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ABD-WFM-005, R.2.1

Basis for Interim Operation for Waste Characterization, Reduction, and Repackaging Facility (WCRRF)

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Revision Log for the WCRRF BIO

Rev. No.	Description of Change	Affected Pages	Submittal to NNSA LASO Date	NNSA LASO Approval Date
0	Original Issue	All	04/23/07	04/25/07
1	Annual Update	All	04/25/08	
1.1	Page changes pertaining to FSS freeze protection (Addendum 1) and HEPA filter efficiency (Addendum 2)		1/29/10 FSS freeze protection 3/23/10 HEPA	3/16/10 FSS freeze protection 5/3/10 HEPA
1.2	Page changes to allow lnstallation of Fire Suppression Sprinkler in the Waste Characterization Glovebox and Relocation of the Building 50-82 Transformer, including: Changed title of FireSuppression System from "Building 50-69 Fire Suppression System" to "Building 50-69 and WCG Fire Suppression System." Changed descriptions of the Fire Suppression System to include the WCG sprinkler head and consequences of activation. Added hazard introduced by water pressure within the WCG Added two hazard scenarios related to activation of the WCG sprinkler head. Changed consequences of relevant hazard scenarios to reflect Activation of the WCG sprinkler head. Changed the safety function of the Fire Suppression System to reflect the WCG sprinkler head Changed scenario development for Operational Fires Inside Building TA-50-69, Case 1 (3.4.2.3.1) to reflect activation of the WCG sprinkler head. Changed Function requirements for the Fire Suppression System to reflect the WCG Sprinkler	ES viii,3-503-52,3A-97, 3A-98, 3A-99,3A-104, 3A-106, 3A-109, 3A-118, 3A-129,3A-136,4-1, 4-2, 5-4, 4-11, 4-12 2-14,2-18,2-19, 4-11,4-12 3A-79 3-42, 3A-91, 3A-130, 3A-131 3A-119, 3A-128 3-54,4-2,4-11,4-12, 5-4 3-85 4-12,4-13	9/2/2010	10/5/2010

Rev. No.	Description of Change	Affected Pages	Submittal to NNSA LASO Date	NNSA LASO Approval Date
1.3	Page changes to Chapters 3, 4, 5, and Appendix 3A to clarify the combustible control limits and exclusions: • Clarified that flammable and combustible liquid restrictions were intended to reduce the possibility of spontaneous combustion as an initiating event for a fire. Class IIIB liquids, which have a flashpoint far above room temperature, are not easily ignited and were not the focus of this control. • Documented the combustible control exclusions for listed material and equipment.	3-28, 3-31, 3-39, 3-56, 3-60, 3-81 4-40, 4-41, 4-42, 4-43 5-12, 5-13, 5-26, 5-27, 5-28 3A-74, 3A-86, 3A-117	1/12/2011	1/14/2011
2.0	Annual update (including roll-up of previously approved page changes, and addressing adjustments to the controls as credited in the Hazard and Accident Analyses and other clarifications in response to comments from the DOE review of the annual update of the WCCR BIO). The combustible loading control for waste staged outside of Building 50-69 was changed from the control implemented as an element of the Fire Protection Program to a control implemented as part of an LCO. The former limited combustibles within 10 ft of TRU waste containers, and the latter limits combustibles within 10 ft of transportainers, because the waste staging control requires TRU waste containers staged outside to be placed in transportainers.	All *Except Appendices 3C, 3D, 3E*	11/3/2010 and 1/20/2011 for incorporation of Rev 1.3 page changes per direction of letter COR-SO-1.13.2011-315245	5/27/2011

Rev. No.	Description of Change	Affected Pages	Submittal to NNSA LASO Date	NNSA LASO Approval Date
2.1	Page changes to address a proposed increase in the building inventory limit from 300 PE-Ci equivalent combustible waste to 800 PE-Ci equivalent combustible waste (as analyzed in the Hazard Analysis, Appendix 3A). The increase is necessary to permit the characterization and repackaging of higher activity waste containers from Area G. The affected accident scenario consequences (fire inside, seismic & fire, and deflagration) were updated to reflect the change in MAR for the building. Page changes to clarify exhaust flow information for GBE and WCG confinement ventilation system and associated HEPA filter temperatures (as required by SER-WCRRF-ESS-11-001, Rev 0). The Lightning Protection System (LPS) was changed from a credited design feature to a defense-in-depth system (maintained according to NFPA 780 requirements through the Maintenance Program) because the LPS cannot provide a factor of 100 reduction in frequency as appropriate for a credited SSC. The combustible control SAC was expanded to include limitations inside (in addition to those within 10 ft of the outside) of transportainers (as required by COA #3 in SER WCRRF.01, Revision 1). The FSS safety function and functional requirement wording was edited to improve consistency between Chapters 3, 4, and 5. Update of UPS and HVAC equipment descriptions in Chapter 2 to reflect design changes that did not result in an Unreviewed Safety Question. The transportainer was removed as a design feature because it only provides defense-in-depth and was not credited with any accident mitigation (i.e., reduction in damage ratio or other source term parameter). Credited SACs were retained to require placement and use of transportainers for staging of TRU waste containers, and control of combustibles in and around the transportainers.	Exec Summary, Ch. 2. Ch 3, Ch. 4, Ch. 5, and Appendix 3A and Appendix 3B have text changes. *All other chapters have header date change only.*		

Rev. No.	Description of Change	Affected Pages	Submittal to NNSA LASO Date	NNSA LASO Approval Date
	The electrical distribution system was removed as a safety-significant support system as it is only required to provide normal power to the containment ventilation system, when available. Availability of electrical power is not a requirement for the successful achievement of the confinement ventilation systems' safety function to mitigate the release of MAR in conjunction with the confinement provided by the building's structural integrity. The 40ºF temperature interlock discussion in Chapter 4 was clarified. The containment ventilation interlock secures building supply air to minimize the introduction of cold air into the building but it does not start the thermostatically-controlled attic heaters. A new SAC was developed and described in Chapter 4 to address the note before Table 3A-20 concerning the prohibition of staging or processing of waste within the GBE (as required by SER-WCRRF-ESS-11-002, Rev 0). A new table with collocated worker chi/Q values and a reference to the LANL calculation was added to Appendix 3B. In Chapter 3 and Appendix 3A, Moderate and Low consequence EG values for collocated workers were revised to match DOE-STD-5506, Table 6.2-1. Retained A and B consequences were replaced with DOE-STD-5506 consequence bin names (as required by COA #1 in SER WCRRF.01, Rev.1). Confinement Ventilation System text in Chapters 3, 4, and 5 was modified to address assessment findings (as required by COA #4 in SER WCRRF.01, Revision 1). For consistency, the header date was changed on all pages.			

EXECUTIVE SUMMARY

E.1 FACILITY BACKGROUND AND MISSION

The Waste Characterization, Reduction, and Repackaging Facility (WCRRF) was constructed in the mid-1980s with an initial mission to sample, examine, characterize, reduce the volume, and repackage a variety of transuranic (TRU) wastes. The WCRRF mission has been identified as critical for the National Nuclear Security Administration (NNSA) and Los Alamos National Laboratory (LANL) to meet a New Mexico Consent Order requirement to close Technical Area (TA)-54 as a TRU waste storage site by 2015.

The WCRRF operations are carried out in Building TA-50-69 and in outdoor waste staging areas. Building TA-50-69 and the outdoor waste staging areas comprise the WCRRF site. Building TA-50-69 is used primarily for waste remediation and repackaging activities, specifically in the waste characterization glovebox (WCG).

The Building TA-50-69 structure is rated at Performance Category (PC) 2 for seismic, wind, and snow. It is the only nuclear facility at LANL that has a ready capability to remediate or repackage several above-ground TRU waste containers with material-at-risk (MAR) greater than 56 plutonium-239 equivalent curies (PE-Ci). This requires that Building TA-50-69 be raised to Hazard Category (HC) 2 to manage these specific waste containers.

The remediation or repackaging of TRU waste drums with MAR greater than 56 PE-Ci enables their shipment to WIPP, resulting in a reduction of close to 33,000 PE-Ci from the above-ground inventory at TA-54, Area G. This remediation or repackaging also results in a significant reduction of risk to the public caused by dose consequences related to the current Area G radioactive waste inventory. In fiscal year (FY) 2007, under the safety basis in this BIO, TRU waste containers with more than 18,000 PE-Ci have been remediated in the WCRRF waste characterization glovebox in preparation for their shipment to WIPP.

Other options to manage the above-ground TRU waste containers with MAR greater than 56 PE-Ci involve major building upgrades to available waste management facilities. These upgrades would require a significant amount of time and result in a failure to meet the New Mexico Consent Order deadline of 2015, hence the dependence on a risk-based strategy for the WCRRF safety basis, i.e., low public risk for WCRRF operations as a HC-2 facility balanced against significant reduction in public risk by removing large quantities of MAR from TA-54, Area G.

Work activities at the WCRRF are managed by the Environmental and Waste Management Operations (EWMO) Division. The remediation or repackaging of current above-ground, high-activity TRU waste containers is expected to be complete within a year.

The WCRRF mission to support the closure of TA-54 is expected to be complete by 2012. Therefore, the WCRRF is considered a limited-life facility. Because of this limited time period, a basis for interim operations (BIO) has been prepared. The DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis,* is used as the safe harbor for the preparation of this documented safety analysis (DSA) and is consistent with DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*. The approach to the development of this DSA is in accordance with Section 10 of the Code of Federal Regulations (CFR), Subpart 830, *Nuclear Safety Management*.

E.2 FACILITY OVERVIEW

The WCRRF is located in the northwest corner of TA-50 in the LANL complex. The facility is south of Pecos Drive, across from TA-55 and west of Building TA-50-37 (the Actinide Research and Technology Instructional Complex Facility). The WCRRF is comprised of Building TA-50-69 and a partially fenced, partially paved outside yard containing support facilities, equipment, and TRU waste container (transportainer) staging areas.

Building TA-50-69 is a small, one-story building; waste repackaging and remediation activities occur in the WCG. Another walk-in glovebox enclosure (GBE) is also present in Building TA-50-69 and is under ventilation. This BIO does not support any process operations in the GBE, although the GBE must be considered in and of itself because its ventilation system is tied to the WCG. A vehicle airlock is used to move waste containers and equipment to and from the building. Transportainers are used to stage waste containers in the WCRRF outside yard.

Utilities (electricity and water) are provided to the WCRRF from Laboratory infrastructure support systems. Los Alamos County provides fire department services through a formal memorandum of understanding. Full medical facilities and a hospital are within a five-minute drive.

E.3 FACILITY HAZARD CATEGORIZATION

To accomplish repackaging of TRU waste containers with MAR greater than 56 PE-Ci, the final Hazard Category (HC) for the entire WCRRF for the duration of this BIO must be HC-2, in accordance with DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* Segmentation is not relied upon to achieve this Hazard Category.

E.4 SAFETY ANALYSIS OVERVIEW

The hazard evaluation considered both outdoor and indoor operations at the WCRRF, which include TRU waste container receipt, staging, transfer to Building TA-50-69, processing (remediation), and repackaging. To manage the TRU waste containers with MAR > 56 PE-Ci, operations at the WCRRF occur under two administratively controlled MAR limits as follows:

Table ES-1. Administrative MAR Limits

Total Site[1]	Building TA-50-69
1,800 PE-Ci	800 PE-Ci of equivalent combustible waste

The total site MAR was chosen by engineering and operations management after balancing

- The throughput of waste containers that must be processed at WCRRF to achieve maximum operational efficiency while limiting the number of road transfers of waste containers between TA-54, Area G, and WCRRF, and,

[1]The total WCRRF MAR limit of 1800 PE-Ci is the summation of the MAR outside and inside Building TA-50-69 based on a TRU waste container PE-Ci content, regardless of waste matrix.

- The throughput needed to meet repackaging campaign goals to support the successful completion of the shipment of TRU waste out of TA-54, Area G, by 2012.

The MAR limit of 800 PE-Ci of equivalent combustible waste is chosen based on the inventory of waste containers > 56 PE-Ci with mainly combustible material. The unit of equivalent combustible waste is used to take advantage of the differences in the airborne release and respirable fractions for different waste matrices in the consequence analysis. Rather than establish and track inventory limits for each type of contaminated waste material, a conversion factor is developed that equates the inventory of the different types of material to a combustible waste form, so that for implementation a MAR radiological inventory limit of800 PE-Ci of equivalent combustible waste is used. The combustible equivalency is based on the amount of TRU waste in a particular waste matrix (e.g., noncombustible or filter media inventory) that would result in the same dose consequence resulting from an inventory of 800 PE-Ci combustible waste for the bounding accident scenario.

From the hazards analysis, nine accident scenarios were selected for detailed analysis as design-basis accidents. On the presumption that the MAR limits are entirely based on combustible material, the resulting dose to the maximally exposed off-site individual (MEOI) according to the accident analysis is as follows:

Table ES-2. WCRRF BIO Design-Basis Accidents/Results of Consequence Analysis

Design-Basis Accident (DBA)		MAR (PE-Ci)	Unmitigated MEOI Dose (rem)
1. Operational Fires Outside Building TA-50-69 Involving Ordinary Combustibles		1,800	3.2 rem
2. Operational Fires Outside Building TA-50-69 Involving Liquid Fuel Pool Fires		1,800	64.3 rem
3. Operational Fires Inside Building TA-50-69			
Case 1: Fire in Main Process Area		800	3.7 rem
Case 2: Fire in WCG		800	28.3 rem
4. Drum Deflagration		800	1.5 rem
5. Loss of Confinement / Containment		1,800	0.6 rem
6. Seismic and Fire			
Case 1: All MAR Outside	Outside Seismic Impact and Fire	1,800	7.0 rem
Case 2: Waste Containers in Main Process Area in Building TA-50-69	Inside Seismic Impact and Fire	800	3.1 rem
	Outside Seismic Impact and Fire	1000	3.9 rem
Case 3: Waste Contents in WCG	Inside Seismic Impact and Fire	800	3.1 rem
	Outside Seismic Impact and Fire	1000	3.9 rem
7. Wildfire		1,800	3.2 rem
8. Lightning Strike and Fire *(Bounded by DBA No. 3, Case 2)*		800 - 1,800	28.3 rem
9. Airplane Crash		1,800	64.3 rem

As shown in Table ES-2, DBA No. 2, *Operational Fires Outside Building TA-50-69 Involving Liquid Fuel Pool* (64.3rem), DBA No. 3, *Operational Fires Inside Building TA-50-69, Case 2 Fire in WCG* (28.3 rem), and DBA No. 9, *Airplane Crash* (64.3 rem), result in unmitigated doses to the MEOI that

exceed the Evaluation Guideline (EG) of 25 rem when conservatively assuming that the heat from the associated fuel pool fires does not cause beneficial lofting of the plume. Safety-class (SC) controls have been selected to prevent or mitigate the consequences from DBA No. 2 and DBA No. 3 for protection of the public. For DBA No. 9, no safety controls will prevent or mitigate the consequences of an airplane crash.

The selected safety-class controls are comprised of both engineered controls and several specific administrative controls (SACs).

Additional safety-significant controls for defense-in-depth and worker protection also include engineered controls and SACs.

The following SSCs are identified as being the most important to safety for operations at the WCRRF:

- Vehicle barriers (SC)
- TRU waste containers (safety-class DF outside/SS-DF inside Building TA-50-69)
- Building TA-50-69 and WCG fire suppression system (SS)
- Building TA-50-69 structural integrity (SS)
- Building TA-50-69 confinement ventilation system (SS)
- WCG confinement ventilation system (SS)
- Waste characterization glovebox (SS)
- Waste characterization glovebox drum lift (SS)
- Uninterruptible Power Supply (SS Support

The following SACs are also identified as being the most important to safety:

- Combustible Loading Control (SC/LCO)
- Hotwork prohibition (SS)
- Vehicle fuel restrictions (SC)
- TRU waste container inspection (SS)
- TRU waste container staging practices (SS)
- Inventory limits (SC)
- Transportainer placement (SC)
- TRU waste containers staged in transportainers (SS)
- Vehicle access system (SC)
- Diesel generator refueling exclusion (SC)
- Critical lift (SS)
- Use of drum lid restraints when breaching unvented, sealed 30- to 5-gallon waste packages in WCG (SS)
- Use of nonsparking tools and processes/de-energization of WCG electric receptacles when breaching unvented, sealed waste packages in the WCG (SS)
- Grounding waste packages before breaching unvented, sealed waste packages (SS)
- Prohibit storage, staging, or processing of inventory within the confines of the Glovebox Enclosure (GBE) (SS).
- Extra Fire Controls for High-MAR Processing in WCG

E.5 SAFETY ANALYSIS CONCLUSIONS

The safety analysis used a very conservative approach to assess risks and consequences. When carried out using the controls developed from the hazard evaluation and the accident analysis, the operations and processes defined in this BIO provide a compliant safety basis for WCRRF operations. The controls also allow for the safe operation of WCRRF repackaging operations in support of TRU waste removal from TA-54, Area G, by 2012 and the fulfillment of New Mexico Consent Order requirements to close TA-54, Area G, by 2015.

E.6 DSA ORGANIZATION

This BIO consists of six chapters and a set of Technical Safety Requirements that are prepared in conformance with a graded approach as provided in DOE-STD-3009-94 for a facility with a limited lifetime.

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1.0 SITE CHARACTERISTICS

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Acronyms and Abbreviations

ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BIO	Basis for Interim Operation
CFR	Code of Federal Regulations
DOE	Department of Energy
FHA	Fire Hazards Analysis
IBC	International Building Code®
JCO	justification for continued operation
LAM	Los Alamos County Airport
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
MCE	Maximum Considered Earthquake
MDA	Material Disposal Area
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NPH	natural phenomena hazard
OLASO	Office of Los Alamos Site Operations
PC	Performance Category
PF	Plutonium Facility
PGA	peak ground acceleration
RCRA	Resource Conservation and Recovery Act
SWEIS	Site-Wide Environmental Impact Statement
TA	Technical Area
WCRRF	Waste Characterization, Reduction, and Repackaging Facility

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1.0 SITE CHARACTERISTICS

1.1 INTRODUCTION

This chapter describes the general site characteristics of Los Alamos National Laboratory (LANL or the Laboratory) and gives specific descriptions for Technical Area (TA) 50, where the Waste Characterization, Reduction, and Repackaging Facility (WCRRF) is located.

The Laboratory is an existing site administered by the National Nuclear Security Administration (NNSA) in the Department of Energy (DOE) and is operated by Los Alamos National Security LLC. Operations at LANL began in 1943. The WCRRF site at TA-50 is located within LANL boundaries. A *Site-Wide Environmental Impact Statement* (SWEIS, DOE 2008, 2009) assessed potential cumulative environmental impacts associated with previous, known, future, and continuing activities at LANL.. The SWEIS provides detailed environmental information on the Los Alamos area.

In this chapter, the general LANL site characteristics are summarized from the SWEIS and other documents. Site-specific information for TA-50 and the area of WCRRF operations is provided to support and clarify those assumptions used in the hazard analysis. Of particular importance is the information used to support the identification and analysis of potential external and natural phenomena hazards (NPH), accident initiators, and accident consequences external to the facility.

1.2 REQUIREMENTS

The WCRRF Basis for Interim Operation (BIO) was developed in accordance with Title 10 of the Code of Federal Regulations (CFR), Part 830, *Nuclear Safety Management* (CFR 2003), which requires the contractor responsible for a DOE nuclear facility to analyze the facility, the work to be performed, and the associated hazards, and to identify the conditions, safe boundaries, and hazard controls necessary to protect workers, the public, and the environment from adverse consequences. DOE G 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830* (DOE 2001), was used as the basis for compliance with 10 CFR 830. DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002a), was followed in developing this BIO and will serve as the safe harbor as described in 10 CFR 830. DOE Order 420.1B, *Facility Safety* (DOE 2005), was used to establish facility safety requirements related to nuclear safety design, criticality safety, fire protection, and NPH mitigation.

The following standards were prepared to implement the NPH mitigation requirements of DOE Order 420.1B:

- DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities* (DOE 2002b);
- DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components (DOE 2002c);
- DOE-STD-1022-94, *Natural Phenomena Hazards Site Characterization Criteria* (DOE 2002d); and
- DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria* (DOE 2002e).

1.3 SITE DESCRIPTION

This subsection describes the LANL site, with appropriate emphasis on TA-50, the site boundaries, and areas beyond the boundaries that could be affected by the release of hazardous materials from the WCRRF that could affect the WCRRF and its operations.

1.3.1 Geography

1.3.1.1 Location

The Laboratory is located in Los Alamos County in northern New Mexico (Fig. 1-1), about 56 km (35 mi) by highway from Santa Fe. It is 32 km (20 mi) from those populated areas that are outside the supporting communities of Los Alamos and White Rock. The general area is known as the Pajarito Plateau, a deeply eroded flank of the Jemez Mountains draining to the Rio Grande, which is 16 km (10 mi) to the east. The terrain is dominated by a series of finger-shaped mesas separated by canyons, many of which are several hundred feet deep.

The Laboratory technical areas are generally located in the area bounded by State Roads 4, 501, and 502 (Fig. 1-2). TA-50 lies at a lower elevation than these areas, off the east side of Pajarito Road and closer to the eastern site boundary.

