. Dose rates from many low-level samples are at background radiation levels, whereas dose rates from some waste tank samples can be quite high. Analytical work is performed on samples with low dose rates by hands-on handling in fume hoods. High-dose-rate samples are normally subsampled in the hot cells to radiation levels suitable for fume hood work. Liquid samples are normally received at the laboratory in shielded containers (known as pigs) or in polybottles. The pig sample carrier is made of stainless-steel-encased lead or uranium for shielding and weighs between 45 and 68 kg (100 and 150 lb). Radioactive liquid samples are generally transported within the laboratory in shielded sample carriers.

Waste tank core samples, taken from the double-shell and single-shell waste tanks for waste characterization, are received in specially designed core sample casks. The cask is constructed of stainless-steel encased lead for shielding and weighs approximately 320 kg (700 lb).

The 222-S Laboratory liquid mixed wastes, containing some dissolved solids, are normally transferred to tank farms via the 219-S Waste Handling Facility. A path for disposing of radioactive liquid from the laboratory is through the specially designed "hot" disposal sinks and transfer jets in the decontamination hood 16, located in Room 2-B. The waste flows by gravity from the 2-B drains through welded, corrosion-resistant piping to corrosion-resistant tanks located below ground level in a concrete vault located in 219-S. In addition to the hot sinks, there are hot cell drains so that aqueous hot cell waste can be discharged directly from the hot cells to waste tanks in 219-S. The underground piping from 219-S to the tank farms is an encased fiberglass line to provide double containment and is equipped with leak detection capability. The boundary of the waste transfer piping for the SNL-5350 and SNL-5351 going to the 241-SY tank farm is at the exterior wall of 219-S. This containment meets Washington State Department of Ecology (WDOE) requirements for piping.

The following precautions are observed while handling radioactive liquids within the laboratory.

- Radioactive liquids are transported in closed containers. The containers of liquids with significantly high dose rates are enclosed in shielded containers that may include the following:
  - Pigs
  - Minipigs
  - Sample carriers
  - Core sample casks

- Containers of radioactive liquid are opened only in hoods or hot cells. Containment barriers against airborne radioactive particulates are provided by the walls of the hoods and hot cell, the laboratory ventilation system in the hood and hot cell HEPA filters (inlet and outlet).

- Isolated, high-integrity, corrosion-resistant piping and receiving tanks are the first containment barrier for radioactive aqueous waste in transit to and at the 219-S Waste Handling Facility. All waste lines in the laboratory building are double-contained, welded piping. The underground piping is double contained in stainless-steel casings, and the receiving tanks are enclosed in a concrete vault with stainless-steel liners for secondary containment. The stainless-steel liners provide secondary containment, which meet WDOE requirements. Flow from the laboratory drains to the receiving tanks is by gravity. The waste can be pumped between tanks within the 219-S vault and from the 219-S Waste Handling Facility to the tank farms.

- Laboratory aqueous wastes, with a small potential for being contaminated with hazardous waste or radioactivity, flow by gravity and accumulate in concrete retention basins at the 207-SL retention basin. This waste is released to the Treated Effluent Disposal Facility (TEDF) or the Effluent Treatment Facility (ETF) only after analysis shows that the effluent is within release/acceptance criteria. Through the use of administrative procedures, the potential for hazardous material or radioactive contamination in this waste is low.

2.4 Facility Structure

The 222-S Laboratory was constructed between 1950 and 1951. Since 1951 the building has been modified to increase the laboratory and office space. The modifications were designed and constructed to the applicable codes and standards current at the time the modifications were performed.

The original 222-S Laboratory was designed to meet the codes and standards in place in 1949 (Turnbull 1949). The applicable portions of the following codes were used during facility design and construction efforts: Uniform Building Code (UBC 1949) and all codes recommended by the National Board of Fire Underwriters. Applicable standards from the following organizations also were used: American Society for Testing and Materials, American Institute of Steel Construction, American Welding Society, American Institute of Electrical Engineers, National Electrical Manufacturers' Association, and National Association of Fan Manufacturers. Other design and construction specifications were taken from the applicable Washington State codes, federal specifications, and Hanford Works specifications.

During 1974 the functional design criteria for exhaust ventilation improvements to the 222-S Laboratory Building were developed and approved (Vitro 1974). In compliance with these criteria, the 222-SB Filter Building and connecting ductwork were constructed. Applicable standards and specifications from the following sources were used in the design and construction efforts: American Association of State Highway Officials, American Conference of Government Industrial Hygienists, American Concrete Institute, American Institute of Steel Construction, Air Moving and Conditioning Association, American National Standards Institute (ANSI), American Society of Mechanical Engineers, American Society for Testing and Materials, American Welding Society, National Electrical Manufacturers' Association, National Fire Protection Association (NFPA), Sheet Metal and Air Conditioning Contractors National Association, Steel Structures Painting Council, and Underwriters' Laboratories. Other applicable specifications and criteria that were complied with include federal specifications, Occupational Safety and Health Administration (OSHA) regulations, and Hanford Plant Standards.

During 1980 two buildings were added to the 222-S Laboratory: the 222-SC Filter Building and the 222-S Laboratory Annex. Both buildings were designed to the 1979 Uniform Building Code (UBC 1979), the National Electrical Code (NEC), and other applicable codes and standards (RHO 1979 and 1980).

In September 1980 the 222-SA Standards Laboratory was procured. This facility is a five-wide trailer. The units were purchased from a commercial manufacturer and were designed and manufactured to all applicable UBC, NEC, and other codes for general purpose modular facility construction (Vitro 1978).

Construction of a new exhaust filter building (222-SE) and a hot cell expansion to the 222-S Laboratory Building was completed in 1994. The 222-SE Filter Building was designed to the applicable requirements (KEH 1992) of DOE Order 6430.1A, *General Design Criteria*, and the UBC for 1991 (UBC 1991). The hot cell expansion was designed to the requirements of Division 11, "Equipment," and Division 13, "Special Facilities" (Sections 1300, "General Requirements," and 1325, "Laboratory Facilities" [including hot laboratories]) of DOE Order 6430.1A and UBC 1991 (WHC-SD-W041-FDC-001, *Functional Design Criteria for the Environmental Hot Cell Expansion*). Both the 222-SE Filter Building and hot cell expansion designs meet or exceed the following requirements:

- Seismic: Important or low-hazard facility, maximum ground acceleration of 0.12g, UCRL-15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural phenomena Hazards*; Zone 2B, importance factor I = 1.25, UBC (1991).

- Wind: ANSI A58.1, Section 6 (ANSI A58.1); UCRL-15910, basic wind speed of 112.6 km/h (70 mi/h), importance factor I = 1.07 (for 100-year recurrence level), Exposure Category C (UCRL-15910).

- Roof Loads: ANSI A58.1, Section 4 (ANSI 1982); snow loads of 97.6 kPa (20 lb/ft^2) in accordance with ANSI A58.1, *Minimum Design Loads for Buildings and Other Structures*.

2.4.1 Laboratory and Support Facilities

The laboratory and support facilities consist of the 222-S Laboratory Building, which provides analytical chemistry services for the Hanford Site, and the auxiliary buildings that support the mission of 222-S Laboratory. Each of the laboratory and support facilities is described individually in the following paragraphs. Each building is depicted in Figure 2-1.

<u>222-S Laboratory Building</u>--The 222-S Laboratory Building is a two-story building 111.5 m (366 ft) long and 32.6 m (107 ft) wide located in the southeast corner of the 200 West Area.

The first floor of the 222-S Laboratory Building (Figure 2-2) is divided into four general areas. The west end contains the lunch room, offices, and locker rooms, which are maintained free of radioactivity and toxic chemicals. The west central section contains laboratory rooms and service areas for work with radioactive and/or toxic materials. The east central section, commonly referred to as the multi-curie section, contains laboratory rooms, hot cells, and service areas for working with radioactive samples. The east end contains the Hot Cell Facility, room 11A (Figure 2-3). The Hot Cell Facility contains six cells for instrument analysis of high-dose rate samples.

The second floor includes the ventilation supply fans, supply and exhaust ductwork, the ventilation system control room, an electrical shop, a manipulator repair shop, and storage areas (Figure 2-4).

The partial basement includes tunnels containing service piping and vacuum pumps, a counting room, an instrument maintenance shop, and a scanning electron microscopy laboratory (Figure 2-5).

222-SA Standards Laboratory—The 222-SA Laboratory is a five-wide trailer located southeast of the 222-S Laboratory Building. Non-radioactive standard preparation and nonradiological process development was previously performed in this building. The building is no longer routinely used and is planned for removal.

222-SB Filter Building—The 222-SB Filter Building, located south of the 222-S Laboratory Building, houses 96 high-efficiency particulate air (HEPA) filters to provide final filtration for the 222-S Laboratory. Under normal operation of the ventilation system, three electrically powered fans exhaust air from the 222-S Laboratory. Exhaust air leaves the 222-SB Filter Building through the 296-S-21 stack. If exhaust plenum differential pressure becomes too low, supplementary exhaust ventilation will be provided through the 222-SE Filter Building via direct drive diesel powered exhaust fan.

222-SC Filter Building—The 222-SC Filter Building, located north of the 222-S Laboratory Building, contains the second- and third-stage HEPA filtration for hot cells 1-A, 1-E-1, 1-E-2, 1-F, and 11-A-1 through 11-A-6. The hot cells in Rooms 1-A, 1-E, 1-F, and 11-A are serviced by the main building supply and exhaust ventilation. The 222-SC Filter Building houses five parallel pairs of HEPA filters, which provide filtration to hot cell exhaust air before it enters the main exhaust plenum and final filtering in the 222-SB and 222-SE Filter Buildings.

222-SE Filter Building—The 222-SE Filter Building, located south of the 222-S Laboratory Building, is a facility that houses 56 HEPA filters. This building provides redundant backup filtering capabilities for the 222-S Laboratory exhaust utilizing a diesel powered exhaust fan.

212-S Gas Storage Dock—Storage area, located on the south side of the 222-S Laboratory, will accommodate a large number of gas cylinders that support instruments in the laboratory. These docks allow separation of the cylinders into new and used, and into flammables and oxidizers.

Chemical Storage Unit (CSU)—The CSU (HS-0065) is located north of 222-SA Building and was used to provide safe storage of bulk chemicals. The unit is divided into two separate sections. Half of the unit is presently being used as a 90 day accumulation area for hazardous waste. The other half is used for storage of recyclables but may also be used for hazardous waste if necessary. The sections have numerous sump areas to prevent incompatible chemicals/waste from mixing in case of accidental breakage.

CFX Pit—The CFX Pit is located to the south of 222-SB Filter Building. It is a 5.2-m (17 ft) deep pit with a 3.7 m (12 ft) deep tank located therein. This tank was emptied of water and removed from service in 2012. The tank was previously used for storage and shielding of two ^{252}Cf sources.

2.4.2 Waste Handling Facilities

Those facilities dedicated to the processing, storage, or handling of wastes from the 222-S Laboratory and auxiliary buildings are described in the following paragraphs and are depicted in Figure 2-1.

207-SL Retention Basin—The 207-SL retention basin, located northeast of the 222-S Laboratory, provides temporary hold-up of wastewater with a low potential for having radioactive or hazardous constituents prior to discharge to the Treated Effluent Disposal Facility (TEDF) or the Effluent Treatment Facility (ETF). This facility is comprised of two below-grade 94,635-L (25,000 gal) compartments and three above-grade 75,708-L (20,000 gal) tanks. This facility allows batch collection, sampling, and discharge of the waste, provided the wastewater meets release/acceptance criteria. Water not meeting the release criteria will normally be transferred to the holding tanks and an action plan for disposal will be developed.

225-WB—The 225-WB Building houses the electronic interface to the TEDF.

218-W-7 Dry Waste Burial Ground—The 218-W-7 Dry Waste Burial Ground is located southeast of the 222-S Laboratory Building. This underground tank was removed from service before 1975. It was used primarily for disposal of contaminated dry hood waste generated by the 222-S Laboratory. It is classified as a Regulatory Past Practice (RPP) site in the 200-SW-2 Operable Unit.

219-S Waste Handling Facility—The 219-S Waste Handling Facility, located north of the 11-A hot cell addition to the 222-S Laboratory Building, collects liquid mixed waste generated by the 222-S Laboratory operations. This facility consists of a below-grade containment vault, an operations building, and an attached concrete-walled sample gallery. The containment vault is divided into two sections, called cells A and B, which contain the liquid waste tanks and a moisture deentrainer tank. The waste tanks are vented through the deentrainer and a HEPA filter to the atmosphere via the 296-S-16 stack. The operations building contain the operating gallery, the pipe trench, a chemical addition drum that may be used to prepare waste for transfer and a caustic tank that may be used to neutralize the waste tanks. The concrete sample gallery contains the waste sampling hood, which is vented through HEPA filtration to the atmosphere via the 296-S-23 stack. This area is classified as a Resource Conservation and Recovery Act (RCRA) TSD component.

222-SD Solid Waste Handling/Storage System—The 222-SD Solid Waste Handling/Storage System, located north of the 222-S Laboratory Building, is a concrete-shielded drum storage area. This area is used for temporary storage of radioactive waste drums before transfer to the burial ground.

222-S Dangerous and Mixed Waste Storage Area (DMWSA)—This area consists of two metal storage lockers (HS-0082 and HS-0083), with RCRA compliant secondary containment, sited on a concrete pad north of the 222-S Laboratory Building, which can store drums of radioactive waste, mixed waste, and nonradioactive dangerous waste. The drums are stored until transferred to an onsite or offsite facility for treatment and disposal.

2.5 Process Description

This section describes individual processes within the facility. Details of basic process parameters, including a summary of the types and quantities of hazardous materials, process equipment, instrumentation, control systems and equipment, and operational considerations associated with individual processes including major interfaces and relationships. The intent is to provide an understanding of the assessment of normal operations, the safety analysis and its conclusions, and insight into the types of operations for which safety management programs are devised.

2.5.1 Toxicological Hazards

The 222-S Laboratory provides analytical chemistry support to many Hanford missions. Reagents are stored for use in a variety of analytical chemistry forms. These reagents are often toxic chemicals; however, the quantities are mostly limited to bench scale applications in analysis and standard preparations. An example of the hazardous chemical inventory of the 222-S Laboratory Building and 222-SA Laboratory is provided in Table 2-1. These chemicals are on at least one of the following lists: 40 CFR 302.4 as Hazardous substances, 40 CFR 355, Appendix A, as Extremely Hazardous substances, 40 CFR 68.130 as regulated toxic and flammable substances or 29 CFR 1910.119, Appendix A, as toxic and highly reactive hazardous chemicals. Table 2-1 indicates that the Threshold Planning Quantities (TPQs) for emergency preparedness are significantly higher than the current inventory of these chemicals and substances. Therefore, the toxicological consequences to the offsite and onsite receptors are not significant and will not be further evaluated. The safety of the facility worker is emphasized through safety meetings, training, the installation of safety equipment (showers, eyewash, etc.), and the implementation of Industrial Health and Safety programs.

2.5.2 Waste Management Systems

This section describes the configuration and operation of the retention basin waste system and the radioactive liquid waste system in the 222-S Laboratory facility.

2.5.2.1 207-SL Retention Basin Waste System

The 222-S Laboratory retention basin, 207-SL, waste system handles water flushes, cooling water, and other liquid waste streams that have a low potential to contain radioactive contaminants or hazardous chemical waste.

Effluents from the 222-S Laboratory, 222-SA Standards Laboratory, and the 219-S operating gallery are routed to the 207-SL retention basin. The effluent is sampled and verified to be within specified limits before transfer to the TEDF.

<u>222-SA Standards Laboratory</u>—Drains from the laboratory sinks, fume hoods, and glass washer discharge to a polyvinyl chloride (PVC) pipe drain that flows to a 757-L (200 gal) lift station pump pit. The collected effluent is automatically pumped to the inlet weir box at the 207-SL retention basin. Water from the kitchen and rest rooms goes to the sanitary sewer.

Table 2-1. Extremely Hazardous Chemicals. (2 sheets)

Listed Chemical Name	CAS Number	Quantity in Laboratory (lb)	Reportable Quantity (lb)	Threshold Planning Quantity (lb)
Acetylene	74-86-2	220		10,000
Aldrin	309-00-2	<0.005	1	500
Ammonia solutions (20% or greater) *as Ammonium hydroxide*	7664-41-7	20	100	500
Aniline	62-53-3	<0.005	5,000	1,000
Arsenous oxide	1327-53-3	<0.005	1	100
Boron trifluoride	7637-07-2	<0.005	1	500
Bromine	7726-95-6	1	1	500
Butane	106-97-8	1.1		10,000
Cadmium oxide	1306-19-0	<0.005	1	100
Carbon disulfide	75-15-0	<0.005	100	10,000
Cellulose nitrate (>12.6% nitrogen)	9004-70-0	0.5		2,500
Chlordane	57-74-9	<0.005	1	1,000
Chloroform	67-66-3	0.68	10	10,000
Cresol, o-	95-48-7	<0.005	1000	1,000
Cumene hydroperoxide	80-15-9	0.1		5,000
Dichloroethyl ether	111-44-4	<0.005	10	10,000
Dimethoate	60-51-5	<0.005	10	500
Dinitrocresol	534-52-1	<0.005	10	10
Dinoseb	88-85-7	<0.005	1,000	100
Disulfoton	298-04-4	<0.005	1	500
Endrin	72-20-8	<0.005	1	500
Ethyl ether	60-29-7	0.125		10,000
Ethyl chloride	75-00-3	<0.005		10,000
Ethylene oxide	75-21-8	<0.005	10	1,000
Ethylenediamine	107-15-3	1.5	5,000	10,000
Formaldhyde	50-00-0	1	100	500
Hexachlorocyclopentadiane	77-47-4	<0.005	10	100
Hydrazine *as hydrazine monohydrate*	302-01-2	6	1	1,000
Hydrogen fluoride	7664-39-3	26	100	100
Hydrogen chloride (conc. ≥37%)	7647-01-0	96		15,000
Hydrogen bromide	10035-10-6	10		5,000
Hydrogen peroxide (conc >52%) as *30% hydrogen peroxide*	7722-84-1	29	1,000	1,000
Hydrogen	1333-74-0	8		10,000
Isobutane	75-28-5	30		10,000
Isodrin	465-73-6	<0.005	1	100
Lindane	58-89-9	<0.005	1	1,000
Mercuric oxide	21908-53-2	0.25	1	500
Mercuric chloride	7487-94-7	0.22	1	500
Methane	74-82-8	150		10,000

Table 2-1. Extremely Hazardous Chemicals. (2 sheets)

Listed Chemical Name	CAS Number	Quantity in Laboratory (lb)	Reportable Quantity (lb)	Threshold Planning Quantity (lb)
Methyl ether	115-10-6	11		10,000
Methyl chloride	74-87-3	<0.01		10,000
Methyl bromide	74-83-9	<0.005	1,000	1,000
Nitric acid	7697-37-2	350	1,000	1,000
Nitroaniline	100-01-6	<0.005		5,000
Nitrobenzene	98-95-3	<0.005	1,000	10,000
Nitrogen dioxide *As fuming nitric acid (conc 90%)*	10102-44-0	0.1	10	100
Nitromethane	75-52-5	0.13		2,500
Nitrosodimethylamine	62-75-9	<0.005	10	1,000
Parathion	56-38-2	<0.005	10	100
Parathion-methyl	298-00-0	<0.05	100	100
Phenol	108-95-2	0.6	1,000	500
Phorate	298-02-2	<0.005	10	10
Phosphorus	7723-14-0	0.1	1	100
Potassium cyanide	151-50-8	1	10	100
Propane	74-98-6	500		10,000
Propyne	74-99-7	5		10,000
Pyrene	129-00-0	<0.005	5,000	1,000
Selenious acid	7783-00-8	<0.005	10	1,000
Sodium cyanide	143-33-9	1	10	100
Sulfuric acid	7664-93-9	150	1,000	1,000
Tellurium	13494-80-9	<0.005	1	500
Thionazin	297-97-2	<0.005	100	500
Trimethylchlorosilane	75-77-4	<0.005	1	1,000
Vanadium pentoxide	1314-62-1	<0.005	1,000	100
Vinyl acetate monomer	108-05-4	<0.05	5,000	1,000
Vinyl chloride	75-01-4	<0.005		10,000
Vinylidene chloride	75-35-4	<0.005		10,000

219-S Waste Handling Facility—Sump 8 from the operating gallery empties into a stainless steel utility drain that runs west out of the 219-S Building to manhole No. 4 where it connects to a fiberglass reinforced pipe (FRP). This FRP runs inside a concrete-encased vitrified clay pipe (VCP) to another FRP running inside a concrete-encased VCP. This line in turn empties into the 207-SL retention basin.

222-S Laboratory Drain System Description—The 222-S Laboratory Building can be divided into two sections; the analytical section occupies the western side of the building, and the multi-curie section occupies the eastern side. The analytical section retention basin effluents go to two drain lines in the basement tunnels. The multi-curie section retention basin effluents go to two different drain lines in the basement tunnels.

Basement Tunnels—All effluents from the 222-S Laboratory Building to the 207-SL retention basin are discharged through four different lines; a stainless-steel retention basin waste line and carbon-steel coolant and condensate line (no longer in service) for the analytical section, and a stainless-steel retention basin waste line and a carbon steel steam condensate drain (no longer in service) for the multi-curie section.

Cold tunnel sumps 1, 2, 3, 4, 5, and 6 function as floor drains and discharge into the analytical section retention basin waste line. Sump 5 also receives flow from a floor drain in the stairwell outside 222-S, near door No. 19, on the north side of the building. The analytical section retention basin waste, coolant, and condensate lines run north out to manhole No. 6. From the manhole the FRP lines flow to the 207-SL retention basin inlet weir box.

Cold tunnel sump 7 acts as a floor drain in the east end of the cold tunnels but it also receives flow from a floor drain outside door No. 18. Sump 7 discharges to the multi-curie section stainless steel retention basin waste line. The lines exit the north side of the building to manhole No. 5. At manhole No. 5 the lines connect to a FRP going to the 207-SL retention basin inlet weir box.

First-Floor Analytical Section—All laboratory sinks and hood condensate drains, except in Rooms 2-B and 2-B-2, go to the retention basin waste line. The laboratory hood drain in Room 2-B and all drains in 2-B-2 go to the 219-S Waste Handling Facility. All analytical section service sinks go to the analytical section retention basin waste line.

First-Floor Multi-curie Section—Generally, all multi-curie section laboratory sinks and hood condensate drains go to the multi-curie section retention basin waste line.

Second-Floor Equipment Room—The distilled water overflow and drain lines, firewater sprinkler system drain, backflush and drain from the deionized water unit, a floor drain near the deionized water unit, all go to the analytical section coolant and condensate line.
A floor drain on the second floor in area S-1-A goes to the multi-curie section retention basin waste line.

French Drains—A french drain serves as an evaporative cooler drain for the 2716-S Storage Building. The french drains discharge directly into the ground instead of the 207-SL retention basin. The condensate from the evaporative cooler has not entered radiation zones prior to discharge to these drains and, as such, are not considered to have a potential for radiological contamination.

2.5.2.2 Radioactive Liquid Waste System

This section describes the design and operation of the radioactive liquid waste system for the 222-S Laboratory Facility. All waste in this system is generated in the 222-S Laboratory and is classified as low-level waste.

From the laboratory hot sink drains and hot tunnel sumps, radioactive waste flows or are jetted through stainless steel lines to waste tanks in the 219-S Waste Handling Facility. These lines are encased in stainless steel from the point of origin in the 222-S Laboratory Building into the 219-S vault. Waste that is transferred to tank farms is sampled, analyzed, and neutralized prior to the transfer.

Process Description—Radioactive liquid waste that is transferred to the 219-S Waste Handling Facility is generated from several locations throughout the 222-S Laboratory, as follows.

- Decontamination hood No. 16 in Room 2-B, the inductively coupled plasma spectrometers in Room 1-J, and the hot tunnel sump in T-4 are routed through tunnel T-4.
- Room 1-A hot cell, 1-E hot cells (1-E-1 and 1-E-2), 1-F hot cell, and the hot tunnel sumps in T-7, and T-8 are routed through tunnel T-8.
- Room 11-A hot cells are routed to the waste tanks in the 219-S Waste Handling Facility vault via two additional stainless-steel drain lines.

Each of the drain lines is encased in stainless steel from the point of origin in the 222-S Laboratory Building into the 219-S Waste Handling Facility and each is equipped with leak detection.

The 219-S Waste Handling Facility consists of an enclosed, below-grade, concrete vault containing stainless-steel waste tanks; transit building; the pipe trench and operating gallery; and an attached concrete-walled sample gallery. The waste tanks are vented by an electrical exhaust fan, through a deentrainer or demister and a HEPA filter, and to the atmosphere via the 296-S-16 stack.

Any leakage from the active waste tank in cell B is collected in sump 9, and leakage from the waste tanks in cell A is collected in sump 7. Leakage to the sumps will sound an alarm in the 219-S operating gallery and Room 3-B of 222-S. Pumps are used to transfer waste back into the tank system.

Process Technology—The waste level in all tanks is maintained below the high-level limit. Any leakage of waste can be pumped back into the tank system. The high liquid level alarms are normally set at 90% of the maximum tank volume. These limits are set to reduce the potential for overflow and allow for caustic and nitrite additions.

There are several requirements for the composition of liquid waste generated by the 222-S Laboratory. No separable organic phase or emulsions are allowed in the liquid waste. To protect the piping and the tanks, no materials detrimental to 304 stainless steel are allowed in the liquid waste without prior neutralization or thorough flushing of the lines after transfer. Before the waste is transferred to tank farms, it must meet their acceptance criteria.

Process Control—Liquid level indicators monitor for waste leakage. Also, the hot tunnel sumps and the sumps in 219-S have lighted and audible alarms to indicate when the liquid-level limit is exceeded. The alarms for the tanks and the 219-S sumps are located in Room 3-B of the 222-S Laboratory Building and the 219-S operating gallery. The alarms for the hot tunnel sumps are located in the Control Room S-3-D and Room 3-B in the 222-S Laboratory.

2.5.3 Solid Waste Management

Solid waste will be low-level radioactive, mixed, or hazardous waste. Waste segregation techniques are employed to ensure packaged waste does not contain noncompatible waste materials. 222-S Laboratory generated waste materials consists of office paper, used surgeon's gloves, paper towels, tissues, rubber matting, glass vials, metal planchets, reagent bottles, wood, steel, tools, etc. Waste materials will be contaminated with low-level radioactive constituents, radioactive constituents plus hazardous materials (mixed waste), or hazardous materials.

The solid low-level radioactive and mixed wastes are normally packaged for treatment or disposal in standard 55-gallon drums, burial boxes, or other approved containers. The waste containers used to accumulate waste are transferred to 90 Day Accumulation Areas or to a TSD unit prior to shipment. Radioactive contaminated organic liquid is classified as mixed waste and is collected in glass bottles inside the hoods. Hazardous waste, consisting primarily of expired chemicals, reagents, and analytical waste, is accumulated in Satellite Accumulation or in 90-Day Accumulation Areas. The placement of waste materials in 55-gallon drums, surrounded by absorbents, is considered lab packed. The lab-packed waste may be stored in a TSD unit or shipped directly to the offsite disposal facility.

The 222-S Laboratory does not routinely generate transuranic (TRU) waste. Transuranic waste is, without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g. If a waste package is generated that is determined to be TRU, the containment, packaging, characterization, and shipping requirements of the waste receiver will be adhered to.

2.5.4 Environmental Considerations Overview

Effluents from the operation of the 222-S Laboratory including liquid and airborne environmental discharges of low-level radioactive, nonradiological, potentially hazardous, or nonhazardous chemical wastes shall be managed in accordance with the guidelines and requirements of DOE, Washington State, and Federal regulations.

The Hanford Site RCRA permit, WA 7890008967, was issued in August 1994. The 222-S Laboratory is continuing to operate under interim status until the 222-S Laboratory Part B permit is issued and incorporated into the site permit.

2.5.5 Derivation of Material at Risk

2.5.5.1 MAR Type, Form, and Storage Location

The process of receiving, logging, tracking, analyzing, archiving, storing, and disposing of radioactive waste samples is described in Section 2.3. Most samples brought into the 222-S Laboratory for radiochemical analysis are from the tank farms and are liquid, solid liquid mixtures, or solids. The container holding the sample material is typically transported to the laboratory inside closed transport containers. The contained samples are normally removed from the sealed transport carriers inside hoods or hot cells. A core sample cask is mated with the 11-A hot cell and the stainless steel sampler, about 310 ml volume, is removed. The sample is extruded from the sampler inside the hot cell. Any liquid portion of the core segment is captured in a glass jar during the extrusion, while the solids are usually photographed and scraped from the extrusion tray into a glass jar(s). The glass jars are approximately 250 ml in size and are closed with screw caps. Liquid grab samples from the tank farms, with small amounts of suspended, dissolved, or settled solids are generally received in 125-ml sample containers, but have been received in containers as large as 1 liter. Some liquid samples from processing plants have been received in containers as large as 4 liters. The liquid samples are generally brought into the hot cell or hood where the volume and mass of sample is determined prior to transferring the sample into the storage jars. Samples are stored in the hot cell inside these jars until an aliquot or subsample is retrieved for sample analysis.

Actual sample analysis is completed on small portions of the original sample referred to as an aliquot or sub-sample. The aliquot volume is carefully measured to be small enough to facilitate radiochemical analysis with a priority on as low as reasonably achievable (ALARA) concerns. The quantity of sample material actually outside the confines of the hot cell is very small compared to original sample volumes. Sample analysis procedures may require small aliquots of liquid or solid samples to be dissolved in strong acids or bases (<pH 2.0 or >pH 12.5) or organic solvents, like formaldehyde. The quantity of these extremely hazardous chemicals required to facilitate analysis is very small and is normally used up in the analysis procedure. Aliquots that are mixed with extremely hazardous chemicals and must be stored during the sample analysis constitute a very small portion of the total facility radioactive material. The quantity of extremely hazardous chemicals in the facility is listed in Table 2-1.

Aliquots are normally stored in Room 2-B (sample storage) or in Room 2-E, while sample analysis is being conducted. These areas provide convenient storage for the small quantity aliquot vials; however they are carefully monitored and the room is managed to ensure the radiation dose is minimal. While the bulk of radioactive material is located inside the 11-A hot cell, all other areas may be used to store sample aliquots. After analysis is completed, the aliquots are normally discharged into the 219-S liquid waste system.

2.5.5.2 MAR Composition

An investigation into the radiological inventory residing in the 222-S Laboratory was completed in April 2002 (HNF-10754, *222-S Laboratory Radiological Inventory Comparison with Accident Dose Consequences*). The Best-Basis Inventory (BBI) estimates for radionuclides in the tank waste were chosen to provide radionuclide concentration data for samples being tracked in the facility inventory. The BBI is documented in the Tank Waste Information Network System (TWINS) maintained by the Pacific Northwest National Laboratory (PNNL). The BBI is the result of a team of experts assembled to review all available sample data, model estimates, and derive point estimates that represent the best possible estimate for each tank. These constituents represent greater than 99.9% of the chemical mass and total radioactivity in the tank inventory.