1.3.1.2 Local and Regional Transportation Routes

The major transportation routes to LANL are the highways and the Los Alamos County Airport (LAM). The highways that pass through or border LANL boundaries include State Roads 4, 501, and 502. The only local access road to TA-50 is Pajarito Road, about 150 m (500 ft) from the WCRRF.

Located approximately 3 km (1.9 mi) northeast of TA-50, LAM has a single runway running from east to west that handles a low number of small commercial and private flights. Because of local conditions and air space restrictions over the LANL site, all air traffic enters from and exits to the east. The west end of the runway is typically used for run-ups or taxiing.

Data for numbers of aircraft operations at LAM were obtained from the U.S. Department of Transportation Federal Aviation Administration's Airport Master Record for the Los Alamos County Airport (GCR 2004). The current traffic tally for the commercial air taxi is 1,500 total takeoffs and landings per year (750 takeoffs and 750 landings). General aviation traffic totals 18,500 takeoffs and landings per year (9,250 takeoffs and 9,250 landings), and helicopter traffic involves 95 operations per year.

1.3.1.3 Industrial Structures and Nearby Facilities

TA-50 has no nearby industrial facilities except for the LANL technical areas, which are depicted in Fig. 1-2. As shown in this figure, the closest technical areas to TA-50 that house various laboratories and test facilities are TA-35 and TA-55. A private, non-LANL entity, Spectra Gases Inc., operates a stable isotope production facility called Isotopes of Carbon, Oxygen, and Nitrogen (ICON) on leased LANL space in TA-46, approximately 2.4 km (1.5 mi) from the WCRRF. Figure 1-3 is a partial site map of TA-50 which shows the WCRRF facility boundary, Building TA-50-69 (Bldg. WM-69 on Figure 1-3), and other structures in the immediate vicinity of TA-50-69. Bldgs. 75 and 194 are transportainers where TRU waste containers are staged; Bldg. 54 is a machine shop; Bldg. WM-84 is a portable office trailer; Bldg. 189 is a Morgan shed; Bldg. 241 is a cargo container; Bldg. 187 is a storage shed; Bldg. 191 is a generator; Bldg. 50-196 is a portable office trailer; and Bldg. 37 is the Arctic Facility. Section 1.7 *Nearby Facilities* cites the facilities in the immediate vicinity of the WCRRF Building TA-50-69, as well as other buildings or facilities near the WCRRF.

1.3.1.4 Exclusion Areas

The DOE controls the area within LANL boundaries and can completely restrict access. The Laboratory has a dedicated emergency response organization and a protective force capable of controlling Laboratory roads available to the public. Limited access by the public is allowed in certain areas of the LANL site. The public was previously allowed access to Pajarito Road (see Fig. 1-2), but it is now closed to the public and will not be reopened for public access in the foreseeable future. The definition of "Site Boundary" contained in DOE-STD-3009-94 (DOE 2006) includes the following statement: "A public road traversing a DOE site is considered to be within the DOE site boundary if, when necessary, DOE or the site contractor has the capability to control the road during accident or emergency conditions." Based on this definition, these roads are within the LANL site. In contrast, roads are not considered within the LANL site but are part of the site boundary if civilian residences are present and evacuation would involve these residents (e.g., East Jemez Road; LASO 2002). All commercial ventures and municipal operations on LANL property are subject to LANL lease agreements and evacuation procedures; thus, they are not considered public receptors. The Laboratory recently addressed changes to the Los Alamos Site Office (LASO) Site Boundary Policy (NNSA 2006) as a result of land transfers and attendant changes in off-site doses to the public. As of October 17, 2006, the NNSA approved the LASO Site Boundary Policy and its impact on the Safety Basis for the LANL Nuclear Facilities (NNSA 2005).

1.3.2 Demography

In 2000, Los Alamos County had a population of 18,343 (Census Bureau 2000). The Los Alamos town site, including the original area of development and the residential areas known as Eastern Area, Western Area, North Community, Barranca Mesa, and North Mesa, had an estimated population of 11,900. The White Rock area, which includes the residential areas of White Rock, La Senda, and Pajarito Acres, had about 6,100 residents.

Approximately 40% of the people employed at Los Alamos commute from other counties. About 12,500 people work at LANL, with about 75% of them working within 4.8 km (3 mi) of the WCRRF. Population estimates for 2000 place about 264,000 persons within an 80-km (50-mi) radius of Los Alamos.

1.4 ENVIRONMENTAL DESCRIPTION

This section provides information on area meteorology, hydrology, and geology that is pertinent to this Documented Safety Analysis. The information presented here was used to define the regional natural phenomena of concern for facility operation and accident assessment modeling. Much of the information is described in *Environmental Surveillance at Los Alamos during 2002* (LANL 2004).

1.4.1 Meteorology

Los Alamos County has a semiarid, temperate mountain climate. A detailed discussion of the climate of the county, including frequency analyses of extreme events, can be found in *Environmental Surveillance at Los Alamos during 2002* (LANL 2004).

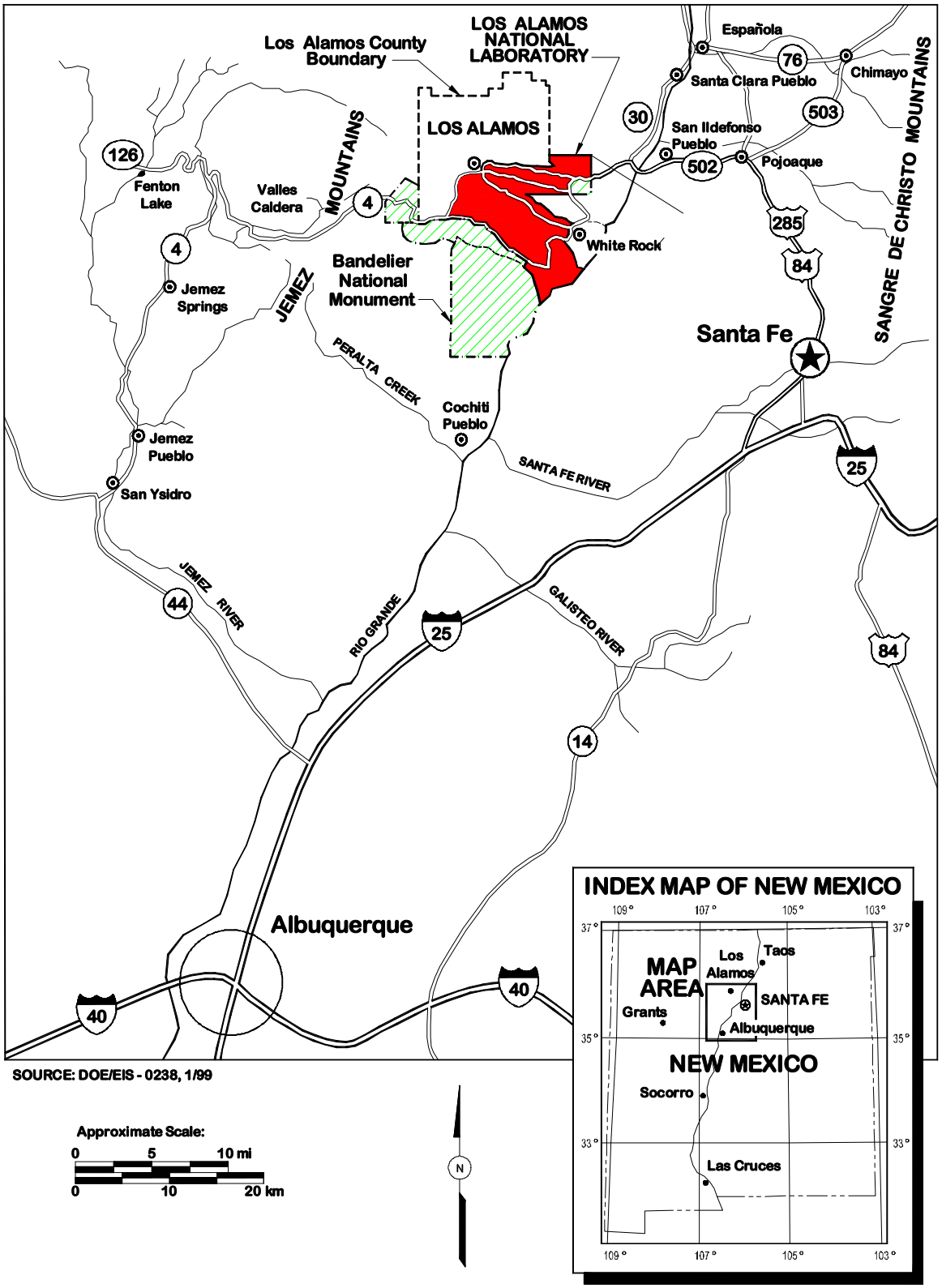

Figure 1-1. Location of Los Alamos in Northern New Mexico

Technical Areas

TA	Nomenclature
2	Omega Site
3	South Mesa Site
5	Beta Site
6	Two-Mile Mesa South Site
8	Anchor West Site
9	Anchor East Site
11	K-Site
14	Q-Site
15	R-Site
16	S-Site
18	Pajarito Laboratory
21	DP-Site
22	TD-Site
28	Magazine Area A
33	HP-Site
35	Ten Site
36	Kappa Site
37	Magazine Area C
39	Ancho Canyon Site
40	DF-Site
41	W-Site
43	Health Research Laboratory/ DOE Headquarters
46	WA-Site
48	Radiochemistry Site
49	Frijoles Mesa Site
50	Waste Management Site
51	Environmental Research Site
52	Reactor Development Site
53	Los Alamos Neutron Science Center
54	Waste Disposal Site
55	Plutonium Facility
57	Fenton Hill Site
58	Two-Mile Mesa North Site
59	OH-Site
60	Sigma Mesa Site
61	East Jemez Site
62	Northwest Site
63	Pajarito Service Site
64	Central Guard Site
66	Central Technical Support Site
67	Pajarito Mesa Site
68	Water Canyon Site
69	Anchor North Site
71	Southeast Site
72	East Entry Site
73	Airport Site
74	Otowi Site

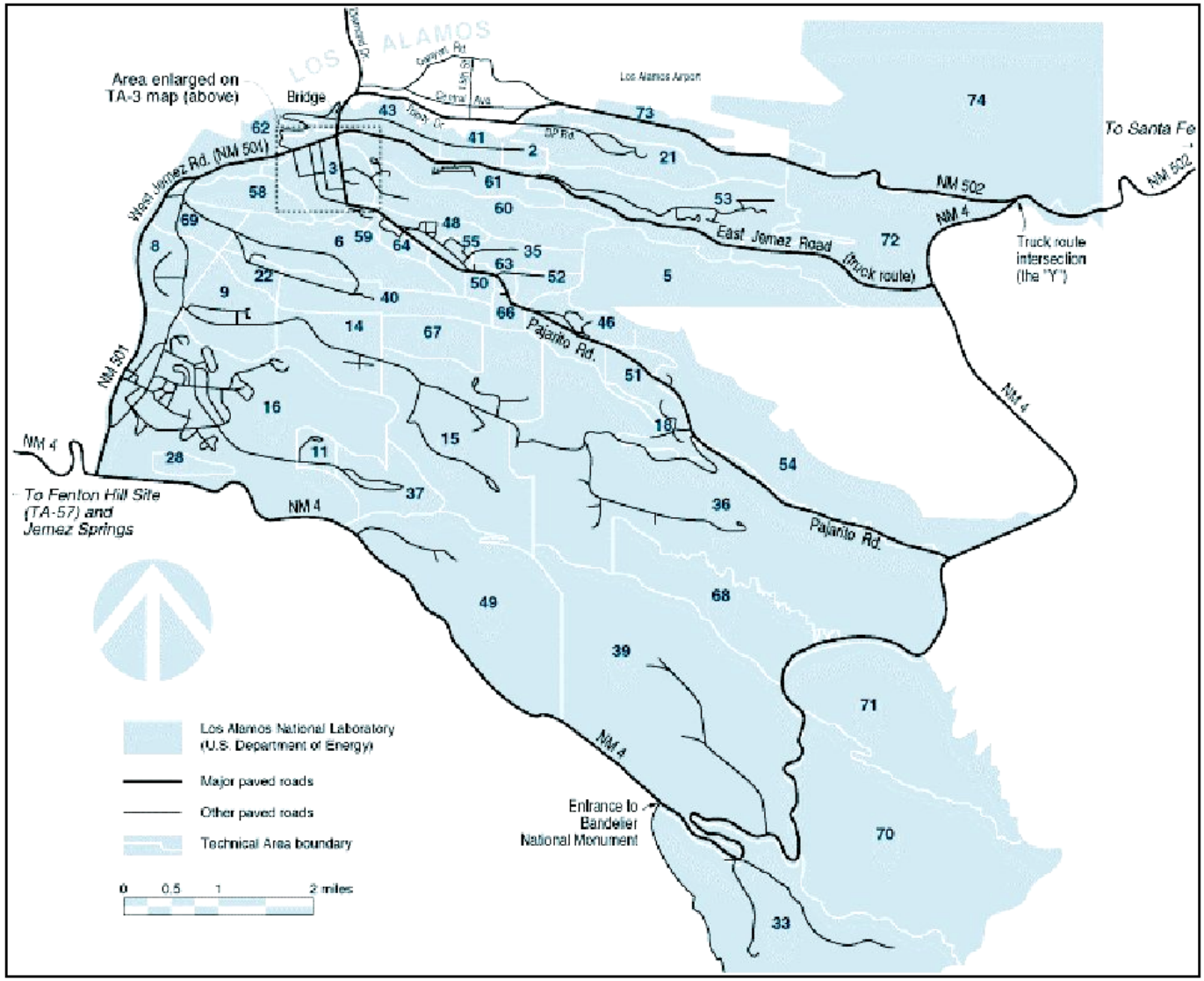

Figure 1-2. Los Alamos National Laboratory Technical Areas

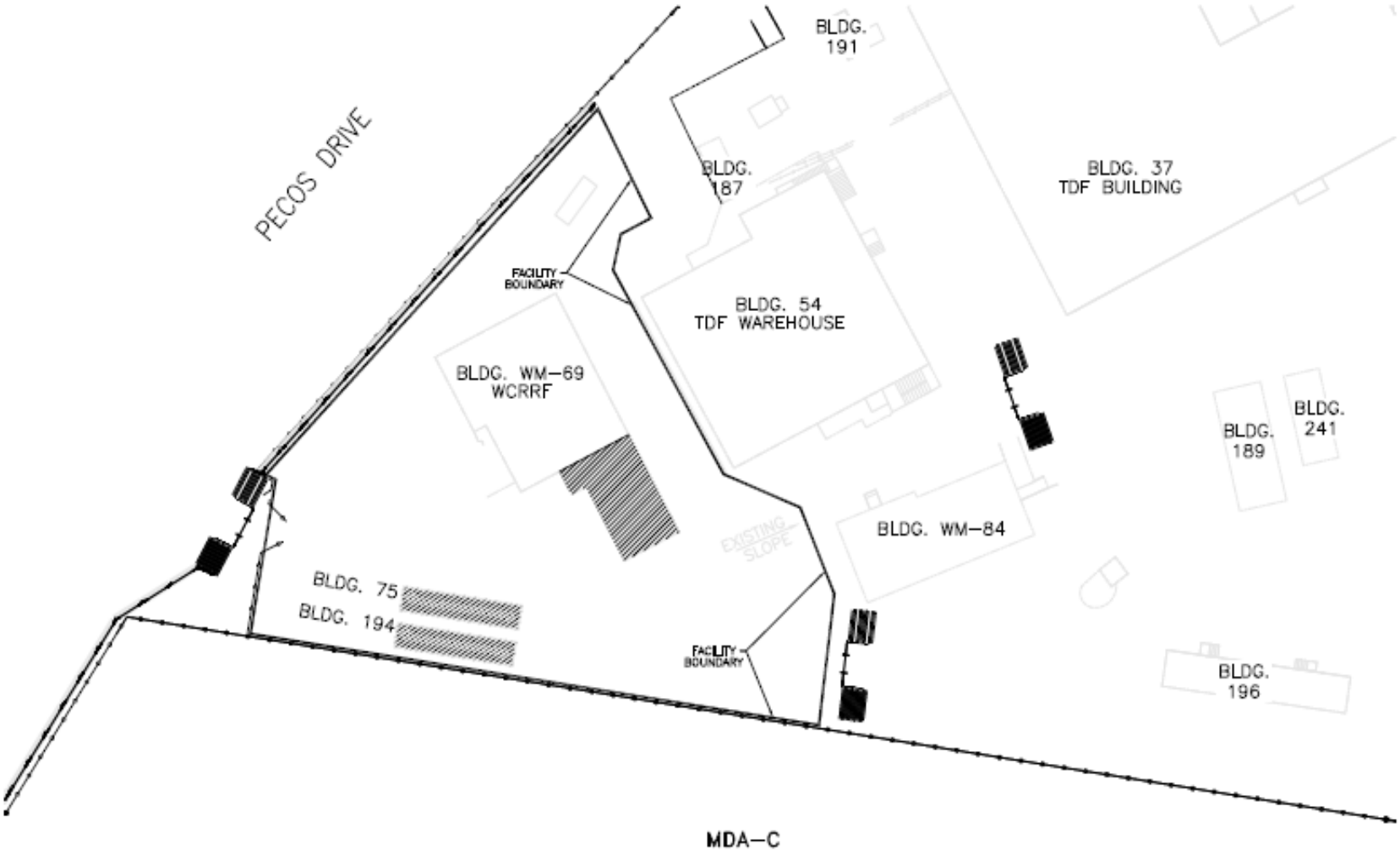

Figure 1-3. Technical Area 50 Site Map

1.4.1.1 Wind Speed and Direction

Wind speed and direction are measured at six locations around LANL. The monitoring stations collect data at a height of 11 m (36 ft) and 92 m (302 ft) above ground level. Four towers are located atop mesas of the Pajarito Plateau (TAs 6, 49, 53, and 54). The remaining towers are located in a canyon (TA-41) and atop Pajarito Mountain. Winds vary dramatically with time of day, location, and height above ground level. Figures 1-4 and 1-5 present the average wind roses for daytime and nighttime conditions, as observed in the year 2004 from five of the monitoring towers (LANL 2005). Both figures show predominant south-southwesterly winds blowing up the Rio Grande Valley. However, westerly, down-slope winds from the Jemez Mountains are commonly observed at night. Even though the frequency of wind directions varies with the season of the year, a high frequency of south-southwesterly winds is evident during all four seasons. In winter, north-northeasterly winds occur at about the same frequency as south-southwesterly winds. Winds atop Pajarito Mountain are most representative of the upper-level flows (LANL 2005). Appendix 3B, *Radioactive Material Dispersion Calculations Using MACCS2 and POSTMAX*, describes the applicability of these data to the WCRRF safety analysis.

1.4.1.2 Temperature

Summer afternoon temperatures in Los Alamos County typically range from 20° to 25°C (68° to 77°F), infrequently reaching temperatures greater than 32°C (90°F), and nighttime temperatures typically range from 10° to 15°C (50° to 59°F). Typical winter temperatures are between –1° and 10°C (30° and 50°F) in the daytime, and between –10° and –3°C (14° and 27°F) at night, occasionally dropping to –17°C (1°F) or below.

1.4.1.3 Precipitation

Average annual precipitation in the Los Alamos area is about 48 cm (19 in.), with about 37% of the precipitation occurring as brief, intense thunderstorms during July and August. Snowfall is greatest from December through March, with infrequent heavy snowfall in other months. Annual snowfall averages about 150 cm (59 in.) Variations in precipitation from year to year can be quite large: annual precipitation extremes in Los Alamos range from 17 cm (7 in.) to 77 cm (30 in.) Daily rainfall extremes of 2.54 cm (1 in.) or greater occur in most years, and the estimated 100-year daily rainfall extreme is about 6.4 cm (2.5 in.). Precipitation generally increases westward as the elevation increases.

1.4.1.4 Atmospheric Stability

Atmospheric stability is measured on a six-part Pasquill scale, A-F, with A being the most unstable and F the least. During the winter, the frequencies of atmospheric stability categories are 52% unstable (A-C), 21% neutral (D), and 27% stable (E-F), as measured at TA-49. During the summer, the frequencies are 44%, 22%, and 34% respectively. The stability categories are based on the vertical change in thermal conditions. The combined meteorological data (stability classes, wind speeds, wind directions, and their associated frequencies) for the LANL site have been compiled and evaluated using a straight-line Gaussian dispersion model (see Appendix 3B, *Radioactive Material Dispersion Calculations Using MACCS2 and POSTMAX*).