Historically, the laboratory source term included 15 isotopes. Conclusions presented in HNF-10754 indicate that plutonium, americium, cesium, and strontium account for approximately 97% of the dose equivalent curies (DE-Ci) for accident analysis. Therefore, the incremental contribution to dose consequences of all the other isotopes is considered negligible and not included in this DSA. The components of MAR for the accident analysis include the plutonium isotopes, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu; ^{241}Am, ^{137}Cs, ^{90}Sr, and ^{90}Y. The ^{90}Y is included because it is in equilibrium with ^{90}Sr and will contribute to the dose consequences.

The 222-S Laboratory does not routinely generate transuranic (TRU) waste; however, future commitments can not preclude having both TRU and low-level waste (LLW) at the facility. Both releases of TRU and LLW are given in terms of DE-Ci values. The DE-Ci concept effectively converts radiological consequences for the inhalation pathway for either individual isotopes or mixes of isotopes to that of ^{239}Pu. For TRU waste, the most abundant of these distributions are 6% (nominal) ^{240}Pu and 12% (nominal) ^{240}Pu. The majority of waste containing plutonium will be waste containing contamination from weapons-grade plutonium (6% ^{240}Pu) produced in Plutonium Finishing Plant (PFP) processing. However, significant contributions from other distributions come from reprocessed N Reactor fuel used for power generation (typically about 12% ^{240}Pu) and Fast Flux Test Facility fuels development (also typically about 12% ^{240}Pu). The majority of TRU waste received from offsite generators is related to breeder reactor fuel production, testing, etc., and should also be nominally 12% ^{240}Pu.

For this DSA the bounding isotopic distribution of the plutonium contaminated waste samples is assumed to be that of 12% (nominal) ^{240}Pu, 20-year aged waste. This is conservative because the 12% distribution has higher potential radiological consequences than 6% ^{240}Pu. The added ^{90}Sr, ^{90}Y, and ^{137}Cs provide a reasonable consideration of the operational dose consequences to the facility worker since the DE-Ci contribution of these isotopes for accident analysis is very small.

2.5.6 Criticality Safety

The 222-S Laboratory complex contains less than 225 g of TRU with a composition equivalent to 20-year-aged 12% ^{240}Pu fuel and is physically separated from other facilities that contain fissionable materials by at least 6 feet edge to edge. The smallest mass of plutonium that will sustain a nuclear chain reaction under the most ideal conditions, the minimum critical mass, is 530 g. Therefore, at the facility limit of 225 g of TRU, a nuclear excursion is not a credible event. Even if a failure of the facility inventory tracking system allowed the quantity of fissionable material to be twice the limit and accumulate 450 g of TRU, the facility will not have enough mass to sustain a criticality.

A criticality safety program, commensurate with the graded approach for the facility classification as described in procedures, is implemented. The fissionable material inventory will not exceed 225 g of plutonium equivalence, providing assurance that the risk of an inadvertent criticality is not credible. Therefore, a criticality alarm or criticality detection system is not required.

2.6 Confinement Systems

This section describes the sets of structures, systems, and components that perform confinement functions. Specific structures whose function is confinement of radioactivity in normal operation are the hot cells, fume hoods and sample storage units.

Hot cells, also referred to as cubicles or shielded caves, are thick walled enclosures located in Rooms 1-A, 1-E, 1-F, and 11-A. The thick walls provide shielding to permit operations involving samples with a high level of radioactivity. Separate ventilation is provided, and the hot cells are maintained at a negative pressure with respect to the room. Airflow through the hot cells is designed to provide greater than seven air changes per hour.

Fume hoods are facilities for handling samples. A sash window is provided, and the ventilation is designed to provide a hood face velocity for confinement of chemical fumes and radioactive particulates.

The Room 2-B sample storage units consist of shielded compartments with lead plate on the sides and top. These units are used to store samples awaiting analysis. Directional airflow from the storage compartments over the samples minimizes the potential for a spread of contamination from an accidental spill.

2.6.1 Airborne Contamination Control

Two methods are used in the 222-S Laboratory Building to prevent release of airborne radioactivity to the environment or to laboratory work areas. One method, containment, is a physical barrier between the material or atmosphere containing radioactivity and the areas where personnel are permitted. The other method, confinement, depends on the ability of the building ventilation system to channel all air through HEPA filters. There are no design provisions for removing gaseous radioactive or chemical species from the air.

Physical barriers for airborne contamination control may be either partial or total and either single or multiple layer. Examples of total physical containment barriers in the laboratory are tightly closed sample containers and the hot cells. Hoods are examples of confinement barriers.

The laboratory ventilation system normally operates to ensure that

- The air within the worker-occupied areas of the facility is both healthful and comfortable for the facility occupants.
- Areas within the laboratory that are routinely occupied by personnel are maintained free from airborne contamination.
- Airflows from low potential contamination areas towards higher potential contamination areas.

2.6.1.1 Ventilation

The 222-S Laboratory Building ventilation system is designed to ensure that air flows from areas of low contamination potential to areas of high contamination potential and is operated by maintaining zone differential pressures.

The supply system takes in outside air on the second floor of the building. The air is filtered and brought to a temperature normally between 16°C and 27°C (60°F and 80°F). It is then discharged into a main supply plenum from which branch ducts distribute the air throughout the building. Four electrically driven supply fans are installed; normally three are in operation and the fourth is maintained in standby service. Electrical power to the supply fans is provided through the electrical distribution system described in section 2.8.1.

The supply ducts are arranged so that the major air supply enters the offices and corridors and an auxiliary supply enters the laboratory rooms through the perforated ceilings or diffusers. The supply system is set up in this manner so that the airflow will be from the offices, through the corridors, and into the laboratory rooms; i.e., from "cold" areas to areas of potential radioactive contamination.

The major volume of exhaust air from the first floor is exhausted via the laboratory hoods or hot cells (Figure 2-6). Confinement of airborne radioactive particulates or chemical fumes is maintained with an air velocity through the face opening of the hoods. Hoods that do not conform to air velocity requirements are taken out of service. Laboratory hood and auxiliary exhaust air is filtered by a prefilter and single-stage HEPA filter before entering the exhaust ducts. Exhaust air from the basement service tunnels is filtered by a prefilter and single-stage HEPA filter. The individual exhausts are manifolded into a main exhaust duct that leads to the main exhaust plenum. Examination of old duct systems during exhaust system modifications indicated that holdup of radioactive materials was not present in the ductwork.

Building exhaust air is directed through the 222-SB Filter Building, located south of the 222-S Laboratory Building, housing 96 HEPA filters to provide final filtration. Under normal operation of the ventilation system, three electrically powered fans exhaust air from the laboratory. Exhaust air leaves the 222-SB Building through the 296-S-21 stack.

If the electrically powered exhaust fans fail to operate, exhaust ventilation can be provided through the 222-SE Filter Building via a diesel powered exhaust fan. The 222-SE Filter Building houses 56 HEPA filters. This building provides backup filtering capabilities for the building exhaust. The diesel powered exhaust fan provides approximately one-half of the normal exhaust ventilation flow rate and is used during a loss of electricity, fan failure, or during maintenance activities on the 222-SB Filter Building or exhaust fans.

<u>Hot Cell Ventilation</u>**—**Hot cells are cubicles generally built of steel and high-density concrete capable of reducing radiation dose rates from tens of rems per hour in the cubicle to <10 mrem/h through the outer wall. The hot cells are used for operations that exceed operating limits for the hoods. There are 10 hot cells in the 222-S Laboratory Building: one each in Rooms 1-A and 1-F; two in Room 1-E; and six in Room 11-A.

The main building exhaust ventilation services the hot cells. Supply air to the hot cells is pulled through a single HEPA filter before entering the cell. This is to reduce contamination if reverse flow (from the cell to the room) should occur and to reduce dust loading on the first stage of exhaust HEPA filtration. Exhaust air from the cells passes first through a HEPA filter located as close as practical to the cell to avoid contaminating ductwork. The exhaust air then passes through the 222-SC Filter Building where it goes through two more stages of HEPA filters and then is ducted to the 222-SB Filter Building where it passes through one final stage of filtration before being exhausted to atmosphere. In the event that the diesel fan is in operation, the final HEPA filtration will be through the 222-SE Filter Building. In total, four stages of HEPA filtration are provided for the hot cell exhaust. Figure 2-6 shows the airflow path for the hot cell exhaust.

The hot cell ventilation operates to provide a differential pressure between room and cubicle operating areas, and airflow through the hot cells sufficient to provide adequate air dilution.

Laboratory Fume Hood Ventilation—The laboratory fume hoods are designed to provide confinement boundary for analytical operations. The laboratory fume hood contamination levels are maintained ALARA. A sash window is provided, and the ventilation is designed to provide a hood face velocity for confinement of chemical fumes and radioactive particulates.

Counting Room Ventilation—The Counting Rooms (B-1-A, B-1-F, and B-1-G) and the scanning electron microscope Room (B-1-B) located in the basement are supplied by a ventilation system separate from the main 222-S Laboratory system. Most of the air is circulated through two stages of HEPA filtration with a small portion lost through louvered doors to the stairwell and used as supply ventilation air for the sample storage stairwell.

This system has air conditioners that maintain the air in the counting room at temperatures desired for the proper operation of counting room instruments.

The 219-S Ventilation System—Two separate ventilation systems are used for contaminated areas in the 219-S Waste Handling Facility: an exhaust system for the vault storage tanks and an exhaust system for the sample gallery.

Exhaust air from the venting of the 219-S vault waste tanks is discharged through the 296-S-16 stack. A moisture de-entrainer and a single HEPA filter provide filtration.

During sample gallery use, ventilation air is exhausted from the sample gallery via an exhaust hood over the sample station, which is connected to an exhaust fan that maintains flow across the open portion of the hood. The exhaust air goes through double HEPA filtration and is discharged through the 296-S-23 stack.

The operating gallery has no significant contamination; therefore, no inlet or exhaust HEPA filtration is provided.

2.7 Safety Support Systems

This section identifies and describes the principal systems that perform safety support functions (i.e., safety functions that are not part of specific processes). The text presents the purpose of each system and provides an overview of each system, including principal components, operations, and control function. The section is designed to organize the presentation of information, not to designate any special class of equipment.

2.7.1 Fire Protection

This section describes the fire protection systems for the 222-S Laboratory. The fire protection systems at the 222-S Laboratory are tested, inspected, and maintained in compliance with TFC-ESHQ-FP-STD-04, *Fire Protection System Testing, Inspection, and Maintenance.* HNF-SD-CP-FHA-003, 2*22-S Laboratory Fire Hazard Analysis*, presents a complete discussion of the fire hazards and fire-related concerns in the 222-S Laboratory Complex.

Raw and Sanitary Water System—The first-floor sprinkler system in the 222-S Laboratory Building, except for Room 11-A, is supplied with raw water which enters on the north side of the facility. This is the only raw water supply to the 222-S Laboratory Building. Raw water is used primarily for the first-floor sprinkler system and a fire hydrant. Sanitary water is used for all the other sprinkler systems and six fire hydrants.

Fire Protection and Alarm Control Panel—The 222-S Laboratory Building is equipped with a fire protection and alarm control panel. It was designed to meet NEC NFPA 70 requirements.

The system's detection devices (ionization, photoelectric, or thermal) are uniquely addressable, and their sensitivity can be measured by the system's control circuitry.

The system is designed so that alarm operation has first priority over all other modes of operation. Should the system lose commercial power, the battery backup will maintain the system. The Hanford Fire Department must reset the system when power is restored.

Fire Alarms—The 222-S Laboratory Building fire alarm pullboxes are located throughout all three floors of the building. The majority are located adjacent to the emergency exits. The building has zones that alarm to the 200 Area Fire Department via the radio fire alarm system. Fire gongs are installed in strategic locations on all three floors of the building.

Fire Protection and Control—The 222-S Laboratory Building is constructed primarily of noncombustible or fire-resistant materials. Fire protection systems at 222-S Laboratory Facility include wet and dry pipe automatic sprinkler systems, special limited water volume suppression systems, fire alarm systems, and some rated fire barriers. The only rated fire walls surround the elevator shaft and interior stairway. Applicable fire extinguishing capability is provided for each laboratory area depending on the type of fire potential existing therein. Portable fire extinguishers are provided at various locations within the building.

There are seven fire hydrants (risers) located around 222-S. The first-floor sprinkler system and one fire hydrant are supplied with raw water. The second-floor sprinkler system, the Rooms 11-A and 11-A hot cells, the annex sprinkler system, and six fire hydrants are supplied by sanitary water.

Hot cells 1-E-2 and 11A plus the gloveboxes in Room 1C are equipped with sprinklers supplied by a limited volume pressurized water fire system.

2716-S Storage Building—This facility is a metal building with a partitioned off area that is used for handling and repackaging of hazardous wastes. The remainder of the building provides long-and short-term storage capability for laboratory materials. It is protected with a dry-pipe automatic sprinkler system, heat detectors, a manual pullbox, and a portable fire extinguisher. The fire alarm system will alarm at the 222-S Laboratory Building and send a signal to the 200 Area Fire Station.

227-S Conditioned Storage Building - 227-S is a pre-engineered metal storage building containing several storage racks and a fenced in area used for controlled items. The building is protected throughout by a wet automatic fire sprinkler system and alarming system. The fire alarm system will alarm at the 222-S Laboratory Building and send a signal to the 200 Area Fire Station.

2.7.2 Air Monitoring

Vacuum Air Sampling System—The vacuum air sampling system currently provides air to open-face, filter-paper record, fixed-head air samplers located in some laboratory rooms, and service tunnels of the 222-S Laboratory Building. Air samples from each location are analyzed for alpha and/or beta-gamma radioactivity. The analyses are reviewed by radiological control personnel to ensure that the radioactive concentration of the air at various locations remains ALARA.

Air Monitoring—Beta-gamma continuous air monitor (CAM) units and alpha CAM units may be found in the 222-S Laboratory Building. The CAMs are placed in the various locations based on the potential for airborne radioactivity as determined by Radiological Control.

The gaseous effluent from the main 296-S-21 stack of the 222-S Laboratory Building is continuously sampled. The samples are analyzed to determine the quantity of alpha and beta radioactivity released to the atmosphere.

Gaseous effluent from the 296-S-16 stack, which exhausts the 219-S Waste Handling Facility waste tanks, is periodically sampled and analyzed to determine the quantity of alpha and beta radioactivity released to the atmosphere.

The gaseous effluent from the 296-S-23 stack, which exhausts the 219-S Waste Handling Facility sample gallery, is not sampled or monitored. Nondestructive assay (NDA) is performed every two years as the method for periodic confirmatory measurements as required by the Hanford Site Air Operating Permit to verify low emissions of radionuclides.

2.7.3 Safety Shower and Eyewash Locations

The 222-S Laboratory is equipped with safety showers at various locations if an inadvertent exposure to hazardous chemicals occurs. Eyewash stations are installed at most safety shower locations. Safety showers and eyewashes are installed in accordance with applicable OSHA, RCRA, and American Society of Mechanical Engineers (ASME) requirements ASME NQA-1-1989, *Quality Assurance Program Requirements for Nuclear Facilities*.

The 222-SA Laboratory is equipped with combination safety showers/eyewashes at four locations, and 219-S is equipped with two safety showers.

2.7.4 Survey Instrumentation

Survey instruments for detecting radioactive contamination are set at step-off pad locations in hallways and exits from designated laboratory rooms. The instruments permit early detection of personnel contamination and minimize the potential for spread of contamination to "clean" zones.

2.7.5 Safety Communications and Controls

The 222-S Laboratory communication systems consist of the following:

- Plant, cellular, or outside telephone system
- Internal paging system
- Emergency audible alarm system
- Fire alarm system

The plant, cellular, or outside telephone systems are commercial telephones that provide outside communication for all primary control locations and offices. The plant and outside systems are also tied to the area "CRASH" alarm system.

The 222-S Laboratory Public Address system provides internal paging and communication within the 222-S Laboratory.

2.7.6 Liquid Level Alarm Systems

High-liquid-level alarms are installed in the 207-SL retention basin, 219-S tanks, and 219-S sumps. When the liquid reaches a predetermined height, an annunciator light is activated locally and in Room 3-B of 222-S Laboratory Building. High-liquid-level alarms are also installed in the hot tunnel sumps and the cold (regulated) tunnel sumps. The hot tunnel sumps alarm in the S-3-D Control Room and Room 3-B, and the cold tunnel sumps alarm locally and in Room 3-B. These alarms, when activated, are acknowledged by 222-S Laboratory operating personnel who then take appropriate corrective action. During maintenance or outages of an alarm, increased surveillance frequencies can be invoked to ensure these parameters are not exceeded.

2.8 Utility Distribution Systems

2.8.1 Electrical Service

13.8-kV lines C8-L3 and C8-L4 from 251-W substation normally supply electrical service to the 222-S Laboratory. This voltage is transformed down to 480V by two 1000-kVA transformers. These transformers feed 480V to the main breakers F8X336 and F8X337 in the 222-S Laboratory substation. The 222-S Laboratory substation normally operates in a split-bus configuration with main breakers F8X336 and F8X337 normally closed and bus tie breaker F8X338 open.

In the event of a loss of power to one of the 13.8-kV feeders, the main breaker on the affected line will normally open and bus tie breaker F8X338 will normally close reestablishing power to the facility. This configuration will remain until power is available on the affected line and electricians manually return the system to the original configuration.

In the event of a loss of power to both 13.8-kV feeders, both main breakers will normally open and remain in this condition until at least one source becomes available, at which time the respective main breaker will close. The bus tie breaker F8X338 will close 5 seconds later, reestablishing power to the facility. This configuration will remain until power is available on the remaining line and electricians manually return the system to the original configuration.

2.8.2 Water

Water supply to the 200 West area comes from pumps taking water from the Columbia River near B-Reactor. Water is pumped from the 181-B (River Pump house) to the 182-B Export Water Reservoir/Pump house. From the 182-B pump house the water is pumped to the Export Distribution System. Pumps at D-Reactor serve as redundant backup to the B-Reactor pump facilities. The original installation provided one 24-inch diameter export water supply to the 200 West water treatment plant. In the late 1990s, a 12-inch-diameter underground water pipe was installed connecting the 200 West sanitary water system with the 200 East sanitary water system. More recently, an 18-inch-diameter pipe was installed to provide a second export water pipe to the 200 West area.

The primary water supply for the laboratory area consists of two underground 12 -inch mains, one sanitary water and one raw water. Both sanitary and raw water supplies are the far south end loops of the 200 West water systems. These loops originate at the 200 Area water treatment plant located near the intersection of Beloit Avenue and 20th Street. Both water supply loops run along the north side of 222-S Laboratory Building. A sanitary water pipe loops around 222-S Laboratory Building to supply fire suppression systems and fire hydrants. About two thirds of this loop is 6-in. pipe and the remaining third is 12-in. pipe.

Two raw water supply lines and two sanitary water supply lines normally feed the 222-S Laboratory Complex from the 200 W water utilities. Both of the raw water lines are valved and tied together and both of the sanitary water lines are valved and tied together on the north side of the facility to provide two looped feeds. Water supply duration for sprinkler systems is based on ENS-ENG-IP-05, *ORP Fire Protection Program*. Section 6.5.1 requires "Fire flows shall be available for a minimum of 2 hr except that a minimum 4-hr supply shall be provided for large buildings, buildings with special public or physical hazards, multiple building sites, or groups of combustible buildings." The 200 West water supply systems, raw and sanitary, are capable of providing a 4-hr flow duration of combined fire suppression and building operational uses.

The raw water supply is the source of water for the majority of the 222-S Laboratory Building first floor fire sprinkler system and provides make-up and flush water for the processes at the 219-S Waste Handling Facility.

The sanitary water feed line for the building is connected to the feed line from water utilities on both the east and west ends of the 222-S Laboratory Building to provide a loop around the facility. The sanitary water supply provides the source for the fire suppression systems in 222-SA, 2716-S, 227-S, the systems in 222-S Laboratory that are not supplied by raw water, and the fire hydrants around the facility that are not supplied by raw water. In addition, it provides the complex with domestic water, safety shower water, and the feed for the 222-S Laboratory process water.

2.9 Auxiliary Systems and Support Facilities

This section provides other supporting information that facilitates the conceptual model of the facility as it pertains to the hazard and accident analysis.

222-S Laboratory Building Annex—The 222-S Laboratory Building Annex, which is attached to the south side of the 222-S Laboratory Building, houses the maintenance shop, instrument shop, gas dock, and the counting room filter building.

227-S Conditioned Storage Building- 227-S is a pre-engineered metal storage building, located south of the 222-S Laboratory Building, containing several storage racks and a fenced in area used for controlled material storage items.

2716-S Storage Building—The 2716-S Storage Building, located south of the 222-S Laboratory Building, is a metal building with an area partitioned off that can be used to accumulate hazardous waste and to package hazardous materials for recycle. It provides both long- and short-term storage capability for laboratory materials and contains no radioactive materials.

Connex Boxes—Connex boxes are located around the facility and are utilized for the storage of maintenance materials, laundry, rags, various spare parts and other equipment.

Administrative and Office Buildings—There are administrative and office buildings located within the 222-S Laboratory Complex (Figure 2-1). There are three office buildings, 2704-S, 2713-S and 2705-S. The others are trailers (or modular offices), MO -037, -291, -648, and -409. All of these buildings are used primarily as office buildings for the administrative support of the laboratory operations. Although these Administrative Buildings are within the 222-S Complex, they do not create any hazardous conditions or consequences to 222-S or the other auxiliary or support buildings.

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FIGURE 2-1. 222-S LABORATORY COMPLEX.

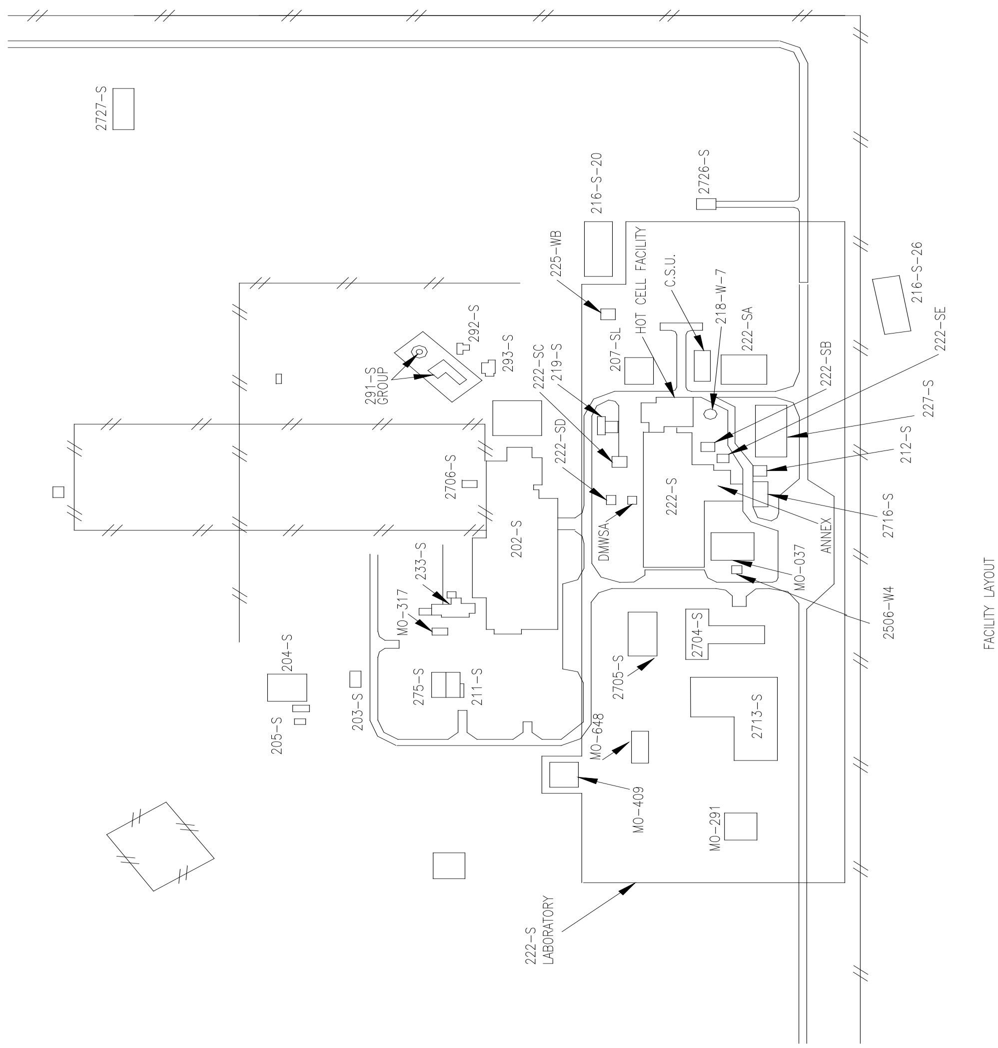


FIGURE 2-2. 222-S LABORATORY LAYOUT OF THE FIRST FLOOR.

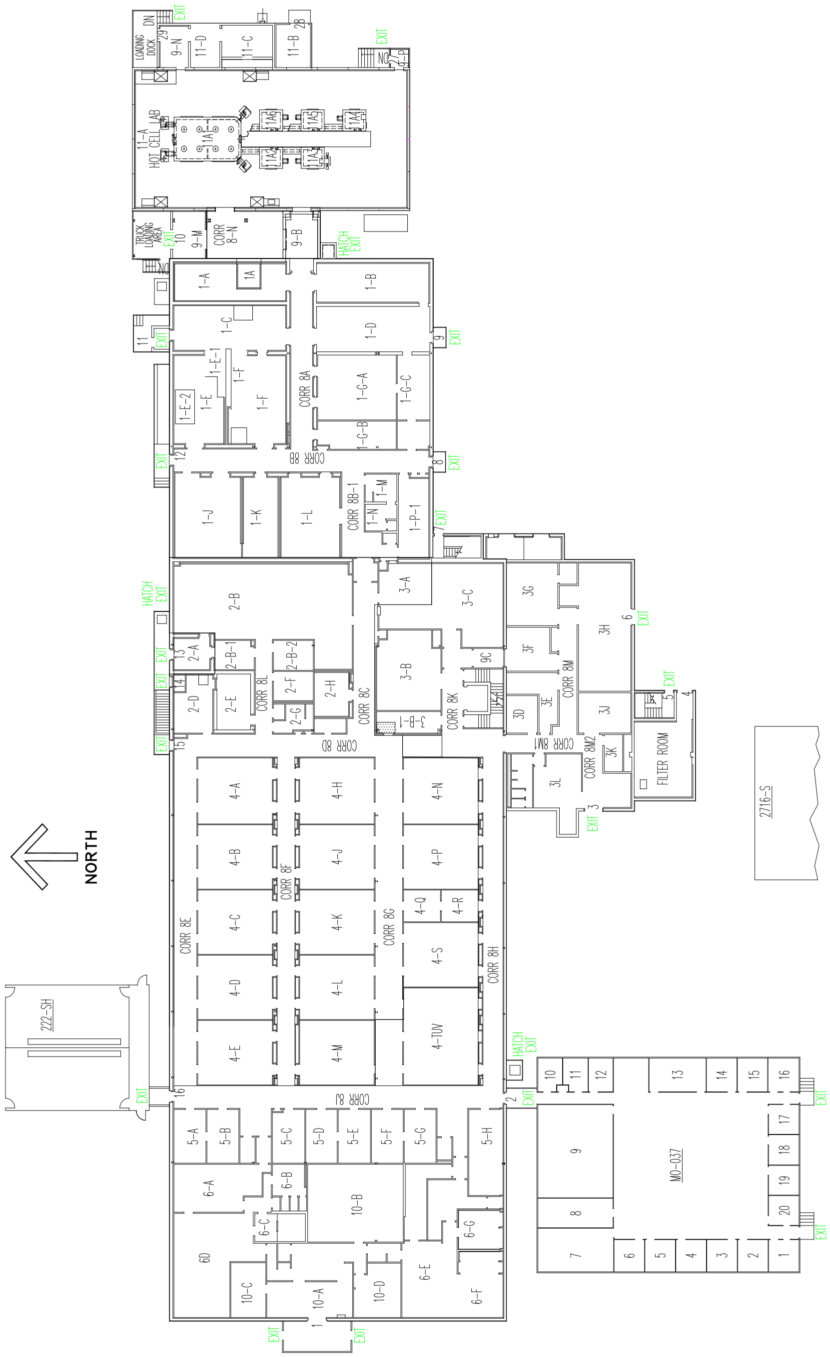


FIGURE 2-3. 222-S LABORATORY LAYOUT OF THE 11A HOT CELL.

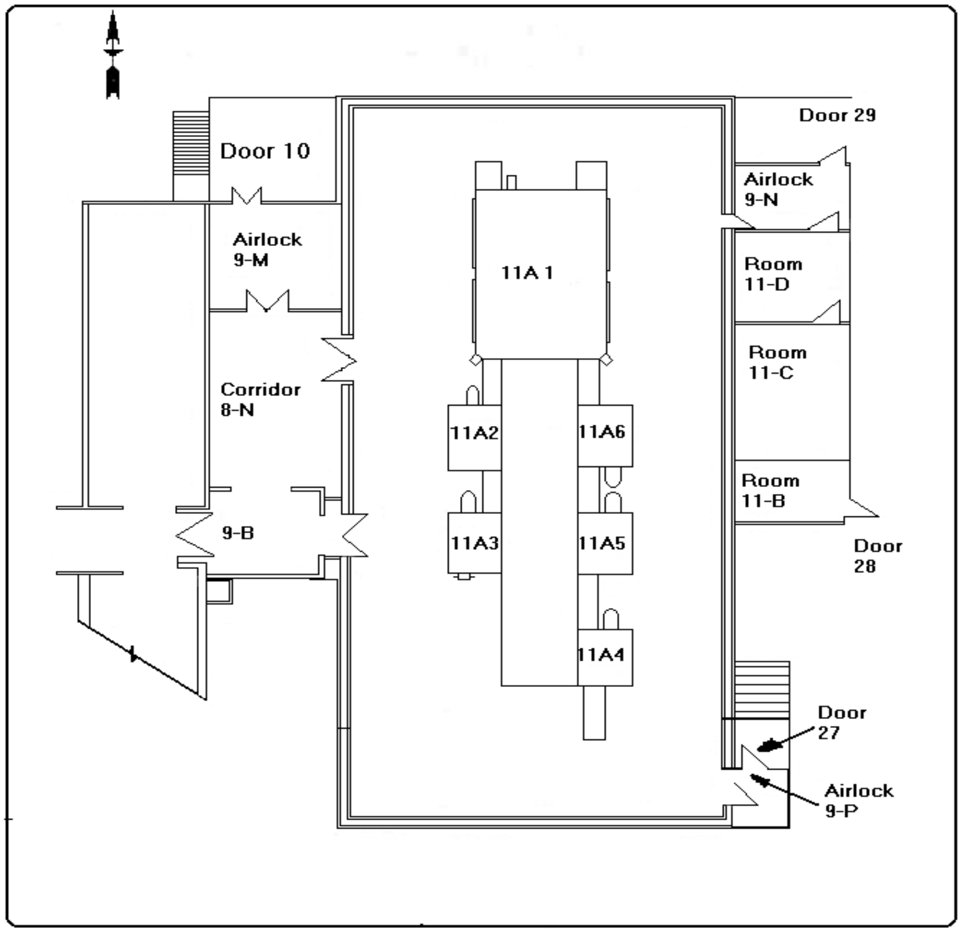


FIGURE 2-4. 222-S LABORATORY LAYOUT OF THE SECOND FLOOR.