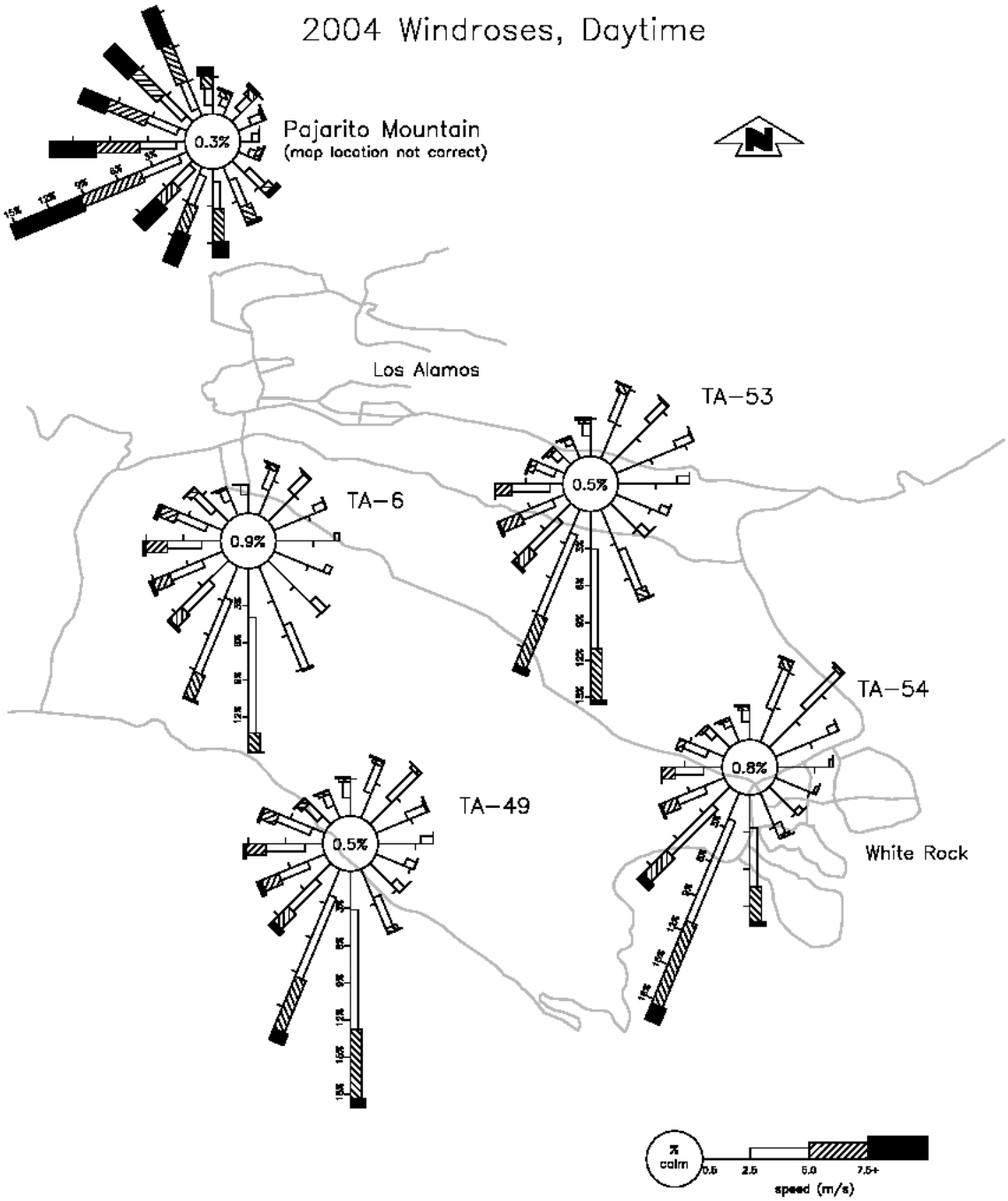

Figure 1-4. Daytime Wind Roses at Los Alamos

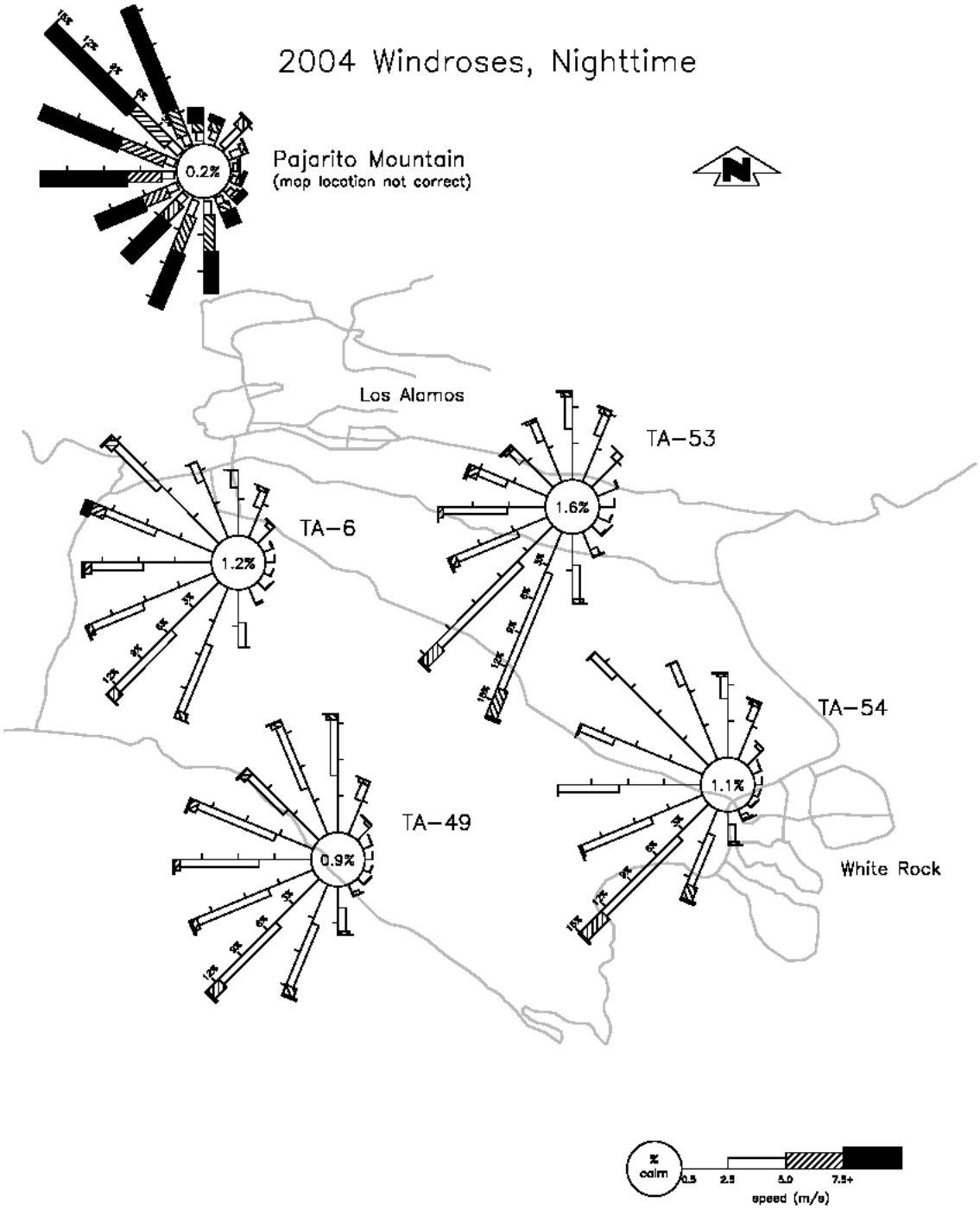

Figure 1-5. Nighttime Wind Roses at Los Alamos

1.4.2 Hydrology

Stream flow in the Los Alamos area is intermittent. Surface water runoff occurs during snowmelt and occasionally during summer thunderstorms. Surface water runoff in the vicinity of the WCRRF drains toward an arroyo tributary to Ten Site Canyon, and an ephemeral tributary to Mortandad Canyon. Mortandad Canyon is a tributary to the Rio Grande, and infrequent runoff in this canyon percolates into the alluvium within 3 mi downstream from the Pajarito Plateau. It is anticipated that even under extreme surface water flow volume in the general area, water traversing the WCRRF site would be of little consequence. The Laboratory currently does not use any surface water resources, and no potable water storage reservoirs are in the vicinity of the WCRRF.

Groundwater in the LANL region occurs in two separate systems: (1) an upper perched groundwater body in the alluvium of Mortandad Canyon and (2) a deep aquifer about 400 m (1,300 ft) below the site in the Tesuque and Puye Formations. The primary recharge for the main aquifer is thought to be from small streams on the western flank of the Sierra de Los Valles and the western part of the Pajarito Plateau (Conover et al. 1964, Cushman 1965). Additional recharge from alluvial aquifers is also possible. In contrast, recharge to the main aquifer from infiltration from the mesa tops is unlikely because of the great thickness of unsaturated tuff underlying the mesas.

When LANL facilities opened in 1943, water was derived solely from surface water sources. Water wells using groundwater sources were installed as a result of later expansions. The Laboratory and the communities of Los Alamos and White Rock are currently supplied by water pumped from 18 deep aquifer wells in Otowi and Guaje canyons and on the Pajarito Plateau. Production from these wells is from the main aquifer in the Los Alamos area. This aquifer is the only one in the area capable of supporting municipal and industrial water supply requirements. Two small reservoirs are also present in the Los Alamos area.

1.4.3 Geology

This section provides the geological information necessary to define regional phenomena of any concern with respect to facility hazards. Basic geological data presented in this section are derived primarily from the LANL SWEIS (DOE 2008, 2009) and *Environmental Surveillance of Los Alamos during 2002* (LANL 2004).

1.4.3.1 Geologic Setting

The Laboratory is situated on the Pajarito Plateau, sloping from about 8,000 ft at the Sierra de Los Valles on the west to about 7,000 ft towards the Rio Grande on the east. Finger-like mesas that are separated by numerous narrow and steep-sided canyons characterize the Pajarito Plateau. The majority of LANL is underlain by the Tshirege Member of the Bandelier Tuff. The tuff is derived from welded volcanic detritus. The tuff is composed of layers dipping slightly to the southeast. The Bandelier Tuff is more than 300 m (1,000 ft) thick in the western part of Pajarito Plateau and about 80 m (260 ft) thick toward the east along the west side of the Rio Grande. Along the western edge of the plateau, the tuff overlaps the older volcanic soils that form the Jemez Mountains.

The volcanic eruptions producing the Bandelier Tuff occurred about 1.2 million and 1.6 million years ago. The 1.2-million-year-old Valles Caldera was formed when a great volume of magma was ejected along ring fractures that now define the caldera structure. Another primary geologic feature in the region

is the Rio Grande Rift that extends from northern Mexico to central Colorado (the valley of the Rio Grande). The north-trending Pajarito Fault system is part of the Rio Grande Rift and consists of a group of interconnecting faults that are nearly parallel to each other.

1.4.3.2 Stratigraphy

The Bandelier Tuff forms the surface rocks of the Pajarito Plateau. The Bandelier Tuff is rhyolitic in composition, with phenocrysts of quartz and sanidine crystals, crystal fragments, and a few small rock fragments of dacite and rhyolite in an ashy matrix. A volcanic pumice layer is also present; the pumice is cellular in structure, and the matrix is gray ash. The tuff and pumice range in porosity from 30% to about 60% by volume, with densities ranging from less than 1 g/cm^3 (60 lb/ft^3) for pumice to as much as 1.8 g/cm^3 (115 lb/ft^3) for moderately welded tuff.

The Tshirege Member of the Bandelier Tuff is composed of several distinct layers. Layers 3 and 4 are important as contributors to the mesa-top soils. Layer 3 is a (comparatively) strongly welded rock that resists erosion sufficiently to form the mesa topography. Layers 2 and 3, as well as the nonwelded bed between them, are exposed along the canyons.

1.4.3.3 Soils

Soils on the mesas can vary widely in thickness and are typically thinnest near the edges of the mesas, where bedrock is often exposed. The walls of the canyons often consist of steep outcrops and patches of shallow, undeveloped colluvial soils (e.g., the clay, silt, sand, and gravel deposited at the base of a slope). The south-facing canyon walls are steep and usually have little or no soil material or vegetation, while the north-facing walls or slopes generally have areas of very shallow, dark-colored soils that are more heavily vegetated.

1.4.3.4 Subsurface Geology Investigation

The subsurface geology beneath LANL was investigated through a program of core hole drilling, downhole velocity measurements, and dynamic laboratory testing of core samples. Based on these LANL-specific data and the seismic source characterization, deterministic and probabilistic ground motions were estimated in terms of peak accelerations and response spectra. The deterministic ground motions were evaluated through empirical and stochastic approaches.

The youngest localized volcanic episode within the Pajarito Plateau occurred during the late Pliocene (2.4 million to 2.6 million years ago). Samples of temporally and chemically correlative flows were encountered in several water and test wells distributed in the central part of the Pajarito Plateau. Most of these subsurface flows are exposed along both sides of the White Rock Canyon. They represent the northern part of the widespread and voluminous eruptions of the Cerros del Rio volcanic field east of the Pajarito Plateau.

1.4.3.5 Geologic Faults in the Laboratory Area

The Rio Grande Rift represents a series of connected, *en echelon* structural basins flanked on both sides by a series of uplifted, tilted, and faulted north-south-trending blocks. The major faults in the basins express a predominantly northward trend and, although discontinuous, develop *en echelon* zones of closely spaced parallel faults.

On the east side of the Jemez Mountains, the Pajarito fault system has pre- as well as post-Bandelier Tuff ages (1.2 million years). Most of the pronounced *en echelon* fault displacement occurs in pre-Tshirege Member rocks. The presence of older and younger *en echelon* fault members is evidence of a long history of recurrent fault movement on both sides of the caldera. The Upper Bandelier Tuff has been vertically offset more than 150 m (500 ft) by the Pajarito fault system along the west side of the Pajarito Plateau. This information suggests that this major fault system is geologically active.

The three potentially active fault zones in the Pajarito Plateau are shown in Table 1-1. These faults are accompanied by numerous smaller, secondary faults. The larger faults are clearly expressed by surface offsets at some locations and inferred from geologic evidence at others. The faults, including the young faulting that is significant in determining the seismic hazard at LANL, have been recently mapped. However, recent detailed mapping in the vicinity of TA-55 showed no southern extensions of the young faults.

Table 1-1. Major Faults at Los Alamos National Laboratory

Name	Approximate Length (km)	Type*	Most Recent Movement	Maximum Earthquake (Mw)**
Pajarito	26	Normal, East Side Down	100,000 to 200,000 years ago	6.9
Rendija Canyon	9	Normal, West Side Down	8,000 to 9,000 years ago	6.5
Guaje Mountain	8	Normal, West Side Down	4,000 to 6,000 years ago	6.5

* "Normal Fault" describes a steep to moderately steep fault for which the movement is downward for the rocks above the fault zone.

** "Mw" denotes the moment magnitude scale, which is physically based and calibrated to the Richter local magnitude scale at the lower values.

The Pajarito fault is considered the currently active western boundary fault of the Española Basin and is easily visible above West Jemez Road as an east-facing escarpment about 91 m (300 ft) high.

The Rendija Canyon and Guaje Mountain faults are shorter than the Pajarito fault. These three faults influence the estimates of seismic hazard at TA-50 because of their lengths, trends, proximity, and evidence of geologically young movement. All three faults are capable of producing future earthquakes.

1.4.3.6 Seismology

As stated before, the Laboratory site is situated between the Pajarito fault system and the Rio Grande along the western part of the Española Basin of the Rio Grande Rift. This region has been shaped by tectonic and volcanic processes since its inception about 32 million years ago. Instrumental and historical records about faulting and earthquakes in the Pajarito Plateau and the adjacent Jemez Mountains are sparse because available documents extend back only about 100 years.

An evaluation of the seismicity recorded by the LANL network from 1973 to 1992 can be found in *Seismic Hazards Evaluation of the Los Alamos National Laboratory* (Wong at al. 1995). Only one earthquake has occurred near the Laboratory or the three local faults. Although active on the microearthquake level, the Laboratory region has experienced only six earthquakes of estimated Richter's local magnitude (M_L) 5.0 or greater. The most significant event was the May 18, 1918, Cerrillos earthquake of an estimated M_L 5.5, Intensity VIII, that occurred approximately 50 km (30 mi) southeast of Los Alamos. An earthquake of M_L 4.0 to the southwest of the Laboratory in 1952 caused a reported modified Mercalli Intensity of V in Los Alamos.

The three major faults listed in Table 1-1 were examined to estimate the risk of a seismic hazard in the region. Earthquakes in the region, however, are not always well correlated with faults that are expressed in the surface geology. Evidence suggests that there may be a stronger correlation between earthquakes and stress from magmatic activity. Only a few of the epicenters for reported earthquakes from 1873 through 1992 were near the Pajarito and Rendija Canyon faults (within the uncertainties of the epicenter determinations). The important conclusion that can be drawn from the geologic and seismic evidence is that faulting in the region is an ongoing process.

1.5 NATURAL EVENT INITIATORS

This section describes natural phenomena and environmental threats that may contribute significantly to the risks that TA-50 poses. The discussion focuses on negative consequences that result from natural phenomena events, including releases of radioactive and hazardous materials.

Effects on the buildings and equipment from accidents that are caused by credible natural phenomena are considered and evaluated in Chapter 3, *Hazard and Accident Analyses*. Tornadoes, hurricanes, and flooding are eliminated from evaluation based on the criteria found in DOE-STD-1020-2002 (DOE 2002b).

Five performance categories (PCs) for NPH resistance are specified in DOE-STD-1020-2002 (DOE 2002b). These categories range from PC-0 for structures, systems, and components that require no hazard evaluation, to PC-4, a desired performance level comparable to commercial nuclear power plants.

1.5.1 Earthquakes

Seismic Hazards Evaluation of the Los Alamos National Laboratory (Wong et al. 1995) details the regional and local tectonic setting for the LANL site. Site-specific ground motions have been estimated, both probabilistically and deterministically, for eight facility sites that are closest to TA-50 (TA-2, TA-3, TA-16, TA-18, TA-21, TA-41, TA-46, and TA-55). The objective of the evaluation was to determine and characterize the seismic tectonics of the area and the seismic design criteria for LANL. Within the LANL region defined in the study, 26 faults and 5 seismic source zones were identified as potential seismic sources significant to LANL in terms of ground shaking. In particular, the three most significant and closest faults to LANL were the focus of the study: the Pajarito, Guaje Mountain, and Rendija Canyon faults.

As commonly observed throughout the Basin and Range Province, and reinforced by seismicity data recorded at the LANL network from 1973 to 1992, seismicity is generally not associated with mapped faults or structures. However, some microearthquakes that occurred in the region appear to correlate with faults located in the region, including Puye, La Bajada-Rosario, and La Canada del Amagre-Clara Peak fault zones. Only one earthquake has occurred near LANL or the three local faults. The Valles Caldera

also appears to be seismically quiescent. Maximum magnitudes for the random earthquakes in these provinces range from Mw 6 to 6.5. Recurrence for these source zones was computed in the Woodward-Clyde study (Wong et al. 1995) based on an evaluation of historical and contemporary seismicity. The study identified a hypothesized simultaneous rupture of the Pajarito Fault, Guaje Mountain Fault, and Rendija Canyon Fault as the maximum credible event associated with these fault zones.

Seismic hazard curves were developed for each LANL site for peak horizontal accelerations and response spectral accelerations at periods of 0.2 and 2.0 seconds. These curves were based upon a probabilistic, seismic hazard analysis using logic trees. This approach allows incorporation of the full range of possible sources, paths, and site parameters and their uncertainties.

DOE-STD-1020-2002 (DOE 2002b) specifies the seismic design requirements for each PC to be used as design criteria for structures at the Laboratory. The seismic performance categories and hazard exceedance levels from DOE-STD-1020-2002 are presented for each PC in Table 1-2.

Table 1-2. Seismic Performance Categories and Hazard Exceedance Levels

Performance Category	Mean Seismic Hazard Exceedance Levels, P_H	Remarks
0	No requirements	
1	Follow IBC (International Building Code®) 2000*	Use IBC 2000 Seismic Use Group I Criteria-2/3 MCE (Maximum Considered Earthquake) Ground Motion
2	Follow IBC 2003*	DOE-STD-1020 PC-2 IBC-2003 Seismic Design Category D Building Category IV: Seismic Importance Factor = 1.50 5% damped design spectral response acceleration at short periods, SDS, = 0.54 g, and at 1-s periods, SD1, = 0.26 g.
3	4×10^{-4}	0.34 g peak horizontal acceleration**
4	1×10^{-4}	0.56 g peak horizontal acceleration (Wong et al. 1995)

* Based on MCE Ground Motion–generally 2% exceedance probability in 50 years from the seismic hazard maps, modified to account for site effects. $P_H = 4 \times 10^{-4}$.

** Extrapolated from data presented in Wong et al. 1995 using the exceedance level $P_H = 4 \times 10^{-4}$.

It is worthwhile to note that while DOE-STD-1020-2002 (2002b) invokes the IBC for PC-2 buildings, DOE-STD-1020-2002 also contains provisions for existing facilities to meet seismic performance goals. The WCRRF, Building TA-50-69, meets the performance goal of DOE-STD-1020-2002 for PC-2 structures.

In 2007, a new Probabilistic Seismic Hazards Analysis was prepared for Los Alamos (Wong et al. 2007). The new characterization of the Pajarito Fault System in this analysis is significantly revised based on new mapping, displacement measurements, and paleoseismic data for the Pajarito Fault System. The new data shows the Pajarito Fault System exhibits complex rupture patterns and shows evidence for at least two, probably three, surface-faulting earthquakes in the last 11,000 years. This recent clustering is in contrast to evidence for the occurrence of only six to nine events in the last 110,000 years, although this longer record was judged to be possibly incomplete. In the Probabilistic Seismic Hazards Analysis, a suite of topographic amplification factors was developed for LANL on the basis of recent LANL modeling results, other modeling results and observations in the literature, and recommendations of international seismic codes. The modeling shows the Pajarito Fault System primarily controls the peak ground acceleration (PGA). The Pajarito Fault System also controls the LANL seismic hazard for longer-period ground motions such as 1.0 second spectral acceleration. Background seismicity in the Rio Grande Rift, which contributed to the hazard at LANL in the 1995 study, is not a significant contributor in this new analysis. This is probably because of the increased activity rate in the Pajarito Faults System in the Holocene (clustering).