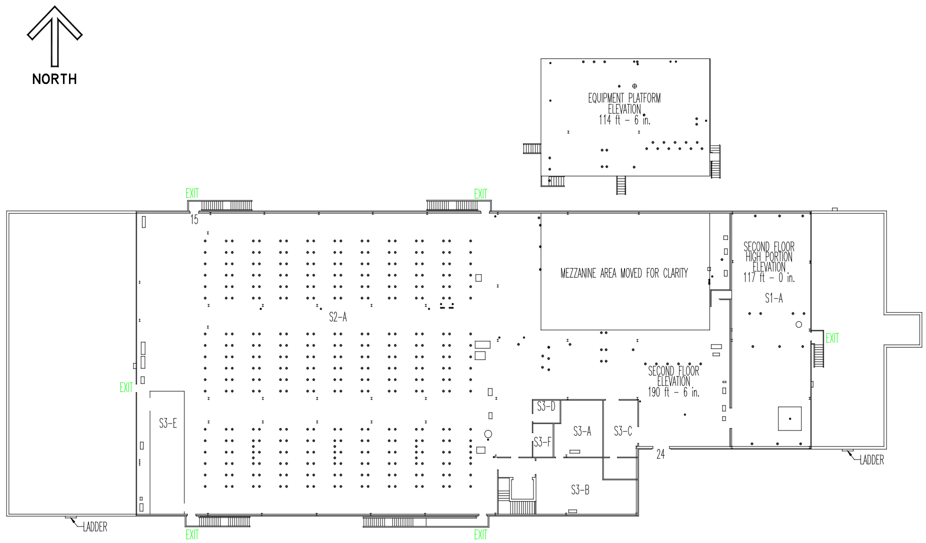


FIGURE 2-5. 222-S LABORATORY LAYOUT OF THE BASEMENT/TUNNEL.

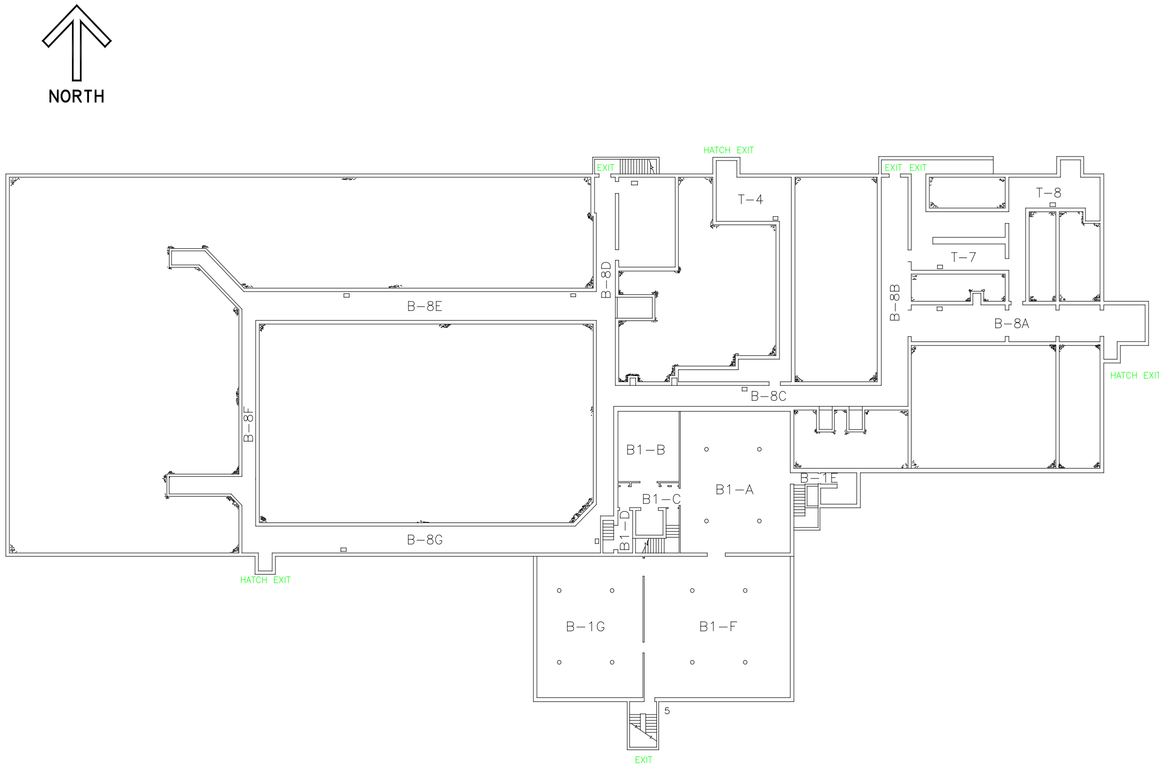
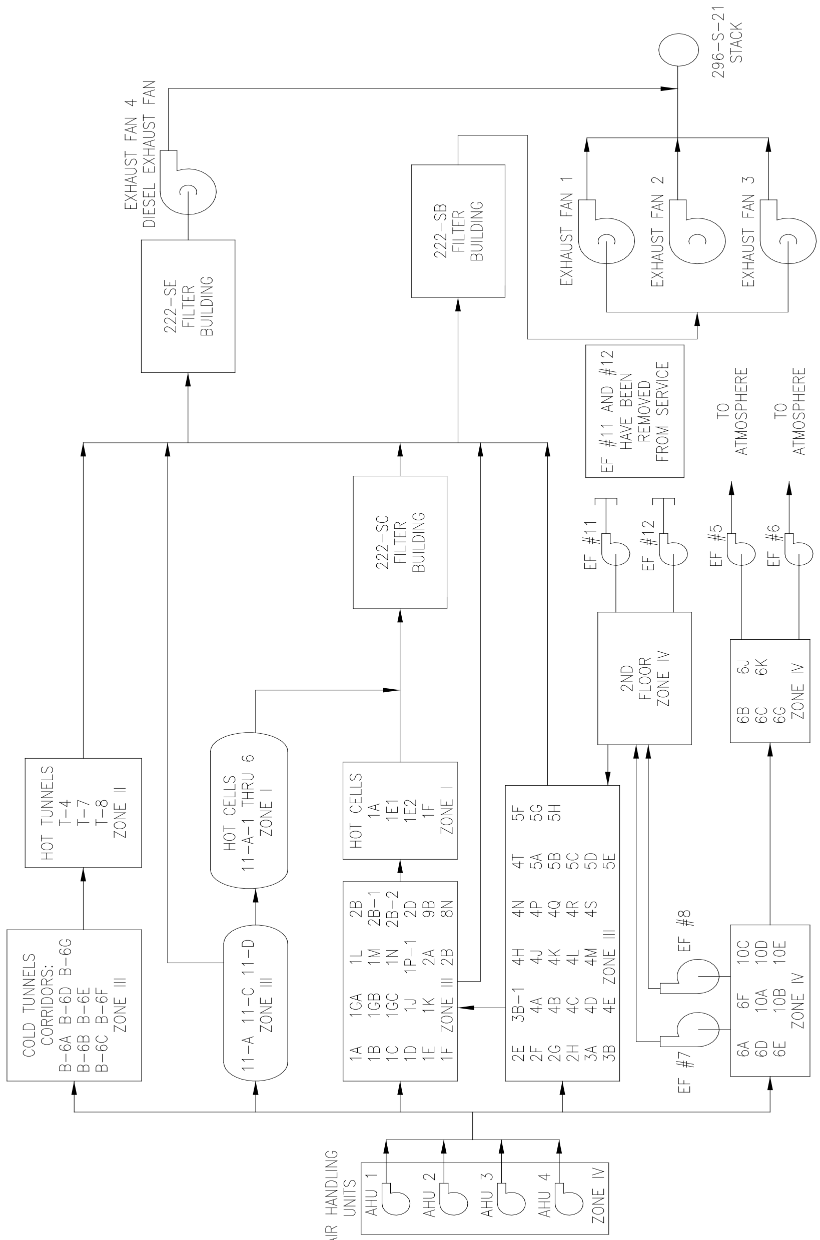


FIGURE 2-6. 222-S LABORATORY BUILDING VENTILATION SYSTEM.



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3.0 HAZARD AND ACCIDENT ANALYSIS

This chapter presents the methodology and results for the hazard and accident analysis for the 222-S Laboratory Complex.

3.1 Introduction

A flow diagram of the DSA safety analyses process is illustrated in Figure 3-1. This process is designed to meet the guidance in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*. This chapter conforms to the direction presented in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH). The safety analyses process is applied with a graded approach. The 222-S Laboratory Complex is a Hazard Category 3 facility. Therefore, some aspects of the process do not require the same level of rigor as for Category 1 and Category 2 nuclear facilities.

The safety analysis process consists of the following major elements.

- Hazard Analysis
  - Hazard Identification
  - Hazard Evaluation
  - Candidate Accident Selection
- Accident Analysis
  - Accident Analysis (Unmitigated)
  - Accident Analysis (Mitigated)
- Final Hazard Categorization
- Control Decision Process

Hazards that can contribute to the uncontrolled release of radioactive or hazardous materials (called hazardous conditions) are systematically and comprehensively identified through the Hazard Analysis (Section 3.3). The set of potential uncontrolled releases identified is subject to a candidate selection process. This process identifies candidate representative accidents, which are the starting point for the accident analysis (Section 3.4). Results of the accident analysis and the hazard analysis are used to support the control decision process. This process identifies safety-related controls and classifies safety-related structures, systems, and components (SSCs). The controls (including safety management programs) are allocated to all hazardous conditions identified by the hazard analysis.

Results of the accident analysis also support determination of the final hazard categorization (Section 3.3.2.2).

The expectation for Hazard Category 3 facilities, according to HNF-8739, SARAH, is the establishment of an inventory limit based on quantification of unmitigated risk from bounding scenarios so that the only Technical Safety Requirement (TSR) needed is inventory control. However, all steps of the safety analysis process are required in some level of detail. In general, quantitative accident analysis is not necessary for Hazard Category 3 facilities, and controls are derived from the hazard evaluation. For 222-S Laboratory the dose consequences of the worst-case accident are quantified.

3.2 Requirements

The requirements for the hazard and accident analysis are contained in Title 10, *Code of Federal Regulations* Part 830 (10 CFR 830), Subpart B, "Safety Basis Management." Recommended practices for hazard screening, accident selection, and accident analysis are included in DOE-STD-3009-94. Additional guidance is presented in HNF-8739.

3.3 Hazard Analysis

This section presents the methods used and the results obtained for the hazards analysis. As shown in Figure 3-1, the hazard analysis consists of three activities:

- Hazard Identification
- Hazard Evaluation
- Candidate Accident Selection

A description of these activities is provided in the following sections.

3.3.1 Methodology

This section presents the methodology used to identify and characterize hazards and to perform a systematic evaluation of basic accidents.

3.3.1.1 Hazard Identification

Identification of all hazards and energy sources is performed by using the checklist provided in Appendix A and marking those that apply to the facility. A hazard is defined as an energy source or harmful material (radioactive or hazardous).

Any hazards identified from the checklist that meet one of the following criteria were not considered for further detailed analysis in the hazard evaluation:

- Hazards routinely encountered and/or accepted by the public
- Hazards controlled by regulations and/or one or more national consensus standards
- General radiological hazards subject to 10 CFR 835, "Occupational Radiation Protection"
- Hazards likely to be found in homes, general retail outlets, and associated with open-road transportation subject to U.S. Department of Transportation regulation.

However, for completeness, these types of industrial and radiological hazards are included in this section along with the safety management programs that address them. A Hazard Description and Protection Form, Appendix B, is used to complement Appendix A. This form provides a specific description of the types of hazards and lists the potential consequences. The use of this form is discussed in Section 3.3.2.1.

3.3.1.1.1 Material at Risk (MAR)

During the development of this DSA, it was determined that a quantity of TRU that provides a reasonably bounding accident dose consequences without undue conservativeness could be obtained from ANS/ANSI 8-3, Criticality Accident Alarm System. ANS/ANSI 8-3 states:

> The need for criticality alarm systems shall be evaluated for all activities in which the inventory of fissionable materials in individual unrelated areas exceeds 700 g of U-235, 500 g of U-233, 450 g of Pu-239 or 450 g of any combination of these three isotopes.

The fissionable material inventory in the 222-S Laboratory does not challenge the conditions of ANSI/ANS-8.3, but the criticality safety practice of a double batching consideration provides a basis for a total inventory of 225 g of transuranic (TRU) waste. The chosen quantity of ^{90}Sr, ^{90}Y, and ^{137}Cs for the accident analysis is a conservative amount, based on the Best Basis Inventory (BBI) presented in HNF-10754, *222-S Laboratory Radiological Inventory Comparison with Accident Dose Consequences*, and bounds current operations and estimated future commitments.

The dose equivalent factor (DEF) is the ratio of the 50-year total effective dose (TED) from a quantity (Ci) of each isotope to that for an equivalent quantity of ^{239}Pu, or equivalently the ratio of the dose conversion factor (DCF) for the isotope to that of ^{239}Pu. By definition, 1 Ci of ^{239}Pu = 1 dose equivalent curie (DE-Ci). The current direction from the U.S. Department of Energy (Klein 2002) is to use the International Commission on Radiological Protection (ICRP) 68, *Dose Coefficients for Intakes of Radionuclides by Workers,* dose conversion models to calculate dose for workers and ICRP 71/72, *Age-Dependent Doses to the Members of the Public from Intake of Radionuclides: Parts 4 and 5, Complication of Ingestion and Inhalation Coefficients*, should be applied to the maximum offsite individual (MOI). Table 3-1 presents the facility inventory and DE-Ci conversion.

3.3.1.2 Hazard Evaluation

The hazard evaluation technique was selected from the AIChE handbook, *Guidelines for Hazard Evaluation Procedure*s. For the 222-S Laboratory Complex, a Preliminary Hazards Analysis (PHA) study was used to identify potential hazardous conditions and estimate their potential harm. A decomposition of facility mission into activities that can occur at specified locations is made to support the PHA.

A wide-ranging set of significant hazardous conditions was formulated that could lead to release of radioactive or hazardous materials from contained sources within the 222-S Laboratory Complex. A hazardous condition is defined as a condition or combination of conditions that result in an uncontrolled release of radioactive or hazardous material. The following format was used while postulating the hazardous conditions:

"*Release of* (material type) *to* (a location) *from* (a source) *due to* (a cause)."

Table 3-1. Material at Risk and Dose Equivalent Curies.

Isotope	Mass Fraction of 12% Fuel	Isotope Mass (g)	Isotope (Ci)	ICRP 68 For Collocated Workers			ICRP 71/72 for Maximum Offsite Individual		
				Dose Conversion Factor [a] (Sv/Bq)	DE-Ci Factor	DE-Ci	Dose Conversion Factor [a] (Sv/Bq)	DE-Ci Factor	DE-Ci
^{238}Pu	0.0008	0.18	3.08	3.0E-05	0.94	2.89	4.6E-05	0.92	2.84
^{239}Pu	0.8395	188.89	11.71	3.2E-05	1.00	11.71	5.0E-05	1.00	11.71
^{240}Pu	0.1297	29.18	6.62	3.2E-05	1.00	6.62	5.0E-05	1.00	6.62
^{241}Pu	0.011	2.48	254.93	5.8E-07	0.02	4.62	9.0E-07	0.02	4.62
^{242}Pu	0.0003	0.07	2.65E-04	3.1E-05	0.97	2.6E-04	4.8E-05	0.96	2.54E-04
^{241}Am	0.0175	3.94	13.51	2.7E-05	0.84	11.34	4.2E-05	0.84	11.34
^{90}Sr		12.95	1800	3.0E-08	9.4E-04	1.69	3.6E-08	7.2E-04	1.30
^{90}Y		3.3E-03	1800	1.7E-09	5.3E-05	0.11	1.5E-09	3.0E-05	0.05
^{137}Cs		7.31	633	6.7E-09	2.1E-04	0.13	4.6E-09	9.2E-05	0.058
Total	0.9988					39.11			38.54

[a] Absorption values from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*.

The only exception to this format was the recording of radiation protection and occupational issues that were raised as result of postulating uncontrolled releases. They were recorded if they could result in excessive exposure of personnel to radioactive/hazardous material or injury; therefore they were not described as a release.

The PHA also developed an estimate of the risk. The risk for a hazardous condition was determined by estimating the likelihood that such a condition would develop and by estimating the consequence if it did.

A PHA is a systematic brainstorming process using a multi-disciplinary team of knowledgeable individuals. Results are captured on PHA worksheets, which are described in Section 3.3.1.2.1. Because these assessments are to be qualitative in nature, the expertise and experience of the team is of primary importance in establishing the credibility of the analysis. Facility personnel representing the operations, engineering, nuclear safety, radiation protection, fire protection, industrial safety, and environmental safety organizations should participate in the PHA process.

The PHA sessions start with development of preparatory information: (1) evaluation of facility operational history, (2) hazard and energy source identification, (3) definition of the MAR, and (4) decomposition of process into activities. Based on this information, brainstorming of hazardous conditions is performed. All tasks related to each activity as well as the failure of associated personnel, equipment, and systems are considered.

3.3.1.2.1 PHA Worksheet Description

The worksheets in Appendix C are used to capture the information resulting from the PHA sessions. The worksheets contain a series of columns where information should be filled in for each identified hazardous condition.

- Identifier—The identifier is a unique code for each hazardous condition (or radiation protection or occupational safety entries). It contains an indication of the facility and activity related to the entry.
- Activity—The activity assessed for hazardous conditions.
- MAR—A description of the type and location of the material inventory considered for release in each entry. The analysis uses a reasonably conservative description of this MAR for determining potential consequences.
- Hazardous Condition—A brief description of the uncontrolled release of material including the location of the release and the condition of the release.
- Candidate Causes—A brief description of the cause of the uncontrolled release, generally an identification of the initiating event for the release.
- Immediate Consequences—A brief description of the physical consequences of the hazardous condition that indicates the form of the release and how personnel are affected.

- Candidate Controls—Engineering features or administrative controls that currently exist or might be implemented as preventive or mitigative features.
- Frequency Category—Categorization used in estimating the frequency of the hazardous condition.
- Consequence Category—Categorization used in estimating the consequence of the hazardous condition.

  S1—Consequence for the facility worker.
  S2—Consequence at the collocated worker (CW).
  S3—Consequence for the MOI.

- Risk Class Bins—Risk class based on frequency and consequence from Table 3-6.

3.3.1.2.2 Likelihood Category Definitions

The likelihood of each hazardous condition was estimated by assigning one of the categories defined in Table 3-2.

Table 3-2. Frequency Category Definitions.

	Frequency Category	Category Description	Nominal Range of Likelihood
F3	Anticipated	For abnormal events expected to occur in the lifetime of a facility (spills, fires)	1E-2 to 1
F2	Unlikely	For events not expected to occur during the lifetime of a facility (but collectively an event from this category may occur)	1E-4 to 1E-2
F1	Extremely unlikely	For events that are extremely unlikely (design-basis accidents)	1E-4 to 1E-6
F0	Beyond extremely unlikely	For situations for which no credible scenario can be identified	<1E-6

3.3.1.2.3 Consequence Category Definitions

The health and safety consequence of each hazardous condition was estimated by assigning one of the categories defined in Table 3-3.

The environmental consequence of each hazardous condition was estimated by assigning one of the categories listed in Table 3-4.

Table 3-3. Consequence Category Definitions.

	Consequence Category	Public (MOI) - S3	Collocated Worker - S2	Facility Worker - S1
A	High	Significant amounts of radioactive or hazardous material reach site boundary (>25 rem TED or >ERPG- 2/TEEL-2)	Significant amounts of radioactive or hazardous material reach workers at 100 m (>100 rem TED or >ERPG-3/TEEL-3)	Prompt fatality or serious injury
B	Moderate	Some amount of radioactive or hazardous material reaches site boundary >1 rem TED or >ERPG-1/TEEL-1	Some amount of radioactive or hazardous material reach workers at 100 m (>25 rem TED or >ERPG-2/TEEL-2)	Significant radiological or chemical exposure (immediate but reversible health effects)
C	Low	Small amounts of radioactive or hazardous material reaches site boundary (<moderate consequences >none)	Small amounts of radioactive or hazardous material reach workers at 100 m (<moderate consequences >none)	<Moderate consequences >none
D	None	No impact on public	No impact on 100-m worker	No impact on facility worker

Table 3-4. Environmental Consequence Category Definitions.

E0	No significant environmental consequence
E1	Localized discharge
E2	Significant discharge onsite
E3	Offsite discharge or discharge to groundwater

3.3.1.2.4 Overall Assessment Assumptions

The following are the overall assumptions used during the course of the PHA.

- The frequency of a hazardous condition is estimated assuming controls (engineered or administrative) are absent. It does not include the likelihood contribution of control failures. It might include the combination of more than one frequency contributor if required to create (be an initiator for) the hazardous condition.
- Consequence is estimated assuming controls (engineered or administrative) are absent. Passive controls that do not need to be “protected” are credited.
- No leak path reduction factor is assumed. If some material that is contained in buildings, structures, and vessels can be released, it is assumed that all the material (available for release as a result of certain damage or failure) is released.
- Only one hazardous condition was postulated for each type of natural phenomenon and external event identified. The hazardous condition chosen is considered to represent the greatest risk.

3.3.1.2.5 Candidate Representative Accident Selection

From the PHA a wide-ranging set of hazardous conditions is formulated that could lead to a release of radioactive or hazardous materials from contained locations within the facility vessels and piping. Based on this, a list of candidate representative accidents is selected that represent and bound all hazardous conditions HNF-12648, *Candidate Representative Accidents for the*

222-S Laboratory Complex. From this candidate list, accidents are defined and analysis performed to quantitatively determine safety impacts.

The accident selection process was comprised of the following steps:

- Initial screening
- Assignment of release attribute categories
- Assignment of hazard identification codes
- Sorting of all hazardous conditions by release attribute category, and then within a release attribute category by hazard identification code
- Allocation of hazardous conditions to accident group
- Selection of representative hazardous condition for each accident group
- Selection of representative accidents.

3.3.1.2.6 Initial Screening

Hazardous conditions that would not result in a release of radioactive or hazardous material are not considered for further detailed analysis. In some cases hazardous conditions that cannot lead to a release of hazardous material but could lead to occupational injury or increased radiation exposure were recorded. For these entries, the letters "OCC" (for occupational) or the letters "RAD" (for radiological) are recorded in the MAR column since there is no MAR. These hazardous conditions are not formulated as a release of radioactive or hazardous material and are not allocated to an Accident Group, but they still warrant consideration in appropriate radiation protection and occupational safety programs. In some cases hazardous conditions were postulated that could result in both a release of radiological or hazardous material to the environment and a nonradiological injury. These hazardous conditions are considered further because release of material is postulated.

3.3.1.2.7 Assignment of Release Attributes Categories

Hazardous conditions are assigned release attributes based on (1) the energy level of the potential accident, (2) the location of the potential release, and (3) the form of the potential release. Assignment in each of these areas creates a combination that forms the release attribute category. This categorization provides an initial rough grouping of hazardous conditions that lead to like-kind accident phenomena.

Energy level attribute assignments were made according to the following definitions:

- H - High
- M - Moderate
- L - Low

High level is used for energetic events such as explosions and fires. Moderate level is used for moderate energy events such as spray leaks, drops of dispersible material, breach of ventilation with fans running, and other pressurized releases. Low level is used for low energy events such as leaks from nonpressurized vessels and leaks from nonpressurized (or failed) vent systems.

Release location attribute assignments were made according to the following definitions. For releases into multiple locations, the location that leads to the most severe consequence was used.

- 1 - Atmosphere
- 2 - Ground surface
- 3 - Subsurface

Release form attribute assignments were made according to the following definitions.

- G - Vapor/gas/aerosols
- L - Liquid/slurry
- S - Solid/sludge/particulates

So, for example, an explosion in an evaporator vessel due to flammable gases that have accumulated and ignited would be assigned to the "H-1-L" group. A pipe failure that results in a spray leak in a liquid waste slurry line would be "M-1-L." A slow leak of waste slurry from an evaporator vessel breach that subsequently finds a flow path out of the facility and forms a pool would be "L-2-L." An excavation that breaches a transfer line and does not pool to the surface would be assigned to the "L-3-L" group.

3.3.1.2.8 Assignment of Hazard Identification Codes

Identification of hazards and energy sources was performed during the hazards assessment process by marking hazards present in the facility on the hazard identification checklist provided in HNF-8739. In addition, each hazardous condition is assigned a general hazard code, shown in Table 3-5, that associates it with a class of hazards from the SARAH checklist. In some cases more than one hazard or energy source would be applicable, but the one most associated with the accident phenomena is chosen. For example, a vehicle impact might cause rupture of the gasoline fuel tank, which could cause a fuel pool fire engulfing nearby waste containers. In this case, the hazard is considered to be the gasoline (TP) rather than the linear motion (KE) of the vehicle.

Table 3-5. Hazard Categories from Checklist.

General Hazard ID Code	General Hazard ID Code
1. EE - Electrical energy	9. ME - Mechanical energy
2. LOFE - Loss of electrical	10. RM – Radioactive material
3. TE - Thermal energy	11. CE - Chemical energy
4. TP - Thermal potential energy	12. CM - Chemical materials
5. RE - Radiant energy	13. BIO - Biological
6. AE - Acoustic energy	14. NPH - Natural phenomena
7. KE - Kinetic energy	15. LOTE - Low thermal energy
8. PE - Potential energy	16. OTH - Other

3.3.1.2.9 Sorting Results by Release Attribute Categories and Hazard Codes

The hazardous condition data were sorted by release attribute categories. Within each release attribute category, hazardous conditions were then sorted by the hazard code to provide further differentiation. The resulting sort is the starting point for allocating hazardous conditions to like-kind accident groups.

3.3.1.2.10 Allocation of Hazardous Conditions to Accident Groups

Based on the release attribute categories and hazard code, a set of hazardous conditions is identified that would to lead to like-kind accidents. These sets are examined to confirm that each hazardous condition involves the same phenomena. In some cases more differentiation is needed (e.g., explosions involving waste containers and fire involving waste containers belong to the same release attribute category but need further differentiation). Differentiation is also needed if the cause of the harm mandates the use of controls that are greatly different from other hazardous conditions in the set. However, some sets are combined because less differentiation is needed (low-energy container breaches were combined regardless of the initiator such as drum corrosion, container heatup, and vibration).

In some cases an accident set may consist of only one hazardous condition. This one hazardous condition represents a unique situation.

3.3.1.2.11 Selection of Representative Hazardous Condition for Each Accident Group

For each accident group, a representative but bounding case hazardous condition is selected from the set to help characterize the group. In some cases more than one hazardous condition could be selected if one condition cannot adequately represent the set. A bounding case hazardous condition is defined as one representing the highest risk (frequency and consequence combination).

3.3.1.2.12 Selection of Candidate Representative Accidents

Accident groups whose representative hazardous condition(s) fall into a high risk class bin are candidate representative accidents and require further detailed analysis. If the risk to the MOI (S3) or CW (S2) is assigned to Risk Class I or II as defined in Table 3-6, then it is considered high. Controls in the form of TSRs will need to be identified to reduce the risk to Risk Class III or IV. Equipment associated with these controls will be designated as safety-significant.

Table 3-6. Risk Class Bins.

	Beyond Extremely Unlikely Below 10E-6/yr	Extremely Unlikely 10E-4-10E-6/yr	Unlikely 10E-2-10E-4/yr	Anticipated Above 10E-2/yr
High consequence	III	II	I	I
Moderate consequence	IV	III	II	I
Low consequence	IV	IV	III	III

3.3.1.2.13 Candidate Representative Accident Worksheet Definitions

Hazards assessment information recorded during the PHA on worksheets is presented in Appendix D. The key fields of the worksheet are the following:

- Representative Accident Number—A number identifier that associates the hazardous condition with a representative accident set.
- Release Attribute Category—Categorization that groups hazardous conditions into accident phenomena of like kind.
- Hazard Code—Code applied to each hazardous condition that links it to one of the general classes of hazards in the SARAH hazards and energy sources checklist.
- Identifier—A unique identifier for each hazardous condition (or radiation protection or occupational safety entries). Activity—The activity assessed for hazardous conditions.
- MAR—A description of the type and location of the material inventory considered for release in each entry. The analysis uses a reasonably conservative estimate.
- Hazardous Condition—A brief description of the uncontrolled release of material including the location of the release and the condition of release.
- Candidate Causes—A brief description of the cause of the uncontrolled release; generally an identification of the initiating event for the release.
- Candidate Controls—Engineering features or administrative controls that currently exist or might be implemented as preventive or mitigative features.
- Frequency Category—Categorization used in estimating the frequency of the hazardous condition.
- Consequence Category—Categorization used in estimating the consequence of the hazardous condition.

  S1—Consequence for the facility worker.

  S2—Consequence at the CW.

  S3—Consequence for the MOI.
- Risk Class Bins—Risk class based on frequency and consequence from Table 3-6.

3.3.1.2.14 Selection Assumptions

Key assessment bases and assumptions are the following:

- If a hazardous condition could only occur in one situation, it was considered to be unique.
- Hazardous conditions that were defined so broadly that they could lead to a range of different kinds of accidents were allocated to the highest consequence representative accident set (e.g., flammable gas ignition that could lead to overpressurization, fire, or explosion).
- Within a representative accident set of hazardous conditions, a single hazardous condition was selected (in some cases two were chosen) to be bounding and representative of all others. So all allocated hazardous conditions in that set represent similar or lower risk.

3.3.2 Hazard Analysis Results

3.3.2.1 Hazard Identification

The completed Hazard Identification Checklist is presented in Appendix A and the Hazard Description and Protection Form is presented in Appendix B. As seen from these appendixes, 222-S Laboratory hazards include a wide range of standard industrial hazards as well as hazards associated with the potential release of radioactive or hazardous materials from contained sources within the 222-S Laboratory Complex.

Safety management programs protect the facility worker from the standard industrial types of hazards. The 222-S Laboratory follows the WRPS Integrated Environment, Safety, and Health Management System (ISMS) described in RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Farm Contractor*, which describes the ISMS structure, policies, programs, processes, and implementing mechanisms. Key safety management programs (SMP) supporting worker protection for the 222-S Laboratory Complex, are further explained in Section 3.3.2.3.3.

As described in Section 3.3.1.1, most of these industrial hazards are not considered further in the hazard evaluation because they do not contribute to the consequences of the worst-case accident. Hazards that contribute to an uncontrolled release are important to the development of hazardous conditions in the PHA process presented in Section 3.3.2.2.

3.3.2.2 Hazard Categorization

The 222-S Laboratory is operated as a Hazard Category 3 nonreactor nuclear facility and the nuclear material inventory will be restricted such that the total facility inventory remains below the Category 2 threshold quantities listed in DOE-STD-1027-92. Table 3-7 provides the radioactive material inventory for the 222-S Laboratory and compares it to the Category 2 threshold quantities.