The new Probabilistic Seismic Hazards Analysis shows that the horizontal surface peak ground acceleration values are about 0.5 g at a return period of 2,500 years. The vertical PGA values at the same return period are about 0.3 g. The 1995 horizontal PGA values for a return period of 2,500 years are about 0.33 g. The estimated hazard increased significantly from the 1995 study because of the increased ground motions from the site-specific stochastic attenuation relationships and increased activity in the Pajarito Fault System. The site response effects as modeled in this study with the newer site geotechnical data appear to amplify ground motions more than the 1995 analysis. Other factors could be the increased epistemic uncertainty incorporated into the empirical attenuation relationships and the characterization of the Pajarito Fault System.

The site-wide PGAs as a function of Return Period are as follows in Table 1-3.:

Table 1-3. Site-Wide PGAs as a Function of Return Period

Return Period	Horizontal PGA	Vertical PGA
1,000 year Return Period	0.27 Horizontal PGA	0.32 Vertical PGA
2,500 year Return Period	0.52 Horizontal PGA	0.60 Vertical PGA
10,000 year Return Period	1.03 Horizontal PGA	1.21 Vertical PGA

Based on the increased seismic hazard at LANL, a site-wide Justification for Continued Operation (JCO) was prepared and submitted to LASO for approval. The JCO was approved for all LANL nuclear facilities including Area G. The JCO requires facility specific seismic analysis of all PC-2 and PC-3 Systems, Structures, and Components for all nuclear facilities by June 2009.. The WCG and the drum lift fixture have been determined to meet PC-2 NPH seismic criteria.

1.5.2 Volcanism

The El Cajete pumice fallout, which forms the youngest volcanic eruption within the Valles Caldera, erupted about 50,000 to 60,000 years ago after a long period of quiescence (about 460,000 years). Vestiges of volcanism continue today, as evidenced by gas venting and hot spring activity in the caldera

moat, notably at Sulfur Springs, which is more than 32 km (20 mi) west of the facility, and southwest of the caldera at several localities in San Diego Canyon along the present course of the Jemez River.

The expected return period for volcanic events is much longer than the return periods for NPH resistance goals specified for DOE facilities (on the order of thousands of years). The DOE has not established standards for resistance to a volcanic event. Therefore, volcanic events are eliminated from further evaluation.

1.5.3 Floods

Large-scale surface flooding is not common in New Mexico. Flooding is possible in the spring from snowmelt, although snowmelt flooding is usually confined to areas where the larger rivers in the state are located. Snowmelt can cause muddy conditions in the Los Alamos area, along with minor flooding of streams in the Jemez Mountains.

Although large-scale surface flooding is less common in New Mexico, flash floods from heavy thunderstorms are possible in susceptible areas such as arroyos and canyons. Flooding from a heavy thunderstorm could occur in Los Alamos in canyons or facility low spots. Drainages from the watersheds above Los Alamos, which were burned by the Cerro Grande Fire of May 2000, are at extreme risk of flash flooding under even normal rainfall patterns. The WCRRF is located atop the mesa, with immediate drainage to Ten Site Canyon, approximately 100 m to the southeast. Because of the location of the WCRRF structures in relation to the mesa drainage slope (see Section 1.4.3, *Geology*), external flooding events are eliminated from further evaluation.

1.5.4 Wildland Fire

The semiarid climate, particularly during a dry season, makes the region susceptible to human-caused forest fires and those started by lightning. Four forest fires in the area (American Springs [June 1954], La Mesa [June 1977], Dome [spring 1996], and Cerro Grande [May 2000]) have threatened the Laboratory. The Cerro Grande fire damaged some facilities but did not result in release of nuclear material. Wildland fires are considered credible scenarios and are addressed as a design-basis accident in Chapter 3, *Hazard and Accident Analyses*.

The Laboratory has provided firebreaks and cleared areas around buildings to reduce the threat of wildland fire. The Los Alamos Fire Department is trained and experienced in fighting forest fires. Adjacent forested lands to the south and west of LANL boundaries are owned by the U.S. Park Service and U.S. Forest Service, respectively. These services have fire-fighting teams on-call to fight fires in these areas.

Wildland fire exposure has been evaluated in the Fire Hazard Analysis (FHA) for the WCRRF operations (LANL 2007). The FHA concludes that wildland fires result in a low hazard rating to the WCRRF, as long as wildland fuels are controlled.

1.5.5 Severe Weather

This section describes severe weather conditions that can affect the design and operation of LANL facilities. The following discussions are taken from *Los Alamos Climatology* (LANL 1990).

1.5.5.1 Cold Weather Conditions

Frigid weather occasionally occurs in Los Alamos when polar or Arctic air masses settle over the region. Normally, the temperature drops to –17°C (1°F) or below only once or twice a year. Los Alamos cold waves can be defined as times when the temperature drops to –23°C (–9°F) or lower, or when the temperature drops to –17°C (1°F) or below for at least two consecutive days. The most severe cold wave probably occurred during the week beginning January 3, 1971. Temperatures plunged after a snowstorm dropped 25 cm (10 in.) of snow on Los Alamos. From January 3 to January 7, 1971, Los Alamos morning low temperatures were –22°C (–9°F), –25°C (–13°F), –27°C (–17°F), –26°C (–15°F), and –22°C (–8°F) respectively. Between January 4 and January 7, 1971, high temperatures recorded in the Los Alamos area only reached –16°C (3°F), –13°C (9°F), –13°C (9°F), and –13°C (9°F). The WCRRF structures were designed for extremes in temperature.

1.5.5.2 Snow or Rain

Winter storms with snowfalls of 10 cm (4 in.) or more are common in Los Alamos. Winter storms with winds above 24 km/h (15 mph) may be associated with cold temperatures, resulting in dangerous wind chills, considerable drifting, and low visibility. Occasionally, snowstorms cause heavy snowfall in the mountains, while little snow falls in Los Alamos. The combination of heavy snowfall and restricted visibility may create hazardous driving conditions.

The accumulation of snow on trees, followed by strong winds, may result in downed trees and utility lines. Such conditions are often created after wet snows, which are common in the late fall and spring. The record snowfall in Los Alamos occurred in January 1987. Snow from a single storm accumulated 122 cm (4 ft) at TA-59 and 152 to 183 cm (5 to 6 ft) in North Community. Another 122 cm (4 ft) of snow fell at TA-59 during February 1987. The snow's weight damaged or collapsed several residential roofs in Los Alamos. The water equivalent from the 1987 monthly snowfall totaled 8.71 cm (3.43 in.) in January and 8.74 cm (3.44 in.) in February.

1.5.5.3 Lightning Strikes

Lightning in Los Alamos can be frequent and intense during thunderstorms. Lightning strike data based on an informal communication with LANL personnel previously assigned to Environment, Safety, and Health (ESH-17—now part of Meteorology Services in the Environment and Remediation Support Services Division) and information obtained from the National Oceanic and Atmospheric Administration (NOAA) Web site (NOAA) indicate a local lightning strike density/frequency of approximately six strikes/km2/yr. This frequency is among the highest in the United States. Lightning strikes were considered in the hazard analysis (see Appendix 3C, *Lightning-Initiated Fire Frequency*).

1.5.5.4 Tornadoes and Strong Winds

Historically, tornadoes have not been reported in Los Alamos County. However, a funnel cloud was reported near White Rock on August 23, 1983. In addition, numerous funnel clouds were reported near Santa Fe on August 24 and 25, 1987. A tornado touched down in Albuquerque on September 20, 1985, and caused damage to a small area.

Dust devils are more likely to cause damage in Los Alamos. Dust devils theoretically could develop upper winds of 179 km/h (112 mph). Strong dust devils commonly produce 120 km/h (75 mph) winds. Several

have caused damage in Los Alamos. A strong dust devil on April 24, 1973, at TA-53 knocked a trailer off its supports and rolled it one complete revolution.

High-speed, short-duration gusts can be generated locally by outflow (microbursts) from summertime thunderstorms. Sustained, high-speed winds, on the other hand, occur with cold frontal passages and when Los Alamos is situated in a sharp pressure gradient field, between high- and low-pressure systems. A high pressure gradient field was responsible for the sustained high winds that occurred during the Cerro Grande Fire of May 2000.

Los Alamos is considered a light wind site, with surface winds at the Laboratory averaging 7 mph. Wind gusts exceeding 50 mph are common during the spring. The highest recorded wind gust in recent history was 77 mph on Nov. 15, 1998. DOE-STD-1020-2002 (DOE 2002b) recommends that the peak gust wind speeds listed in Table 1-4 be used as design-basis criteria for a PC-2 structure at the Laboratory.

Table 1-4. Peak Gust Wind Speeds and Annual Exceedance Probabilities for LANL

Performance Category	PC-2
Annual exceedance probabilities	1E-2
Return period (yr)	100
Peak gust wind speed (mph)*	90*

1.6 MAN-MADE EXTERNAL ACCIDENT INITIATORS

1.6.1 Natural Gas Lines

The natural gas supply line to the WCRRF has been capped outside the facility boundary.

1.6.2 Aircraft Activities

The frequency of an airplane crash into a LANL facility has been calculated in numerous safety basis documents. The number varies depending on the physical dimensions of each facility and location with respect to LAM, but the calculated frequencies for most facilities fall in a range of about 5E-7 to 1E-5 per year. The frequency of a crash into the WCRRF would fall near the low end of the credible range, based on its size relative to the buildings that have been evaluated. The overall mission to characterize TRU waste at LANL, as a precursor to certifying the waste as part of TRU waste removal from TA-54 and repackaging for shipment to the Waste Isolation Pilot Plant, will be conducted in approximately 3 to 4 years. In this BIO, Appendix 3E, *Aircraft Crash Frequency Analysis*, indicates a total aircraft crash frequency of 2.85×10^{-6} per year.

*A 90 mph three-second gust wind speed as required by both IBC-2003 and American Society of Civil Engineers (ASCE) 7. ASCE 7, which provides the technical basis for the wind speed used in the building codes, changed from fastest-mile to three-second-gust wind speed in the 1995. ASCE 7 supersedes American National Standards Institute (ANSI) A58.1. All buildings are currently designed to three-second-gust wind speeds.

1.6.3 Transportation Activities

The WCRRF is on Pecos Drive, which is accessible from the main transportation artery, Pajarito Road, at a traffic light. Pajarito Road is about 500 ft from the WCRRF at its closest point as it crosses the southern portion of TA-50.

Pecos Drive runs immediately adjacent to the WCRRF along the northwest side of the site. The section of the site bordering Pecos Drive is fenced and accessed through a vehicle gate. The TRU-waste shipments to and from WCRRF occur through a gate on the northeast side of TA-50-69 on the WCRRF site.

The auxiliary generator to support WCRRF activities cannot be supplied with diesel fuel conveniently from inside the TA-50 site. A pull-off area is designated for a fuel truck outside the TA-50 boundary fence on Pecos Drive adjacent to the generator. Refueling is accomplished by extending a hose through the fence to the generator's fuel tank. Such refueling is expected to be infrequent, as the generator runs only during power outages and testing.

1.7 NEARBY FACILITIES

No industrial facilities except for those in the Laboratory technical areas are near the WCRRF. The following buildings or facilities are located nearest to the WCRRF (distances are approximate).

- Machine shop and offices (currently occupied by the Engineering Sciences and Applications Division), TA-50-54 (40 ft east) (see Figure 1-3)
- Radioactive Liquid Waste Treatment Facility (RLWTF), TA-50-1 (450 ft east);
- National High Magnetics Field Lab, TA-35-301 (east of TA-50)
- Portable office trailer (location of personnel controlling access to the WCRRF site), TA-50-84 (60 ft east-southeast) (see Figure 1-3)
- Portable office trailer, TA-50-196 (150 ft southeast) (see Figure 1-3)
- Material Disposal Area (MDA)-C landfill (adjacent to WCRRF staging area, due south)
- Telephone relay facility, TA-50-184 (325 ft southwest)
- Target Fabrication Facility, TA-35-213 (north of TA-50 across Pecos Drive)
- Actinide Research and Technology Instructional Complex Facility, TA-50-37 (150 ft northeast) (see Figure 1-3)

In addition, the TA-50-250 Pump House and Influent Storage Facility is under construction east of the RLWTF.

The WCRRF is adequately isolated from hazards such as fire and explosion from these facilities and operations. Thus, no hazards at these facilities that could impact the WCRRF have been identified. Hazards from surrounding facilities are negligible. A November 21, 2003, LANL report entitled *Initial Categorization of Environmental Sites* (LANL 2003) identifies the MDA-C landfill as a nuclear hazard Category 2 facility.

Technical areas bordering TA-50 include TAs 35, 40, 55, 63, and 66. Located northeast of TA-50, TA-35 includes facilities that conduct nuclear safeguards research and development, a wastewater treatment plant, and MDA-W sodium storage tanks. TA-40, which is south and west of TA-50, is used in developing special detonators for high-explosive systems. The facilities at TA-55, which are west of TA-50, house plutonium processing and metallurgy research. Located east of TA-50, TA-63 is a

developing area for Waste Management Facilities. TA-66, which is southeast of TA-50, includes the Defense and Homeland Security offices. Hazardous operations are conducted in the Plutonium Facility (PF) 4 at TA-55. PF-4 is located approximately 850 ft northwest of the WCRRF.

No industrial, transportation, or military facilities are nearby except the Los Alamos Airport, which was discussed in Section 0, *Man-Made External Accident Initiators*.

Section 2.4.5 provides additional detail on ancillary structures at TA-50.

1.8 VALIDITY OF EXISTING ENVIRONMENTAL ANALYSIS

The LANL SWEIS was approved in September 2008, with a second Record of Decision in July 2009. With the exception of decontamination and denitrification operations that are no longer conducted, the operational descriptions in the SWEIS are still essentially valid. The validity of the analysis is evaluated at least annually by LANL and documented in the annual *SWEIS Yearbook* (LANL 2001). The *SWEIS Yearbook* compares the levels of operations and the capabilities permitted under the SWEIS Record of Decision to the actual calendar year levels for each key and non-key facility.

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2.0 FACILITY DESCRIPTION

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Acronyms and Abbreviations

ANSI	American National Standards Institute
BIO	Basis for Interim Operation
CAM	continuous air monitor
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EWMO	Environmental and Waste Management Operations (Division)
FMG	Factory Mutual Global
FSS	Fire Suppression System
GBE	glovebox enclosure
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilating, and air conditioning
IBC	International Building Code®
ICBO	International Conference of Building Officials
LANL	Los Alamos National Laboratory
LLW	low-level waste
LPS	Lightning Protection System
MAR	material-at-risk
NFPA	National Fire Protection Association
NPH	natural phenomena hazard
OIT	operator interface terminal
PC	Performance Category
PID	prohibited item disposition
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RLWTF	Radioactive Liquid Waste Treatment Facility
SSC	structure, system, and component
SWB	standard waste box
TA	Technical Area
TRU	transuranic (waste)
UBC	Uniform Building Code®
UPS	uninterruptible power supply
VAS	vehicle access system
VE	visual examination
WAC	waste acceptance criteria
WCG	waste characterization glovebox
WCRRF	Waste Characterization, Reduction, and Repackaging Facility
WIPP	Waste Isolation Pilot Plant

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2.0 FACILITY DESCRIPTION

2.1 INTRODUCTION

This chapter provides a summary description of the Waste Characterization, Reduction, and Repackaging Facility (WCRRF)—its location, size, mission, general design criteria, configuration, processes and equipment, and its structures, systems, and components (SSCs). Information necessary to perform the safety analysis in this Basis for Interim Operation (BIO) is emphasized.

Operations in the WCRRF are required to support the Environmental and Waste Management Operations (EWMO) Division's mission to process transuranic (TRU) waste at Los Alamos National Laboratory (LANL) to certify it for shipment to the Waste Isolation Pilot Plant (WIPP). These operations are critical to meet the New Mexico Consent Order to close Technical Area (TA)-54 as a TRU waste storage site by 2015. The WCRRF mission to support the closure of TA-54 is expected to be complete by 2010; therefore, it is considered a limited-life facility.

The WCRRF includes TA-50, Building 69 (TA-50-69) and its adjacent yard, with ancillary structures and equipment. A description of the facility is provided in Section 2.3, *Facility Overview*. The building is described in Section 2.4, *Facility Structure*. Section 2.5, *Process Description*, provides a discussion of the operations conducted at the facility. The TA-50-69 systems are discussed in Sections 2.6, *Confinement and Containment Systems*, and 2.7, *Safety Support Systems*. Site utilities are discussed in Section 2.8, *Utilities*, and structures and equipment located in the yard are discussed in Section 2.9, *Auxiliary Systems and Support Facilities*.

2.2 REQUIREMENTS

The following essential regulatory documents, including federal laws and U.S. Department of Energy (DOE) orders and standards, contain the requirements for establishing the facility's safety basis:

- Title 10 of the *Code of Federal Regulations* (CFR), Part 830, *Nuclear Safety Management* (CFR 2003)
- DOE Order 420.1B, *Facility Safety* (DOE 2005)
- DOE Guide 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Nonnuclear Facilities* (DOE 2000)
- DOE Guide 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830* (DOE 2001)
- DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* (DOE 2002a)
- DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components* (DOE 2002b)
- DOE-STD-1022-94, *Natural Phenomena Hazards Site Characterization Criteria* (DOE 2002c)
- DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria* (DOE 2002d)
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- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002e)
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* (DOE 2006)
- DOE O 6430.lA, *General Design Criteria* (DOE 1989) (Section 1324, as applicable)
- DOE Office of Nuclear Safety Policy and Standards, *Interim Advisory on Straight Winds and Tornados* (DOE 1998)

The following industry codes and standards, in effect at the time Building TA-50-69 was designed, contain the requirements for establishing the building's safety basis:

- International Conference of Building Officials (ICBO), *Uniform Building Code* (*UBC*), 1976 (ICBO 1976)
- International Association of Plumbing and Mechanical Officials (IAPMO) and ICBO, *Uniform Mechanical Code,* 1976 (IAPMO 1976)
- American National Standards Institute (ANSI) A58.1, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures,* 1972 (ANSI 1972)
- National Fire Protection Association (NFPA) Standards 13 (1976), 70 (1978), 72A (1975), 90A (1976), and 90B (1976) (NFPA 1976a, NFPA 1978, NFPA 1975, NFPA 1976b, NFPA 1976c)
- National Association of Plumbing-Heating-Cooling Contractors, *National Standard Plumbing Code,* 1975 (NAPHCC 1975)

2.3 FACILITY OVERVIEW

The WCRRF is located in the northwest corner of TA-50. The facility is south of Pecos Drive, across from TA-55, and west of TA-50-37. A partial site layout of TA-50 is shown in Fig. 1-3, which shows the WCRRF Building TA-50-69 and structures or facilities in the immediate vicinity of TA-50-69.

The WCRRF primary mission is to sample, examine, process, and repackage a variety of TRU waste packages. The facility comprises

- TA-50-69 and
- a partially fenced, partially paved yard area containing ancillary structures and equipment.

The TA-50-69 structure is a small, one-story, steel-frame building used to perform waste processing and repackaging activities. These activities are conducted in a large process area that is serviced by the building's ventilation system (including high-efficiency particulate air [HEPA] filtered exhausts), a fire suppression system (FSS), radiation monitoring, and other support systems. The primary equipment in the building used for waste processing activities is the waste characterization glovebox (WCG). A large walk-in glovebox enclosure (GBE) is also installed in the building but will not be used to support the TRU waste processing activities addressed in this Documented Safety Analysis (DSA). The GBE is mentioned throughout the DSA to the extent that it shares the ventilation system with the WCG. The TRU waste containers are moved to and from the building through a vehicle airlock.

Several transportainers (commercial cargo containers of various sizes) are located in the yard area south of TA-50-69. These transport containers are used for staging and inspection activities involving TRU waste containers.

Other ancillary structures and equipment, including office trailers, an equipment and empty drum storage pad, and electrical power distribution equipment, are also located in the yard area. An auxiliary diesel generator supporting the WCRRF is installed northeast of TA-50-69, just inside the WCRRF boundary.

The EWMO Division manages the WCRRF. The EWMO personnel conduct waste processing, repackaging, and associated operations at the facility.

2.4 FACILITY STRUCTURE

2.4.1 Building TA-50-69

The TA-50-69 structure is a one-story, high-bay building with external dimensions of 88 ft by 45 ft and an internal floor area of approximately 2,712 ft^2. The core of the building was constructed in 1979. Additions and major system upgrades were constructed in 1986. Recent upgrades have included reconfiguring the WCG ventilation system to accommodate an increased negative pressure differential, and upgrading the building to meet the performance goal of DOE-STD-1020-2002 for Performance Category (PC) 2 structures (DOE 2002a). The exterior walls are constructed of 6-in.-deep, 14-gauge structural steel studs supporting ½-in.-thick gypsum board sheathing and 2-in. rigid insulation with a plaster finish on the outside and ⅝-in. gypsum board sheeting on the inside.

The building consists of a vehicle airlock, an unloading area, a high-bay area, a mezzanine, and a change room. A floor plan of the main floor is provided in Fig. 2-1. The unloading and high-bay areas are known as the *main process area*, where waste processing and repackaging operations are conducted. Personnel enter the building through the north and south airlocks, as well as through the vehicle airlock.

2.4.1.1 Vehicle Airlock

Vehicle access to TA-50-69 is by way of an airlock consisting of two roll-up doors. The vehicle airlock is separated from the unloading and processing areas by one vehicle airlock door. The second vehicle airlock door provides an exit to the outside. The vehicle airlock floor space area is approximately 360 ft^2. Its primary purpose is to maintain building confinement when TRU waste containers and equipment are moved to and from the building. Personnel doorways provide access and egress from the building through the vehicle airlock to the outside.

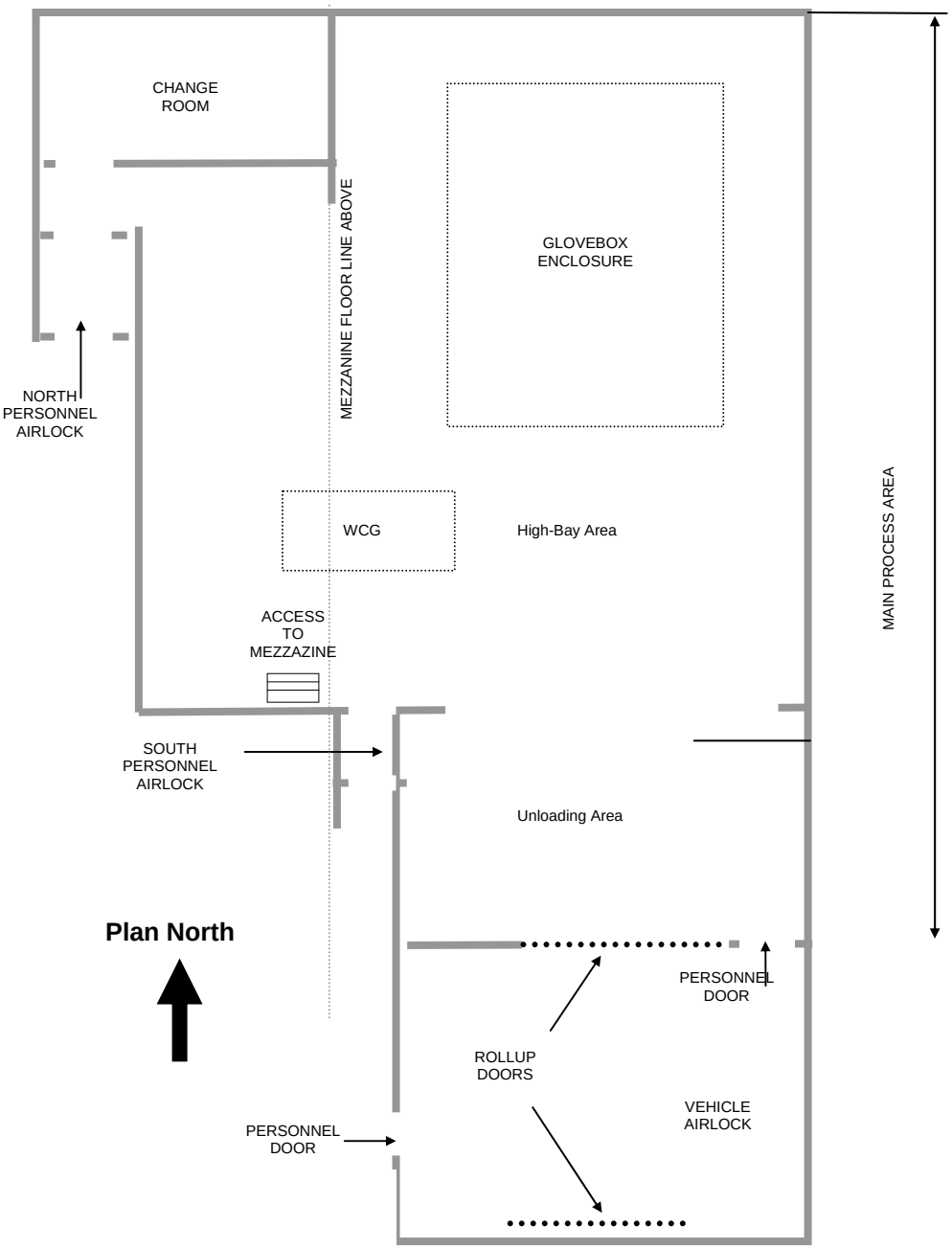


Figure 2-1. TA-50-69 Floor Plan (not to scale)

2.4.1.2 Main Process Area

The unloading and high-bay areas are known as the main process area, and together they provide the necessary space to conduct TRU waste processing and repackaging operations.

2.4.1.2.1 Unloading Area

The unloading area (the southernmost portion of the main process area) is about 360 ft^2 and houses a decontamination fume hood and a flexible welding fume exhaust trunk. A large portion of the area is free space for moving containers through the vehicle airlock to and from the high-bay area. This space is also used for staging TRU waste containers.

2.4.1.2.2 High-Bay Area

The high-bay area contains the WCG, which is used to examine and repackage TRU waste container contents. The high-bay area also houses the GBE, which was originally installed to support several waste management operations, including waste processing, waste size reduction, and waste repackaging. The GBE contains residual surface radiological contamination from past activities. Under this DSA, operation of the GBE is not requested or authorized for the TRU waste processing activities that are addressed. However, surveillance and maintenance activities may occur in the GBE. The GBE and WCG occupy a significant amount of floor space in the approximately 1,860 ft2 main process area and share a common HEPA exhaust train (FE-003). Miscellaneous support equipment occupies the west side of the main process area.

2.4.1.2.3 Mezzanine

There is a mezzanine over the western portion of the high-bay area. Its floor is constructed of reinforced concrete poured over steel joists and metal decking. The mezzanine is used for building process-support equipment, including portions of the TA-50-69 ventilation system. Access to the mezzanine (see Fig. 2-1) is by a ladder mounted on the south wall of the main process area.

2.4.2 TA-50-69 Structural Design

The exterior walls of TA-50-69 are load-bearing, and are constructed of structural steel-stud framing with a plaster finish. The floor is a reinforced concrete slab on compacted fill. Roofing consists of fire-retardant 4-ply membrane roofing with bitumen and gravel. The roofing rests on 2 inches of rigid insulation supported by a metal roof deck. The metal roof deck is supported by a bar joist that spans between load-bearing stud walls. A ⅝-inch gypsum ceiling is suspended from the bar joist. The roof supports the heating, ventilating, and air conditioning (HVAC) ductwork that is part of the ventilation system. Table 2-1 shows the applicable design criteria that the building was originally designed to meet. In 2007, the building was upgraded to the PC-2 natural phenomena hazard (NPH) design criteria included in the 2006 LANL *Engineering Standards Manual;* these criteria are summarized in Table 2-2.

Table 2-1. TA-50-69 Original Design Criteria

Wind Load	ANSI A58.1 Exposure C: 88 mph[1] Maximum velocity based on mean recurrence interval of 100 yr
Seismic Load	UBC (1976), Zone 2 Occupancy Importance = 1.5 Site-Structure Resonance = 1.5
Live Load	Roof: 30 psf Floor: 250 psf Mezzanine: 50 psf
Fire Rating	Interior surface non-combustible Fire-retardant roofing

Table 2-2. TA-50-69 Upgrade Natural Phenomena Hazard Criteria

Wind Load	DOE-STD-1020 PC-2 International Building Code (IBC) 2003 (ICC 2003) Wind Exposure Category C Basic Wind Speed 90 mph[2] Building Category IV: Wind Importance Factor = 1.15
Seismic Load	DOE-STD-1020 PC-2 IBC-2003 Seismic Design Category D Building Category IV: Seismic Importance Factor = 1.50 Five-percent damped design spectral response acceleration at short periods, S_{DS}, = 0.54 g, and at 1-s periods, S_{D1}, = 0.26 g.

2.4.3 Seismic Capability

The WCRRF is a one-story, light-framed metal-stud structure. The structure includes a lateral force-resisting system that consists of horizontal diaphragms that distribute lateral forces to tension-only diagonal braces. A seismic evaluation was performed to investigate the building's seismic capacity (LANL 2007). The report indicates that, with recent building upgrades, TA-50-69 (existing facility) meets performance goal requirements in DOE-STD-1020-2003 for a PC-2 facility.

[1] Resisting 88-mph fastest-mile wind speed is the requirement identified by ANSI A58.1.
[2] Resisting 90-mph three-second-gust wind speed is the requirement identified by both IBC 2003 (ICC 2003) and ASCE 7. The latter code, which provides the technical basis for the wind-speed resistance requirement in the building codes, changed from fastest-mile to three-second-gust wind speed in the 1995 code revision. The ASCE 7 code supersedes the ANSI A58.1 code. All buildings are currently designed to three-second-gust wind speeds.

2.4.4 Transportainers

The WCRRF site uses transportainers to stage TRU waste containers. Transportainers are staged on the south side of TA-50-69. Transportainers are commercially procured, all-metal dry-cargo shipping containers and are provided with passive ventilation via four small (approximately 4-in. x 4-in.) vents at each upper corner. The larger ones are approximately 40 ft long, 8 ft wide, and 8 ft high; the smaller ones are roughly half as long. The transportainers are not airtight. The transportainers may be raised and leveled less than 4 ft above grade and supported in that position.

The TRU waste containers are loaded and unloaded from the transportainer doorways using forklifts. The TRU waste containers are moved within the transportainers manually, usually on TRU waste container dollies.

2.4.5 Ancillary Structures

Building TA-50-84 is a transportable office structure with wood frame, walls, and floors. This structure is considered Type V(000) according to NFPA 220 and Type V-N according to the UBC. This building is located outside the WCRRF footprint. (See Figure 1-3.)

The nearby structure, TA-50-54, is a two-story building with a noncombustible exterior and built-up roof. It is considered at least a Type II(000) according to NFPA 220 and II-N according to the UBC. This building is outside the WCRRF footprint and is sufficiently distant from TA-50-69 that it does not present a fire exposure hazard to TA-50-69. (See Figure 1-3.)

2.4.6 Vehicle Access System

A vehicle access system (VAS) is established around the WCRRF. This system is defined by vehicle barriers and administrative procedures. Gasoline-, diesel-, propane-, or other combustible-fueled vehicles or forklifts are not used inside the VAS while TRU waste is present. An exception to this fuel restriction is the use of a vehicle with less than 5 gal of fuel for the purpose of snow and ice removal and grounds maintenance activities.

2.5 PROCESS DESCRIPTION

This section describes the typical processes performed at the WCRRF, starting with an overview and followed by discussions of the individual processes. Details include process parameters, process equipment, control systems, and operational considerations.

2.5.1 Overview

The following are the major tasks performed at the WCRRF. These tasks include prohibited item disposition (PID) activities.

- **TRU-Waste Container Shipping and Receipt:** Authorize receipt at the WCRRF, receive TRU waste containers, and ship from the WCRRF site.
- **Staging and Handling:** Hold TRU waste containers until they are needed for operations; load, unload, and move TRU waste containers; and position TRU waste containers.

- **Opening of (parent) TRU waste containers in the WCG:** The parent TRU waste container is a vented 55-gallon drum.
- **Visual Examination (VE):** Inspect the contents to compare to previous radiography results and to ensure all waste packaged into daughter drums is WIPP-compliant.
- **Repackaging:** Remove radioactive contents from a TRU waste container and repackage the waste into new TRU waste containers.
- **Remediation*:*** Remediate noncompliant conditions, such as non-Resource Conservation and Recovery Act (RCRA) or non-WIPP-compliant items, and includes the opening of various sized sealed or unsealed containers (i.e., nested drums in the parent TRU waste containers) and prohibited items, including free or residual liquids, in the WCG.

Each TRU waste container's movement through the WCRRF depends on the operations needed for that container. A general depiction of the flow of TRU containers is shown in Fig. 2-2.

After waste processing is completed, TRU waste containers are closed and returned to staging within the WCRRF or moved directly to another process. After processing and repackaging, containers are staged, awaiting transport for storage or shipment.

2.5.2 Waste Container Receipt and Shipping

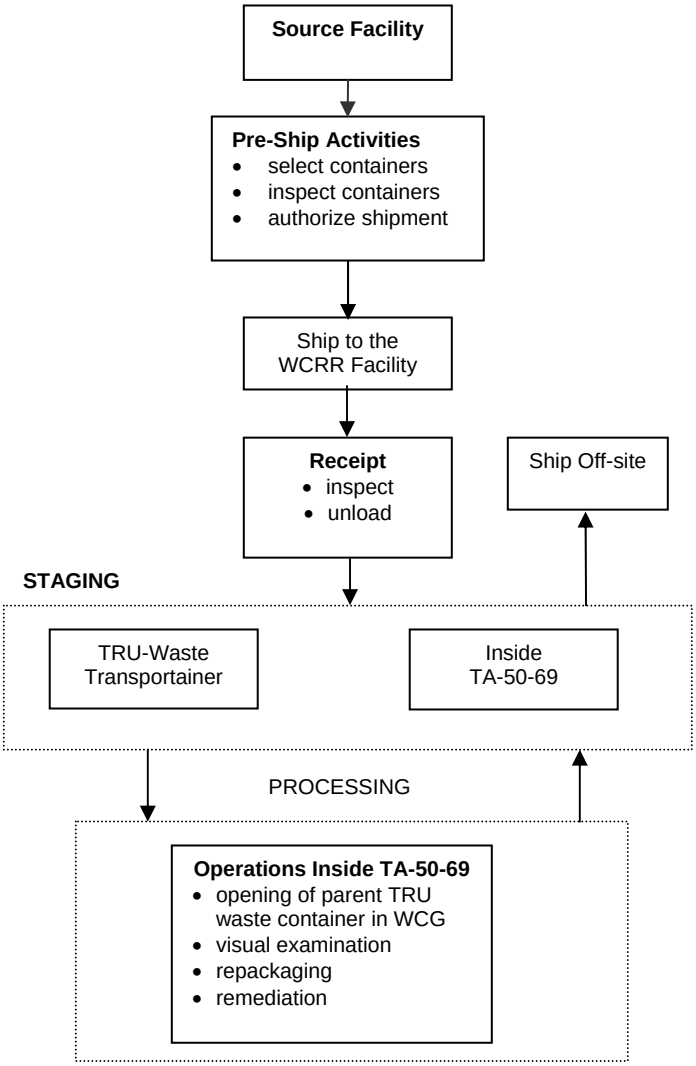
The receipt and shipping process includes the following activities:

- Reviewing generator documentation for information on the material-at-risk (MAR) within a waste container received at WCRRF to ensure that MAR limits are not exceeded and waste contents and waste matrices are identified and examining real-time radiography analysis results so that WCRRF WCG operators have an understanding of the contents of a waste container to be remediated.
- Visually inspecting TRU waste containers and vents and verifying acceptability to bring on-site, including all prerequisites.
- Loading and unloading TRU waste containers from transport trucks (**Note:** containers may contain degraded or loss of integrity containers of TRU waste).
- Inspecting TRU waste containers and conducting a radiation survey upon arrival.

2.5.3 TRU-Waste Container Staging and Handling

Outside transportainer areas are designated for holding TRU waste containers that await processing. TRU-containers may also be staged inside TA-50-69.

Forklifts, dollies, pallet jacks, and hand trucks are used to move TRU waste containers in the WCRRF. Forklifts can move individual drums using grapplers. A pallet of drums can be moved using the forklift tines. Forklifts may be equipped with approved lifting rigs to remove degraded or loss-of-integrity drums from TRU waste containers inside the TA-50-69 unloading area.



NOTE: Several processes can be undertaken simultaneously inside a glovebox, including VE, repackaging, remediation, and other operations.

Figure 2-2. Process Flow through the Waste Characterization, Reduction, and Repackaging Facility (typical)

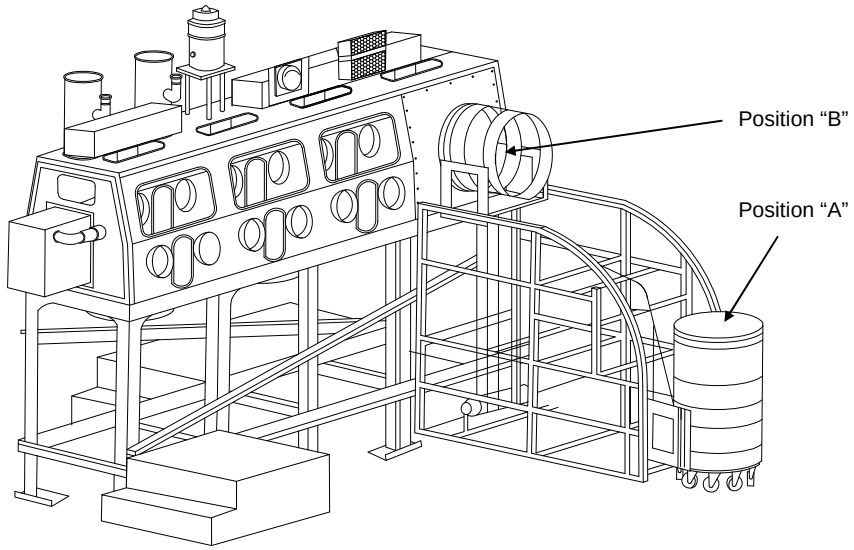


Figure 2-3. Waste Characterization Glovebox (typical)

2.5.4 Opening of (Parent) TRU Waste Container in the WCG

At the WCG, drums are secured to an electronically operated drum lift fixture. The drum is clamped to the lift in an upright position; see position A of Figure 2-3. The lift rotates the drum to the horizontal position and lifts it to the entry port, Position B of Figure 2-3. A plastic sleeve that joins the drum to the glovebox establishes a contamination control barrier.

Inside the WCG, workers use glove ports to manipulate hand tools (wrench, battery-operated drill, etc.) to loosen the drum lid retainer ring and remove the lid, exposing the container’s contents. Examiners then lift the waste items from the open drum into the WCG for examination.

2.5.5 Visual Examination

Visual examination is the process of inspecting and documenting the daughter drum contents. It is an invasive process conducted in the WCG (see Fig. 2-3). See Section 2.6, *Confinement and Containment Systems*, for a discussion of WCG confinement. The VE process documents remediation of waste that is not compliant with WIPP waste acceptance criteria (WAC) or the segregation of waste that cannot be remediated. Nonconforming items that cannot be remediated are placed in a separate drum that is set aside for future actions.

Throughout the VE process of opening the drum and examining and removing the contents, a video camera records the actions and the examiners’ comments describing the contents. Once examined, waste items are packaged into a new (daughter) drum, which is bagged onto a port on the bottom of the WCG at the opposite end of position B in Fig. 2-3. The WCG can accommodate only one drum in the entry port

and two drums in the packaging ports. The empty drum (the original drum) is bagged off the WCG entry port and processed as low-level waste (LLW).

A radiological control technician (RCT) is present whenever VE is being conducted to perform radiation surveys and monitor contamination control practices.

2.5.6 Repackaging

The TRU waste containers that do not comply with WIPP WAC requirements are remediated and repackaged at the WCRRF. Knowledge of specific noncompliance is obtained from generator records or from a waste characterization process. Repackaging involves opening drums in the WCG, separating the waste items, remediating noncompliant waste, placing them into one or more new drums, documenting the items placed in each drum, and closing and bagging out the newly packaged drums.

2.5.7 Remediation (Prohibited Item Disposition)

During remediation, items that are not in conformance with the WIPP WAC are removed. Items that cannot be brought into compliance are usually placed in drums and sent to a LANL site for storage or further action.

The remediation process also includes the opening of sealed and unsealed containers of various sizes, such as containers as large as 30 gallons and as small as a 30-milliliter vial or less. In addition, arbuoy-sized containers (~5 gallons) with residual liquids have been encountered. The types of liquids that have been encountered include cleaning solutions (sometimes in their original packaging—such as a "Fantastik" bottle) and organic solvents such as ethanol and acetone. Other organic liquids, such as pump oil, which could be within a discarded pump, or paint, etc., have also been encountered. Aerosol cans with some residual contents that have not been punctured have also been removed from parent drums.

A liquid absorbent may be added to these containers having liquids to absorb, including free or residual liquids, according to WIPP WAC requirements, or, if the containers with liquids cannot be remediated, they are separated for alternate disposal.

All waste matrices may be found in sealed or unsealed containers within the parent drum including but not limited to lead (Pb) shielding, liquids (both organic and aqueous), and combustibles. These waste matrices may be remediated, bagged out of the WCG, and segregated into daughter drums in accordance with WIPP WAC requirements.

Items that cannot be shipped to WIPP (such as containers with free liquids that cannot be absorbed as described above) are also segregated into a separate drum and removed from the WCRF WCG for later disposition either as low-level, mixed low-level, or chemical waste in accordance with applicable LANL site procedure.