Table 3-7. 222-S Laboratory Inventory of Radioactive Material.

Isotope	Operating Inventory (Ci)	Category 2 Threshold (Ci)	Sum of Fractions
^{238}Pu	3.08	62	4.97E-02
^{239}Pu	11.71	56	2.09E-01
^{240}Pu	6.62	55	1.20E-01
^{241}Pu	254.93	2900	8.79E-02
^{242}Pu	0.000265	55	4.81E-06
^{241}Am	13.51	55	2.46E-01
^{90}Sr	1800	22000	8.18E-02
^{90}Y	1800	22000	8.18E-02
^{137}Cs	633	89000	7.11E-03
Total			0.883

As seen from Table 3-7, the operating inventory of the 222-S Laboratory is below the Category 2 thresholds and the sum of fractions is 0.883. The hazards evaluation and accident analysis presented show no potential for significant offsite or onsite consequences. This is consistent with a Hazard Category 3 designation of the 222-S Laboratory.

3.3.2.3 Hazard Evaluation

The hazard evaluation characterizes the identified hazards in the context of the actual facility and process. The results of the hazard evaluation are (1) identification of the accident scenarios to be evaluated, (2) estimation of the frequency and consequences of these scenarios, (3) description and evaluation of the adequacy of the controls available to prevent or mitigate the accidents, and (4) determination of the need for more detailed accident analysis. HNF-12652 presents the hazard evaluation results including the PHA tables. The PHA tables for the 222-S Laboratory Complex are provided in Appendix C. The PHA is organized by 222-S Laboratory activity or location.

3.3.2.3.1 Planned Design and Operational Safety Improvements

The hazard evaluation did not identify a need for planned design or operational improvement. The consequences of accidents to the facility worker are the result of standard industrial hazards that are mitigated through the implementation of SMPs and ISMS. Consequences to the public receptors for the accidents identified are within guidelines so mitigation through design changes or operational safety improvements are not warranted.

3.3.2.3.2 Defense in Depth

Decisions on classifying SSC as safety-class and safety-significant, selecting required TSR controls, identifying SMP controls, and identifying additional controls specifically for environmental protection are developed with a disciplined methodology and process using established control decision criteria. Applying this control decision process, controls are derived on the basis of control decision criteria, best available information, and the collective expertise and experience of the participating hazard and accident analysis, engineering, operations, and management personnel.

Candidate controls identified in the PHA were used to develop a list of defense-in-depth controls by safety analysis and engineering staff. Both engineered features and administrative controls were considered. Each recommended defense-in-depth control was related to a specific SMP. Table 3-8 shows the SMPs that support the Defense-in-Depth Controls.

The evaluation guidelines for the offsite public (MOI) and CWs (Worker) are presented in SARAH, HNF-8739, and given in Table 3-3. Table 3-6 provides the risk class bins. Based on the accident analysis, no risk to the MOI (S3) or CW (S2) were assigned to Risk Class I or II, thus controls in the form of Safety Class SSCs, Safety Significant SSCs, or TSRs were not considered to reduce the risk to Risk Class III or IV. However, an administrative control on the 222-S Laboratory facility radioactive inventory is required to ensure that it remains Category 3 and the dose consequences from the bounding worst-case accident remain below the guidelines. This is a key control and should be a TSR.

Appendix D provides a listing of the defense-in-depth controls as a specific category in the Candidate Representative Accident Worksheet. The specific control is followed by a short abbreviation that relates the control to the appropriate SMP. Table 3-8 provides the correlation between the short abbreviation in Appendix D to the program that provides defense-in-depth barriers to contain uncontrolled hazardous material or energy releases.

Table 3-8. Safety Management Programs Supporting Defense-in-Depth Controls.

Criticality Safety Program (CS)	DOE O 420.1B, *Facility Safety* ATS-310 Section 1.12, *Criticality Safety Program* ATS-LO-180-107, *222-S Laboratory Radiological Sample Inventory Control* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-49, *Tank Farm Contractor Nuclear Criticality Safety Program*
Radiation Protection Program (RP)	10 CFR 835, *Occupational Radiation Protection* DOE O 5400.5, Chg. 2, *Radiation Protection of the Public and the Environment* HNF-5183, *Tank Farms Radiological Control Manual (TFRCM)* HNF-MP-5184, *Washington River Protection Solutions LLC Radiation Protection Program* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor*
Hazardous Material Protection Programs • Industrial Hygiene (IH) • Occupational Safety (OS) • Industrial Safety (OS) • Environmental Protection (EPROTECT)	10 CFR 851, *Worker Safety and Health Program* 29 CFR 1910, *Occupational Safety and Health Administration* 40 CFR 302, *Designation, Reportable Quantities, and Notification* DOE O 231.1A, *Environment, Safety, and Health Reporting* DOE O 5400.5, Chg. 2, *Radiation Protection of the Public and the Environment* DOE O 5480.4, *Environmental Protection, Safety, and Health Protection Standards* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-34, *Industrial Hygiene Exposure Assessment Strategy* TFC-PLN-47, *Worker Safety and Health Program* TFC-POL-14, *WRPS Safety and Occupational Health* TFC-POL-16, *Integrated Safety Management System Policy*
Radioactive and Hazard-ous Material Waste Management Programs (RWM)	49 CFR 178, *Specifications for Packagings* 49 CFR 173, *Shippers--General Requirements for Shipments and Packagings* DOE O 435.1, Chg. 1, *Radioactive Waste Management* HNF-5183, Tank Farms Radiological Control Manual (TFRCM) RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-33, *Waste Management Basis* TFC-PLN-100, *Requirements Basis Document*

Table 3-8. Safety Management Programs Supporting Defense-in-Depth Controls.

Testing In-Service Surveillance and Maintenance Program • Maintenance (M)	DOE O 433.1B, *Maintenance Management Program for DOE Nuclear Facilities* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* RPP-PLN-39433, *Procurement, Construction, and Acceptance Testing Plan* RPP-PLN-39434, *Construction and Acceptance Testing Program* TFC-CHARTER-01, *Tank Operations Contractor Charter* TFC-PLN-26, *Testing Program Plan* TFC-PLN-29, *Nuclear Maintenance Management Program* TFC-PLN-100, *Requirements Basis Document*
Operational Safety Program • Fire Protection (FP) • Conduct of Operations (CO)	DOE O 420.1B, *Facility Safety* DOE O 422.1, *Conduct of Operations* DOE/RL-94-02, *Hanford Emergency Management Plan* ENS-ENG-IP-05, *ORP Fire Protection Program* HNF-SD-CP-FHA-003, *222-S Laboratory Fire Hazards Analysis* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-05, *Conduct of Operations Implementation Plan* TFC-PLN-13, *Fire Protection Program* TFC-PLN-100, *Requirements Basis Document*
Procedures Development and Training Program • Training (TNF)	DOE O 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-61, *Tank Operations Contractor Training and Qualification Plan* TFC-PLN-80, *Procedure Program Description* TFC-PLN-100, *Requirements Basis Document*
Quality Assurance Program (QA)	10 CFR 830, Subpart A, “Quality Assurance Requirements” DOE O 414.1C, *Quality Assurance* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-02, *Quality Assurance Program Description* TFC-PLN-29, *Nuclear Maintenance Management Program* TFC-PLN-100, *Requirements Basis Document* TFC-PLN-112, *Graded Approach to Quality*
Emergency Preparedness Program (EPLAN)	40 CFR 355, “Emergency Planning and Notification” DOE-0233, Emergency Plan Implementing Procedures DOE O 151.1C, *Comprehensive Emergency Management System* DOE/RL-94-02, *Hanford Emergency Management Plan* ATS-MP-1036, *Building Emergency Plan for the 222-S Laboratory Complex* RPP-MP-003, *Integrated Environment, Safety, and Health Management System Description for the Tank Operations Contractor* TFC-PLN-85, *Emergency Management Program* TFC-PLN-100, *Requirements Basis Document*
Management, Organiza-tion, and Institutional	10 CFR 830, Subpart B, “Safety Basis Requirements” RPP-MP-003, *Integrated Environment, Safety, and Health Management*

Table 3-8. Safety Management Programs Supporting Defense-in-Depth Controls.

Safety Provisions • Configuration Management (CM)	*System Description for the Tank Operations Contractor* TFC-CHARTER-01, Tank Operations Contractor Charter TFC-PLN-02, *Quality Assurance Program Description* TFC-PLN-03, *Engineering Program Management Plan* 16 TFC-PLN-05, *Conduct of Operations Implementation Plan* TFC-PLN-17, *Document Control and Records Management Program Description* TFC-PLN-29, *Nuclear Maintenance Management Program* TFC-PLN-47, *Worker Safety and Health Program* TFC-PLN-100, *Requirements Basis Document*

3.3.2.3.3 Worker Safety

As discussed previously, most of the standard industrial hazards are not further considered as the PHA focuses on release of radioactive or hazardous material. The PHA, however, does contain, (as described in Section 3.3.1.2.6) a few hazardous conditions that do not lead to a release of hazardous material but could lead to occupational injury or increased radiation exposure because they were postulated during the PHA sessions. There is no MAR for these hazardous conditions and they are not considered for further analysis. The letters “OCC” (for occupational) or the letters “RAD” (for radiological) are recorded in the MAR column. The consequence category assignment to the CW and the offsite receptor is always Negligible (D).

Some hazardous conditions were postulated that result in both a release of radiological or hazardous material to the environment and a nonradiological injury to the facility worker. These hazardous conditions are further considered because release of material is postulated. The consequence category assignment in some of these cases is High (A) to the facility worker (S1). However, in every case (15 cases) where the consequence assignment is High to the facility worker, the consequences are related to industrial safety. This is supported by explanations recorded in the “Immediate Consequence” column of those hazardous conditions (refer to the PHA table presented in Appendix C). Furthermore, none of the industrial safety-related injuries that were postulated are a result of an event initiated by the nuclear material properties of the released material. Rather, they were related to other phenomena such as explosion of compressed cylinders, temperature or chemical-related overpressure, and falling structural elements degraded by a natural event (i.e., earthquake, tornado, etc.). The safety management programs supporting worker protection and protective controls are listed in Table 3-9.

Hazardous conditions, in which the harm is caused directly by release of nonradiological material such as toxic chemicals, were also not further considered as candidates for a representative accident. These hazardous conditions are not controlled by the DSA as part of the nuclear safety and licensing basis. As seen from the PHA, potential releases of chemicals primarily impact the worker. Small laboratory quantities of toxic, corrosive, and reactive materials are routinely used in research and sample analysis at 222-S. Hazardous material protection programs provide for identification and control of hazardous materials and training of personnel to minimize occupational exposure to hazardous materials. ATS 310, Administration manual (*Analytical Technical Services 222-S Laboratory Administration*) section 4.5, *222-S Laboratory Complex Chemical Hygiene Plan*, is written in accordance with 29 CFR 1910.1450, “Occupational Exposure to Hazardous Chemicals in Laboratories,” and covers all laboratory work areas in which hazardous chemicals are used. This plan sets general principles for work with laboratory chemicals and sets specific precautions for work with materials considered to be extremely hazardous. Table 2-1 provides a representative list of the extremely hazardous chemicals present at 222-S Laboratory and compares them to reportable quantities of 40 CFR 302, "Designation, Reportable Quantities, and Notification," and threshold planning quantities of 40 CFR 355, "Emergency Planning and Notification."

As seen from Table 2-1, the 222-S Laboratory hazardous chemical inventory is very small when compared to the Reportable Quantity and the Threshold Planning Quantity. Hazardous Material Protection Programs and the Chemical Hygiene Plan control risks posed by chemical hazards.

Table 3-9. Safety Management Programs Supporting Worker Protection.

SMP	SMP Protective Controls
Criticality Safety Program (CS) • Training (TNF)	Consists of criticality safety plans and procedures, criticality training, determination of operational nuclear criticality limits, and criticality infraction reporting.
Radiation Protection Program (RP) • ALARA • Training (TNF)	Consists of the ALARA Program, radiological protection training, radiation exposure control, radiological monitoring, radiological protection instrumentation, and radiological protection record keeping.
Hazardous Material Protection Programs • Industrial Hygiene (IH) • Occupational Safety (OS) • Industrial Safety (OS) • Environmental Protection (EPROTECT)	Consists of the Safety and Health procedures, hazardous material training, hazardous material exposure control, hazardous material monitoring, hazardous material instrumentation, hazardous material record keeping, and the hazard communication program.
Radioactive and Hazardous Material Waste Management Programs (RWM)	Consists of compliance to waste acceptance criteria, waste management composite analysis, and performance acceptance.
Testing In-Service Surveillance and Maintenance Program • Maintenance (M)	Consists of initial testing program, in-service surveillance, and maintenance programs.
Operational Safety Program • Fire Protection (FP) • Conduct of Operations (CO)	Consists of conduct of operations and fire protection (combustible loading control, fire fighting capability, and fire fighting readiness).
Procedures Development and Training Program • Training (TNF)	Consists of procedures and training programs.
Quality Assurance Program (QA)	Consists of quality improvement, documents and records, and quality assurance performance.
Emergency Preparedness Program (EPLAN)	Consists of assessment actions, notification, emergency facilities and equipment, protective actions, training and drills, and recovery reentry.
Management, Organization, and Institutional Safety Provisions • Configuration Management (CM)	Consists of review and performance assessment, configuration and document control, occurrence reporting, and safety culture.

3.3.2.3.4 Environmental Protection.

The most severe environmental consequences of the hazards listed in Appendix C is Category E2 (significant discharge onsite) which is consistent with a Hazard Category 3 facility. The E2 consequences are from hazardous conditions that release the total radiological inventory and one scenario that releases 10% of the radiological inventory plus chemicals from 219-S. The frequency assigned to most these hazardous conditions is unlikely, therefore, no design or operational features that reduce the potential for large material releases to the environment are needed.

3.3.2.3.5 Accident Selection

The accident analysis entails the formal quantification of the limited subset of accidents. These accidents represent, as noted in DOE-STD-3009-94 Change 2, "a complete set of bounding conditions." The identification of design basis accidents (DBAs) results from the hazard evaluation ranking of the complete spectrum of facility accidents.

3.3.2.3.5.1 Candidate Representative Accident Selection Results

Using the representative accident selection process described in Section 3.3.1.2.5, all 104 hazardous conditions postulated in the PHA were distilled down into six accident groups. Every hazardous condition was assigned to one of the accident groups. Then a bounding hazardous condition was selected for each accident group. The bounding hazardous condition is the one representing the highest risk (frequency and consequence combination) and provides the starting point for quantitative accident analysis if needed. Appendix D presents the Candidate Representative Accident Worksheet, where hazardous conditions are listed by accident group, from highest risk to the lowest. The first hazardous condition listed is bounding and provides the starting point for quantitative accident analysis if warranted for that group. The accident group number for the bounding hazardous condition is followed by an "X". Chemical releases are provided for completeness but they are not considered part of the candidate representative accident selection.

The following are the six accident groups:

- Fire/Explosion
- Storage Tank Failure/Leaks
- Container Handling Accidents
- Container Overpressure Accidents
- Confinement System Failure
- Natural Phenomena/External Events

The following section describes each of the six accident groups and characterizes all hazardous conditions allocated to that group. As part of the description, the Risk Class Bins are presented for the highest risk conditions in the group for both the CW and the off site receptor. The Risk Class Bin is not determined for the facility worker per guidance in SARAH. Accident groups that fall into Risk Class Bin I or II are candidates for further detailed quantitative analysis. The only accident group meeting that criteria is the fire/explosion accident group.

3.3.2.3.5.2 Fire/Explosion

This accident group encompasses hazardous conditions resulting from a fire or explosion and ranges from local fires (e.g., gloveboxes, loading dock area and waste drums) to building-wide fires. The release of radioactive material is primarily in the form of airborne particulates, which can be passed directly to the environment or released to the building and then to the environment via building leaks or the ventilation system. The cause of the explosions is the leak of flammable gas, such as propane into a laboratory room, inside the 222-S Laboratory Building. Fires can result from flammable chemicals or other combustible material and ignition sources. Explosions can be followed by fire and the assumption is that fires and explosions could breach containers. Combustibles that could be ignited and lead to fire include diesel oil, hydraulic oil, flammable liquids in a glovebox, electrical equipment, and general combustibles. HNF-SD-CP-FHA-003, *222-S Laboratory Fire Hazards Analysis*, presents a complete discussion of the fire hazards and fire related concerns in the 222-S Laboratory Complex.

The MAR is either the local inventory in the vicinity of the fire or the building contents in case of a building-wide fire. The MAR related to a local fire is very specific to the location of the fire. A building-wide fire is limited by the inventory of the 222-S Laboratory Complex and is estimated to be 39.11 DE-Ci.

Based on initial qualitative estimates associated with the representative hazardous conditions for this accident group, consequences range up to high for the facility worker (S1-A), moderate for the CW (S2-B), and low for the offsite receptor (S3-C). The initial frequency assigned to the consequences for the CW and offsite receptor was “unlikely” for the higher risk hazardous condition. According to Table 3-6, this accident fell into the Risk Class Bin II for the CW and Risk Class Bin III for the offsite receptor. Therefore, it met the criteria for a representative accident that should be analyzed in more detail.

A building-wide fire that starts in the 222-S Laboratory Building is selected as the bounding accident for the 222-S Laboratory Complex and is analyzed in more detail in Section 3.4. As shown in that section, the quantitative analysis of the accident indicates that the building-wide fire is in Risk Class Bin III for the CW and the offsite receptor for the “unlikely” and “anticipated” frequency categories; therefore no safety-significant controls are required. The facility worker, S1, is protected from the hazards of a building-wide fire through the implementation of the SMPs. An administrative control on the 222-S Laboratory Facility radioactive inventory is required to ensure that the consequences to the CW, S2, and the offsite public, S3, of this bounding accident remain within the guidelines. The engineering and administrative features identified in the PHA provide defense-in-depth against uncontrolled release of radioactive material that could adversely affect the public, the CW, the facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.3.2.3.5.3 Storage Tank Failure/Leak

This accident group addresses hazardous conditions resulting from spray or pool leaks. It includes various leaks from tanker transfer operations, sampling operations, and vessel failure in the 219-S Waste Handling Facility and 207-SL Retention Basin. The liquid release may be pressurized from a pump or have a modest static head (such as in a tanker). Therefore, some leaks have the potential for forming aerosols, which may be suspended in the atmosphere. The amount of aerosols created will depend on the pressure, leak size, liquid properties, and leak duration. The release is to the environment.

The MAR is the liquid contents of 219-S tanks that contain mixed waste from laboratory operation or from 207-SL tanks that contain low levels of contaminated waste water. A 219-S tank was assumed to contain 10% (3.91 DE-Ci) of the total radioactive material inventory and have a pH ranging from 0.5 to 12.5.

Consequences associated with the representative hazardous conditions for this accident group range up to low for the facility worker (S1-C), low for the CW (S2-C), and negligible for the offsite receptor (S3-D). The frequency assigned to these consequences for the CW and offsite receptor was “anticipated.” According to Table 3-6 this accident falls into the Risk Class Bin III for the CW and does not fall into a Risk Class Bin for the offsite receptor. Therefore, this accident group does not meet the criteria for a representative accident that should be analyzed in more detail. No safety-significant controls are required for this accident category. An administrative control on the 222-S Laboratory Facility radioactive inventory is required. The engineering and administrative features identified in the PHA provide defense-in-depth against uncontrolled release of radioactive material that could adversely affect the public, the collocated worker, facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.3.2.3.5.4 Container Handling Accidents

This accident group addresses hazardous conditions resulting from a spill of liquid or solid contents from a waste container or sample container. It includes container damage due to drops, impacts, crushes, and punctures. Some hazardous conditions are postulated to happen outside, so the release is directly to the environment. Others are postulated to happen inside but are transported to the environment via building leaks or the heating, ventilation, and air conditioning (HVAC).

The MAR is the liquid or solid contents of waste containers and sample containers. The content of waste containers is assumed to be no greater than 8.3E-1 DE-Ci. A realistic average value is 1.7E-2 DE-Ci per container. A sample is assumed to be no greater than 30 g of Pu (4.95 DE-Ci).

Consequences associated with the representative hazardous conditions for this accident group range up to high for the facility worker (S1-A), low for the CW (S2-C), and negligible for the offsite receptor (S3-D). The frequency assigned to the consequences for the CW and offsite receptor was “anticipated.” According to Table 3-6, this accident falls into the Risk Class Bin III for the CW and does not fall into a Risk Class Bin for the offsite receptor. Therefore, this accident group does not meet the criteria for a representative accident that should be analyzed in more detail. No safety-significant controls are required for this accident category. An administrative control on the 222-S Laboratory facility radioactive inventory is required. The engineering and administrative features identified in the PHA provide defense-in-depth against uncontrolled release of radioactive material that could adversely affect the public, the CW, facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.3.2.3.5.5 Container Overpressure Accidents

This accident group addresses hazardous conditions resulting from a spill of liquid or solid contents from a waste container or the 219-S tank due to mixing of incompatible materials and/or gas generation. It assumes that a container is breached due to overpressurization in the container and that the contents are expelled. Some hazardous conditions are postulated to happen outside, so the release is directly to the environment. Others are postulated to happen inside but are transported to the environment via building leaks or the HVAC.

The MAR is the liquid or solid contents of waste containers or the 219-S mixed waste storage tanks. The content of waste containers is assumed to be no greater than 8.3E-1 DE-Ci. A realistic average value is 1.7E-2 DE-Ci per container. A 219-S tank was assumed to contain 10% of the total radioactive material inventory and have a pH ranging from 0.5 to 12.5.

Consequences associated with the representative hazardous conditions for this accident group range up to high for the facility worker (S1-A), low for the CW (S2-C), and negligible for the offsite receptor (S3-D). The frequency assigned to the consequences for the CW and offsite receptor was “anticipated.” According to Table 3-6, this accident falls into the Risk Class Bin III for the person at the facility boundary and does not fall into a Risk Class Bin for the offsite receptor. Therefore, this accident group does not meet the criteria for a representative accident that should be analyzed in more detail. No safety-significant controls are required for this accident category. An administrative control on the 222-S Laboratory facility radioactive inventory is required. The engineering and administrative features identified in the PHA provide defense-in-depth against uncontrolled release of radioactive material that could adversely affect the public, the CW, facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.3.2.3.5.6 Confinement System Failure

This accident group addresses hazardous conditions resulting from a release of hazardous material from a confined location. This includes release of airborne particulates or aerosols from a hood, glovebox, or hot cell due to ventilation failure or breach due to various causes, including a gas cylinder missile. Lastly, this includes building ventilation failure that leads to spread of airborne particulates in the form of loose contamination or release from high-efficiency particulate air (HEPA) filters. Some hazardous conditions are postulated to release directly to the outside environment. Others are postulated to happen inside but are transported to the environment via building leaks or the HVAC.

The MAR in most cases is assumed to be loose contamination (up to 1.04E-2 DE-Ci) or airborne particulates from the maximum inventory that can accumulate on the HEPA filters (5.41E-1 DE-Ci). The content of waste containers is assumed to be no greater than 8.3E-1 DE-Ci. A realistic average value is 1.7E-2 DE-Ci per container.

Consequences associated with the representative hazardous conditions for this accident group range up to high for the facility worker (S1-A), low for the CW (S2-C), and negligible for the offsite receptor (S3-D). The frequency assigned to the consequences for the CW and offsite receptor was "anticipated." According to Table 3-6, this accident falls into the Risk Class Bin III for the CW and does not fall into a Risk Class Bin for the offsite receptor. Therefore, this accident group does not meet the criteria for a representative accident that should be analyzed in more detail. No safety-significant controls are required for this accident category. An administrative control on the 222-S Laboratory facility radioactive inventory is required. The engineering and administrative features identified in the PHA provide defense-in-depth against an uncontrolled release of radioactive material that could adversely affect the public, the CW, facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.3.2.3.5.7 Building Degradation Caused by Natural or External Events

This accident addresses hazardous conditions resulting from a natural or external event that have the potential to degrade a 222-S Laboratory Complex building and release hazardous or radioactive material. A range fire is not considered to be in this accident group because it is not likely to breach building structures and was therefore grouped with hazardous conditions resulting in fire and explosion. Flooding is also not considered to be in this accident group for the same reason and was grouped with hazardous conditions resulting in loss of confinement. For the hazardous conditions assigned to this accident group (extreme winds, volcanic ashfall and heavy snowfall, seismic events, and an airplane crash), it was assumed that the natural or external event breached the facility and had the potential to release the entire hazardous and radioactive material content.

The MAR is assumed to be the 222-S Laboratory radioactive inventory. That inventory is estimated to be 39.11 DE-Ci.

Resulting consequences from this accident range up to high for the facility worker (S1-A), moderate for the CW (S2-B), and low for the offsite receptor (S3-C). The high consequence to the facility worker is a result of potential worker death from falling debris caused by a collapsing part of the structure. In the two cases (seismic event and airplane crash) where the consequence to the CW is moderate, the frequency is considered to be extremely unlikely. In the other cases where the frequency is higher, the consequences are low. The building-wide fire bound the radiological dose consequences of this accident group. No safety-significant controls are required for this accident category. An administrative control on the 222-S Laboratory facility radioactive inventory is required. The engineering and administrative features identified in the PHA provide defense-in-depth against an uncontrolled release of radioactive material that could adversely affect the public, the CW, facility worker, and the environment. However, these features are not designated as safety-significant because the low dose consequences from this Hazard Category 3 facility are below the risk guidelines.

3.4 Accident Analysis

A building-wide fire that is started in the 222-S Laboratory Building is selected as the bounding accident for the 222-S Laboratory Complex. As shown in the PHA, such a fire can result from failure of a flammable compressed gas cylinder or gas line in a laboratory. The building-wide fire scenario is assumed to result from the spread of either a local fire or a local deflagration and resulting fire. The local fire or local deflagration is assumed to interact with flammable chemicals stored in the laboratory, and the fire is assumed to spread to adjacent laboratory rooms and throughout the 222-S Laboratory facility. Any deflagration is not large enough to cause building-wide damage. It may result in an immediate release of radioactivity in a laboratory hood or room but this release will be small compared to the release resulting from the fire spreading and burning the entire facility. No credit is taken for engineered and administrative controls. The assumed source term is bounding because the entire 222-S Laboratory radiological inventory is exposed to the fire.

3.4.1 Methodology

It is conservatively assumed that the fire impacts the total radiological inventory of the 222-S Laboratory. A bounding airborne release fraction of 5.0E-4 and a respirable fraction of 1.0 are based on the SARAH and DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. The values used are those for accidents involving fire and packaged waste. Packaged waste is defined as contaminated material contained by a noncontaminated barrier (i.e., a noncontaminated barrier such as a plastic bag between the waste and the environment). This category is intended to cover contaminated material in cans, bags, drums, and boxes but does not cover strong containers that result in smaller release fractions. The MAR quantity used in the accident analysis is consistent with the derivation of the MAR presented in Section 3.3.1.1.1.

The worst-case accident scenario for the 222-S Laboratory is not complex, so the dose consequences were hand calculated. The consequences of the building-wide fire was calculated for the 100-m CW and the MOI at the closest Hanford site boundary. The atmospheric dispersion parameters (χ/Q) for these receptors, 1.09E-2 s/m^3 and 1.13E-5 s/m^3, for the CW and MOI respectively, were taken from values derived in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Appendix L. A ground level release was assumed and a building wake model was used. No credit was taken for an elevated release from the fire. Inhalation is the dominant radiation exposure pathway for this accident. The ICRP 68 dose factors were used for the CW. The ICRP 71/72 dose factors were used for the MOI. A standard light breathing rate of 3.33E-4 m^3/s from RPP-13482 was used. The airborne release fraction of 5E-4 and a respirable fraction of 1.0 equate to a total release fraction (RF) of 5E-4. The details and results of the consequence calculations are provided in Table 3-10 and Table 3-11.

3.4.2 Design Basis Accidents

The analysis of DBAs is made to quantify consequences and compare them to evaluation guidelines. The major categories are internally initiated operational accidents (e.g., fires, explosions, spills, criticality); natural phenomena events for the site (e.g., earthquakes, tornadoes) that could affect the facility; and externally initiated, man-made events such as airplane crashes, transportation accidents, adjacent events, etc. The six accident groups presented in Section 3.3.2.3.5.1, whose representative hazardous condition fall into the High Risk Bin (I or II) for the CW or MOI, are candidate representative accidents and require detailed analysis. For the 222-S Laboratory, the building-wide fire is the only hazardous condition that results in a Risk Bin II and is the only accident condition that warrants further quantitative analysis.

3.4.2.1 Building-Wide Fire

The accident scenario that describes a fire consuming the whole building and exposing the entire radiological inventory for release is an operational accident.

Table 3-10. Bounding Accident Analysis Summary for the Collocated Worker.

Isotope	Operating Inventory (Ci)	Dose Conversion Factor ICRP 68 (Sv/Bq)	Dose Conversion Factor (rem/Ci)[a]	(OI*RF*BR) (Ci-m^3/s)[b]	Dose to the 100 m Collocated Worker (rem)[c]
^{238}Pu	3.08	3.00E-05	1.11E+08	5.08E-07	6.15E-01
^{239}Pu	11.71	3.20E-05	1.18E+08	1.93E-06	2.48
^{240}Pu	6.62	3.20E-05	1.18E+08	1.09E-06	1.40
^{241}Pu	254.93	5.80E-07	2.15E+06	4.21E-05	9.87E-01
^{242}Pu	2.65E-04	3.10E-05	1.15E+08	4.38E-11	5.49E-05
^{241}Am	13.51	2.70E-05	9.99E+07	2.23E-06	2.43
^{90}Sr	1800	3.00E-08	1.11E+05	2.97E-04	3.59E-01
^{90}Y	1800	1.70E-09	6.29E+03	2.97E-04	2.04E-02
^{137}Cs	633	6.70E-09	2.48E+04	1.04E-04	2.81E-02
Total					8.32

[a] Converted ICRP 68 (Sv/Bq) to (rem/Ci) by multiplying (3.7E10 Bq/Ci) x (100 rem/Sv)
[b] Operating Inventory (Ci) x release fraction (5.0E-4) x breathing rate (3.3E-4 m^3/s)
[c] Rem/Ci x (OI*RF*BR) x χ/Q; for the CW χ/Q = 1.09E-02 s/m^3 (RPP-13482, Appendix L)

Table 3-11. Bounding Accident Analysis Summary for the Maximum Offsite Individual.

Isotope	Operating Inventory (Ci)	Dose Conversion Factor ICRP 71/72 (Sv/Bq)	Dose Conversion Factor (rem/Ci)[a]	(OI*RF*BR) (Ci-m^3/s)[b]	Dose to the 13 km Maximum Offsite Individual (rem)[c]
^{238}Pu	3.08	4.60E-05	1.70E+08	5.08E-07	9.76E-04
^{239}Pu	11.71	5.00E-05	1.85E+08	1.93E-06	4.03E-03
^{240}Pu	6.62	5.00E-05	1.85E+08	1.09E-06	2.28E-03
^{241}Pu	254.93	9.00E-07	3.33E+06	4.21E-05	1.58E-03
^{242}Pu	2.65E-04	4.80E-05	1.78E+08	4.38E-11	8.81E-08
^{241}Am	13.51	4.20E-05	1.55E+08	2.23E-06	3.91E-03
^{90}Sr	1800	3.60E-08	1.33E+05	2.97E-04	4.46E-04
^{90}Y	1800	1.50E-09	5.55E+03	2.97E-04	1.86E-05
^{137}Cs	633	4.60E-09	1.70E+04	1.04E-04	2.00E-05
Total					0.0133

[a] Converted ICRP 71 (Sv/Bq) to (rem/Ci) by multiplying (3.7E10 Bq/Ci) x (100 rem/Sv)
[b] Operating Inventory (Ci) x release fraction (5.0E-4) x breathing rate (3.3E-4 m^3/s)
[c] Rem/Ci x (OI*RF*BR) x χ/Q; for the MOI χ/Q = 1.13E-05 s/m^3 (RPP-13482, Appendix L)

3.4.2.1.1 Scenario Development

The building-wide fire is started with the failure of a compressed flammable gas cylinder that is ignited causing a local fire or explosion that spreads through the whole facility. The release of radioactive material is primarily in the form of airborne particulates, which can be passed directly to the environment or released to the building and then to the environment. The complete fire scenario is presented in Section 3.3.2.3.5.2.

3.4.2.1.2 Source Term Analysis

The radioactive material handled in the 222-S Laboratory is primarily waste tank core samples, other radioactive samples from the environmental restoration and waste management program, radioactive analytical standards, and 222-S Laboratory generated waste. Almost the entire inventory of radioactive material is represented by the waste tank core samples and these are primarily stored in the hot cell facility but can be located throughout the 222-S Laboratory. The amount of uncontained waste (samples) at any given time within the 222-S Laboratory Complex is very small. The only appreciable uncontained volumes are samples being prepared for analysis. Sample analysis is completed on small portions of the original delivered sample (i.e., aliquot or subsample). Samples are usually delivered in 125-ml volumes. Aliquot volumes are much smaller and are controlled to be as low as reasonably achievable.

In some cases a flammable solvent is used to strip certain material from the samples (1 to 2 ml quantity). This is collected in small jars to be disposed of en masse. However, the radioactive material content is very small (e.g., no shielding is used). So although the airborne release fraction (ARF) for boiling aqueous waste is higher than containerized waste, the consequences of release from this waste form are not calculated because it would be an insignificant contributor. The amount of uncontained waste and flammable solvent material is small so an ARF of 5.0E-4 and a respirable fraction of 1.0 assumed for the entire material inventory provide an upper bound estimate of the dose consequences of this accident. It is very conservative for the waste tank core samples and is representative of the other types of samples and waste in 222-S.

The building-wide fire is assumed to impact the entire source term in the facility. Therefore, the accident source term is the same as the MAR defined in Section 3.3.1.1.1. The quantity of TRU, with a composition of 12% ^{240}Pu fuel, is 225 g. The added quantity of ^{90}Sr (12.95 g), ^{90}Y (3.3E-3 g), and ^{137}Cs (7.31 g) is a conservative amount based on the Best Basis Inventory (BBI) presented in HNF-10754. The added consequences to the accident receptors for the added ^{90}Sr, ^{90}Y, and ^{137}Cs is very small; however, the radioactive dose to the facility workers for these isotopes in the waste tank samples warrants consideration.

The conversion of mass to dose equivalent curies is presented in Section 3.3.1.1.1. The 222-S Laboratory source term of 225 g TRU is equivalent to 37.10 DE-Ci calculated with the Dose Conversion Factor from ICRP 71/72 or 0.165 DE-Ci/g of TRU for all public receptors. Calculations of DE-Ci for 225 g of TRU with ICRP 68 for the CW totals 37.24 DE-Ci or 0.166 DE-Ci/g of TRU. These same calculations for the entire MAR in the facility result in 38.54 DE-Ci or 0.156 DE-Ci/g of MAR using ICRP 71/72 and 39.11 DE-Ci or 0.160 DE-Ci/g of MAR using ICRP 68.

The estimated inhalation dose due to a release to the air from 222-S Laboratory at any time for any given inventory can be calculated as follows:

$$D = (Q)(\chi/Q)(BR)(DCF)$$

where

D	=	inhalation dose
Q	=	total release ((facility DE-Ci)(5.0E-4))
χ/Q	=	atmospheric dispersion coefficient
(CW	=	1.09E-2 s/m^3, MOI = 1.13E-5 s/m^3)
BR	=	receptor breathing rate (assumed 3.33E-4 m^3/s)
DCF	=	dose conversion factor
(CW	=	1.18E+8 rem/DE-Ci, and MOI = 1.85E+8 rem/De-Ci)

3.4.2.1.3 Consequence Analysis

The location of the MOI receptor is derived in Section 1.3.1 to be 13.0 km (8.1 miles) from the 222-S Laboratory. The radiological dose consequence of the worst-case building-wide fire was completed by hand calculations and presented in Tables 3-10 and 3-11. The dose consequence to the CW, 100 m, is determined to be 8.32 rem and the dose to the MOI is determined to be 0.0133 rem.

3.4.2.1.4 Comparison to the Evaluation Guideline

As seen from Table 3-11, the consequences to the MOI are in the low consequence category. The consequence to the 100-m CW is 8.32 rem. This is substantially below the 25-rem guideline for a moderate consequence category. In development of the PHA, this accident was originally determined to be in the “unlikely” frequency category. Further assessment has led to the determination that the “unlikely” frequency may not be conservative and this accident would be classified in the “anticipated” frequency category. In either case, “unlikely” or “anticipated”, according to Table 3-6 this accident falls into the Risk Class Bin III. No safety-significant controls are required. This is consistent with the Hazard Category 3 designation of the 222-S Laboratory.

3.4.2.1.5 Summary of Safety-Class Structures, Systems, and Components, Specific Administrative Controls and Technical Safety Requirements Controls

The accident results are used to identify safety-class and SSCs TSRs. The objective is to identify the necessary and sufficient safety SSCs and TSRs that lower the risks associated with identified accidents to values that satisfy the evaluation guidelines. The designated controls are required if the dose consequences and frequency to the CW or MOI are determined to be in Risk Bin I or II. The 222-S Laboratory worst-case bounding accident is in Risk Bins III and IV for the CW and MOI, respectively, and therefore do not require safety-class SSCs or safety-significant controls. However, a Specific Administrative Control on the 222-S Laboratory facility radioactive inventory is required to ensure that it does not exceed the dose equivalent curies used to calculate the dose consequences of the bounding accident. This is a key control and should be a TSR.

3.4.3 Beyond Design Basis Accidents

An evaluation of accidents beyond the design basis provides perspective of the residual risk associated with the operation of the facility. Because the worst-case accident scenario for 222-S Laboratory consumes the entire facility and radiological inventory, there is no residual risk and no need for a beyond design basis analysis.

3.5 References

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

10 CFR 851, *Code of Federal Regulations*, “Worker Safety and Health Program,” as amended.

29 CFR 1910, *Code of Federal Regulations*, “Occupational Safety and Health Administration,” as amended.

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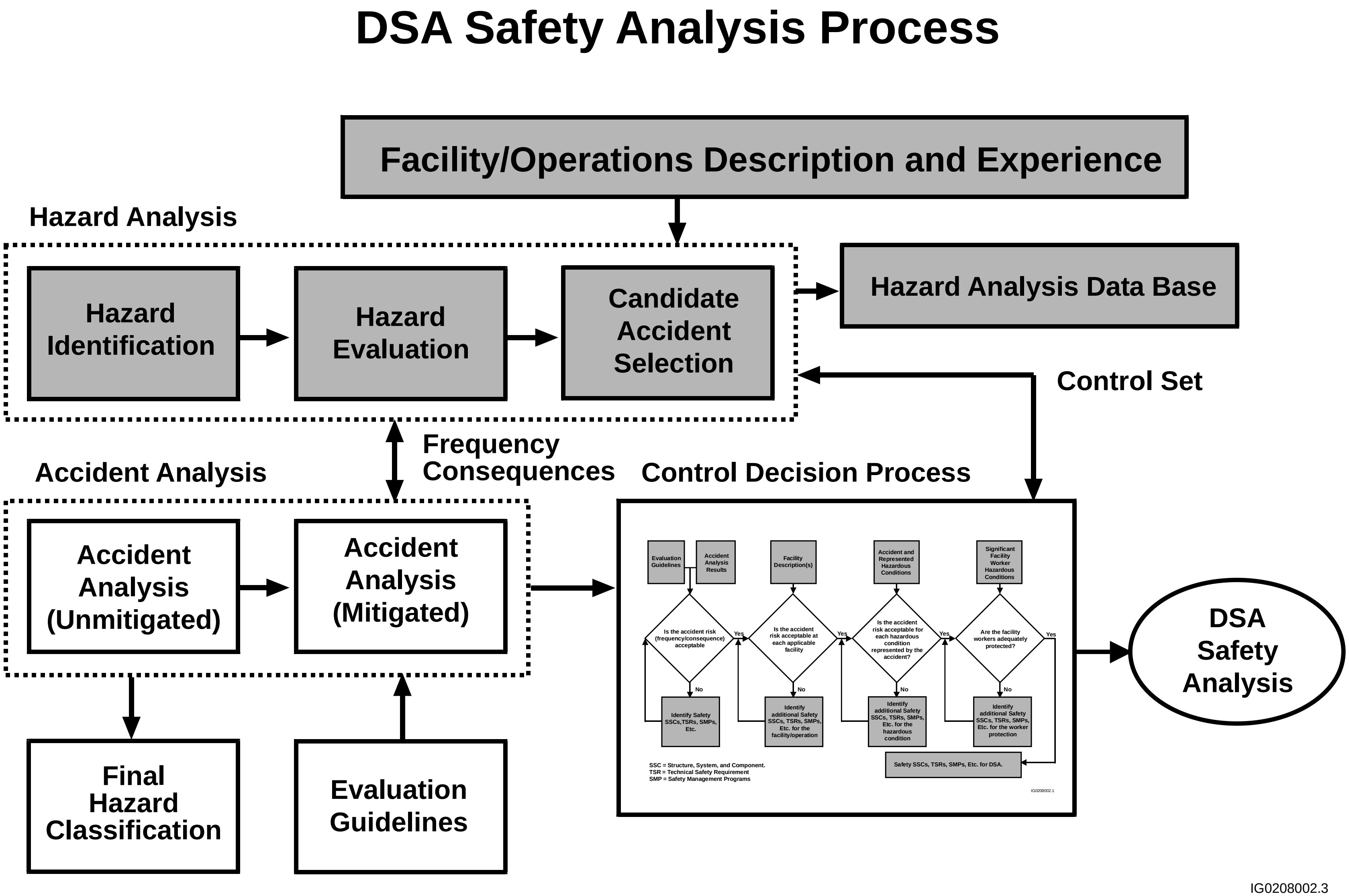
TFC-POL-16, *Integrated Safety Management System Policy*, as amended, Washington River Protection Solutions LLC, Richland, Washington.

FIGURE 3-1. DSA SAFETY ANALYSIS PROCESS.



4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

This chapter presents and evaluates the adequacy of safety-class structures, systems and components (SSCs), safety-significant SSCs, and Specific Administrative Controls (SAC) by providing for each SSC or SAC its safety functions (as assumed in Chapter 3.0), a brief description, the functional requirements to support the safety functions, an evaluation with respect to the functional requirements as defined through performance criteria, and the associated technical safety requirement (TSR). This chapter concentrates on providing reasonable assurance that the safety function and functional requirements for each SSC or SAC are met.

This chapter complies with Title 10, *Code of Federal Regulations,* Part 830 (10 CFR 830) Subpart B, "Safety Basis Requirements," and provides information consistent with the guidance provided in Chapter 4.0, "Safety Structures, Systems, and Components" of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*.

4.2 REQUIREMENTS

The codes, standards, regulations, and DOE Orders used to establish the safety basis for the 222-S Laboratory are contained in Contract DE-AC27-08RV14800.

10 CFR 830 identifies DOE-STD-3009 as the "safe harbor" methodology for the preparation of the safety basis for a Hazard Category 3 nuclear facility. This chapter has been prepared in accordance with the requirements of DOE-STD-3009-94, Chapter 4.0, Safety Structures, Systems, and Components.

4.3 Safety Class Systems, Structures, and Components

The hazard and accident analysis conducted in Chapter 3.0 did not identify any safety structures, systems, or components that require safety-class designation.

4.4 Safety-significant Systems, Structures, and Components

The hazard and accident analysis conducted in Chapter 3.0 did not identify any safety structures, systems, or components that require safety-significant designation.

4.5 Specific Administrative Controls

4.5.1 Radioactive Materials Inventory

4.5.1.1 Safety Function

The safety function of the radioactive material inventory is to ensure the inventory of radioactive material shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident.

The basis for this control is provided in the accident scenario in Section 3.4. This scenario, which produced the highest dose consequences (bounding worst-case accident scenario), assumed a building-wide fire that consumed the entire facility inventory as shown in Table 3-1

4.5.1.2 SAC Description

This Specific Administrative Control is implemented through HNF-SD-CP-MA-002, *222-S Laboratory Radiological Inventory Program* and implementing procedures. This document describes the methodology and assumptions that provide the basis for tracking, reporting, and demonstrating compliance with the radioactive material inventory limits in the 222-S Laboratory to ensure the facility inventory does not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident. Since this is strictly an inventory control there is no reasonable engineering control alternative such as SSC's. The hazard analysis does not assume a specific time frame to perform this activity.

Radiological material that is received at the laboratory is entered into a sample tracking system or is credited to the facility holdup value which is pre-inventoried. Those samples containing radionuclides that contribute to the radiological MAR of the facility, based on process knowledge of the source, are assigned a conservative inventory value and added to the facility inventory. Fissionable material is inventoried separately, but into the same database. When additional information is acquired, such as weight of the sample, the inventory is adjusted. The radiological material is removed from the inventory after it is removed from the facility or sent to facility waste tanks, where it becomes part of the facility hold-up. A total facility inventory report is normally issued every day except for weekends and holidays, but at least weekly, and the present DE-Ci inventory is reviewed to ensure radioactive materials do not exceed the facility limits.

4.5.1.3 Functional Requirement

The Functional Requirements of the radiological inventory control is to ensure the MAR limit for the facility is less than the derived radioactive material inventory of 39.11 DE-Ci, which produces the worst-case calculated dose to the collocated worker, to ensure that the bounding consequences are not exceeded as analyzed in the DSA.

4.5.1.4 SAC Evaluation

The material at risk (MAR) limit is the underlying assumption for the accident analysis performed in Chapter 3.0. The MAR limit, as stated in dose equivalent curies, protects this assumption and ensures that the consequences determined in the accident scenario are not invalidated thereby placing the facility in formally unanalyzed space.

The Hazard and Accident Analysis do not take credit for personnel actions to mitigate the consequences of the worst-case accident and does not assume a specific time to perform this activity. However, when radioactive material is received, a minimum of one qualified person is required to maintain radioactive material inventory control. Inventory control is a simple process performed in accordance with reference use procedures. There are no hazardous conditions involved with inputting the information. The personnel who receive radioactive material are qualified and trained on the procedures. Re-qualification is every two years.

The radioactive material is inventoried upon receipt at the 222-S Laboratory. The inventory is input into a verified and validated computer software program or if necessary logged and manually calculated. The 222-S radiological inventory control procedures use conservative DE-Ci values for the radiological materials booked into the inventory system to enhance compliance. The inputs into the system are overviewed to ensure accuracy. There is no required time or distance separation for this action. A report is normally issued daily, except on weekends and holidays, but at least weekly. The reports provide the facility inventory in DE-Ci.

The inventory control program and implementing procedures use a graded approach to ensure inventory of radioactive material shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident. Although conservative values are already used, as the facility inventory reaches set limits, management notification or written approval will be required.

Given the above, this control provides adequate assurance that the inventory of radioactive material shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident.

4.5.1.5 TSR

The Radioactive Material Inventory Control is implemented as a direct action Specific Administrative Control with the following requirements:

The inventory of radioactive material shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident.

4.6 References

DE-AC27-08RV14800, 2008, *Tank Operations Contract*, Section J-2, “Requirement Sources and Implementing Documents,” as amended, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE-STD-3009-94, 2006, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, Change Notice 3, U.S. Department of Energy, Washington D.C.

10 CFR 830, Title 10 *Code of Federal Regulations* Part 830 Subpart B, “Safety Basis Requirements,” as amended.

HNF-SD-CP-MA-002, *222-S Laboratory Radiological Inventory Program,* WRPS, Richland Washington.

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5.0 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

5.1 Introduction

This chapter builds on the control functions determined to be essential in Chapter 3.0, "Hazard and Accident Analysis," and Chapter 4.0 "Safety Structures, Systems, and Components," for the derivation of Technical Safety Requirements (TSRs). This chapter complies with Title 10, *Code of Federal Regulations*, Part 830 (10 CFR 830) Subpart B, "Safety Basis Requirements," and provides information consistent with the guidance provided in Chapter 5.0, "Derivation of Technical Safety Requirements," of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. Also, the content of this chapter follows the direction provided in HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook* (SARAH).

As discussed in Chapter 3.0, a hazard categorization process assessed the hazardous material at risk (MAR) for release, unmitigated by any safety features. The TSRs are developed based on a graded approach applied to the hazards and accident analyses and the final Hazard Category 3 designation for the 222-S Laboratory.

The derivation of TSRs consists of summaries and references to pertinent sections of the DSA in which design and administrative features are needed to prevent or mitigate the consequences of accidents. Design and administrative features addressed include ones which (1) provide significant defense-in-depth in accordance with the screening criteria of 10 CFR 830 Subpart B, (2) provide significant worker safety, or (3) maintain consequences of facility operations below Evaluation Guidelines. This chapter contains the following information with sufficient basis from which to derive, as appropriate, any of the following TSR parameters as applicable to 222-S Laboratory operations:

- Safety Limits (SLs)
- Limiting Control Settings (LCSs)
- Limiting Conditions for Operations (LCOs)
- Surveillance Requirements (SRs)
- TSR Administrative Controls (ACs) for specific control features or to specify programs necessary to perform institutional safety functions

The information provided herein is based on a graded approach to classifying the controls in which more emphasis is placed on active engineered features which are covered by LCSs versus ACs that are covered in the AC section of the TSRs.

As identified in Chapter 3.0, facility inventory controls will reduce the potential risk to the public, collocated workers (CW), facility workers, and the environment from uncontrolled releases of radioactive and hazardous material and will ensure facility operations are maintained within the "envelope" bounded by this DSA. Also as evaluated in Chapter 3.0, no systems, structures, or components (SSCs) require designation as safety-class or safety-significant; thus no SLs, LCSs, LCOs, or SRs will be included in the TSRs for the 222-S Laboratory.

5.2 Requirements

The codes, standards, regulations, and DOE Orders used to establish the safety basis for the 222-S Laboratory are contained in Contract DE-AC27-08RV14800.

10 CFR 830 identifies DOE-STD-3009 as the "safe harbor" methodology for the preparation of the safety basis for a Hazard Category 3 nuclear facility. This chapter has been prepared in accordance with the requirements of DOE-STD-3009-94, Chapter 5.0, *Derivation of Technical Safety Requirements*.

The Control Identification Process is described in HNF-8739, the SARAH.

5.3 Technical Safety Requirements Coverage

This section provides assurances that TSR coverage for the 222-S Laboratory is complete. The TSR coverage is necessary for the following:

- SSCs that have been designated safety-class.
- SSCs that have been designated safety-significant.
- ACs or SACs, including safety management programs, are required to ensure that initial conditions and assumptions made in the accident analysis remain correct. These controls maintain consequences of facility operations below Evaluation Guidelines.

The first two bullets refer to safety-class and safety-significant SSCs; however, the hazard and accident analysis did not identify any SSCs that are designated as safety-class or safety-significant so there are no TSRs specifically applied to SSCs.

The third bullet applies to ACs or SACs. The SACs, Table 5-1, which requires TSR coverage, ensures the inventory of radioactive materials does not exceed the inventory used to calculate dose consequences of the analyzed accidents.

5.3.1 Summary of Items Requiring Technical Safety Requirements Coverage

The ACs based on the hazard evaluation are presented in Table 5-1.

Table 5-1. Hazard Evaluation Administrative Control.

Hazard	TSR Control	Specific Administrative Control
Radioactive dose consequence from release of radioactive or hazardous materials	Yes	The total quantity of dose equivalent curies (DE-Ci) must be less than the quantity used to calculate the dose consequences to the collocated worker as a result of the worst-case accident.

Table 5-2 presents the relevant hazard from the hazard evaluation and the safety management programs (Section 3.3.2.3.3), plus the major features of each program that are relied on for protection against that hazard. This information provides a basis for selecting the SMPs that require TSR coverage and/or provides a statement of justification for not committing to an SMP coverage at the TSR level.

Table 5-2. Safety Management Programs Supporting Worker Protection.

Hazard	SMP	TSR Coverage	SMP Protective Controls or Justification for Not Requiring TSR Coverage
Criticality	Criticality Safety Program	No	Fissile material inventory is less than a critical mass and is controlled as a subset of the radiological inventory control. Implementation of a criticality program is required for compliance with WRPS policy.
Release of radioactive materials	Radiation Protection Program	Yes	Consists of the ALARA Program, radiological protection training, radiation exposure control, radiological monitoring, radiological protection instrumentation, and radiological protection record keeping.
Release of hazardous materials	Hazardous Material Protection Programs	No	ALARA considerations for protection from hazardous material are a subset of radiation protection, training, and other safety programs.
Release of radioactive or hazardous materials	Radioactive and Hazardous Material Waste Management Programs	No	Consists of compliance to waste acceptance criteria, waste management composite analysis and performance acceptance. Protection is provided through other safety programs.
Release of radioactive or hazardous material from equipment failure	Testing In-Service Surveillance and Maintenance Program	No	Consists of initial testing program, in-service surveillance, and maintenance programs. The functioning of equipment is not credited for the mitigation of dose consequences from the worst-case accident.
Release of radioactive or hazardous material	Operational Safety Program	Yes	Consists of conduct of operations and fire protection (combustible loading control, fire fighting capability, and fire fighting readiness).
Release of radioactive or hazardous material from a procedure or operator error	Procedures Development and Training Program	Yes	Consists of procedures and training programs.
Release of radioactive or hazardous material from a procedure or operator error	Quality Assurance Program	No	Consists of quality improvement, documents and records, and quality assurance performance. Quality assurance is implemented through contractor level requirements.
Reduce the effectiveness of mitigating the consequence of a release of radioactive or hazardous materials	Emergency Preparedness Program	Yes	Consists of assessment actions, notification, emergency facilities and equipment, protective actions, training and drills, and recovery reentry.
Release of radioactive or hazardous materials from human error	Management, Organization, and Institutional Safety Provisions	Yes	Consists of review and performance assessment, configuration and document control, occurrence reporting, and safety culture.

5.4 Derivation of Facility Modes

The 222-S Laboratory has only one facility mode, OPERATION, and it is described as follows.

OPERATION	Radioactive materials can be received, stored, are present, and shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident. Research, analytical techniques, waste handling, decontamination activities, maintenance, repair, and surveillance activities are authorized throughout the facility and performed under approved procedures or analytical test plans. During backshift and facility closure days, the facility mode is OPERATIONAL when all systems, subsystems, components, and personnel are capable of performing the specified safety and mission functions.

5.5 Technical Safety Requirements Derivation

The hazard and accident analysis are used to identify safety-class and safety-significant SSCs, TSRs, and other controls required for protection of the public, collocated workers, facility workers, and the environment. The necessary safety management programs supporting worker protection are derived in Table 5-2 with supporting information presented in Chapter 3.0, Section 3.3.2.3.3.

5.5.1 Inventory Control

5.5.1.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

The hazard and accident analysis did not identify safety-class or safety-significant SSCs for inventory control; therefore no SLs, LCSs, or LCOs are required for the safe operation of the facility.

5.5.1.2 Surveillance Requirements

In accordance with Section 5.5.1.1, there are no SLs, LCSs, or LCOs for inventory control so it is not necessary to address testing, calibration, or inspection requirements to maintain safe operation of the facility within SLs, LCSs, and LCOs.

5.5.1.3 Administrative Controls

The hazard and accident analysis determined that one SAC for the radiological inventory is required. Also, an AC for the contractor organization, minimum shift complement, and TSR VIOLATIONS will be implemented.

5.5.1.4 Radioactive Material Inventory Control

The material at risk (MAR) limit is the underlying assumption for the accident analysis performed in Chapter 3.0. The MAR limit, as stated in dose equivalent curies, protects this assumption and ensures that the consequences determined in the accident scenario are not invalidated thereby placing the facility in formally unanalyzed space.

The control will state: "The inventory of radioactive material shall not exceed the dose equivalent curies used to calculate the dose consequences to the collocated worker as a result of the worst-case accident."

The basis for this control is provided in the accident scenario in Section 3.4. This scenario, which produced the highest dose consequences (bounding worst-case accident scenario), assumed a building-wide fire that consumed the entire facility inventory as shown in Table 3-1. Therefore, the MAR limit for the facility must be less than the derived radioactive material inventory of 39.11 DE-Ci, which produces the worst-case calculated dose to the collocated worker, to ensure that the bounding consequences are not exceeded as analyzed in the DSA.

5.6 Design Features

The hazard and accident analysis does not identify design features for safety SSCs. Design features are those features that are not covered elsewhere in the TSRs and which, if altered or modified, would have a significant effect on safety. They are normally passive characteristics of the facility not subject to change by operations personnel; e.g., shielding, structural walls, relative locations of major components, installed poisons, or special materials. Design features are those permanently built-in features critical to safety that do not require, or infrequently require, maintenance or surveillance. Since none of the features of the 222-S Laboratory design were credited in the hazard and accident analysis, there are no "design features for safety" designated for the 222-S Laboratory facility.

5.7 Interface With Technical Safety Requirements From Other Facilities

There are no identified TSRs at other facilities that affect routine operations at the 222-S Laboratory.

5.8 References

DE-AC27-08RV14800, 2008, *Tank Operations Contract*, Section J-2, "Requirement Sources and Implementing Documents," as amended, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE-STD-3009-94, 2006, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, Change Notice 3, U.S. Department of Energy, Washington D.C.

10 CFR 830, Title 10 *Code of Federal Regulations* Part 830 Subpart B, "Safety Basis Requirements," as amended.

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

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Appendix A

Hazard Identification Checklist

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Hazard Identification Checklist

LOTE Low Thermal Energy

- ☐ 1 Freeze Seal Equip
- ☒ 2 Liquid N2 in Dewars
- ☐ 3 Liquid N2 in Tanks
- ☐ 4 Liquid N2 Production
- ☒ 5 Loss of HVAC [system impacts]
- ☒ 6 Loss of HVAC [worker impacts]
- ☒ 7 Freezers/Chillers
- ☐ 8 Other Cryogenic Sys
- ☐ 9 Other Low Ambient Temperatures

AE Acoustic Energy

- ☒ 1 Equipment/Platform Vibration
- ☒ 2 Motors
- ☐ 3 Pumps
- ☒ 4 Fans
- ☒ 5 Compressors
- ☐ 6 Cutting Devices
- ☐ 7 Decon Devices
- ☐ 8 Other Devices
- ☐ 9 Equipment Rooms
- ☐ 10 Other Decon & Size Reduction Tools

BIO Biological

- ☒ 1 Dead Animals
- ☒ 2 Animal Droppings
- ☐ 3 Animal Bites
- ☒ 4 Insect Bites
- ☒ 5 Insect Stings
- ☒ 6 Allergens
- ☒ 7 Toxins
- ☐ 8 Bacteria
- ☐ 9 Viruses
- ☐ 10 Sewage
- ☐ 11 Blood/Body Fluids
- ☐ 12 Medical Waste
- ☐ 13 Other Animals/Insects
- ☐ 14 Other Plants
- ☐ 15 Other Diseases

NPH Natural Phenomena

- ☒ 1 Earthquakes
- ☐ 2 Natural Radiation
- ☒ 3 Lightning
- ☒ 4 Solar/Heat Wave
- ☒ 5 Range Fire
- ☒ 6 Dust/Sand
- ☒ 7 Fog
- ☐ 8 Heavy Rain
- ☐ 9 Flooding [from rain]
- ☐ 10 Sediment Transport
- ☐ 11 Hail
- ☐ 12 Low Temperatures
- ☒ 13 Freeze
- ☒ 14 Heavy Snow
- ☒ 15 High Winds
- ☐ 16 Tornadoes
- ☒ 17 Volcanoes
- ☒ 18 Volcanic Ash

OTH Other

- ☐ 1 Dust [breathing]
- ☒ 2 N2/He Atmosphere
- ☒ 3 Tanks
- ☒ 4 Basins
- ☒ 5 Manholes
- ☒ 6 Pits
- ☒ 7 Water in Confined Space
- ☐ 8 Respirator Fogging
- ☒ 9 Dust [visibility]
- ☐ 10 Glare
- ☐ 11 Aircraft Crash
- ☐ 12 Offsite Transportation Accident
- ☐ 13 Offsite Explosion
- ☐ 14 Major Fire
- ☐ 15 Reservoir Failure
- ☐ 16 Unknown Material
- ☐ 17 Unknown Config
- ☐ 18 Other Inert Atmosphere
- ☒ 19 Other Confined Spaces
- ☐ 20 Inadequate Visibility
- ☐ 21 Other External/Offsite Event

KE Kinetic Energy

- ☐ 1 Rail Cars/Trains
- ☐ 2 Excavators/Backhoes
- ☒ 3 Cranes/Crane Loads
- ☒ 4 Trucks/Cars
- ☒ 5 Forklifts/Loaders
- ☐ 6 Conveyors
- ☒ 7 Hoists
- ☒ 8 Carts/Dollies
- ☒ 9 Crane Loads [load]
- ☒ 10 Forklifts [load]
- ☐ 11 Conveyors [load]
- ☒ 12 Hoists [load]
- ☒ 13 Pallet Jacks [load]
- ☒ 14 Carts/Dollies [load]
- ☐ 15 Impact Tools
- ☐ 16 Projectile Tools
- ☐ 17 Relief Valve Blow-down
- ☐ 18 Other Vehicles
- ☐ 19 Other Man-Powered Devices
- ☐ 20 Other Transports [load]
- ☐ 21 Other Man-Powered Transports [load]
- ☐ 22 Other Decon & Size Reduction Tools

LOEE Loss of Electrical

- ☒ 1 Motor Stoppage
- ☒ 2 Pump Stoppage
- ☐ 3 Flow Reversal
- ☐ 4 Supply Fan Pressurization
- ☐ 5 Static Air Situation
- ☐ 6 Accumulation of Hazardous Vapors
- ☐ 7 Accumulation of Asphyxiants
- ☐ 8 Accumulation of Flammable Gases
- ☐ 9 Loss of Air [dry-pipe]
- ☐ 10 Loss of Air [no inert]
- ☐ 11 Reduced PPE Pressure
- ☐ 12 Loss of Heaters [system impacts]
- ☐ 13 Loss of Heaters [worker impacts]
- ☐ 14 Misdirected Flow
- ☐ 15 Loss Instrumentation
- ☒ 16 Inadequate Light [operations impacts]
- ☒ 17 Inadequate Light [worker impacts]
- ☒ 18 Loss of Batteries/DC
- ☐ 19 Other Loss of Equipment
- ☐ 20 Other Fan Stoppage
- ☒ 21 Other Areas Loss of Differential Pressure
- ☐ 22 Other Areas Loss of Ventilation
- ☐ 23 Other Loss of Air Pressure