Based on the waste acceptance criteria and container characterization studies, Class 1 oxidizers such as nitrates and reactive flammables such as lithium metal or hydrides are not expected. However, because of limited uncertainty in the waste characterization, oxidizers, pyrophoric materials, and flammable liquids are considered as initiators to fire events during glovebox operations, and these events are considered unlikely, based on existing characterization data, as indicated in the hazard analysis.

2.5.8 Miscellaneous Operations

2.5.8.1 Decontamination

Items designated for reuse that have internal or surface contamination can be decontaminated at the WCRRF using the facilities and equipment discussed previously. Decontamination equipment includes brushes, rags, water, and surface cleaning solutions. Radiation protection program controls with RCT support are in place. The LLW is collected and bagged out during the decontamination steps.

2.5.8.2 Secondary Waste Handling

The LLW is collected from decontamination activities, RCT surveys, spill cleanup, bag-in/bag-out, and glovebox operations. Certain LLW must be characterized to ensure that it is not TRU waste. Radioactivity levels also must be defined to place the waste into the proper waste stream.

2.5.8.3 Glovebox Operations and Maintenance Activities

Common operational steps are the bag-in and bag-out steps that are used to connect and remove drums or other containers from the WCG. Bag-in and bag-out steps essentially ensure contamination and radioactive material control when attaching or removing drums from the glovebox. Consumable plastic sleeves, bags, and sealing devices such as straps and tape are used for bag-in or bag-out. Container lids are installed in accordance with the manufacturer's instructions and LANL procedures.

Routine glovebox maintenance includes glovebox inlet HEPA filter replacement and changing gloves, glass panels, seals, or other mechanical items when necessary.

The WCG is decontaminated routinely to prevent accumulation of radioactive material. The decontamination process might use surfactants, detergents, and mild acids or bases, which are neutralized before disposal.

2.5.8.4 Forklift Battery Recharging

Forklift batteries must be periodically recharged. The recharging station for the forklift batteries is located outside of the facility, preventing accumulation of dangerous levels of hydrogen during the recharging.

2.6 CONFINEMENT AND CONTAINMENT SYSTEMS

Primary confinement inside TA-50-69 is provided by TRU waste containers, as well as by the WCG. Final confinement is provided by the building structure (roof, walls, and slab), HEPA filter banks, and airlocks. In addition to maintaining appropriate air quality in the building, the ventilation systems provide differential pressure control and filtration functions; these limit contamination spread and mitigate potential releases. The TRU waste containers are staged in transportainers outside the building.

2.6.1 Waste Containers

A variety of TRU waste containers can be present at the WCRRF. The predominant types are 55-gal drums and standard waste boxes (SWBs). The TRU waste containers acceptable for use at WCRRF have a filtered vent and are of steel construction, and the container design prototype has been free-drop tested to survive a 4-ft drop as specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests*. The SWBs with

TRU waste are shipped to the WCRRF, but some SWBs are also used to package waste at the facility. The SWB dimensions are 6 ft by 4.5 ft by 3.2 ft—large enough to hold four 55-gal drums. The SWBs are sealed with metal lids and secured with flat-head bolts.

2.6.2 Glovebox Enclosure

Surveillance and maintenance are the only GBE operations (no TRU waste processing or storage). The GBE is divided into three functional areas as shown in Fig. 2-4: an airlock, a process area, and a packaging/bag-out area.

2.6.3 Waste Characterization Glovebox

The WCG shown in Fig. 2-3 is similar to many gloveboxes used at LANL. It has three drum ports and is equipped with gloveports. One 55-gal drum port is located on the side of the glovebox. The WCG also has an introductory box to pass tools and other supplies to the glovebox.

The WCG is maintained at a negative pressure with respect to the main process area by exhausting air from the WCG to the exhaust ducts that lead to a HEPA filtration unit on the mezzanine; the air is then exhausted from the building. The WCG has two HEPA-filtered 2-in. intakes and two HEPA-filtered 2-in. exhaust lines that are combined into a single exhaust line. The exhaust line is routed to the GBE exhaust ductwork at the mezzanine level just before the HEPA filtration unit that serves both the GBE and WCG. The exhaust systems for the GBE and the WCG operate in parallel until the flow is combined upstream of the HEPA filtration unit.

The exhaust from the WCG goes through HEPA canisters located on the glovebox. The exhaust flows through the exhaust line containing about 30 feet of ductwork before the exhaust flow is introduced to the GBE exhaust header. The combined exhaust flow then passes through a spark-arrestor screen, prefilters, HEPA filters, and fan (located on the mezzanine) and then out the glovebox exhaust stack.

The WCG instrumentation includes differential pressure gauges, which are connected to the automated ventilation system operator interface terminal (OIT). Loss of negative pressure in the WCG caused by changes in the exhaust flow rate or glovebox confinement activates warning alarms on the OIT. See Section 2.6.5.5 for a description of the OIT and Section 2.7.3 for a description of the alarms. Operators can check the pressure differential locally by using the Magnehelic® gauges mounted on the WCG. The WCG is equipped with a horizontal sidewall sprinkler connected to the building fire suppression system. The water supply to the WCG sprinkler head can be isolated with a valve at the WCG.

The seismic capacity of the WCG and the lift rack immediately adjacent to the glovebox has been evaluated (LANL 2004) by structural engineers. Based on this evaluation, the WCG and the lift rack are considered able to meet PC-2 NPH seismic criteria. A seismic expansion joint allows the sprinkler system component mounted to the glovebox to move independently from those that are supported by the building structure.

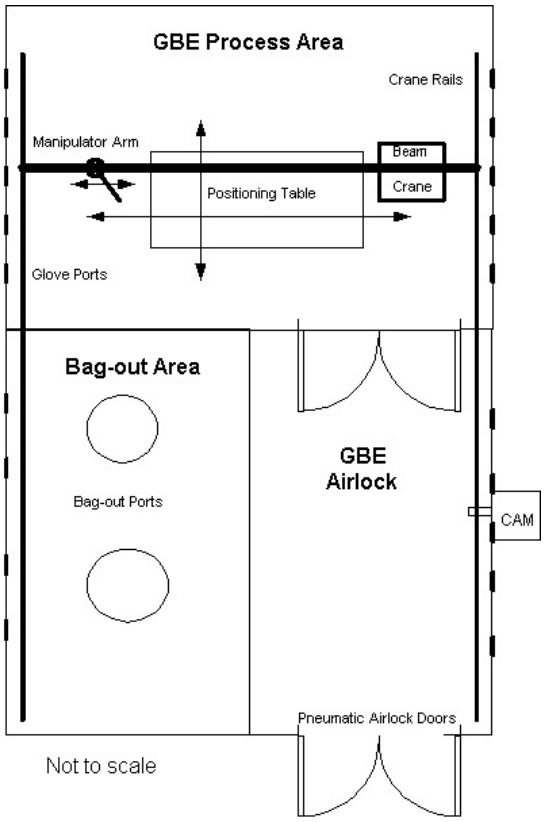


Figure 2-4. Glovebox Enclosure

2.6.4 Final Confinement–Building Structure

The structure, which includes the roof, walls, and cement slab floor, provides final confinement in the event of a release of radioactive material inside the building. Roofing consists of a fire-retardant 4-ply membrane roofing with bitumen and gravel. The roofing rests on 2 inches of rigid insulation supported by a metal roof deck. The metal roof deck is supported by a bar joist which spans between load-bearing stud walls. A 5/8-inch gypsum ceiling is suspended from the bar joist. The exterior walls are constructed of structural steel-stud framing with a plaster finish. Penetrations through the exterior walls typically include ductwork, electrical conduit, breathing air lines, and personnel and vehicle doors. Equipment penetrations are sealed.

Building TA-50-69 has a vehicle airlock that is used for moving waste containers to and from the main process area. The airlock is separated from the outside environment and the main process area inside the building by a pair of overhead rollup doors. One door opens to the outside, and the other door separates the main process area from the vehicle airlock. The vehicle airlock also helps ensure that the building is maintained at a negative pressure relative to the outside environment while personnel and materials move to and from the building. In addition to the roll-up doors, there are personnel doorways into the vehicle airlock from the outside and into the main process area from the airlock.

Two sets of personnel access doors are on the west side of the building. One set provides access to the change room (normal personnel access), and the second set provides access directly to the main process area. These doors and the spaces between each pair of doors serve as airlocks to maintain building confinement.

2.6.5 TA-50-69 Ventilation System

Building TA-50-69 employs the zone concept of contamination control, wherein air is drawn from areas with the lowest potential for contamination into areas with increasingly greater potential for contamination. In addition to a negative air pressure gradient toward areas of higher contamination potential, this flow is accomplished through the physical configuration of equipment provided by enclosures, walls, roof, and portals such as doors and glovebox ports. The TA-50-69 ventilation system provides the necessary airflow and pressure control for the GBE and WCG, the main process area, the change room, and the vehicle airlock.

The ventilation system includes one common supply air/HVAC system and three autonomous exhaust systems. The supply air/HVAC system and the building exhaust systems are designed and controlled to maintain a negative pressure inside the building relative to atmospheric pressure outside the structure. Air pressure in the GBE and WCG is negative with respect to the ambient room air, which is negative with respect to the atmospheric pressure outside the structure.

All air entering the building is routed once-through (no air is recirculated). Outside air entering the building is filtered and conditioned for habitability by the supply air/HVAC system. The building and gloveboxes are exhausted directly to the atmosphere through HEPA filter banks.

2.6.5.1 TA-50-69 Supply Air/HVAC System

The supply air/HVAC unit (HVA-1) provides fresh, conditioned air to the building. Intake air passes through prefilters, a refrigerant cooling coil, an electric heating coil, and a hot water heating coil. Refrigeration, back-up heat, and air handler units are mounted on pads located north of Building TA-50-69. Intake air is routed through ductwork on the roof and through a backdraft damper before it is distributed throughout the building.. Hot water for the heating coil is provided by two natural gas boilers located northwest of Building TA-50-54. Electric heaters are installed in the vehicle airlock and in the attic to provide supplemental heating when necessary.

Makeup air is drawn into the GBE continuously from the building through three HEPA filter banks that are mounted on the sides of the GBE. Makeup air enters the WCG through two inlet HEPA filters mounted over an inlet atop the glovebox and exhausts through two HEPA canisters atop the glovebox.

2.6.5.2 Exhaust Systems

The building employs three separate exhaust systems, each of which consists of ductwork, HEPA filters, a fan, and exhaust ductwork leading to building exhaust stacks. The main process area, WCG, and GBE exhaust systems operate continuously during *Operation* and *Warm Standby* modes.

Filtration of the exhaust air is discussed in Section 2.6.5.3, *Exhaust Filtration Systems*. The main process area exhaust system exhausts approximately 6,000 cfm from the building. The main process area exhaust system ductwork does not extend into the vehicle airlock. The system includes a fan (FE-002) coupled with a 15-kW (20 hp) motor. Airflow is adjusted by a variable frequency drive on the TA-50-69 exhaust fan. Airflow adjustment is necessary to maintain negative pressure with respect to the outside environment as the HEPA filter resistance gradually increases as a result of filter loading. The main process area is maintained at a negative pressure with respect to the outside environment.

When the inner vehicle airlock door is closed, air is drawn from the vehicle airlock into the building through an opening in the wall adjacent to the door. A filter in the wall opening reduces the introduction of dust and other debris into the building.

The WCG and GBE have a dedicated exhaust system that maintains negative pressure with respect to the main process area. The system consists of an industrial fan (FE-003) coupled with a variable-speed electric motor, which permits the fan capacity to be adjusted automatically to maintain the necessary negative-pressure relationships as the filter resistance gradually increases with use.

2.6.5.3 Exhaust Filtration Systems

Air cleaning equipment for all three exhaust systems consists of nuclear-grade HEPA filters. All filters are listed by Underwriters Laboratories® as fire-resistive. Table 2-3 summarizes the components of the three exhaust filtration systems.

The exhaust fans and filtration systems for the GBE and WCG exhaust system (FE-003) and the welding fume hood exhaust system (FE-001) are located on the mezzanine. The exhaust fan (FE-002) and the filtration system for the main process area exhaust system are located outside the building, where they are mounted on a concrete pad adjacent to the west wall of the building.

Table 2-3. TA-50-69 Exhaust Filtration Systems[1]

System	System Designator	HEPA Filter Bank (minimum efficiency)
GBE and WCG Exhaust	FE-003	Single-Stage 99.95%[2]
Welding Spot Exhaust	FE-001	Single-Stage 99.95%
Main Process Area Exhaust[2]	FE-002	Single-Stage 99.95%

[1]This system also exhausts the decontamination fume hood.
[2]A two-stage HEPA system is installed, but the system is treated and tested as a single-stage system.

The HEPA filters listed in Table 2-3 are tested in place to establish that they meet the performance requirements. Prefilters and HEPA filters are changed as required.

2.6.5.4 Exhaust Stacks

The main process area exhaust stack is located on the ground next to the west side of the building and extends to a height of 41 ft above grade. The GBE and WCG exhaust system stack and the welding fume hood exhaust system stack are both located on the roof of the building, which is 23 ft above grade. Both stacks are 12 ft tall, resulting in an outlet elevation of 35 ft above grade. Table 2-4 summarizes the characteristics of the three exhaust stacks.

Table 2-4. TA-50-69 Exhaust Stack Characteristics

Exhaust System	Stack Height (ft above grade)	Inside Dimensions at Release Point Exit (in.)	Effluent Temperature (ºF)
GBE and WCG	35	12	60–95
Welding Fume Hood	35	8	60–95
Main Process Area	41	10	60–80

2.6.5.5 Ventilation Control System

An OIT installed on the west wall of the main process area controls the supply air system, the main process area, and the GBE exhaust systems. The OIT is an electronic, programmable monitoring and control unit with alarm capability to alert personnel of abnormal conditions. The unit monitors differential pressures, flow rates, and other system parameters and makes the necessary ventilation system adjustments to maintain each parameter in its normal operating range.

Of primary importance is controlling the pressure differentials between the building and the outside atmosphere and between the GBE and WCG and the building (main process area). The OIT adjusts the exhaust flows automatically to maintain the input pressure differentials.

If the OIT is unable to maintain the operational parameter within the desired range, it initiates alarm signals and system shutdowns, as required. Alarms are visual and audible.

The OIT also includes logic to sequence the starting of the ventilation system on the auxiliary generator in the event of a loss of normal power. The auxiliary generator automatically picks up the facility system loads, and upon operator command, the OIT starts the systems in the sequence necessary to maintain required pressure differentials.

2.7 SAFETY SUPPORT SYSTEMS

2.7.1 Fire Suppression

Firefighting water is gravity-fed from a 500,000-gal storage tank that supplies water to all TA-50 facilities. A 12-in. water main supplies water to an 8-in. WCRRF water line. The 8-in. water line supplies a hydrant and water to two separate lines: a 2-in. domestic line and a 6-in. fire line. This 6-in. fire line provides firefighting water to TA-50-69. A single FSS is provided for TA-50-69, including the WCG, and consists of a wet-pipe sprinkler system that protects the building and the GBE. The FSS is hydraulically designed for Ordinary Hazard Group II coverage (NFPA 1976a). Fire sprinkler water flows from the building floor drains (see Section 2.8.4) through a common drain line that flows to the Radioactive Liquid Waste Treatment Facility (RLWTF).

Activation of the building, WCG, or GBE sprinkler heads automatically activates the fire alarm panel and transmits a fire alarm signal to the Los Alamos Central Alarm Station. Fire alarm pull stations located by exit doors also transmit a fire alarm to the Central Alarm Station. The Central Alarm Station dispatcher notifies the fire department. The fire alarm panel is equipped with a backup battery in case of power failure.

With a fire localized to the WCG, the single sidewall sprinkler inside the WCG should activate independently of the building sprinklers, limiting the volume of fire suppression water generated in the event of a glovebox fire.

2.7.2 Radiological Monitoring

Continuous air monitors (CAMs) are located throughout TA-50-69 to monitor airborne radioactivity. Each CAM has a visual sample airflow meter and a local alarm for low airflow and radiation. Service checks and filter changes are conducted regularly.

The CAMs are located throughout the facility at key locations to take advantage of airflow patterns and to be in close proximity to material-at-risk. The CAMs may be moved from their current locations if more effective locations are identified in the future as operational parameters vary. The flow through each CAM is regulated to meet the minimum flow requirement of each head.

In the event of an electrical failure, CAMs receive emergency power from an uninterruptible power supply. However, the auxiliary diesel generator provides long-term backup power once it picks up the loads.

In addition to the CAMs, personnel monitors and portable instruments are available to detect and measure ionizing radiation. The personnel monitors consist of stationary monitors and portable alpha and beta/ gamma survey instruments. In addition, fixed-head air samplers are scattered throughout the building to provide more accurate airborne radiological data. The samples they collect are analyzed regularly to monitor airborne radioactive materials during normal operation. Vacuum pumps are located outside Building TA-50-69 to support CAMs and fixed-head air sampling. The vacuum pumps' maximum airflow is approximately 75 cfm. Discharge from the vacuum pumps is directly to the outside with no filtration.

2.7.3 Communication/Warning System

Telephones are installed throughout the WCRRF. Red-light beacons installed outside TA-50-69 above personnel doors (as part of the Radiation Protection Program) provide notification when hazardous activities such as operations requiring respirators are being performed in the building. Automatic alarms, both visual and audible, are installed in the OIT unit as described in Section 2.6.5.5, *Ventilation Control System*. The OIT display indicates which alarm is activated and maintains an electronic record of each alarm activation.

2.7.4 Lightning Protection

The lightning protection system for Building TA-50-69 consists of multiple, independent earth-grounded conductors connected to a grounding grid. The transportainers are also provided with lightning protection via grounding as recommended by NFPA 780, *Standard for the Installation of Lightning Protection Systems* (NFPA 2004). These systems are maintained operable in accordance with NFPA 780.

2.8 UTILITIES

2.8.1 Electrical Power

Electrical power is supplied to the WCRRF by 13.2-kV/480V 225 kVA transformer, structure TA-50-279, located near the northwest corner of TA-50-54. The oil-filled transformer is located more than 25 ft northeast of Building TA-50-69. The transformer supplies power to building TA-50-69 and office building TA-50-84. Mineral oil is used as the transformer insulating and cooling oil, with a maximum volume of 275 gal. The Material Safety Data Sheet for the mineral oil (MSDS number 400800E-2) lists an NFPA rating (health, fire, reactivity) of 0, 1, 0. The flashpoint using the Cleveland Open Cup method is 545 ºF (285 ºC). The specific gravity is 0.87. The transformer location meets the Factory Mutual Global, Property Loss Prevention Data Sheets 5-4 (FMG 2003) requirement that an oil-filled transformer filled with less than 500 gal of mineral oil must be located at least 25 ft from any structure of combustible construction and at least 5 feet from adjacent equipment.

All electrical power systems were designed and installed in accordance with the National Electric Code and other applicable industry standards in effect when the equipment was installed.

2.8.2 Auxiliary Diesel Generator

A 100-kW, 125-kVA auxiliary diesel generator installed northeast of TA-50-69 supplies power for WCRRF electrical loads. If normal site power fails, the auxiliary generator provides alternating current power to TA-50-69 loads and yard loads that normally receive power from the building. The generator is mounted on a concrete pad approximately 28 ft east of the northeast corner of TA-50-69, just inside the WCRRF boundary. The diesel fuel tank is double-walled to contain potential leaks from the primary tank.

The auxiliary generator is connected to the electrical distribution system through an automatic transfer switch. When the switch detects a loss of utility power, it signals the generator to start. The transfer switch does not have built-in load sequencing capability. To restore TA-50-69 ventilation after shutdown, the OIT is used to initiate the programmed time delay/start sequence. The fans are sequenced to start in the following order:

- WCG/GBE exhaust fan
- Main process area exhaust fan
- Building supply fan

2.8.3 Uninterruptible Power Supply

The uninterruptible power supply (UPS) is located in the vehicle airlock on the south side of Building TA-50-69. The UPS is rated at 10 kVA, 9 kW. The UPS input voltage is 208 V/120V, 3-phase, with 120-V output to continuous air monitors and the ventilation control system.

2.8.4 Water and Drainage Systems

Water supply for the WCRRF is provided by a gravity-fed system from a 500,000 gal storage tank, which supplies all of TA-50. Water for the WCRRF is drawn from a 12-in. cast-iron water main extending along the north side of Pecos Drive through an 8-in. cast-iron pipe. At a hydrant located on the west side of TA-50-69, the water is split into a 6-in. fire protection line with a post indicator valve and a 2-in. galvanized steel domestic water line. A service valve is located in the domestic line just inside the

building. A main pressure-reducing valve regulates the building water system pressure. Potable water supplies facility loads.

Two floor-level drain openings are provided for the GBE. These openings are located inside the GBE, one in the process area and one in the airlock. Water in the GBE can be pumped through a filter assembly into a small (100 gal) vacuum holding tank that is located in a pit adjacent to the GBE. The water can be pumped to a second holding tank (273 gal) in the pit, where it can be drained from the building through the line to the RLWTF. The pit provides access to the GBE holding tanks and the pump. The filter assembly is removable from inside the GBE. The GBE is not to be used for waste-processing activities, waste staging or storage, or any other purpose under this DSA.

One floor drain is in the vehicle airlock and two floor drains are in the main process area south of the GBE. All liquids from the floor drains, janitor closet, GBE drain system, and decontamination fume hood connect to a common drain line in a pit just outside the south side of the building. This pit provides access to the drain lines for maintenance purposes. From there, the water drains through a double-encased pipe to the RLWTF[3]. The drains are 2-in.-diameter pipes. These pipes are sufficient to capture fire suppression water from some of the sprinklers, but may be insufficient to flow all the water in a 2-hr design-basis fire. In this case water, would be expected to flow out of the facility unless emergency actions are taken.

Sanitary effluent flows to the TA-46 Sanitary Treatment Plant for processing.

2.9 AUXILIARY SYSTEMS AND SUPPORT FACILITIES

Auxiliary equipment and facilities required to accomplish the WCRRF mission are described in the following subsections. Several auxiliary equipment items are used inside TA-50-69. Auxiliary facilities include transportainers used for TRU waste container staging outside the building.

2.9.1 Remote Disassembly Equipment

Remotely operated equipment located in the GBE is not used at this time because GBE operations are not authorized under this DSA.

2.9.2 Forklifts

Electric forklifts are available to move large items around the WCRRF. The batteries for these forklifts are charged outside TA-50-69. Only electric forklifts are used at WCRRF.

2.9.3 Waste Staging Facilities

The TRU waste containers are staged outside TA-50-69 in transportainers located in the VAS. A portion of the staging area is a RCRA-permitted staging area, and mixed-waste containers must be staged there. Transportainers are described in Section 2.4.4.

[3]A tank farm is currently under construction at the RLWTF to provide a 360,000-gal. capacity. It is anticipated that half of this storage volume may be used for normal operations, with the other half reserved for the fire suppression water run-off.

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3.0 HAZARD AND ACCIDENT ANALYSIS

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Acronyms and Abbreviations

AA	accident analysis
AC	Administrative Control
AED	Aerodynamic Equivalent Diameter
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ARF	Airborne Release Fraction
BEU	Beyond Extremely Unlikely
BIO	Basis for Interim Operation
BR	Breathing Rate
CAM	Continuous Air Monitor
CDF	Cumulative Distribution Function
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
DBA	Design Basis Accident
DCF	Dose Conversion Factor
DF	design feature
DID	defense-in-depth
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DR	Damage Ratio
DSA	Documented Safety Analysis
DSF	Dose to Source-term Scaling Factor
ED	equipment design
EG	Evaluation Guideline
EP	emergency preparedness
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
FGE	Fissile Gram Equivalent
FGR	Federal Guidance Report
FHA	Fire Hazards Analysis
FMEA	Failure Modes and Effects Analysis
FSS	Fire Suppression System

GBE	Glovebox Enclosure
HA	Hazard Analysis
HAZOP	Hazard and Operability Study
HC	Hazard Category
HE	hazard evaluation
HEPA	High-Efficiency Particulate Air
HRR	Heat release rate
ICRP	International Commission on Radiological Protection
ID	identification
LEL	lower explosive limit
LFL	lower flammability limit
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
LCO	Limiting Condition for Operation
LLW	Low-Level Waste
LPF	Leak Path Factor
LPG	Liquid Propane Gas
LPS	Lightning Protection System
MAR	Material-at-Risk
MDA	Material Disposal Area
MEOI	Maximally Exposed Off-Site Individual
NC-CSP	Nuclear Criticality Safety Program
NDA	Nondestructive Assay
NEC	National Electric Code
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
NPH	Natural Phenomena Hazard
OIT	Operator Interface Terminal
OSHA	Occupational Safety and Health Administration
PC	Performance Category
PE-Ci	Plutonium Equivalent Curie
PHA	Preliminary Hazard Analysis
PISA	Potentially Inadequate Safety Analysis
PMMA	polymethylmethacrylate

PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RF	Respirable Fraction
RQ	Reportable Quantity
RP	radiation protection
RPP	Radiation Protection Program
SAC	Specific Administrative Control
SC	Safety-Class
SIH	Standard Industrial Hazard
SMP	Safety Management Program
SNL	Sandia National Laboratory
SS	Safety-Significant
SSC	Structure, System, and Component
ST	Source Term
STD	Standard
SWB	Standard Waste Box
TA	Technical Area
TEDE	Total Effective Dose Equivalent
TQ	Threshold Quantity
TRU	Transuranic
TSD	Transportation Safety Document
TSR	Technical Safety Requirement
UPS	Uninterruptible Power Supply
USEPA	U.S. Environmental Protection Agency
USQD	Unreviewed Safety Question Determination
VAS	Vehicle Access System
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WCD	Waste Container Design
WCG	Waste Characterization Glovebox
WCRR	Waste Characterization, Reduction, and Repackaging
WHC	Westinghouse Hanford Corporation
WI/CL	What-If Checklist
WIPP	Waste Isolation Pilot Plant

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3.0 HAZARD AND ACCIDENT ANALYSIS

3.1 INTRODUCTION

This chapter describes the hazard and accident analyses performed for the Waste Characterization, Reduction, and Repackaging Facility (WCRRF). It analyzes the hazards that exist and the accidents that are postulated to occur during WCRRF activities. These activities include transuranic (TRU) waste processing and repackaging operations. General facility hazards and hazards associated with natural phenomena and nearby Los Alamos National Laboratory (LANL) facilities are considered. The WCRRF is composed of both the outside area where TRU waste containers are stored in transportainers, and the inside of Building Technical Area (TA)-50-69, where repackaging and remediation activities in the Waste Characterization Glovebox (WCG) occur.

The hazard and accident analyses comply with the requirements of Title 10 of *Code of Federal Regulations* (CFR) Part 830, "Nuclear Safety Management" (CFR 2003). For a facility with a limited operational life, which is the status of the WCRRF, 10 CFR 830 identifies two U.S. Department of Energy (DOE) standards (STDs) for preparing the safety analysis: DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* (DOE 2006a) and DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002a). DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* (DOE 2007) documents additional expectations for the preparation of safety basis documents for TRU waste facilities. DOE-STD-3009-94 addresses the preparation of a documented safety analysis (DSA) and DOE-STD-3011-2002 addresses preparing a basis for interim operation (BIO), a form of a graded DSA. The hazard and accident analyses described in this chapter were prepared in accordance with DOE-STD-5506-2007, DOE-STD-3011-2002, and DOE-STD-3009-94, using a graded approach.

The Hazard Analysis (HA) methodology begins with a comprehensive list of process-related natural phenomena and external hazards that can result in local, on-site, or off-site consequences of concern if an accident occurs. Hazard evaluation generates the likelihood and consequence estimates used to characterize hazards in the context of potential accidents. This method provides a thorough, predominantly qualitative evaluation of the risk to the public and workers from potential accidents involving the identified hazards. The HA methodology was performed in accordance with DOE-STD-3009-94.

The results of the HA include potential accident scenarios and the associated safety controls (preventive and mitigative); potential safety-class (SC) or safety-significant (SS) structures, systems, and components (SSCs); and a spectrum of scenarios to be evaluated quantitatively in the Accident Analysis (AA). The methodology used to identify and evaluate hazards is documented in Appendix 3A and in Section 3.3.1 of this chapter.

Based on the results of the HA in Section 3.3.2, and the comparison of the WCRRF inventory to the Threshold Quantities (TQs) from DOE-STD-1027-92 (DOE 1997), the WCRRF is categorized as a Hazard Category 2 (HC-2) nuclear facility. According to DOE-STD-3009-94, Accident Analysis is required for HC-2 facilities or activities because there is a potential for exceeding the DOE evaluation guideline (EG) of 25 rem total effective dose equivalent (TEDE) to the maximally exposed off-site individual (MEOI). The MEOI is postulated to be located at the nearest site (Laboratory) boundary.

Section 3.4.1 of this chapter provides a description of the method used in performing the Accident Analysis.

DOE-STD-1027-92 (DOE 1997) and DOE-STD-3009-94 (DOE 2006a) provide guidance for grading the hazard and accident analyses. Grading is a function of both the hazard's potential to produce serious consequences and its complexity. A graded approach dictates that complex, higher hazard facilities be assessed more rigorously and that this assessment be documented more thoroughly than that of simple, lower hazard facilities. Consistent with this approach, if a hazard poses a more significant threat (i.e., health consequences), a more detailed analysis is performed. The hazard and accident analyses presented in this chapter were graded in accordance with these DOE standards.

The analyses in the HA have been performed after considering the consequences from waste containers containing the upper limit of activity to be processed (800 plutonium equivalent curie [PE-Ci] in Building TA-50-69 and 1800 PE-Ci on the site). This examination results in a bounding analysis for all waste containers scheduled to undergo waste processing at the WCRRF under this BIO. The AA is also based on 800 PE-Ci of combustible waste within the WCG, or in staged containers inside Building TA-50-69, and a total site inventory of 1800 PE-Ci.

3.2 REQUIREMENTS

The primary source of requirements governing the preparation of this BIO is 10 CFR 830 (CFR 2003), Subpart B, *Safety Basis Requirements*. Requirements that are specific to the hazard and accident analyses are provided in Section 204 of 10 CFR 830, *Documented Safety Analysis*. Appendix A to Subpart B, *General Statement of Safety Basis Policy*, describes DOE expectations and acceptable methods for implementing the requirements of 10 CFR 830.204.

Other sources of requirements include the following documents:

- DOE O 420.1B, *Facility Safety* (DOE 2005a).
- DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* (DOE 2002b).
- DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components* (DOE 2002c).
- DOE-STD-1022-94, *Natural Phenomena Hazards Site Characterization Criteria* (DOE 2002d).
- DOE-STD-1023-95, *Natural Phenomena Hazards Assessment Criteria* (DOE 2002e).
- DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1997.
- DOE-STD-1104-96, *Review and Approval of Nuclear Facility Safety Basis Documents (Documented Safety Analyses and Technical Safety Requirements)* (DOE 2005b).
- DOE-STD-1186-2004, *Specific Administrative Controls* (DOE 2004).
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- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002a).

- DOE-STD-3014-96, *Accident Analysis for Aircraft Crash into Hazardous Facilities* (DOE 2006b).
- DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* (DOE 2007)

Other sources of DOE guidance include the following documents:

- DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Nonnuclear Facilities* (DOE 2000a).
- DOE G 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830* (DOE 2001a).
- DOE G 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements* (DOE 2001b).
- DOE-HDBK-3010-94, *Airborne Release Fraction/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 2000b).

NOTE: To improve readability, the years of issue are excluded from the DOE standard citations in the remainder of this chapter.

3.3 HAZARD ANALYSIS

Hazard analysis provides a comprehensive assessment of facility hazards and accident scenarios that could produce undesirable consequences for workers and the public. Hazard analysis is divided into three main parts: (1) Hazard identification (ID) of the potential hazards associated with the WCRRF waste handling operations; (2) an unmitigated hazard evaluation; and (3) a mitigated hazard evaluation. The Hazard ID and unmitigated hazard evaluation present a comprehensive evaluation of potential process-related, natural events, and man-made external hazards that can affect the public, workers, and the environment. As part of the unmitigated hazards analysis, events requiring mitigation and further quantitative accident analysis are identified. Potential preventive and mitigative features that are candidates for control selection are also identified. In the accident analysis and mitigated hazard evaluation, those events requiring further analysis are quantitatively or qualitatively analyzed as appropriate, and ultimately, controls are selected for protection of the public and workers. Detailed tables of the information developed in this appendix are presented in Appendix 3A.

Section 3.3.1 presents the methodology that was used for the HA. Section 3.3.2 presents the results of the HA, including discussions of potential accident scenarios and their consequences and risks, evaluations of safety controls, identification of safety SSCs and formal administrative controls (ACs), and a set of accident scenarios to be evaluated quantitatively in the accident analysis. Appendix 3A provides a summary of the HA methodology and the detailed results of the Hazard ID and hazard evaluation (i.e., HA tables). Appendices 3B through 3E provide detailed evaluations that support the HA.

3.3.1 Methodology

This section describes the HA methodology used to present a comprehensive evaluation of process-related, natural phenomena, and external hazards that can affect the public and workers. The HA methodology is based on a graded approach as described in DOE-STD-3009 (DOE 2006a). DOE-STD-5506 (DOE 2007) provides guidance on the identification of hazards expected during various types of

TRU waste operations, as well as a representative (or bounding) minimum set of event types that are applicable based on these hazards.

3.3.1.1 Hazard Identification

Hazard ID involves identifying all facility and process hazards and energy sources. Hazard ID is a comprehensive, systematic process by which all known facility hazards (hazardous materials and energy) are identified, recorded, and screened. Hazard ID is divided into three steps: (1) division of the facility into *facility sections*, (2) facility walkdowns, and (3) screening for Standard Industrial Hazards (SIHs).

Division of the Facility: The facility is divided or grouped into *sections* to facilitate Hazard ID and evaluation. These sections may be individual unit operations, individual or grouped facility systems, specific functions, or physical boundaries inside the facility. The term *facility section* is used in the HA process to distinguish from *facility segments* as defined in DOE-STD-1027-92 (DOE 1997).

Facility Walkdowns: Facility walkdowns include both physical walkdowns and informational walkdowns to identify hazardous materials and energy sources for each facility section. Physical walkdowns permit first-hand familiarization with actual facility systems, processes, practices, equipment, and inventory. The informational walkdown includes a review of available documents such as the facility description, inventory, existing safety documentation (e.g., Fire Hazards Analyses [FHAs]), and consultations with facility system and process experts. The following activities are generally completed as part of the walkdown:

- Assemble the HA team, and
- Gather baseline information.

The WCRRF HA team consisted of safety analysts with backgrounds in fire protection engineering, nuclear engineering, health physics, mechanical engineering, and related technical disciplines. The HA team is responsible for gathering the baseline information needed to complete an HA and walk down the facility. The following topics and sources constitute baseline information:

Facility/Design Information:

- Facility description and drawings
- Materials of construction
- Building layout
- Facility plot plan/building drawings
- Facility systems and utilities
- Building penetrations

Process/Activity/Operational Information:

- Piping and instrument diagrams
- Process flow diagrams
- Instrumentation and controls
- Design bases for vessels/piping
- Design of relief systems

Materials and Hazards Information:

– Hazard type (material, energy source, or action)
– Hazard form and quantity (mass, volume, pressure, temperature, composition, etc.)
– Hazard location and containment (room[s] or exterior locations)

Existing Safety Documents:

– Safety Analysis Reports
– HAs, FHAs
- Technical Safety Requirements (TSRs):
– Unreviewed Safety Question Determinations (USQDs, positive and negative)
– Safety management reports
– Environmental reports

Operations Information:

– Historical occurrences, equipment reliability (failure data)
– Operations procedures, training, limits/controls

Site and Location Characteristics:

– Site characteristics
– Distances to public boundaries, adjacent facilities
– Meteorology, seismology, site hydrology, other applicable natural phenomena
– Population of workers involved and not involved in the work

Additional operations information was obtained by in-depth interviews with the operations team leaders and technicians, and by several facility walkdowns. These facility visits gave the HA team an opportunity to examine facility systems and equipment and observe activities. During the interviews with operations personnel, the HA team obtained valuable details on how the operations are conducted, information on historical incidents (not just reportable occurrences), and an operations perspective on the hazards and potential accidents. In addition, information on plans for future operations and anticipated throughputs was obtained.

As part of the information-gathering process, an inventory list is developed to identify all known radiological and chemical hazards. The inventory includes the material quantity, location, form, and other pertinent information regarding the material (e.g., concentration). Additional hazards that are a byproduct of the process or are due to potential chemical interactions are identified.

The HA team used a Hazard ID Table to support and guide the informational and facility walkdowns. The Hazard ID table provides a comprehensive list of generic facility hazards and energy sources. An example Hazard ID table is shown below (Table 3-1).

Table 3-1. Sample Hazard ID Checklist for the WCRRF HA

Hazards	Hazard Description	Process or Area
Acceleration		
Inadvertent motion		
Sloshing of liquids		
Translation of loose objects		
Deceleration		
Impacts (sudden stops)		
Failure of brakes, wheels, tires, etc. (e.g., vehicle accidents)		
Falling objects		
Fragments or missiles		
Chemical Reaction (nonfire; can be subtle over time)		
Disassociation—product reverts to separate components		
Combination—new product formed from mixture		
Corrosion, rust, etc.		
Improper mixing, reagents, water		
Electrical		
Shock		
Burns		
Overheating		
Ignition of combustibles		
Inadvertent activation		
Explosion, electrical		
Explosions		
Commercial explosive present		
Explosive gas		
Explosive liquid		
Explosive dust		
Flammability and Fires		
Presence of fuel—solid, liquid, gas		
Presence of strong oxidizer—exothermic		
Presence of pyrophoric—self-igniting		
Static electrical discharge		
Presence of strong ignition source—welding torch		
Spontaneous combustion		
Heat and Temperature		
Source of heat		
Hot surface burns		
Very cold surface burns		
Increased gas pressure caused by heat		
Increased volatility caused by heat		
Mechanical		
Sharp edges or points		
Rotating equipment		
Reciprocating equipment		

Table 3-1. Sample Hazard ID Checklist for the WCRRF HA

Hazards	Hazard Description	Process or Area
Pinch points		
Heavy equipment operation (e.g., forklift, Bobcat, loader)		
Weights to be lifted		
Stability/toppling tendency		
Ejected parts or fragments		
Pressure		
Compressed gas		
Compressed air tool		
Pressurized hydraulic fluid		
Pressure system exhaust		
Accidental release—gas, fluid		
Objects propelled by pressure		
Water hammer		
Flex hose whipping		
Overflow (e.g., tanks)		
Static		
Container rupture		
Overpressurization		
Negative pressure effects		
Hose rupture, piping, valve flange, glovebox gaskets		
Leak of Material		
Flammable		
Explosion, deflagration		
Toxic		
Corrosive		
Pyrophoric		
Radioactive		
Slippery		
Radiation		
Ionizing radiation		
Ultraviolet light		
High-intensity visible light		
Infrared radiation		
Microwave, radio		
Laser radiation		
Toxicity		
Gas or liquid		
Asphyxiate		
Irritant		
Systemic poison		
Carcinogen		
Mutagen		

Table 3-1. Sample Hazard ID Checklist for the WCRRF HA

Hazards	Hazard Description	Process or Area
Combination product		
Combustion product		
Vibration		
Vibrating tools		
High noise source level		
Metal fatigue		
Flow or jet vibration		
Supersonics		
Miscellaneous		
Lubricity		

Screening of SIHs: After the hazards and energy sources are identified and documented, the HA team determines whether any potential hazards can be screened from further consideration. Insignificant, or common, everyday hazards are not addressed in this HA. Examples of hazards common to everyday activities include trips and falls while walking or climbing stairs. Similarly, SIHs can be screened from further consideration in the HA. SIHs are defined as hazard sources (material or energy) or events that involve hazards routinely encountered by the general public or in general industry and construction, and for which national consensus codes or standards exist to govern handling or use without the need for special analysis to define safety design and operational parameters. These types of hazards (e.g., SIHs) are evaluated to the extent that they act as initiators and contributors to events that result in a radiological or hazardous material release. The remainder of potential hazards is screened based on material/energy types and quantities.

The following general thresholds are used as a measure of significance for hazard identification.

- Radiological Hazards: All radiological hazards were considered. In some instances, releases that can involve no greater than 10% of the HC-3 thresholds in DOE-STD-1027 (DOE 1997) (e.g., 0.052 Ci or 0.84 g ^{239}Pu) were screened from detailed HA evaluation (DOE 2005a).
- Toxicological Hazards: Greater than 10% of the reportable quantities (RQs) for hazardous and extremely hazardous chemicals as established in 40-CFR-302 and 355, respectively.
- Other Hazards: SIHs or energy sources that could result in releases of radiological or toxic materials or that could result in serious injuries or fatalities to workers at the facility.

All hazards not screened out were carried forward to hazard evaluation. If there was uncertainty as to whether a hazard should be screened, it was carried forward to be evaluated more thoroughly. Hazards screened from further consideration are identified in the *Process or Area* column of the Hazard ID table (see Appendix 3A).

3.3.1.2 Hazard Evaluation

3.3.1.2.1 Unmitigated Hazard Evaluation

The unmitigated hazard evaluation follows the Hazard ID process described in Section 3.3.1.1. The purpose of the unmitigated hazard evaluation is to ensure a comprehensive assessment of facility hazards and to focus attention on those events that pose the greatest risk to the public and workers. Event categorization, identification of event causes, assignment of event frequency and unmitigated consequence level, and identification of potential mitigative and preventive features are tasks performed during the unmitigated hazard evaluation.

Selection of unmitigated hazard evaluation method: The flowchart in Fig. 5.3 of *Guidelines for Hazard Evaluation Procedures*, Second Edition (CCPS 1992), provides a method for selecting a specific Hazard Evaluation technique. Using this flowchart, the technique is selected with the following criteria:

- The unmitigated hazard evaluation study is for regulatory purposes;
- No specific hazard evaluation method is required;
- This is not a recurrent review;
- Expected results are a list of specific accident situations plus safety improvement alternatives;
- The results will not be part of a Quantitative Risk Assessment;
- The process is not operating;
- Detailed design information is not available; and
- Basic process information is available.

Acceptable methods considered include:

- What-If (WI)
- What-If Checklist (WI/CL)
- Preliminary Hazard Analysis (PHA)
- Failure Modes and Effects Analysis (FMEA), and
- Hazard and Operability (HAZOP) study.