CM Chemical Materials

- ☐ 1 Carbon Tetrachloride [hepatotoxins]
- ☐ 2 Chloroform [nephrotoxins]
- ☒ 3 Mercury [neurotoxins]
- ☒ 4 Lead [reproductive toxins]
- ☐ 5 Strychnine
- ☒ 6 Asbestos [lungs]
- ☒ 7 Ceiling Tiles/Insulation
- ☒ 8 Acetone [skin]
- ☒ 9 Organic Solvents [eyes]
- ☐ 10 Ammonia [mucous membranes]
- ☐ 11 Carbon Monoxide/ Cyanides [blood]
- ☒ 12 General Carcinogens
- ☐ 13 Carbon Tetrachloride [carcinogeneticity]
- ☒ 14 PCBs
- ☐ 15 Beryllium/Epoxy Resins
- ☒ 16 Irritants
- ☐ 17 Pesticides/Insecticides
- ☐ 18 Herbicides
- ☒ 19 Asphyxiants
- ☒ 20 Hazardous Wastes
- ☐ 21 Creosote
- ☒ 22 Other Toxins
- ☒ 23 Other Chemical Use
- ☒ 24 Other Chemicals

Hazard Identification Checklist

CE Chemical Energy	ME Mechanical Energy	TP Thermal Potential Energy	EE Electrical Energy
☐ 1 Organic Peroxides	☒ 1 Forklift Tines [puncture]	☒ 1 Natural Gas/Propane	☒ 1 Wiring [high voltage]
☒ 2 General Corrosives/Acids	☒ 2 Piston Compressors	☒ 2 Welding/Cutting Gases	☐ 2 Overhead Transmission Lines
☒ 3 Residual Corrosives/Acids	☐ 3 Presses	☒ 3 Methane/Butane	☒ 3 Transformers [high voltage]
☒ 4 Battery Banks	☒ 4 Pinch Points	☒ 4 H2 [lab]	☒ 4 Switchgear [high voltage]
☐ 5 Water Reactives [sodium]	☒ 5 Sharp Edges/Objects	☐ 5 H2 [containers]	☐ 5 Capacitor Banks
☐ 6 Shock Sensitive Chemicals [nitrates]	☒ 6 Drills [puncture]	☐ 6 H2 [process]	☐ 6 Lightning Grids
☒ 7 Peroxides/ Superoxides/Ethers	☒ 7 Sanders/Brushes [wear]	☒ 7 Sewer Gas	☒ 7 Wiring [low voltage]
☐ 8 Electric Squibs	☐ 8 Shears/Pipe Cutters	☐ 8 Carbon Monoxide	☒ 8 Cable Runs
☐ 9 Dynamites/Caps/ Primer Cord	☒ 9 Grinders	☒ 9 HEPA Test Aerosol Fluid	☒ 9 Overhead Wiring
☐ 10 Dusts [explosive]	☒ 10 Vibration [wear]	☒ 10 Other Petroleum Based Products	☒ 10 Underground Wiring
☐ 11 Corrosion/Oxidation	☒ 11 Saws	☒ 11 Vehicle/Equipment Fuel Tanks	☒ 11 Transformers [low voltage]
☐ 12 Sealants/Fixatives	☒ 12 Belts/Hoist Cables [pull/wrap]	☐ 12 Paint/Cleaning/Decon Solvents	☒ 12 Switchgear [low voltage]
☐ 13 Epoxies/Adhesives	☒ 13 Bearings/Shafts [wrap]	☐ 13 Paints/Epoxies/Resins	☒ 13 Service Outlets
☒ 14 Refrigerants/Coolants	☒ 14 Gears/Couplings [pull]	☒ 14 Paper/Wood Products	☐ 14 Diesel Units
☐ 15 Water Treatment Products	☐ 15 Diesel Generators/ Turbines [wrap]	☒ 15 Cloth/Rags	☒ 15 Battery Banks
☒ 16 Decon Chemicals	☐ 16 Pumps [wrap]	☒ 16 Rubber	☒ 16 DC Systems
☒ 17 Miscellaneous Laboratory Chemicals	☒ 17 Fans [wrap]	☐ 17 Size Reduction Tents/Permacons	☒ 17 Motors
☐ 18 Buried Materials	☒ 18 Rotary Compressors [wrap]	☐ 18 Benelex/Lexan/HDPE	☒ 18 Pumps
☒ 19 Other Oxidizers	☒ 19 Centrifuges [wrap]	☒ 19 Rigid Liners/Poly-Liners/Bagging Materials	☒ 19 Fans
☒ 20 Other Reactives	☒ 20 Drills/Rotary Sanders [wrap]	☐ 20 Other Flammable Gases	☒ 20 Compressors
☐ 21 Other Explosive Substances	☒ 21 Grinders [wrap]	☒ 21 Other Laboratory/ Calibration Gases	☒ 21 Heaters
☒ 22 Other Chemicals	☐ 22 Other Transverse Motion Devices	☐ 22 Other Process Off-Gases	☐ 22 Valves/Dampers
☐ 23 Other Bonding Agents	☐ 23 Other Decon & Size Reduction Tools	☐ 23 Other Flammable/ Combustible Liquids	☒ 23 Power Tools
☐ 24 Incompatible Wastes	☐ 24 Other Reciprocating Motion Devices	☒ 24 Gasoline	☒ 24 Instrumentation
☐ 25 High Temperature Wastes	☐ 25 Other Circular Motion Devices	☒ 25 Diesel Fuel	☒ 25 Grounding Grids
	☐ 26 Other Electric Motors	☒ 26 Oils [lube, coolant]	☐ 26 Static Charge
		☒ 27 Grease	☐ 27 Other High Voltage Equipment
		☐ 28 Gasoline [tank]	☒ 28 Other 13.8 kV Equipment
		☐ 29 Diesel Fuel [tank]	☒ 29 Other Low Voltage Equipment
		☐ 30 Other Combustible Solids	☒ 30 Other 480/240/120 Volt Equipment
		☐ 31 Other Plastic Materials	☐ 31 Other Temporary Power Equipment
			☐ 32 Other Electrical Equipment [low voltage]

Hazard Identification Checklist

RE Radiant Energy	RM Radioactive Material	TE Thermal Energy	PE Potential Energy
☐ 1 Calibration Sources	☒ 1 Metals/Oxides/ Residues	☐ 1 Chemical Reactions	☒ 1 Breathing Air/ Compressed Air/O2
☐ 2 Fissile Material Storage/Holdup	☐ 1a Bag	☐ 2 Pu/U Metal	☒ 2 He/Argon/Specialty Gases
☐ 3 Actinide Solutions	☐ 1b Glovebox [exposed]	☒ 3 Pyrophoric Chemicals	☒ 3 Refrigerants/CO2 Bottles
☐ 4 Waste Containers	☐ 1c Can	☐ 4 Petroleum Based Products	☒ 4 Other Bottled Gases
☐ 5 Contamination	☐ 1d Welded Can	☒ 5 Reactive Chemicals	☒ 5 Gas/Air Receivers/ Compressors
☐ 6 Radiography Equipment	☐ 1e Drum	☒ 6 Nitric Acids/Organics	☐ 6 Pressure Vessels
☒ 7 X-Ray Machines	☐ 1f Overpack	☐ 7 Paint/Cleaning/Decon Solvents	☒ 7 Instrument/Plant Air
☐ 8 Electron Beams	☐ 1g Type B Shipping Container	☐ 8 Cutting Torches	☒ 8 Chemical Reaction Vessels/Autoclaves
☒ 9 Ultra-Intense Lasers	☐ 1h Ducting [exposed]	☐ 9 Welding Torches	☐ 9 Furnaces
☐ 10 Accelerators	☐ 1i Plenum [exposed]	☒ 10 Laboratory Burners	☐ 10 Boilers
☐ 11 Electromagnetic Communication Waves	☐ 1j Filter [exposed]	☒ 11 Furnaces	☐ 11 Steam Header/Lines
☒ 12 Radio-Frequency Generators	☐ 1k Cooler	☐ 12 Boilers	☒ 12 Pneumatic Lines
☐ 13 Microwave Frequencies	☐ 1l Hood [exposed]	☒ 13 Heaters	☐ 13 Impact Tools
☒ 14 Electromagnetic Fields	☒ 2 Actinide Solution	☒ 14 Hot Plates	☐ 14 Sand/CO2 Blasting Equipment
☒ 15 Electric Furnaces	☐ 2a Bottle	☒ 15 Lasers	☒ 15 Water Heaters
☒ 16 Computers	☐ 2b Drum	☐ 16 Incinerators/Fire Boxes	☐ 16 Excavators/Backhoes [hydraulics]
☐ 17 Plasma Arc Magnetic Field	☐ 2c Piping	☐ 17 Engine Exhaust Surfaces	☐ 17 Cranes [hydraulics]
☐ 18 Plasma Arc Infrared/ Ultraviolet Light	☐ 2d Tank	☐ 18 Steam Lines	☐ 18 Trucks/Cars [hydraulics]
☐ 19 Welding	☒ 3 Waste [LLW, LLM, TRU, TRM]	☒ 19 Electrical Wiring	☒ 19 Forklifts [hydraulics]
☒ 20 Low Power Lasers	☐ 3a Bag	☒ 20 Lamps/Lighting	☐ 20 Conveyors [hydraulics]
☐ 21 Solid Fissile Material [criticality]	☐ 3b Glovebox [exposed]	☐ 21 Plasma Arc Surfaces	☐ 21 Other Lifts [hydraulics]
☐ 22 Liquid Fissile Material [criticality]	☐ 3c Drum	☐ 22 Welding Surfaces	☐ 22 Hydrolazing Equipment
☐ 23 Containerized Fissile Material [criticality]	☐ 3d Metal Crate	☒ 23 Grinder/Saw Surfaces	☐ 23 Tool Hydraulic Lines
☐ 24 Irradiated Equipment	☐ 3e Pipe Overpack Container	☒ 24 Loss of Ventilation	☐ 24 Coiled Springs
☐ 25 Other Direct Radiation Sources	☐ 3f Overpack	☐ 25 Areas Around Furnaces/Boilers	☐ 25 Stressed Members
☒ 26 Other Radioactive Material	☐ 3g Shipping Cask	☐ 26 Multiple Layers PPE	☐ 26 Torqued Bolts
☐ 27 Other Ionizing Radiation Devices	☐ 3h Ducting [exposed]	☒ 27 Other Pyrophoric Material	☐ 27 Gaskets/Seals/ O'Rings
☐ 28 Other Non-Ionizing Radiation Sources	☐ 3i Plenum [exposed]	☐ 28 Other Spontaneous Combustion Material	☒ 28 Vacuum Systems
☐ 29 Other Electromagnetic Sources	☐ 3j Filter [exposed]	☐ 29 Other Open Flame Sources	☒ 29 Cranes
☐ 30 Other Welding/ Cutting Devices	☐ 3k Hood [exposed]	☐ 30 Other Heating Devices/Systems	☒ 30 Hoists
☐ 31 Other Potential RE Sources	☐ 3l Wooden Crate	☐ 31 Radioisotope Thermal Generators	☒ 31 Ducting/Lights/Piping
☐ 32 Other Critical Masses	☐ 3m Cargo Container	☐ 32 Radioactive Decay	☒ 32 Rollup Doors
	☒ 4 General Contamination	☐ 33 Other High Temperature Items	☒ 33 Elevators
	☐ 5 Contaminated Soils	☐ 34 Other Electrical Equipment	☐ 34 Roofs/Plenums
	☐ 6 Contaminated Water	☐ 35 Other Welding/ Cutting/Grinding Surfaces	☐ 35 Upper Floor Components
	☐ 7 Contaminated Oil/ Antifreeze	☐ 36 Other Friction Heated Surfaces	☐ 36 Tanks [elevated]
	☐ 8 Burial Grounds	☒ 37 Belts [friction]	☐ 37 Radiography Equipment [elevated]
		☒ 38 Bearings [friction]	☐ 38 Steam/Natural Gas Lines
		☒ 39 Gears [friction]	☒ 39 Power Lines/ Transformers
		☒ 40 Power Tools [friction]	☒ 40 Crane Loads
		☒ 41 Motors/Fans [friction]	☒ 41 Truck Loads
		☐ 42 Other High Ambient Temperature Areas	☒ 42 Forklift/Other Lifts Loads

Hazard Identification Checklist

PE (cont'd)	PE (cont'd)	PE (cont'd)	PE (cont'd)
☐ 43 Conveyor Loads ☒ 44 Hoist Loads ☒ 45 Cart Loads ☐ 46 Stacked Hazardous Materials ☐ 47 Pits/Trenches/ Excavations ☒ 48 Roofs/Elevated Doors/Loading Docks ☒ 49 Stairs/Elevators ☒ 50 Ladders/Fixed Ladders ☒ 51 Cherry-Pickers/ Hysters ☒ 52 Scaffolding/Scissor Jack Scaffolds	☐ 53 Rail Cars/Trains [in motion] ☒ 54 Trucks [in motion] ☒ 55 Forklifts/Loaders [in motion] ☒ 56 Bearings/Rollers/ Shafts ☒ 57 Gears/Couplings/ Pivot Joints ☐ 58 Diesel Generators/ Turbines ☐ 59 Pumps ☒ 60 Fans/Air Movers ☒ 61 Rotary Compressors ☒ 62 Centrifuges	☐ 63 Other Pressure-Related PE Sources ☐ 64 Other Compressed Gases ☐ 65 Other High Pressure Gas Systems ☐ 66 Other High Pressure Decon & Size Reduction Tools ☐ 67 Other High Pressure Liquid Systems ☐ 68 Other Vehicle/Transport Device Hydraulics ☐ 69 Other Decon & Size Reduction Tool Hydraulics ☐ 70 Other Pressurized Systems/Components ☒ 71 Fire Suppression Systems ☐ 72 Other Gravity-Related PE Hazards	☒ 73 Other Elevated Equipment/Structur es ☐ 74 Other Elevated Hazardous Materials ☒ 75 Hand Carried Loads ☐ 76 Solutions in Elevated Equipment ☐ 77 Other Elevated Work Surfaces ☐ 78 Other Momentum-Related PE Hazards ☐ 79 Other Moving Vehicle/Transport Devices ☒ 80 Cranes [in motion] ☐ 81 Other Rotating Equipment ☒ 82 Other Electric Motors

Appendix B

Hazard Description and Protection Form

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Hazard Description and Protection Form

Hazard/Energy Source	Description	Potential Consequences
Electrical Hazard (EE)		
13.8 kV Distribution System	Building transformers step down 13.8 kV to 480 V power for facility electrical systems	Standard industrial hazard – Shock – Electrocution – Could cause loss of power or initiate a fire
480/208/120 V Distribution System	Numerous switchgear, motor control centers, buses, and wires supply power to equipment	Standard industrial hazard – Shock – Electrocution – Could cause loss of power or initiate a fire
Temporary Power	Temporary power will be brought into facilities to accommodate the removal of installed electrical systems. Temporary power includes “bang boards,” extension cords, generators, diesel generators, battery banks, etc.	Standard industrial hazard – Shock – Electrocution – Could cause loss of power or initiate a fire
12-32 V Direct Current Systems	Batteries for diesel generators, LS/DW, and fire panels and control circuitry for various systems	Standard industrial hazard – Shock – Electrocution – Could cause loss of power or initiate a fire
Low Voltage	Electrical equipment such as motors, pumps, fans, compressors, heaters, flow control devices, power tools, instrumentation, static	Standard industrial hazard – Shock – Electrocution – Could cause loss of power or initiate a fire
Loss of Electrical Energy (LOEE)		
Loss of Equipment	Motors, pumps, fans, heaters, illuminators, instrumentation, system pressure	Standard industrial hazard – Pinch – Crush
Loss of Differential Pressure	Flow reversal, Supply fan pressurized, Static air condition	Standard industrial hazard – Could result in spill, uptake
Loss of Ventilation	Accumulation of hazardous vapors or flammable gases Airborne radioactive material	Standard industrial hazard – Toxic exposure – Asphyxiation

Thermal (TE, TP, LOTE)		
Liquid Argon	Dewars used to produce argon gas volumes for inductively coupled plasma spectrometers	Standard industrial hazard – Could injure workers – Burns – Asphyxiation
Liquid N_2	Dewars of liquid nitrogen are used for cooling gamma spectroscopy detectors	Standard industrial hazard – Could injure workers – Burns – Asphyxiation
Combustible liquids	Various quantities and types including HEPA test aerosol fluid, diesel fuel oil, lubricating oils, gearbox oils, and hydraulic fluids.	Standard industrial hazard – Burns – Chemical exposure – Radiological uptake – Could provide fuel for a fire, which injures workers or releases hazardous material
Flammable liquids	Various quantities and types of solvents used for cleaning or decontamination (typically < liter containers). Fuel for generator, light plants, portable heaters, etc.	Standard industrial hazard – Burns – Chemical exposure – Radiological uptake – Could provide fuel for a fire, which injures workers or releases hazardous material
Flammable/Explosive gases	Acetylene used in conjunction with oxygen for welding and cutting. Propane powered vehicles, heating devices. Propane used for analytical equipment.	Standard industrial hazard – Burns – Chemical exposure – Radiological uptake – Could provide fuel for a fire, which injures workers or releases hazardous material
Hydrogen generation	Certain waste containers, solution bottles, tanks, batteries, etc. Hydrogen generators for gas chromatography instruments.	Standard industrial hazard – Radiological uptake – Could build up and cause overpressure, or ignite to cause an explosion, which injuries workers or release hazardous material
Spontaneous Combustion	Pyrophoric material may be present in some storage areas, holdup in equipment. Petroleum based products, reactive chemicals, nitric acid and organics	Standard industrial hazard – Radiological uptake – Could result in fire that releases hazardous material

Combustible Solids	Wood, plastic, tape, clothing, rags, paint, rubber, benelex/lexan windows, HDPE, Polyliners for waste packaging	Standard industrial hazard – Radiological uptake – Could result in fire that releases hazardous material
Portable lighting	Localized lighting to be used as permanent lighting is removed	Standard industrial hazard – Burns – Could cause fires or melt plastic confinement barriers causing a spill
Open Flames	Oxyacetylene cutting torches are used to cut up equipment, magmafusion, Plasma arc, welding, soldering, laboratory burners. Propane flame used on analytical equipment.	Standard industrial hazard – Burns – Radiological uptake – Contamination – Toxic fume inhalation – Could provide ignition source and fuel for a fire or cause an explosion, which releases hazardous material (spill)
High Temperature Devices	Lasers, furnaces, engine exhaust surfaces, halogen lights, hot plates	Standard industrial hazard – Burns – Toxic Fumes – Could provide ignition source for fire or explosion which releases hazardous material (spill)
Grinding and cutting tools	Various hand tools to be used to size reduce gloveboxes, hoods, tanks etc. (e.g., grinders, chop saw).	Standard industrial hazard – Lacerations – Punctures – Repetitive motion – Radiological uptake – Could injure workers or initiate fire that releases hazardous material
Temporary Heaters	Used for temporary heat to be used for personal comfort and freeze protection	Standard industrial hazard – Burns – Could injure workers or result in a fire that releases hazardous material
High temperature environment	High temperature work environment due to loss or removal of HVAC (cooling) systems. Work in confinement structures requiring multiple layers of PPE	Standard industrial hazard – Heat stress

Radiant Energy (RE & RM)		
Low temperature Environments	Low temperature work environments due to removal of HVAC supply (heating) system	Standard industrial hazard – Cold stress
Calibration and Radiological Monitoring Sources	Pu-239 and Sr-90 Calibration sources and numerous Pu-239 sources in rad monitoring equipment	Radiological hazard – Radiation exposure
Fissile material Storage/Holdup	Various isotopes are handled, packaged, stored and are trapped as holdup in facility	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to drops/impacts, fires, over pressurization or explosions or external events – Could cause criticality
Contaminated water	Low level contaminated water generated from housekeeping activities, spill cleanup, safety shower discharge cleanup	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions
General Contamination	Loose surface contamination and fixed contamination is present throughout facilities and may be under layers of paint	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions
Actinide Solution	Residual solutions stored in tanks, piping systems and bottles	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions
Contaminated Oil and antifreeze	Contamination in remaining oil (e.g., drains, equipment reservoirs) and antifreeze.	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions
Waste Containers	Various isotopes are handled, packaged, staged for shipment or stored.	Radiological hazard – Radiation exposure – Radiological uptake – Contamination – Could be released due to spills, explosions

Ionizing Radiation Devices	Radiological equipment is used for NDT, X-ray machines used for analysis, lasers in analytical equipment	Radiological hazard – Radiation exposure
Non-Ionizing Radiation Sources	Electromagnetic furnaces, computers, welding/cutting devices, ground penetrating radar used to characterize facilities	Radiological hazard – Radiation exposure
Acoustic Energy (AE)		
Equipment rooms, supply fan rooms	Fans, pumps, motors, compressors and other equipment	Standard industrial hazard – Loss of hearing – Does not initiate or impact hazardous material releases
Air compressors	Stationary and portable air compressors (inside and out) to support tools and process equipment.	Standard industrial hazard – Does not initiate or impact hazardous material releases
Kinetic Energy (KE)		
Rotating Equipment	Various types of fans, pumps, air movers, compressors, electric motors	Standard industrial hazard – Pinch – Impact – Puncture – Cut – Could result in loss of confinement
Vehicle/Transport Devices	Forklifts, loaders, cranes, trucks, excavators, backhoes, trucks, carts, dollies, elevator	Standard industrial hazard – Impact – Radiological uptake, exposure – Could injure workers or result in loss of confinement through drop, spill or puncture that releases hazardous material. – Could provide fuel for a fire or cause an explosion, which injures workers or releases hazardous material.
Decontamination and Size Reduction Equipment	High pressure hydraulic oil lines and systems in tools (e.g. shears, cranes, loaders, concrete saws, jackhammers)	Standard industrial hazard – Lacerations – Punctures – Repetitive motion/ergonomics – Radiological uptake – Could initiate spill that releases hazardous material.

Potential Energy (PE)		
Pressurized Gas Bottles	P-10 bottles used by PCM2 detector, welding, Headspace Gas Sampling Analysis, miscellaneous gases.	Standard industrial hazard – Extreme temperatures – Could act as a missile and cause hazardous material release (Spill)
Compressed Air	Compressed air used to operate equipment (e.g., scabblers) and breathing air systems and backup bottles, analytical equipment and process equipment	Standard industrial hazard – Pressure release
Hoisting and Rigging, Lifting equipment	Heavy equipment will be lifted and lowered as part of waste shipping, sample shipping, and equipment installations using cranes, hoists, pallet jacks, lift tables, elevators.	Standard industrial hazard – Impact – Radiological uptake – Could result in spill that releases hazardous material.
Mechanical Energy (ME)		
Crush, Shear, Pinch	Presses, grinders, size reduction tools, forklift, puncture, sharp edges, motors, fans, pumps	Standard industrial hazard
Chemical Energy/Explosives (CE)		
Stock Chemicals	Fixatives, adhesives, paints, and other chemicals used for decommissioning corrosives, acids, reagents, oxidizers used in laboratory sampling.	Chemical/Standard industrial hazard – Chemical exposure – Burns – Asphyxiation – Could be released due to spills, fires, overpressure due to chemical reactions, etc.
Waste Chemicals	Oils and aqueous solutions, chemicals no longer required	Chemical/Standard industrial hazard – Chemical exposure – Burns – Asphyxiation – Could be released due to spills, fires, overpressure due to chemical reactions, etc.
Shock Sensitive Chemicals	Nitrates may be located throughout clean-up activities	Chemical/Standard industrial hazard – Chemical exposure – Burns – Asphyxiation – Could cause explosion

Explosive Substances	H_2, gas	Chemical/Standard industrial hazard – Chemical exposure – Burns – Asphyxiation – Could cause explosion
Legacy Materials	May encounter unknown chemicals Waste packaged prior to 1995	Radiological/Chemical/Standard industrial hazard – Chemical exposure – Radiological uptake – Could result in spill, explosion, fire
Chemical Materials (CM)		
Asbestos	Asbestos containing material throughout facility (e.g., ceiling tiles, walls, pipe insulation, floor tiles)	Chemical/Standard industrial hazard – Asbestos dust inhalation – Could be released due to spills, fires, etc. (No offsite impact)
Lead	Lead containing material throughout facility.	Chemical/Standard industrial hazard – Lead poisoning – Fume inhalation – Could be released due to fire (No offsite impact)
PCBs	PCBs in various parts of the facility (e.g., light ballasts, transformers, samples).	Chemical/Standard industrial hazard – Contamination – Could be released due to spills, fires, etc. (No offsite impact)
Biohazard (BIO)		
Pesticides sprayed in buffer zone	Noxious weed control relies on aerial application of pesticides	Chemical/Standard industrial hazard – Chemical exposure
Animal droppings	May encounter animal and bird droppings.	Standard industrial hazard – Disease
Animals	May encounter dead animals in various places in the facility. Live animals may enter the facility	Standard industrial hazard – Disease – Bites

Natural Phenomena (NPH)		
Lightning	May experience natural phenomena before end of facility life	Radiological/Chemical/Standard industrial hazard – Burns – Shock – Could injure workers or release hazardous material through spills, loss of confinement or resultant fires
High winds, tornadoes, heavy rain, floods, heavy snow, earthquakes, aircraft crash	May experience natural phenomena before end of facility life	Radiological/Chemical/Standard industrial hazard – Bodily injury – Radiological uptake – Could injure workers or release hazardous material through spills or resultant fires
Any Other Hazard (OTH)s		
Oxygen deficient atmospheres	Inert gases present in liquid form (N2 dewars) confined space	Standard industrial hazard – Asphyxiation – Could injure workers
Trenching	Removal of underground piping may require trenching	Standard industrial hazard – Burial – Shock – Pressure release

Appendix C

Preliminary Hazards Analysis 222-S Laboratory Complex

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Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-222S-1	222-S Shipping/ Receiving	Tank Farm core sample (one segment or less per cask, 5.2E-3 DE-Ci)	Release of radioactive and/ or hazardous material to the environment from the loading dock due to container drop/ impact/crush/puncture during shipping/ receiving activities	Operator error; equipment failure	Release of solid or liquid sample to ground; surface/ pool formation; particulate release	Shipping container design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	Three casks per truck, only one unloaded at a time.
222S-222S-2	222-S Shipping/ Receiving	PAS-1 Cask (~5.2E-2 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to PAS-1 Cask shipping container sample container (inner PAS-1 container) drop/impact/crush/ puncture during shipping/ receiving activities	Operator error; equipment failure	Release of solid or liquid sample to ground; surface/pool formation; particulate release	Crane/lifting equipment design; Shipping container design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	PAS-1 Cask is a Type-B shipping container. Potential for worker in-jury from fall/drop of cask. Scenario consists of dropping the carrier as it is being removed from the PAS-1 cask.
222S-222S-3	222-S Shipping/ Receiving	Hardigg Case [Barney box] (~1.56E-2 DE-Ci)	Release of radioactive and/ or hazardous material to the environment from the loading dock due to Hardigg Case shipping container sample container drop/impact/crush/ puncture during shipping/ receiving activities	Operator error; equipment failure	Release of solid or liquid sample to ground; surface/pool formation; particulate release	Crane/lifting equipment design; Shipping container design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	Bounded by PAS-1. Barney box is a Type-A shipping container.
222S-222S-4	222-S Shipping/ Receiving	Contents of a pig approximately 1.04E-2 DE-Ci	Release of radioactive and/ or hazardous material to the environment from the loading dock due to pig drop/impact/ crush/puncture during shipping/receiving activities	Operator error; equipment failure	Release of solid or liquid sample to ground; surface/pool formation; particulate release	Pig container design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	Taken out of over pack on truck. Tank farm samples are highly caustic.
222S-222S-5	222-S Shipping/ Receiving	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/ or hazardous material to the environment from the loading dock due to sample container (various) drop/impact/crush/ puncture during shipping/ receiving activities	Operator error; equipment failure	Release of solid or liquid sample to ground; surface/pool formation; particulate release	Container design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	Includes containers such as carboy.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-222S-6	222-S Shipping/ Receiving	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to sample container (various) overpressurization during shipping/receiving activities	Incompatible materials; gas generation	Release of solid or liquid sample to air and ground; particulate release	Container design	Training; procedures; industrial safety program; rad con program	F3	B	C	D	E1	III	IV	Potential industrial injury from overpressure.
222S-222S-7	222-S Shipping/ Receiving	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to fire involving sample container (various) during shipping/receiving activities	Incompatible mater-ials, gas generation, ignition source; maintenance activity with combustibles present ignites and involves container; handling equipment as a fuel source	Release of particulate to environment	Handling equipment design	Fire protection program; housekeeping; manual fire suppression; training; procedures	F3	C	C	D	E1	III	IV	"Single" container fire. New dock design will enclose this space and have fire suppression.
222S-222S-8	222-S Shipping/ Receiving	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to fire involving transportation vehicle	Equipment failure leads to release of fuel which ignites and involves container	Release of particulate to environment	Truck design	Fire protection program; housekeeping; manual fire suppression; requirement for turning off vehicle when parked; maintenance of vehicle; training; procedures	F3	C	C	D	E1	III	IV	Potential to involve more than one container but 30 g is the maximum that can be received. New dock design will enclose this space and have fire suppression.
222S-222S-9	222-S Shipping/ Receiving	Occupational radiological hazard (RAD)	Occupational exposure due to receiving a higher than normal sample.	Procedure/operator error; mis-identification of sample	Higher than expected external exposure to worker		Training; procedures; rad con program	F3	C	D	D	E0	IV	IV	No release. External exposure to worker.
222S-222S-10	222-S Laboratory Hot Cell Operations	Same as single containers in Shipping/ Receiving	Release of radioactive and/or hazardous material to the room and environment from the container due to container drop/impact/crush/puncture during hot cell loading activities	Operator error; equipment failure	Release of solid or liquid sample to room floor; surface/pool formation; particulate release; transport to environment by vent systems or building leak paths	Handling equipment design	Training; procedures; industrial safety program; rad con program	F3	C	C	D	E1	III	IV	Bounded by Shipping/ Receiving activities.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-222S-11	222-S Laboratory Hot Cell Operations	1.14 DE-Ci	Release of radioactive and/or hazardous material to the hot cell and environment from the container due to sample drop/impact/crush/puncture during hot cell activities (multiple samples involved)	Operator error; equipment failure	Release of hazardous and radioactive material to the hot cell; Leak pathway to room; transport through HVAC and release to environment via stack	Hot cell structure; HVAC & HEPAs; negative dP, handling equipment design; sample bin design	Training; procedures	F3	C	C	D	E1	III	IV	MAR involves 2 bins with 5.7E-1 DE-Ci per bin. E1 and S2-C assigned assuming HVAC w/o HEPAs.
222S-222S-12	222-S Laboratory Hot Cell Operations	39.11 DE-Ci	Release of radioactive and/or hazardous material to the hot cell and environment due to a fire inside the hot cell that involves the entire hot cell structure (multiple locations involved)	Ignition of combustible material from electrical services; combination of incompatible chemicals; leak of hydraulic fluid into hot cell from extruder	Release of hazardous and radioactive material to the hot cell environment, room environment via boot failure or window, and potential subsequent transport to the environment via building leaks or through HVAC	Hot cell structure; HVAC and HEPAs; extruder design; fire protection system, hot cell design and segregation of hot cell locations.	Training; procedures; fire protection program	F2	B	B	C	E2	II	III	MAR for this scenario is same as the facility inventory. Hot cell has oil-filled windows.
222S-222S-13	222-S Laboratory Hot Cell Operations	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to a drop/impact/crush/puncture of a waste drum outside of the hot cell during filling or handling	Operator error; equipment failure	Release of hazardous and radioactive material to the room environment and potential subsequent transport to the environment via building leaks or through HVAC; potential industrial injury to worker due to dropped drum	Room HVAC; drum handling equipment design; waste package size limitations; drum design	Training; procedures; rad con program; industrial safety program; maintenance	F3	C	D	D	E0	IV	IV	Industrial hazard due to dropped drum. Mixed waste drum.
222S-222S-14	222-S Laboratory Hot Cell Operations	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to waste drum overpressurization outside of the hot cell during handling	Incompatible materials, gas expansion	Release of hazardous and radioactive material to the room environment and potential subsequent transport to the environment via building leaks or through HVAC; potential serious industrial injury to worker due to drum overpressurization	Room HVAC; drum handling equipment design; waste package size limitations; drum design	Training; procedures; industrial safety program	F3	A	D	D	E0	IV	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls		Freq Cat	Consequence Categories				Risk Bins		Remarks
						Engineered Features	Administrative Controls		S1	S2	S3	E	S2	S3	
222S-222S-15	222-S Laboratory Hot Cell Operations	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to a fire that involves a waste drum outside of the hot cell during filling or handling	Waste drum that contains incompatible chemicals or that contains combustibles which are ignited	Release of hazardous and radioactive material to the room and potential subsequent transport to the environment via building leaks or through HVAC; Potential industrial injury to worker due to dropped drum	Room HVAC; drum handling equipment design; Waste package size limitations; drum design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-222S-16	222-S Laboratory Hot Cell Operations	Liter quantities of acids, bases, alcohol	Release of hazardous material to the room and environment due to a drop/impact/crush/ puncture of a chemical container outside of the hot cell.	Operator error; handling equipment failure	Release of hazardous material to the room and potential subsequent transport to the environment via building leaks or through HVAC.	Room HVAC; handling equipment design; chemical package size limitations	Training; procedures; industrial safety program; industrial hygiene program	F3	B	D	D	E0	IV	IV	Worker chemical exposure issue.
222S-222S-17	222-S Laboratory Hot Cell Operations	Liter quantities of acids, bases, alcohol	Release of hazardous material to the room and environment due to a drop/impact/crush/puncture of a chemical container inside of the hot cell.	Operator error; handling equipment failure	Release of hazardous material to the hot cell; Leak pathway to room; potential subsequent transport to the environment via building leaks or through HVAC	Hot cell design and ventilation; room HVAC; handling equipment design; chemical package size limitations	Training; procedures; industrial safety program; industrial hygiene program	F3	C	D	D	E0	IV	IV	Less than above due to passive barrier of hot cell.
222S-222S-18	222-S Laboratory Hot Cell Operations	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to errors or equipment failures during maintenance of manipulators	Operator error; handling equipment failure	Worker injury; release of particulate to operating area; transport to environment	Equipment design; transport cart; building structure and vent system	Training; procedures; rad con program; industrial safety	F3	B	D	D	E0	IV	IV	Worker injury; worker exposure.
222S-222S-19	222-S Laboratory Hot Cell Operations	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to failure of hot cell viewing window	Extruder failure; manipulator failure	Release of particulate to operating area; potential transport to environment	Equipment design; hot cell design and ventilation	Training; procedures; rad con program; industrial safety	F3	C	D	D	E0	IV	IV	
222S-222S-20	222-S Laboratory Hot Cell Operations	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	Release of particulate to operating area; potential transport to environment	HVAC system design; backup diesel exhaust fan	Training; procedures	F3	C	D	D	E0	IV	IV	
222S-222S-21	222-S Laboratory Operations	30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to a sample drop/impact/crush/ puncture in lab room.	Operator error; handling equipment failure	Release of hazardous and radiological material to the room. Transport through HVAC and release to environment via stack.	Equipment design; transport cart; building structure and vent system	Training; procedures; rad con program; industrial safety	F3	C	D	D	E0	IV	IV	Handling alpha samples may increase S1 to B.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-222S-22	222-S Laboratory Operations	30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to the fume hood and environment due to a sample drop/impact/ crush/puncture in fume hood	Operator error; handling equipment failure	Release of hazardous and radiological material to the fume hood. Leak pathway to room. Transport through HVAC and release to environment via stack.	Fume hood design and ventilation; equipment design; building structure and vent system	Training; procedures; rad con program; industrial safety	F3	C	D	D	E0	IV	IV	No credit assumed for fume hood for this unmitigated case.
222S-222S-23	222-S Laboratory Operations	Gallon quantities of acids, bases, organics	Release of hazardous material to the Room and environment due to drop/impact/crush/ puncture of chemical container outside of fume hood	Operator error; handling equipment failure	Release of hazardous material to the room. Transport through HVAC and release to environment via stack.	Equipment design; transport cart; building structure and vent system	Training; proce-dures; industrial hygiene program; industrial safety program	F3	B	D	D	E0	IV	IV	Potential for impact to worker from chemical.
222S-222S-24	222-S Laboratory Operations	Gallon quantities of acids, bases, organics	Release of hazardous material to the fume hood and environment due to drop/impact/ crush/puncture of chemical container inside of fume hood.	Operator error; handling equipment failure	Release of hazardous material to the fume hood. Leak pathway to room. Transport through HVAC and release to environment via stack.	Fume hood design and ventilation; equipment design; building structure and vent system	Training; procedures; industrial hygiene program; industrial safety program	F3	C	D	D	E0	IV	IV	
222S-222S-25	222-S Laboratory Operations	30 g Pu (4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of hazardous and radioactive material to the fume hood, room, and environment due to fire inside fume hood.	Flammable liquids in hood; ignition source	Release of hazardous and radioactive material to the fume hood and lab room. Transport through HVAC and release to environment via stack.	Fume hood design and ventilation	Training; procedures; fire protection program	F3	C	D	D	E0	IV	IV	See gas cylinder failure for lab-wide fire.
222S-222S-26	222-S Laboratory Operations	Multiple hood damage; (up to six hoods or 5.00 DE-Ci); 30 gal chemical inventory	Release of radioactive and/or hazardous material to the room and environment due to failure of compressed gas cylinder in lab resulting in a missile	Operator error; cylinder valve failure; cylinder handling error	Release of hazardous and radioactive material to the room and potential subsequent transport to the environment via building leaks or through HVAC. Potential serious industrial injury to worker due to gas cylinder failure	Gas cylinder design; support structure design	Training; procedures; industrial safety program	F3	A	C	D	E1	III	IV	One 4.95 DE-Ci sample in one hood, 1.04E-2 DE-Ci in each of the others.
222S-222S-27	222-S Laboratory Operations	OCC	Missile generated from failure of compressed gas cylinder	Operator error; cylinder valve failure; cylinder handling error	Injury or fatality to worker	Gas cylinder design; support structure design	Training; proce-dures; industrial safety program	F3	A	D	D	E0	IV	IV	Only addresses occupational industrial hazard.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-222S-28	222-S Laboratory Operations	Lab chemical and rad inventory; approximately 60 gal; 12 hoods (5.06 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Fire or explosion local to one lab.	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Release of hazardous and radioactive material to the lab room and transport to the environment via building leaks or through HVAC, potential serious industrial injury to worker due to explosion	Gas cylinder design; support structure design; fire protection system; Hanford fire department	Training; procedures; industrial safety program; fire protection program	F3	A	C	D	E1	III	IV	One 4.95 DE-Ci sample in one hood, 1.04E-2 DE-Ci in each of the others.
222S-222S-29	222-S Laboratory Operations	39.11 DE-Ci buiилding inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Interaction with flammable chemicals. Fire propagates to 222-S Laboratory building-wide fire.	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Release of hazardous and radioactive material to the building and transport to the environment, potential serious industrial injury to worker due to explosion	Gas cylinder design; support structure design; fire protection system; Hanford fire department	Fire protection program; training; procedures; emergency response	F2	A	B	C	E2	II	III	Unmitigated, no credit for fire suppression.
222S-222S-30	222-S Laboratory Operations	OCC	Failure of nitrogen dewars in counting room	Operator error; equipment failure	Injury to worker; freeze burns	Dewar design; support structure design	Training; proce-dures; industrial safety program	F3	B	D	D	E0	IV	IV	
222S-222S-31	222-S Laboratory Operations	OCC	Not applicable; halon system in counting room was removed												
222S-222S-32	222-S Laboratory Operations	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the glovebox and environment due to a sample drop/impact/ crush/puncture in glovebox	Operator error; equipment failure	Release of hazardous and radiological material to the glovebox. Leak pathway to room. Transport through HVAC and release to environment via stack.	Glovebox design and ventilation; equipment design; building structure and vent system	Training; procedures; rad con program; industrial safety	F3	C	D	D	E0	IV	IV	
222S-222S-33	222-S Laboratory Operations	Gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the glovebox and environment due to a chemical container drop/impact/crush/ puncture in glovebox	Operator error; equipment failure	Release of hazardous material to the fume hood. Leak pathway to room. Transport through HVAC and release to environment via stack.	Glovebox design and ventilation; equipment design; building structure and vent system	Training; procedures; industrial hygiene program; industrial safety	F3	C	D	D	E0	IV	IV	
222S-222S-34	222-S Laboratory Operations	30 g of Pu (liquid or solid, 4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the glovebox and environment due to a fire in glovebox	Flammable liquids; ignition source	Release of hazardous and radioactive material to the glovebox and lab room. Transport through HVAC and release to environment via stack.	Glovebox design and ventilation; glovebox fire protection system	Training; procedures; fire protection program	F3	C	D	D	E0	IV	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-222S-35	222-S Laboratory Operations	30 g of Pu (liquid or solid, 4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the room and environment due failure of glove or glovebox window in glovebox	Operator error; equipment failure	Release of hazardous and radioactive material to the lab room and exposure to worker	Glovebox design and ventilation; building structure and ventilation system	Training; procedures	F3	C	D	D	E0	IV	IV	Exposure to worker.
222S-222S-36	222-S Laboratory Operations	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to a drop/impact/crush/puncture of a waste drum during filling or handling.	Operator error; equipment failure	Release of hazardous and radioactive material to the room environment and potential subsequent transport to the environment via building leaks or through HVAC. Potential industrial injury to worker due to dropped drum.	Room HVAC; drum handling equipment design; waste package size limitations; drum design	Training; procedures; rad con program; industrial safety program; maintenance	F3	C	D	D	E0	IV	IV	
222S-222S-37	222-S Laboratory Operations	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to waste drum overpressurization during handling	Incompatible materials, gas expansion	Release of hazardous and radioactive material to the room environment and potential subsequent transport to the environment via building leaks or through HVAC. Potential serious industrial injury to worker due to drum overpressurization.	Room HVAC; drum handling equipment design; waste package size limitations; drum design	Training; procedures; industrial safety program	F3	A	D	D	E0	IV	IV	
222S-222S-38	222-S Laboratory Operations	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to a fire that involves a waste drum during filling or handling	Waste drum that contains incompatible chemicals or that contains combustibles which are ignited.	Release of hazardous and radioactive material to the room and potential subsequent transport to the environment via building leaks or through HVAC; potential industrial injury to worker due to dropped drum	Room HVAC; drum handling equipment design; waste package size limitations; drum design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-222S-39	222-S Laboratory Operations	Loose contamination in fume hoods/glove boxes (up to 1.04E-2 DE-Ci). High vapor pressure chemicals	Release of radioactive and/or hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	Release of particulate to operating area; potential transport to environment	HVAC system design; backup diesel exhaust fan	Training; procedures; maintenance	F3	C	D	D	E0	IV	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls		Freq Cat	Consequence Categories				Risk Bins		Remarks
						Engineered Features	Administrative Controls		S1	S2	S3	E	S2	S3	
222S-219S-1	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to drop of cover block/roof panel on storage tanks	Operator error; equipment failure; structural failure	Release of radioactive and chemical materials; aerosol release; worker exposure; transport to environment; release to ground; industrial hazard to worker from dropped cover block	Handling equipment design	Training; procedures; maintenance	F2	B	C	D	E1	III	IV	Does not currently use cover blocks but fire protection may require use of cover blocks. Potential occupational industrial hazard.
222S-219S-2	219-S Tank System	OCC	Cover block/roof panel dropped	Operator error; equipment failure; structural failure	Injury or fatality to worker	Handling equipment design	Training; procedures; maintenance	F3	A	D	D	E0	IV	IV	Only addresses occupational industrial hazard.
222S-219S-3	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to spray release	Operator error; equipment failure; structural failure	Release of radioactive and chemical materials; aerosol release; worker exposure; transport to environment; release to ground	Transfer system design	Training; procedures; maintenance	F3	C	C	D	E1	III	IV	
222S-219S-4	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to tank failure/leak (101, 102, 104)	Operator error; equipment failure; structural failure	Release of radioactive and chemical materials; release to ground; release to air and environment.	Storage tank design; tank level monitoring	Training; procedures; maintenance	F3	C	D	D	E1	IV	IV	
222S-219S-5	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to fire in 219-S	Electrical failure; ignition of plastics/combusti-bles; vehicle impact causes fire	Building structure falls on tank; tank overpressurizes from fire; aerosol release to air; release to ground	Storage tank design	Training; procedures; fire protection program	F2	C	C	D	E1	III	IV	
222S-219S-6	219-S Tank System	700 gal NaOH	Release of hazardous material to environment due to failure/ leak of NaOH tank (201)	Tank structural failure; vehicle impacts building	Release of hazardous material to ground; release to air and environment	Storage tank design	Training; procedures	F3	C	D	D	E0	IV	IV	
222S-219S-7	219-S Tank System	700 gal NaOH	Release of hazardous material to environment due to release during filling NaOH tank during truck transfer operations	Human error; equipment failure	Release of hazardous material to ground; release to air and environment; potential spray release	Transfer system design; safety showers; temporary berm	Training; procedures; industrial safety program	F3	B	D	D	E1	IV	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-219S-8	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material due to leak or valving error during sampling in the sampling gallery.	Human error; equipment failure	Release of liquid spray in hood. Worker safety impact	Hood design	Training; procedures; industrial safety program	F3	B	D	D	E0	IV	IV	
222S-219S-9	219-S Tank System	Sample size bounded by 30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to environment due to drop/impact/crush/puncture of a sample	Human error; equipment failure	Release of liquid sample to ground; surface/pool formation; particulate release	Sample container design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	Bounded by 222-S Laboratory sample drop.
222S-219S-10	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to inadvertent mixing of chemicals and tank overpressurization	Operator error, valve failure, equipment failure	Release of haz chem, rad aerosols, potentially pressurize tank, uncontrolled chemical reaction, potential worker injury	Filters/vent system, transfer system design, tank design	Training; procedures	F3	C	C	D	E1	III	IV	Acid and caustic liquids are mixed during normal operations.
222S-219S-11	219-S Tank System	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to misrouting contents of 219-S tanks	Human error; equipment failure	Mixing of 219-S Tank contents with tanks at evaporator or tank farm. Potential for direct release to environment	Transfer system design	Training; procedures	F2	D	D	D	E2	IV	IV	May impact workers at other facilities.
222S-222FB-1	222-SB, SC, and SE Filter Buildings	Radioactive material on filter 5.41E-1 DE-Ci total	Release of radioactive material to environment due to failure of HEPA filters during replacement/maintenance	Human error; equipment failure	Release of radioactive material to environment	Filter handling equipment design	Training; procedures; rad con program	F3	C	D	D	E0	IV	IV	Filters in series. SC is first filter.
222S-222FB-2	222-SB, SC, and SE Filter Buildings	Radioactive material on filter 5.41E-1 DE-Ci total	Release of radioactive material to environment due to release from HEPA filters due to fire.	Vehicle impacts building and initiates fire; diesel spill during storage tank filling results in fire; flammable gas release (e.g., acetylene, propane) during delivery to 222S results in fire	Release of radioactive material to environment	Filter building design	Training; procedures; fire protection program; DOT shipping requirements	F2	C	C	D	E1	III	IV	
222S-222SD-1	222-SD Solid Waste Handling	4 drums per pallet. (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Release of radioactive and hazardous material to the ground; transport of particulates to the environment	Waste drum design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	SD has jib hoist, other areas do not; forklift handling.

						Candidate Controls			Consequence Categories				Risk Bins		Remarks
Event ID	**Activity or Location**	**Material at Risk (MAR)**	**Hazardous Condition**	**Candidate Causes**	**Immediate Consequences**	**Engineered Features**	**Administrative Controls**	**Freq Cat**	**S1**	**S2**	**S3**	**E**	**S2**	**S3**	
222S-222SD-2	222-SD Solid Waste Handling	4 drums per pallet. (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Release of radioactive and hazardous material to the environment	Waste drum design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-222SD-3	222-SD Solid Waste Handling	One drum at 8.3^{E}-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Release of radioactive and hazardous material to the environment; potential worker injury from overpressure	Waste drum design	Training; procedures	F3	B	C	D	E1	III	IV	
222S-222SD-4	222-SD Solid Waste Handling	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to drop/impact/crush/puncture	Human error; equipment failure	Release of radioactive and hazardous material to the ground; transport of particulates to the environment	Waste box design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	
222S-222SD-5	222-SD Solid Waste Handling	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the en-vironment due to release from waste box due to localized fire	Combustible materials ignite; forklift fuel ignites	Release of radioactive and hazardous material to the environment	Waste box design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-222SD-6	222-SD Solid Waste Handling	64 drums and 4 boxes (2.38 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to 222-SD area-wide fire	Forklift accident re-sults in fire; vehicle accident; ignition of combustible materials	Release of radioactive and hazardous material to the environment	Waste package design	Training; procedures; fire protection program	F2	C	C	D	E1	III	IV	
222S-HS008-1	HS-0082 HS-0083	4 drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Release of radioactive and hazardous material to the ground; transport of particulates to the environment	Waste drum design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	
222S-HS008-2	HS-0082 HS-0083	4 drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Release of radioactive and hazardous material to the environment	Waste drum design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-HS008-3	HS-0082 HS-0083	1 drum at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Release of radioactive and hazardous material to the environment; potential worker injury from overpressure	Waste drum design	Training; procedures	F3	B	C	D	E1	III	IV	
222S-HS008-4	HS-0082 HS-0083	176 drums (4.16 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to area-wide fire	Forklift accident re-sults in fire; vehicle accident; ignition of combustible materials	Release of radioactive and hazardous material to the environment	Waste package design	Training; procedures; fire protection program	F2	C	C	D	E1	III	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-HS006-1	HS-0065 (A&B) Chemical Storage	Up to four 55-gal drums per pallet. 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture during filling or handling	Human error; equipment failure	Release of hazardous material to the ground; transport of particulates to the environment	Waste drum design; handling equipment design	Training; procedures	F3	B	C	D	E1	III	IV	
222S-HS006-2	HS-0065 (A&B) Chemical Storage	Up to four 55-gal drums per pallet. 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to localized fire during filling or handling	Combustible materials ignite; forklift fuel ignites	Release of hazardous material to the environment	Waste drum design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-HS006-3	HS-0065 (A&B) Chemical Storage	One 55-gal drum containing 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to failure of waste drum from overpressure during handling	Incompatible materials; gas expansion	Release of hazardous material to the environment; potential serious industrial worker injury from overpressure	Waste drum design	Training; procedures	F3	A	C	D	E1	III	IV	
222S-HS006-4	HS-0065 (A&B) Chemical Storage	Up to ten 55-gal drum of compatible chemicals per side, 20 total in storage unit	Release of hazardous material to the environment due to area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Release of hazardous material to the environment	Waste package design	Training; procedures; fire protection program	F2	C	C	D	E1	III	IV	
222S-BP-1	"Bull Pen" LLW Storage Area	Either one drum or box (8.3E-1 DE-Ci); four drums (1.32 DE-Ci); or total inventory (upper limit same as HS-0082 and HS-0083, 4.16 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Release of radioactive and hazardous material to the ground; transport of particulates to the environment	Waste drum design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	
222S-BP-2	"Bull Pen" LLW Storage Area	Four drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Release of radioactive and hazardous material to the environment	Waste drum design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-BP-3	"Bull Pen" LLW Storage Area	One drum at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Release of radioactive and hazardous material to the environment; potential worker injury from overpressure	Waste drum design	Training; procedures	F3	B	C	D	E1	III	IV	
222S-BP-4	"Bull Pen" LLW Storage Area	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to drop/impact/crush/puncture	Human error; equipment failure	Release of radioactive and hazardous material to the ground; transport of particulates to the environment	Waste box design; handling equipment design	Training; procedures	F3	C	C	D	E1	III	IV	
222S-BP-5	"Bull Pen" LLW Storage Area	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to localized fire	Combustible materials ignite; forklift fuel ignites	Release of radioactive and hazardous material to the environment	Waste box design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-BP-6	"Bull Pen" LLW Storage Area	Total equivalent to 176 drums/boxes (4.16 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to "Bull Pen" area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Release of radioactive and hazardous material to the environment	Waste package design	Training; procedures; fire protection program	F2	C	C	D	E1	III	IV	
222S-GD-1	212 Gas Storage Dock; Annex Combustible Gas Dock; 4M and 4TUV Gas Dock	222S inventory potentially impacted. Filter Building 222-SE. 5.41E-1 DE-Ci	Release of radioactive and/or hazardous material due to failure of pressurized gas cylinder resulting in missile	Human error; equipment failure	Release of radioactive and hazardous material to the environment	Gas cylinder design; support structure design	Training; procedures; industrial safety program	F3	C	C	D	E1	III	IV	Missile impacting Filter Building is used for consequences.
222S-GD-2	212 Gas Storage Dock; Annex Combustible Gas Dock; 4M and 4TUV Gas Dock	OCC	Worker injury/fatality due to failure of pressurized gas cylinder	Operator error; cylinder valve failure; cylinder handling error	Injury or fatality to worker	Gas cylinder design; support structure design	Training; procedures; industrial safety program	F3	A	D	D	E0	IV	IV	Only addresses occupational industrial hazard.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-GD-3	212 Gas Storage Dock; Annex Combustible Gas Dock; 4M and 4TUV Gas Dock	OCC	Failure of cryogenic dewar	Operator error; equipment failure	Injury to worker; freeze burns	Dewar design; support structure design	Training; procedures; industrial safety program	F3	B	D	D	E0	IV	IV	
222S-GD-4	212 Gas Storage Dock; Annex Combusti-ble Gas Dock; 4M and 4TUV Gas Dock	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to failure of flammable compressed gas cylinder or gas lines in storage dock. Fire propagates to building-wide fire	Operator error; equipment failure; release of gas; ignition; fire or explosion	Release of hazardous and radioactive material to the building and transport to the environment	Gas cylinder design; support structure design; fire protection system; Hanford fire department	Fire protection program; training; procedures; emergency response	F2	B	B	C	E2	II	III	
222S-207SL-1	207-SL Retention Basins	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to spill during transfer	Operator error; equipment failure	Release of hazardous and radioactive material to ground; release to air and environment; potential spray release	Transfer system design	Training; procedures	F3	D	D	D	E1	IV	IV	Included for complete-ness. Primarily an environ-mental issue.
222S-207SL-2	207-SL Retention Basins	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to failure of storage tanks.	Operator error; equipment failure; structural failure	Release of hazardous and radioactive material; release to ground; release to air and environment.	Storage tank design; tank level monitoring	Training; procedures; maintenance	F3	D	D	D	E1	IV	IV	Included for complete-ness. Primarily an environ-mental issue.
222S-207SL-3	207-SL Retention Basins	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to spill during sampling	Operator error; equipment failure	Release of hazardous and radioactive material to ground; release to air and environment; potential spray release	Sampling system design	Training; procedures	F3	D	D	D	E1	IV	IV	Included for complete-ness. Primarily an environ-mental issue.
222S-207SL-4	207-SL Retention Basins	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to environment due to drop of cover block on retention basin	Operator error; equipment failure; structural failure	Release of radioactive and chemical materials; aerosol release; worker exposure; transport to environment; release to ground; industrial hazard to worker from dropped cover block	Handling equipment design	Training; procedures; maintenance	F2	D	D	D	E1	IV	IV	Potential occupational industrial hazard.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-207SL-5	207-SL Retention Basins	OCC	Cover block dropped	Operator error; equipment failure; structural failure	Injury or fatality to worker	Handling equipment design	Training; procedures; maintenance	F3	A	D	D	E0	IV	IV	Only addresses occupational industrial hazard.
222S-222SA-1	222-SA Standards Lab	Four 1-gal containers packaged in a box (HNO3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500 ml bottles/6 bottles per pkg.	Release of hazardous material to the environment due to drop/impact/crush/puncture handling accident during receiving/shipping	Operator error, equipment failure, improper packaging, truck accident	Release of hazardous material to the environment, potentail serious industrial injury to worker due to drop or impact	DOT packaging	Training, procedures, industrial hygiene program, emergency response, spill kits, safety shower	F3	A	C	D	E1	III	IV	
222S-222SA-2	222-SA Standards Lab	Four 1-gal containers packaged in a box (HNO_3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500-ml bottles/6 bottles per pkg.	Release of hazardous material to the environment from the loading dock due to chemical container overpressurization during shipping/receiving activities	Incompatible materials; gas expansion	Release of hazardous material to the environment, potentail serious industrial injury to worker due to overpressure	Container design	Training; procedures; industrial hygiene	F3	A	C	D	E1	III	IV	Potential industrial injury from overpressure.
222S-222SA-3	222-SA Standards Lab	Four 1-gal containers packaged in a box (HNO3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500-ml bottles/6 bottles per pkg.	Release of hazardous material to the environment from the loading dock due to fire during shipping/receiving activities	Incompatible materials, gas generation, ignition source; maintenance activity with combustibles present ignites and involves container; handling equipment as a fuel source	Release of hazardous material to the environment	Handling equipment design	Fire protection program; housekeeping; manual fire suppression; training; procedures	F3	C	C	D	E1	III	IV	
222S-222SA-4	222-SA Standards Lab	Four 1-gal containers of hazardous material	Release of hazardous material to the environment due to drop/impact/crush/puncture of chemical container in single lab	Operator error, equipment failure, defective container	Release of hazardous material to lab room; transport to environment by building leaks or ventilation system	Safety shower, eye wash, room ventilation	Training, procedures, industrial hygiene program, emergency response, spill kits, PPEs	F3	B	D	D	E0	IV	IV	Higher potential to injure employee due to enclosed area, handling individual containers outside DOT package.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3	Remarks
222S-222SA-5	222-SA Standards Lab	Two 8-liter containers of hazardous material (Erlenmeyer)	Release of hazardous material to the environment due to drop/impact/crush/puncture of chemical container in fume hood	Operator error, equipment failure, defective container	Release of hazardous material to fume hood; transport to environment by building leaks or ventilation system	Fume hood, safety shower, eye wash, room ventilation	Training, procedures, industrial hygiene program, emergency response, spill kits, PPEs	F3	B	D	D	E0	IV	IV	
222S-222SA-6	222-SA Standards Lab	Two 1-gal containers of flammable liquids	Release of hazardous material to the environment due to fire or explosion in fume hood	Flammable liquids ignited, electrical equipment/failure, pilot light instrument	Release of hazardous material to fume hood; transport to environment by building leaks or ventilation system	Fixed-head sprinkler system in each hood	Training; procedures; fire protection program	F3	B	D	D	E0	IV	IV	
222S-222SA-7	222-SA Standards Lab	Up to four flammable liquid (60 gal/cabinet) cabinets plus two 20-gal flammable refrigerators. Adjacent containers of haz chemicals (20 gal HNO3, 15 gal HCl, 10 gal H_2SO_4, NaOH, 30 lb miscellaneous oxidizers, small quantities of toxics)	Release of hazardous material to the environment due to fire in fume hood spreading to lab and 222-SA building	Flammable liquids ignited, electrical equipment/failure, pilot light instrument	Release of hazardous material to the building and transport to the environment	Fire protection system; Hanford Fire Dept.; portable fire extinguishers; flammable storage cabinets	Max flammable quantity limit; procedures; training	F3	B	C	D	E1	III	IV	Trailer is constructed of flammable material, room 1 has largest quantities of flammables, 20 gal propane tank in room 2.
222S-222SA-8	222-SA Standards Lab	60-gal cabinet assumed impacted	Release of hazardous material to the room and environment due to failure of compressed gas cylinder in lab resulting in a missile	Operator error; cylinder valve failure; cylinder handling error	Release of hazardous material to the room and potential subsequent transport to the environment via building leaks or through HVAC; potential serious injury to worker due to gas cylinder failure	Gas cylinder design; support structure design	Training; procedures; industrial safety program	F3	A	C	D	E1	III	IV	
222S-222SA-9	222-SA Standards Lab	OCC	Missile generated from failure of compressed gas cylinder	Operator error; cylinder valve failure; cylinder handling error	Injury or fatality to worker	Gas cylinder design; support structure design	Training; procedures; industrial safety program	F3	A	D	D	E0	IV	IV	Only addresses occupational industrial hazard.

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-222SA-10	222-SA Standards Lab	Up to four flammable liquid (60 gal/cabinet) cabinets plus two 20-gal flammable refrigerators. Adjacent containers of haz chemicals (20 gal HNO_3, 15 gal HCl, 10 gal H_2SO_4, NaOH, 30 lb miscellaneous oxidizers, small quantities of toxics)	Release of hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Fire or explosion in lab. Fire spreads to 222-SA building.	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Release of hazardous material to the lab room and transport to the environment via building leaks or through HVAC, potential serious industrial injury to worker due to explosion.	Gas cylinder design; support structure design; fire protection system; Hanford fire department	Training; procedures; industrial safety program; fire protection program	F3	A	C	D	E1	III	IV	
222S-222SA-11	222-SA Standards Lab	Two 8-liter containers of hazardous material (Erlenmeyer)	Release of hazardous material to the environment due to inadvertent mixing of incompatible chemicals	Operator error, equipment failure	Release of hazardous material to the building and transport to the environment	Room ventilation	Procedures; training	F3	B	D	D	E0	IV	IV	
222S-222SA-12	222-SA Standards Lab	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to drop/impact/crush/ puncture during filling or handling	Human error; equipment failure	Release of hazardous material to the ground; transport of particulates to the environment	Waste drum design; handling equipment design	Training; procedures	F3	B	C	D	E1	III	IV	
222S-222SA-13	222-SA Standards Lab	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to localized fire during filling or handling	Human error; combustible materials ignite	Release of hazardous material to the environment	Waste drum design; handling equipment design	Training; procedures; fire protection program	F3	C	C	D	E1	III	IV	
222S-222SA-14	222-SA Standards Lab	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to failure of waste drum from overpressure during handling	Human error; incompatible materials; gas generation	Release of hazardous material to the environment; potential serious worker injury from overpressure	Waste drum design	Training; procedures	F3	A	C	D	E1	III	IV	
222S-222SA-15	222-SA Standards Lab	High vapor pressure chemicals	Release of hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	Release of volatile chemicals to operating area; potential transport to environment	HVAC system design	Training; procedures; maintenance	F3	C	D	D	E0	IV	IV	

Event ID	Activity or Location	Material at Risk (MAR)	Hazardous Condition	Candidate Causes	Immediate Consequences	Candidate Controls: Engineered Features	Candidate Controls: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3	Remarks
222S-NP-1	Seismic Event	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to beyond design basis seismic event	Seismic event	Fail building structure; building-wide fire. Serious worker injury or fatality from falling structure.	Facility design; container design	Procedures; training; emergency response program	F1	A	B	C	E2	III	IV	Worker death from falling debris.
222S-NP-2	Extreme Winds	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to extreme winds	Extreme winds	Fail auxiliary buildings; 222-S Laboratory moderate damage. Serious worker injury or fatality from falling structure or missiles.	Facility design; container design	Procedures; training; emergency response program	F2	A	C	D	E1	III	IV	Worker death from falling debris.
222S-NP-3	Volcanic Ash Heavy Snowfall	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to volcanic ash/heavy snowfall	Volcanic ash or heavy snowfall	Fail roof structures; plug vent system, Serious worker injury or fatality from falling structure.	Facility design; container design	Procedures; training; emergency response program	F2	A	C	D	E1	III	IV	Worker death from falling debris.
222S-NP-4	Range Fire	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to range fire	Range fire	Building-wide fire	Facility design; container design	Procedures; training; emergency response program	F2	B	B	C	E2	II	III	Consequences same as building-wide fire
222S-NP-5	Airplane Crash	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to air plane crash	Airplane crash	Release to the environment of due to fire and hazardous material that became "uncontained" during impact. Serious worker injury or fatality.	Facility design; container design	Procedures; training; emergency response program	F1	A	B	C	E2	III	IV	Worker death from falling debris.
222S-NP-6	Flood	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to flood	Flood				F0	D	D	D	E0	IV	IV	Buildings located above level of maximum flood.

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Appendix D

Candidate Representative Accident Worksheet

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Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
1X	H1S	TP	222S-222S-29	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Interaction with flammable chemicals. Fire propagates to 222-S Laboratory building-wide fire.	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Gas cylinder design (OS); fire protection system (FP); building HVAC & ventilation (RP)	Fire protection program (FP); training (TNF); procedures (CO); emergency response (EPLAN); Hanford Fire Department (FP)	F2	A	B	C	E2	II	III
1	H1G	TP	222S-222SA-10	Up to four flammable liquid (60 gal/cabinet) cabinets plus two 20-gal flammable refrigerators. Adjacent containers of haz chemicals (20 gal HNO_3, 15 gal HCl, 10 gal H_2SO_4, NaOH, 30 lb miscellaneous oxidizers, small quantities of toxics)	Release of hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Fire or explosion in lab. Fire spreads to 222-SA building	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Gas cylinder design (OS); fire protection system (FP);	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP): Hanford fire department (FP): chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV
1	H1S	TP	222S-222S-12	39.11 DE-Ci	Release of radioactive and/or hazardous material to the hot cell and environment due to a fire inside the hot cell that involves the entire hot cell structure (multiple locations involved)	Ignition of combustible material from electrical services; combination of incompatible chemicals; leak of hydraulic fluid into hot cell from extruder	Hot cell structure (RP); HVAC & HEPAs (QA, RP, ALARA); extruder design (OS, ALARA); fire protection system (FP), hot cell design and segregation of hot cell locations (RP).	Training (TNF); procedures (CO); fire protection program (FP);	F2	B	B	C	E2	II	III
1	H1S	TP	222S-GD-4	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to failure of flammable compressed gas cylinder or gas lines in storage dock. Fire propagates to building-wide fire	Operator error; equipment failure; release of gas; ignition; fire or explosion	Gas cylinder design (OS); fire protection system (FP);	Fire protection program (FP); training (TNF); procedures (CO); emergency response (EPLAN); Hanford fire department (FP)	F2	B	B	C	E2	II	III
1	H1S	NPH	222S-NP-4	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to range fire	Range fire	Facility design (OS); container design (RP); fire protection system (FP)	Procedures (CO); training (TNF); emergency response program (EPLAN)	F2	B	B	C	E2	II	III

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3
1	H1S	TP	222S-222S-7	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to fire involving sample container (various) during shipping/receiving activities	Incompatible materials, gas generation, ignition source; maintenance activity with combustibles present ignites and involves container; handling equipment as a fuel source	Handling equipment design (OS, QA), fire extinguisher (FP)	Fire protection program (FP); housekeeping (CO); training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-222S-8	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to fire involving transportation vehicle	Equipment failure leads to release of fuel which ignites and involves container	Truck design (EPROTECT), fire extinguishers (FP)	Fire protection program (FP); housekeeping (CO); requirement for turning off vehicle when parked (CO); maintenance of vehicle (M); training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-222S-15	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to a fire that involves a waste drum outside of the hot cell during filling or handling	Waste drum that contains incompatible chemicals or that contains combustibles which are ignited	Room HVAC (RP); drum handling equipment design (RWP); waste package size limitations (RWP); drum design (RWP); fire protection system (FP)	Training (TNF); procedures (CO); fire protection program (FP)	F3	C	C	D	E1	III	IV
1	H1L	TP	222S-222S-28	Lab chemical and rad inventory; approximately 60 gal; 12 hoods (5.06 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to failure of flammable (propane) compressed gas cylinder or gas line in lab. Fire or explosion local to one lab.	Operator error; equipment failure; release of gas to lab room; ignition; fire or explosion	Gas cylinder design (OS); fire protection system (FP); building HVAC (RP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP); chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV
1	H1L	TP	222S-222S-38	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to a fire that involves a waste drum during filling or handling	Waste drum that contains incompatible chemicals or that contains combustibles which are ignited.	Room HVAC (RP); drum handling equipment design (RWP); waste package size limitations (RWP); drum design (RWP): building fire system (FP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP); chemical hygiene plan (IH)	F3	C	C	D	E1	III	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
1	H1S	TP	222S-222SD-2	Four drums per pallet. (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Waste drum design (RWP); handling equipment design (RP, ALARA, RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-222SD-5	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to localized fire	Combustible materials ignite; forklift fuel ignites	Waste box design (RWP); handling equipment design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-HS008-2	Four drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Waste drum design (RWP); handling equipment design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV
1	H1L	TP	222S-HS006-2	Up to four 55-gal drums per pallet. 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to localized fire during filling or handling	Combustible materials ignite; forklift fuel ignites	Waste drum design (RWM); handling equipment design (RP, OS)	Training (TNF); procedures (CO); fire protection program (FP)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-BP-2	Four drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to localized fire	Combustible materials ignite; forklift fuel ignites	Waste drum design (RWP); handling equipment design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV
1	H1S	TP	222S-BP-5	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to localized fire	Combustible materials ignite; forklift fuel ignites	Waste box design (RP, RWP); handling equipment design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
1	H1L	TP	222S-222SA-3	Four 1-gal containers packaged in a box (HNO_3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500-ml bottles/6 bottles per pkg.	Release of hazardous material to the environment from the loading dock due to fire during shipping/receiving activities	Incompatible materials, gas generation, ignition source; maintenance activity with combustibles present ignites and involves container; handling equipment as a fuel source	Handling equipment design (RP, OS): fire extinguishers (FP)	Fire protection program (FP); housekeeping (CO); training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	C	C	D	E1	III	IV
1	H1L	TP	222S-222SA-7	Up to four flammable liquid (60 gal/cabinet) cabinets plus two 20-gal flammable refrigerators. Adjacent containers of haz chemicals (20 gal HNO_3, 15 gal HCl, 10 gal H_2SO_4, NaOH, 30 lb miscellaneous oxidizers, small quantities of toxics)	Release of hazardous material to the environment due to fire in fume hood spreading to lab and 222-SA building	Flammable liquids ignited, electrical equipment/failure, pilot light instrument	Fire protection system (FP); portable fire extinguishers (FP); flammable storage cabinets (OS)	Max flammable quantity limit (OS); procedures (CO); training (TNF): Hanford Fire Department (FP); chemical hygiene plan (IH)	F3	B	C	D	E1	III	IV
1	H1L	TP	222S-222SA-13	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to localized fire during filling or handling	Human error; combustible materials ignite	Waste drum design (RWP); handling equipment design (RWP): fire protection system (FP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	C	D	E1	III	IV
1	H1L	TP	222S-219S-5	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to fire in 219-S	Electrical failure; ignition of plastics/ combustibles; vehicle impact causes fire	Storage tank design (RP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F2	C	C	D	E1	III	IV
1	H1S	TP	222S-222FB-2	Radioactive material on filter 5.41E-1 DE-Ci total	Release of radioactive material to environment due to release from HEPA filters due to fire	Vehicle impacts building and initiates fire; diesel spill during storage tank filling results in fire; flammable gas release (e.g., acetylene, propane) during delivery to 222S results in fire	Filter building design (RP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP); Hanford fire department (FP); DOT shipping requirements (RWP)	F2	C	C	D	E1	III	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	Consequence Categories: S2	Consequence Categories: S3	Consequence Categories: E	Risk Bins: S2	Risk Bins: S3
1	H1S	TP	222S-222SD-6	64 drums and 4 boxes (2.38 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to 222-SD area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Waste package design (RP, RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F2	C	C	D	E1	III	IV
1	H1S	TP	222S-HS008-4	176 drums (4.16 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Waste package design (RP, RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F2	C	C	D	E1	III	IV
1	H1G	TP	222S-HS006-4	Up to ten 55-gal drums of compatible chemicals per side, 20 total in storage unit	Release of hazardous material to the environment due to area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Waste drum design (RWP)	Training (TNF); procedures (CO); fire protection program (FP)	F2	C	C	D	E1	III	IV
1	H1S	TP	222S-BP-6	Total equivalent to 176 drums/boxes (4.16 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to "Bull Pen" area-wide fire	Forklift accident results in fire; vehicle accident; ignition of combustible materials	Waste package design (RP, RWP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F2	C	C	D	E1	III	IV
1	H1L	TP	222S-222S-25	30 g Pu (4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of hazardous and radioactive material to the fume hood, room, and environment due to fire inside fume hood.	Flammable liquids in hood; ignition source	Fume hood design and ventilation (RP)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	D	D	E0	IV	IV
1	H1S	TP	222S-222S-34	30 g of Pu (liquid or solid, 4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the glovebox and environment due to a fire in glovebox	Flammable liquids; ignition source	Glovebox design and ventilation (RP); glovebox fire protection system (FP, OS)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP)	F3	C	D	D	E0	IV	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
1	H1L	TP	222S-222SA-6	Two 1-gal containers of flammable liquids	Release of hazardous material to the environment due to fire or explosion in fume hood	Flammable liquids ignited, electrical equipment/failure, pilot light instrument	Fixed-head sprinkler system in each hood (FP, ALARA)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV
2X	M1L	PE	222S-219S-3	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to spray release	Operator error; equipment failure; structural failure	Transfer system design (RP)	Training (TNF); procedures (CO); maintenance (M)	F3	C	C	D	E1	III	IV
2	M1L	PE	222S-219S-7	700 gal NaOH	Release of hazardous material to environment due to release during filling NaOH tank during truck transfer operations	Human error; equipment failure	Transfer system design (RP); safety showers (RP, OS); temporary berm (EPROTECT); personnel protective equipment (OS)	Training (TNF); procedures (CO); industrial safety program (OS); fire protection program (FP), Hanford fire department (FP); chemical hygiene plan (IH)	F3	B	D	D	E1	IV	IV
2	M1L	PE	222S-219S-1	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to drop of cover block/roof panel on storage tanks	Operator error; equipment failure; structural failure	Handling equipment design (RP, OS)	Training (TNF); procedures (CO); maintenance (M); chemical hygiene plan (IH)	F2	B	C	D	E1	III	IV
2	L1L	PE	222S-219S-4	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to tank failure/leak (101, 102, 104)	Operator error; equipment failure; structural failure	Storage tank design (RP, EPROTECT); tank level monitors (RP, EPROTECT)	Training (TNF); procedures (CO); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E1	IV	IV
2	M1L	PE	222S-219S-6	700 gal NaOH	Release of hazardous material to environment due to failure/leak of NaOH tank (201)	Tank structural failure; vehicle impacts building	Storage tank design (RP, EPROTECT);	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV
2	L1L	PE	222S-219S-8	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material due to leak or valving error during sampling in the sampling gallery.	Human error; equipment failure	Hood design (RP)	Training (TNF); procedures (CO); industrial safety program (OS); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
2	L1L	PE	222S-207SL-1	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to spill during transfer	Operator error; equipment failure	Transfer system design (RP)	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	D	D	D	E1	IV	IV
2	L1L	PE	222S-207SL-2	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to failure of storage tanks	Operator error; equipment failure; structural failure	Storage tank design (ALARA, QA); tank level monitors (ALARA, EPROTECT)	Training (TNF); procedures (CO); maintenance (M)	F3	D	D	D	E1	IV	IV
2	L1L	PE	222S-207SL-3	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to the environment due to spill during sampling	Operator error; equipment failure	Sampling system design (RP, EPROTECT)	Training (TNF); procedures (CO)	F3	D	D	D	E1	IV	IV
2	L1L	PE	222S-219S-11	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to misrouting contents of 219-S tanks	Human error; equipment failure	Transfer system design (RP)	Training (TNF); procedures (CO)	F2	D	D	D	E2	IV	IV
3X	L1S	PE	222S-222S-5	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to sample container (various) drop/impact/crush/puncture during shipping/receiving activities	Operator error; equipment failure	Container design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP)	F3	C	C	D	E1	III	IV
3	M1L	PE	222S-222SA-1	Four 1-gal containers packaged in a box (HNO_3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500-ml bottles/6 bottles per pkg.	Release of hazardous material to the environment due to drop/impact/crush/puncture handling accident during receiving/shipping	Operator error, equipment failure, improper packaging, truck accident	DOT packaging (RWP)	Training (TNF), procedures (CO); industrial hygiene program (IH); emergency response (EPLAN), spill kits (OS); EPROTECT), safety shower (OS); EPROTECT); chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV
3	L1S	PE	222S-222S-1	Tank Farm core sample (one segment or less per cask, 5.2E-3 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to container drop/impact/crush/puncture during shipping/receiving activities	Operator error; equipment failure	Shipping container design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP, ALARA)	F3	C	C	D	E1	III	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
3	L1S	PE	222S-222S-2	PAS-1 Cask (~5.2E-2 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to PAS-1 Cask shipping container sample container (inner PAS-1 container) drop/impact/crush/puncture during shipping/receiving activities	Operator error; equipment failure	Crane/lifting equipment design (EPROTECT); shipping container design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP, ALARA)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-222S-3	Hardigg Case [Barney box] (~1.56E-2 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to Hardigg Case shipping container sample container drop/impact/crush/puncture during shipping/receiving activities	Operator error; equipment failure	Crane/lifting equipment design (EPROTECT); shipping container design (RWP)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP, ALARA)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-222S-4	Contents of a pig approximately 1.04E-2 DE-Ci	Release of radioactive and/or hazardous material to the environment from the loading dock due to pig drop/impact/crush/puncture during shipping/receiving activities	Operator error; equipment failure	Pig container design (RP, RWP)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP, ALARA)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-222S-10	Same as single containers in Shipping/ Receiving	Release of radioactive and/or hazardous material to the room and environment from the container due to container drop/impact/crush/puncture during hot cell loading activities	Operator error; equipment failure	Handling equipment design (RP, COO)	Training (TNF); procedures (CO); industrial safety program (OS); rad con program (RP, ALARA)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-222S-11	1.14 DE-Ci	Release of radioactive and/or hazardous material to the hot cell and environment from the container due to sample drop/impact/crush/puncture during hot cell activities (multiple samples involved)	Operator error; equipment failure	Hot cell structure (RP); HVAC & HEPAs (RP); negative dP (EPROTECT) handling equipment design (RP); sample bin design (RP, OS)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
3	L1L	PE	222S-219S-9	Sample size bounded by 30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to environment due to drop/impact/crush/puncture of a sample	Human error; equipment failure	Sample container design (RP, OS); handling equipment design (RP, OS)	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-222SD-1	Four drums per pallet. (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Waste drum design (RWP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
3	L1S	PE	222S-222SD-4	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to drop/impact/crush/puncture	Human error; equipment failure	Waste box design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-HS008-1	Four drums per pallet (1.32 DE-Ci)	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Waste drum design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
3	L1L	PE	222S-HS006-1	Up to four 55-gal drums per pallet. 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture during filling or handling	Human error; equipment failure	Waste drum design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	B	C	D	E1	III	IV
3	L1S	PE	222S-BP-1	Either one drum or box (8.3E-1 DE-Ci); four drums (1.32 DE-Ci); or total inventory (upper limit same as HS-0082 and HS-0083, 4.16 DE-Ci).	Release of radioactive and/or hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture	Human error; equipment failure	Waste drum design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
3	L1S	PE	222S-BP-4	One waste box at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to release from waste box due to drop/impact/crush/puncture	Human error; equipment failure	Waste drum design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
3	M1L	PE	222S-222SA-12	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to release from waste drum due to drop/impact/crush/puncture during filling or handling	Human error; equipment failure	Waste drum design (RWP, RP); handling equipment design (RP)	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	B	C	D	E1	III	IV
3	L1S	PE	222S-222S-13	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to a drop/impact/crush/puncture of a waste drum outside of the hot cell during filling or handling	Operator error; equipment failure	Room HVAC (RP); drum handling equipment design (RWP); waste package size limitations (RWP); drum design (RWP, RP, ALARA)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M)	F3	C	D	D	E0	IV	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
3	M1L	PE	222S-222S-16	Liter quantities of acids, bases, alcohol	Release of hazardous material to the room and environment due to a drop/impact/crush/puncture of a chemical container outside of the hot cell.	Operator error; handling equipment failure	Room HVAC(RP) ; handling equipment design (RWP) ; chemical package size limitations (OS)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV
3	M1L	PE	222S-222S-17	Liter quantities of acids, bases, alcohol	Release of hazardous material to the room and environment due to a drop/impact/crush/puncture of a chemical container inside of the hot cell.	Operator error; handling equipment failure	Hot cell design and ventilation (RP, OS); room HVAC (RP); handling equipment design ; (RWP); chemical package size limitations (OS)	Training (TNF); procedures (CO); tad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV
3	L1S	PE	222S-222S-21	30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to a sample drop/impact/crush/puncture in lab room.	Operator error; handling equipment failure	Equipment design (RWP, RWP); transport cart (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M)	F3	C	D	D	E0	IV	IV
3	L1S	PE	222S-222S-22	30 g Pu (4.95 DE-Ci)	Release of radioactive and/or hazardous material to the fume hood and environment due to a sample drop/impact/crush/puncture in fume hood	Operator error; handling equipment failure	Fume hood design and ventilation (RP, OS); equipment design (RWP) ; building structure and vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M)	F3	C	D	D	E0	IV	IV
3	M1L	PE	222S-222S-23	Gallon quantities of acids, bases, organics	Release of hazardous material to the room and environment due to drop/impact/crush/puncture of chemical container outside of fume hood	Operator error; handling equipment failure	Equipment design (RWP); transport cart (RPP); vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV
3	M1L	PE	222S-222S-24	Gallon quantities of acids, bases, organics	Release of hazardous material to the fume hood and environment due to drop/impact/crush/puncture of chemical container inside of fume hood	Operator error; handling equipment failure	Fume hood design and ventilation (OS); transport cart (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
3	L1S	PE	222S-222S-32	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the glovebox and environment due to a sample drop/impact/crush/puncture in glovebox	Operator error; equipment failure	Glovebox design and ventilation (RP); transport cart (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M)	F3	C	D	D	E0	IV	IV
3	L1L	PE	222S-222S-33	Gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the glovebox and environment due to a chemical container drop/impact/crush/ puncture in glovebox	Operator error; equipment failure	Glovebox design and ventilation (RP); transport cart (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV
3	L1L	PE	222S-222S-36	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to a drop/impact/ crush/puncture of a waste drum during filling or handling	Operator error; equipment failure	Room HVAC(RP) ; drum handling equipment design (OS); Waste package size limitations (RWP, RWP); drum design (RWP, RWP);	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV
3	M1L	PE	222S-222SA-4	Four 1-gal containers of hazardous material	Release of hazardous material to the environment due to drop/impact/crush/puncture of chemical container in single lab	Operator error, equipment failure, defective container	Safety shower (OS), eye wash (OS), room ventilation (RP); Personnel protective equipment (OS)	Training (TNF); procedures (CO); industrial safety program (OS); maintenance (M); emergency response (EPLAN); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV
3	M1L	PE	222S-222SA-5	Two 8-liter containers of hazardous material (Erlenmeyer)	Release of hazardous material to the environment due to drop/impact/crush/puncture of chemical container in fume hood	Operator error, equipment failure, defective container	Fume hood (RP), safety shower (OS), eye wash (OS), room ventilation (RP); personnel protective equipment (OS)	Training (TNF); procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M);emergency response (EPLAN); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV

Rep Acc	Rel Bin	Haz ID	Event ID	Material at Risk	Hazardous Condition	Candidate Causes	Defense in Depth: Engineered Features	Defense in Depth: Administrative Controls	Freq Cat	Consequence Categories: S1	S2	S3	E	Risk Bins: S2	S3
4X	M1S	PE	222S-222S-6	30 g of Pu (liquid or solid, 4.95 DE-Ci)	Release of radioactive and/or hazardous material to the environment from the loading dock due to sample container (various) overpressurization during shipping/receiving activities	Incompatible materials; gas generation	Container design (RP, ALARA, EPRTOTECT)	Training (TNF); Procedures (CO); rad con program (RP); industrial safety program (OS); maintenance (M)	F3	B	C	D	E1	III	IV
4	M1L	PE	222S-HS006-3	One 55-gal drum containing 15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three.	Release of hazardous material to the environment due to failure of waste drum from overpressure during handling	Incompatible materials; gas generation	Waste drum design (RWP); personnel protective equipment (OS)	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV
4	M1L	TE	222S-219S-10	10% of rad inventory per tank pH .5 then treat to pH 12.5 (3.91 DE-Ci). Acid (HNO_3 assumed bounding chemical)	Release of radioactive and/or hazardous material to environment due to inadvertent mixing of chemicals and tank overpressurization	Operator error, valve failure, equipment failure	Filters/vent system (RP, EPLAN), transfer system design, tank design (EPLAN)	Training (TNF); procedures (CO)	F3	C	C	D	E1	III	IV
4	M1S	PE	222S-222SD-3	One drum at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Waste drum design (RWP)	Training (TNF); procedures (CO)	F3	B	C	D	E1	III	IV
4	M1S	PE	222S-HS008-3	One drum at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Waste drum design (RWP)	Training (TNF); procedures (CO)	F3	B	C	D	E1	III	IV
4	M1S	PE	222S-BP-3	One drum at 8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the environment due to failure of waste drum from overpressure	Incompatible materials; gas generation	Waste drum design (RWP)	Training (TNF); procedures (CO)	F3	B	C	D	E1	III	IV
4	M1L	PE	222S-222SA-2	Four 1-gal containers packaged in a box (HNO_3, NaOH, methylene chloride, hexane) and adjacent containers; HF, HBr, H_2SO_4, fuming HNO_3 in 500-ml bottles/6 bottles per pkg	Release of hazardous material to the environment from the loading dock due to chemical container overpressurization during shipping/receiving activities	Incompatible materials; gas generation	Container design (RWP); protective equipment (OS)	Training (TNF); procedures (CO); industrial hygiene (IH); chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV
4	M1L	PE	222S-222SA-14	15-gal and 1-gal containers of compatible acids, bases, alcohol in 55-gal drum. A drum contains acids or bases or alcohols but only one of the three	Release of hazardous material to the environment due to failure of waste drum from overpressure during handling	Human error; incompatible materials; gas generation	Waste drum design (RWP, RWP); protective equipment (OS)	Training (TNF); procedures (CO); industrial hygiene (IH); chemical hygiene plan (IH)	F3	A	C	D	E1	III	IV

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4	M1S	PE	222S-222S-14	8.3E-1 DE-Ci	Release of radioactive and/or hazardous material to the room and environment due to waste drum overpressurization outside of the hot cell during handling	Incompatible materials, gas generation	Room HVAC (RP); drum handling equipment design (OS; waste package size limitations (RWP); drum design (RWP)	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	A	D	D	E0	IV	IV
4	M1L	PE	222S-222S-37	8.3E-1 DE-Ci; organic labpacks	Release of radioactive and/or hazardous material to the room and environment due to waste drum overpressurization during handling	Incompatible materials, gas generation	Room HVAC(RP); drum handling equipment design (OS; waste package size limitations (RWP); drum design (RWP)	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	A	D	D	E0	IV	IV
4	M1L	TE	222S-222SA-11	Two 8-liter containers of hazardous material (Erlenmeyer)	Release of hazardous material to the environment due to inadvertent mixing of incompatible chemicals	Operator error, equipment failure	Room ventilation (OS)	Training (TNF); procedures (CO); chemical hygiene plan (IH)	F3	B	D	D	E0	IV	IV
5X	M1L	PE	222S-222S-26	Multiple hood damage; (up to six hoods or 5.00 DE-Ci); 30 gal chemical inventory	Release of radioactive and/or hazardous material to the room and environment due to failure of compressed gas cylinder in lab resulting in a missile	Operator error; cylinder valve failure; cylinder handling error	Gas cylinder design (OS);	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	A	C	D	E1	III	IV
5X	M1S	PE	222S-GD-1	222S inventory potentially impacted. Filter Building 222-SE. 5.41E-1 DE-Ci	Release of radioactive and/or hazardous material due to failure of pressurized gas cylinder resulting in missile	Human error; equipment failure	Gas cylinder design (OS) ;	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	C	C	D	E1	III	III
5	M1L	PE	222S-222SA-8	60-gal cabinet assumed impacted	Release of hazardous material to the room and environment due to failure of compressed gas cylinder in lab resulting in a missile	Operator error; cylinder valve failure; cylinder handling error	Gas cylinder design (OS) ;	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	A	C	D	E1	III	IV
5	L1S	PE	222S-222S-18	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due errors or equipment failures during maintenance of manipulators	Operator error; handling equipment failure	Equipment design (OS) Transport cart (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con (RP); industrial hygiene (IH)	F3	B	D	D	E0	IV	IV
5	L1S	KE	222S-222S-19	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to failure of hot cell viewing window	Extruder failure; manipulator failure	Extruder design (OS) hot cell design (RP, RWP); vent system (RP)	Training (TNF); procedures (CO); rad con (RP); industrial hygiene (IH)	F3	C	D	D	E0	IV	IV
5	L1S	EE	222S-222S-20	Loose contamination in room (up to 1.04E-2 DE-Ci)	Release of radioactive and/or hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	HVAC system design (RP); backup diesel exhaust fan (RP)	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	C	D	D	E0	IV	IV

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5	L1S	KE	222S-222S-35	30 g of Pu (liquid or solid, 4.95 DE-Ci); gallon quantities of acids, bases, organics	Release of radioactive and/or hazardous material to the room and environment due failure of glove or glovebox window in glovebox	Operator error; equipment failure	Glovebox design and ventilation (RP); transport cart (RP, Radioactive Waste Management, RWP); vent system (RP)	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	C	D	D	E0	IV	IV
5	L1S	EE	222S-222S-39	Loose contamination in fume hoods/glove boxes (up to 1.04E-2 DE-Ci). High vapor pressure chemicals.	Release of radioactive and/or hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	HVAC system design (RP); backup diesel exhaust fan (RP)	Training (TNF); procedures (CO); industrial hygiene (IH); maintenance (M)	F3	C	D	D	E0	IV	IV
5	L1S	PE	222S-222FB-1	Radioactive material on filter 5.41E-1 DE-Ci total	Release of radioactive material to environment due to failure of HEPA filters during replacement/maintenance	Human error; equipment failure	Filter handling equipment design (RP)	Training (TNF); procedures (CO); industrial hygiene (IH)	F3	C	D	D	E0	IV	IV
5	L1G	EE	222S-222SA-15	High vapor pressure chemicals	Release of hazardous material to the room and environment due to ventilation system failure	HVAC failure; loss of power	HVAC system design (RP)	Training (TNF); procedures (CO); industrial hygiene (IH); maintenance (M); chemical hygiene plan (IH)	F3	C	D	D	E0	IV	IV
5	M1L	PE	222S-207SL-4	Normally building waste water. Potential for low levels of radioactive or chemical contamination	Release of radioactive and/or hazardous material to environment due to drop of cover block on retention basin	Operator error; equipment failure; structural failure	Handling equipment design (RWP)	Training (TNF); procedures (CO); industrial hygiene (IH); maintenance (M)	F2	D	D	D	E1	IV	IV
6	L1S	NPH	222S-NP-6	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to flood	Flood			F0	D	D	D	E0	IV	IV
6	H1S	NPH	222S-NP-1	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to beyond design basis seismic event	Seismic event	Facility design (RP); container design (RWP, ALARA)	Procedures(TNF); training (CO); emergency response program (EPLAN)	F1	A	B	C	E2	III	IV
6	H1S	NPH	222S-NP-5	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to air plane crash	Airplane crash	Facility design (RP); container design (RWP, ALARA)	Procedures (TNF); training (CO); emergency response program (EPLAN)	F1	A	B	C	E2	III	IV
6	M1S	NPH	222S-NP-2	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to extreme winds	Extreme winds	Facility design (RP); container design (RWP, ALARA)	Procedures (TNF); training (CO); emergency response program (EPLAN)	F2	A	C	D	E1	III	IV
6	M1S	NPH	222S-NP-3	39.11 DE-Ci building inventory; building chemical inventory (bound by 5 times 222-SA)	Release of radioactive and/or hazardous material to the environment due to volcanic ash/heavy snowfall	Volcanic ash or heavy snowfall	Facility design (RP); container design (RWP, ALARA)	Procedures(TNF); training (CO); emergency response program (EPLAN)	F2	A	C	D	E1	III	IV

KEY	**As Low As Reasonably Achievable (ALARA)**	**Maintenance (M)**
	Configuration Management (CM)	**Industrial Safety (OS)**
	Conduct of Operations (CO)	**Occupational Safety (OS)**
	Emergency Planning (EPLAN)	**Quality Assurance (QA)**
	Environmental Protection (EPROTECT)	**Radiation Protection (RP)**
	Fire Protection (FP)	**Radioactive Waste Management (RWM)**
	Industrial Hygiene (IH)	**Training for Nuclear Facilities (TNF)**