The following HA techniques were considered in detail:

- <u>What-If Analysis</u> is the most commonly used and recommended HA technique at LANL. This technique is most useful for systems of limited complexity and relies heavily on a knowledgeable and experienced analysis team.
- <u>Failure Modes and Effects Analysis</u> is used to identify equipment and hardware failures. To apply the FMEA technique, failures of a system's hardware components are postulated and their effects are determined. The FMEA can be used in conjunction with the What-If Analysis method.
- <u>Hazard and Operability Studies</u> provides a systematic way to examine how process variations affect a system. This technique is used widely in the chemical industry where there are continuous process systems. Because of the nature of the work performed at LANL, this technique is used rarely.

The FMEA method was removed from consideration, because it is primarily used for analyzing mechanical systems and active components in an electrical system. The hazards evaluation team selected a hybrid approach that incorporated elements of the WI/CL and PHA methods. This method was selected based on its widespread use and DOE acceptance at other TRU waste handling/storage facilities in the DOE complex. The WI/CL method uses brainstorming to identify a broad spectrum of accidents in combination with the detailed and comprehensive structure provided by using a systematic Hazard ID and Event Category checklist. Additionally, the use of a tabular accident recording form (adapted from the PHA technique) provides for the effective listing and presentation of accidents along with their causes, hazard category, risk assessment, and potential preventive and mitigative features.

Using the Hazard ID and WI/CL as a basis, What-If scenarios are postulated without regard for frequency or consequence for each facility section. These scenarios are evaluated preliminarily to determine the *scenarios of interest* requiring further evaluation. For each hazard, the team reviewed a list of standard accident types, such as fire, spill, explosion, criticality, direct exposure, external event, and natural phenomena, and developed possible accident scenarios. Each postulated accident scenario is assigned a number and listed on a simple What-If Analysis form with the hazard, accident type, initiating event, and the accident scenario description (see Table 3-2). The last two columns on the form are used to document those scenarios that are identified as *scenarios of interest*. For scenarios not identified as such, the basis of this determination is provided. Scenarios that are not considered scenarios of interest include the following:

- scenarios that are not physically possible;
- scenarios that clearly have negligible consequences; and
- scenarios determined to be SIHs.

Table 3-2. Sample What-If Analysis Table

Location: _____
Facility: _____
Site: _____
Process/Activity: _____
Hazards of Concern: _____

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #

What-If Analysis tables also help the analysts to identify accident scenarios representing events with the same phenomenology and controls, group them together, and evaluate them in a collective manner. This makes analysis more manageable, facilitating the process of identifying the scenarios of interest.

From the What-If analysis, a separate HA table is developed for each facility section. The HA tables (Appendix 3A) then serve as input for the subsequent mitigated hazard evaluation.

Scenario Defining Assumptions and Initial Conditions: Before beginning the hazard evaluation, the assumptions and Initial Conditions for the WCRRF are determined. Assumptions are general statements that govern boundaries of the analysis but do not require protection to ensure the validity of the analysis. Initial Conditions are specific conditions that are a part of facility operations or parameters used in the analysis and require protection to ensure the validity of the analysis. Initial Conditions may include inventory information and specific passive features (i.e., no mechanical or human involvement), such as the facility construction. Identified Initial Conditions have the specific information for which the Initial Condition is valid so that it can be credited in the hazard evaluation (HE).

HE Table: The unmitigated HE determines the risks (frequencies and consequences) involved with the facility and its associated operations without regard for any safety controls or programs. That is, no credit is taken for any preventive or mitigative features, other than the specified Initial Conditions.

Using the What-If tables as a basis, event scenarios for the WCRRF are developed wherever a potential exists for a release of hazardous material. The scenarios cover the entire spectrum of possible events for a given hazard, from small-consequence, high-frequency events, to worst-case, low-frequency events. Follow-on events, such as a fire following a seismic event or aircraft impact, are identified and evaluated to ensure that the entire spectrum of possible events is addressed. Information related to the unmitigated hazard evaluation is collected and organized in the HA tables (see Table 3-3). The HA tables are used to capture information relating to both the unmitigated HE and the subsequent mitigated HE.

The following example table provides the basic format for the HA Tables. Information necessary to understand the table, including short descriptions of the items in the column heads, is provided in greater detail in the subsequent text.

Table 3-3. Sample Hazards Analysis Table

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Consequence			Risk			Notes
								P	CW	W	P	CW	W	
HGB-1	Exposure	Worker exposed (GB-1)	Human error	**UNCONTROLLED**			U	L	L	M	IV	IV	II	MAR (56 P E-Ci)
				CONTROLLED/ RESIDUAL RISK			EU	L	L	L	IV	IV	IV	
				Control #1	RP-RPP	PPA PMA	√			√				Note
				Control #2	PR-WCA	PPA	√							Note

Additional detail and pertinent methodology information regarding the major HA table headings are provided below.

Event Number (ID No.)

Events are numbered to provide each with a unique mnemonic sequential reference. The event numbering follows a simple mnemonic sequence based on the facility sections. Haa-## is the format for the unique accident scenario identification number. The *H* indicates that the scenario is an HA scenario (not a What-If Analysis scenario). The *H* is followed by a two-letter designation, such as *GB* for glovebox. The two-letter designation refers to the What-If table that prompted the HA.

Accident Type (Event Category)

Events are categorized according to the nature of the event, with the exception of events that are initiated by External Events or Natural Phenomena Hazards. A standard list of event categories is given in Table 3-4, along with a general description of the consequence mechanism. The first five categories are for internally initiated events, which are typically process-related events. The final two categories are externally initiated events (events whose initiators are beyond the facility's direct control). In select cases, multiple event types may be involved in an accident (e.g., seismic event followed by fire). In these cases, only the initiating event type is listed.

Table 3-4. Event Categories for HA

Event Type	Consequence / Release Mechanism
Fire	Consequences typically due to inhalation/ingestion of released hazardous material. Release of material is due to thermal effects on the material or the material container.
Explosion	Consequences typically due to inhalation/ingestion of released hazardous material. Release of material is due to explosion, or impact from missiles produced by the explosion. (Note: explosions include detonations and deflagrations.)
Loss of Containment / Confinement	Consequences typically due to inhalation/ingestion of released hazardous material. Release of material is due to impacts (including dropping) on the material or material containment and energetic failures due to overpressurization.
Direct Exposure	Consequences typically due to direct exposure to a hazard (contact chemical exposure, radionuclide shine).
Nuclear Criticality	Consequences typically due to direct exposure and release of fission products.
External Events	Consequences typically due to inhalation/ingestion of released hazardous material. Depending on specific event, direct exposure consequences may also be applicable.
Natural Phenomena	Consequences typically due to inhalation/ingestion of released hazardous material. Depending on specific event, direct exposure consequences may also be applicable.

Scenario

A brief description of a postulated event is given in this column. It includes a description of the event (including event progression information) and the release mechanism (e.g., fire, pressurized release, spill, etc.) or other consequence mechanism (e.g., direct exposure). The What-If tables are used to guide in developing the specific scenarios.

Causes or Initiating Events

A cause specifically states the failure, error, operational, or environmental condition that initiated the release event. Causes are identified to support frequency evaluation.

Control Description

Existing controls that the team feels can be effective in preventing or mitigating the accident are listed here. Additional detail regarding the control description and selection process is provided below.

Control ID: A unique control ID is given to each control identified in the HA. A control ID consists of a set of letters connected by a hyphen (e.g., CO-XYZ). The first two letters describe the function or program with which the control is associated, while the last three letters are an abbreviated mnemonic of the control (e.g., WCD = waste container design). The last three letters are used only by the HA team as an easy way to differentiate controls that may have a similar function (e.g., ED [Equipment Design]) or are under a similar program (e.g., EP [Emergency Preparedness]). Examples of potential functions and programs under which control IDs are selected are provided below.

CO: Conduct of Operations	**IC**: Inventory Control	**EP**: Emergency Preparedness	**NC**: Nuclear Criticality
FD: Facility Design	**MP**: Maintenance Program	**ED**: Equipment Design	**RP**: Radiation Protection
HM: Hazardous Material Management	**TR**: Training	**FP**: Fire Protection	**HR:** Hoisting and Rigging

Control Type: In addition, to Control IDs, each control considered in the HA is further described as a preventer or a mitigator, process- or facility-related, or whether the control is administrative or a design feature. The mnemonics used to describe the control type are listed below.

First letter:	P – Preventer that reduces the frequency
	M – Mitigator that can reduce the consequences
Second letter:	P – Process-related control
	F – Facility-related control
Third letter:	A – Administrative control
	F – Design or engineered feature

The control type is listed directly following the Control ID in the HA tables. In the HA table columns immediately after the designation of the control type, a √ denotes those controls that are judged to give the most effective reduction of the frequency or consequence category. *Uncontrolled* means that the scenario frequency and consequences are unmitigated, while *Controlled/Residual Risk* is the risk level determined after taking appropriate credit for the listed and any common controls (the determination of risk is described in the following sections).

Frequency

Unmitigated and mitigated frequency estimates are provided as an important step in identifying controls important to safety. Table 3-5 identifies the frequency bins that are recommended by DOE-STD-5506 (DOE 2007) and are used in the HA.

Table 3-5. Qualitative Frequency Bins

Frequency	Descriptor	Description
I (10^{-1}/yr to10^{-2}/yr)	**ANTICIPATED (A)**	**Likely to occur often to <u>several times</u> during the life of the facility.** (Incidents that may occur during the lifetime of the facility; these are incidents with a mean expected likelihood of once in 50 years)
II (10^{-2}/yr to 10^{-4}/yr)	**UNLIKELY (U)**	**Should not occur during the life of the facility.** (Incidents that are not anticipated to occur during the lifetime of the facility but could; these are incidents having a likelihood of between once in 100 years to 10,000 operating years)
III (10^{-4}/yr to 10^{-6}/yr)	**EXTREMELY UNLIKELY** (EU)	**Unlikely but possible to occur during the life of the facility.** (Incidents that will probably not occur during the lifetime of the facility; these are incidents having a likelihood of between once in 10,000 years and once in a million years)
IV (Below 10^{-6}/yr)	**BEYOND EXTREMELY UNLIKELY** (BEU)	**Should not occur during the life of the facility.** (All other incidents having a likelihood of less than once in 1,000,000 operating years)

The unmitigated frequency estimates do not take credit for safety controls that could lower the frequency. These estimates are based on an interpretation of *unmitigated* to mean that no special safety controls are implemented above and beyond standard industrial practices, and do not credit many of the Laboratory's institutional procedures.

The frequency of an accident scenario is a function of the frequency of the initiating event and the frequency of enabling events. Enabling events are those events that must occur following the initiating event to cause the postulated accident. For example, in the scenario of an earthquake resulting in a fire in a building, the initiating event is the earthquake and an enabling event could be some type of electrical equipment failure that starts the fire. Unmitigated frequency estimates for accident scenarios are generally taken to be the frequency of the initiating event only, with the probability of the enabling event assumed to be 1.0 (i.e., it happens). Therefore, for the example given above, the unmitigated frequency estimate would typically be the frequency of the earthquake. However, under certain circumstances, where the probability of the enabling event is clearly less than 1.0, the overall scenario frequency estimate could be less than the initiating event frequency.

The controlled or mitigated frequency is based on how the controls lower the scenario frequency by reducing either the initiator frequency or the enabling event frequency. In the earthquake scenario example, controls cannot lower the frequency of the postulated initiating event, the earthquake; but if

electrical equipment is designed to withstand the earthquake, or if there are no combustibles present to support a fire, then the frequency estimate for this enabling event and the subsequent fire would be lower. Thus, the overall scenario frequency would be lower.

Consequence

Table 3-6 identifies the consequence categories for the public, collocated worker, and worker that are recommended by DOE-STD-5506 (DOE 2007) and are used to assess the various consequence categories for the postulated accident scenarios.

Public and Collocated Worker: As with the frequency categories, quantitative consequence severity categories are assigned to each of the postulated accident scenarios. These consequence severity categories are qualitatively assessed and consider radiological factors such as inventory, material form, and energy of release; toxic factors include toxicity, inventory, and volatility.

Table 3-6. Consequence Levels and Risk Evaluation Guidelines

Consequence Level (Abbreviation)	Public (P)	Collocated Worker (CW) (at 100 m)	Worker (W) (Involved worker within facility boundary)
High (H)	Considerable offsite impact on people or the environs. CHALLENGE 25 rem EG *	Significant onsite impact on people or the environs. > 100 rem TED	For SS designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, must be considered.
Moderate (M)	Only minor offsite impact on people or the environs. ≥ 1 rem TED	Considerable onsite impact on people or the environs. ≥ 25 rem TED	No distinguishable threshold
Low (L)	Negligible offsite impact on people or the environs. < 1 rem TED	Minor onsite impact on people or the environs. < 25 rem TED	No distinguishable threshold

*Per DOE-STD-3009, the EG for the public is 25 rem. As stated in Section 6.3 of DOE-STD-5506, a public dose greater than 10 rem should be considered sufficient to *challenge* the EG.

Although hazard analysis is mostly a qualitative process, the radiological consequences (doses) to the public and collocated worker are estimated using a simplified quantitative determination. The dose to the MEOI and collocated worker for each postulated accident scenario is estimated by the product of the source term and the dose-to-source-term ratio. To estimate the consequence category, these parameters are estimated using simplifying assumptions, and may be overly conservative in some cases. For the limiting and representative accident scenarios that are carried forward into the Accident Analysis (Section 3.4), the dose consequences to the public and collocated worker will be calculated more precisely based on detailed scenario development and quantitative models of the physical phenomena.

For some accident scenarios, it is expected that the dose consequence analysis in Section 3.4 will result in calculated doses that are less than the consequence category assigned in this HA. These apparent differences are a result of the simplifying assumptions used in the HA and an inventory upper limit that may be refined as a result of the AA. These situations are expected and will not invalidate the results of the HA.

The source term for postulated accident scenarios is determined using the Five-Factor Formula from DOE-HDBK-3010 (DOE 2000b):

$$\text{Source Term (ST)} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF} \qquad \text{[Eq. 3.1]}$$

where

MAR: is material-at-risk, the amount of radionuclides available to be acted on by a given physical stress.

DR: is damage ratio, the fraction of the MAR actually impacted by the energy generated by the postulated accident.

ARF: is airborne release fraction, the fraction of the MAR impacted by the accident that becomes airborne or suspended in air as an aerosol and thus available for transport due to the physical stress created by the accident.

RF: is respirable fraction, the fraction of airborne material that can be transported to the receptor and is respirable, or could be inhaled by humans (particles 10-µm aerodynamic equivalent diameter [AED] or less).

LPF: is leak path factor, the fraction of airborne contaminants that are transported out of the confinement (e.g., building) to the environment.

Worker: Quantitative methodology exists for estimating the public and collocated worker consequences for radiological releases. There have been attempts to provide similar guidance for calculating worker consequences; however, this guidance is limited in value. Senior analysts recognize the difficulty and, also, the errors in calculating worker consequences. A qualitative assessment by the safety analysts and operational team members of worker consequences is considered much more appropriate than calculations.

The predominant exposure pathways for workers from accidents involving TRU waste handling activities are direct exposure to external penetrating radiation or inhalation of airborne radioactive material generated during release events. The radiogenic health effects associated with TRU waste are due primarily to alpha and gamma radiation. External exposure to plutonium poses very little health risk, because plutonium isotopes emit alpha radiation, and almost no beta or gamma radiation. Because of the emission of alpha particles, the WCRRF waste streams pose a significant risk if sufficient quantities are swallowed or inhaled.

Plutonium and other TRU radionuclides that are absorbed from the lungs deposit into the bones, liver, and other body organs. Plutonium that reaches body organs is retained in the body for decades and continues to expose the surrounding tissue to radiation. This exposure may eventually increase a person's chance of developing cancer.

Based on the application of a graded approach (DOE-STD-3009, Chapter 3, pp. 26-27) (DOE 2006a), and on the definition of SS-SSCs (pg. xxii, DOE 2006a), it is apparent that only qualitative evaluation of the unmitigated consequences to the worker is appropriate. Usually the worker consequences would be expected to be as high as or higher than the consequences to the collocated worker. Based on the inventory limits in place at the WCRRF (i.e., 1,800 PE-Ci total site and 800 PE-Ci equivalent combustible waste inside Building TA-50-69), some slowly evolving events that would allow time to flee from the immediate area are qualitatively judged to have Moderate to Low consequences to the worker. However, most events that are determined to have High consequences to the collocated worker would, by inference, also result in High consequences to the worker.

The HA team also estimated a High consequence category for workers as the bounding potential radiological consequences from accidents involving direct exposure or criticality events. A high consequence was also assumed for deflagrations, where severe physical injury is a potential.

Risk

After developing frequency and consequence estimates, the risk rank of each scenario is determined using the matrix given in Table 3-7 and then listed in the HA tables. The risk rank applies to the public, collocated workers, and workers, for both the uncontrolled and controlled cases.

Table 3-7 Risk Matrix

Consequence Level	Beyond Extremely Unlikely (BEU) Below 10-6/yr	Extremely Unlikely (EU) 10-4 to 10-6/yr	Unlikely (U) 10-2 to 10-4/yr	Anticipated (A) 10-1 to 10-2/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	II
Low Consequence	IV	IV	III	III

[1] Industrial events that are not initiators or contributors to postulated events are addressed as a SIH.

HA Table Notes

The notes column in the HA table may contain information regarding the MAR that may be affected by the event. Additionally, scenario defining assumptions and clarification of controls are provided in this column.

3.3.1.2.2 Mitigated Hazard Evaluation

Any events with risk to the public, collocated worker, or worker that fall in risk ranks I or II are considered for further qualitative evaluation and control identification. Worker events that fall in risk rank III are generally protected by Safety Management Programs (SMPs) but are considered on an individual basis by the HA Team. All Public events that have the potential for High consequences are evaluated further and forwarded for formal Accident Analysis in Section 3.4.

The HA team used the following general guidelines in determining the need and classification of controls:

- The risk matrix should never be the decision-maker. A risk matrix is not sophisticated enough to replace sound engineering logic. Therefore, it is important to recognize that the risk matrix only provides useful information to aid in decision-making.
- The risk matrix should not include an indication of acceptable risk.
- Matrices should not be used to determine the safety importance of SSCs, i.e., they should not be used to designate SC- or SS-SSCs. DOE-STD-3009 (DOE 2006a) advocates an approach based on engineering logic to make these classifications.
- One major factor used to assess the significance of safety controls is the risk reduction they provide. One measure of risk reduction can be obtained by examining the risk rankings of applicable accidents for the uncontrolled and controlled cases. This approach is consistent with the philosophy that selecting safety SSCs should be based primarily on engineering logic.
- A distinction must be made between risk to the public and risk to the worker—they cannot be equated.
- Using risk matrices for worker protection is more challenging than using them for public protection because the accident parameters (i.e., source term, distance factors) for the workers are more uncertain than those associated with the more distant public because workers are closer to the accident.
- There is no intent to perform an AA for the worker.
- Risk ranking should not circumvent the HA process. In other words, low initial risk is not an excuse to dismiss a hazard or scenario without further analysis.

DOE-STD-3009 (DOE 2006a), DOE-STD-5506 (DOE 2007), DOE G 421.1-2 (DOE 2001a), and G 423.1-1 (DOE 2001b) provide guidelines for selecting formal safety controls. The control features that are most significant in reducing the scenario frequency were noted in the HA tables with a √ to identify those controls that are major contributors to defense-in-depth. The amount of frequency reduction is based on the individual control and evaluated as such. For determining the amount of *credit* given to a control, the following general guidance was used as a starting point:

- Specific Administrative Controls (SACs) may reduce the scenario frequency by one or more bins, if technically justified.
- Engineering controls that have surveillance requirements or are passive may reduce the frequency by a factor of 100 (one frequency bin), unless specific data available for the control indicates otherwise.
- The accident scenario frequencies are qualitative and based primarily on engineering judgment. When available, site-specific data may be used if it provides added insight.

Before control selection, elimination of a hazard is always the preferred option. In the case of the WCRRF, some SACs have been selected as a means to eliminate the hazards. While these are not engineered controls, a SAC that eliminates the presence of a hazard is considered an effective control (i.e., prevents the event).

The same logic may be applied in determining the effect of mitigative controls, assuming that a decrease in consequence bin is equivalent to a decrease in two orders of magnitude in frequency.. The actual amount of consequence reduction is based on the effectiveness of the individual SAC or engineered control and evaluated as such.

An SSC is selected when available over an AC, passive over active, preventative over mitigative, control closest to the hazard, etc. The desire for reliable SSCs is offset by the lifecycle of the facility. When an SSC is not available or not as effective in controlling the hazard as an AC, a SAC may be selected. In selecting the most appropriate control set for the remaining facility mission, the safety and operations personnel weighed the level of hazard, the effectiveness of available controls, reliability and remaining life of available SSCs, potential safety benefit of installing or upgrading the existing SSCs, the costs associated with the upgrade, and maintenance actions. Particular consideration was given to:

- The capability of the safety-related SSC to prevent or mitigate a hazard and the adequacy of an alternative SAC, and
- The duration and nature of the remaining activities or hazards.

When an AC has been selected in lieu of an SSC, or when an SSC is not available, the following factors from DOE-STD-1186, *Specific Administrative Controls* (DOE 2004), were used as guidance to identify if the controls should be treated as an SAC.

- The AC is identified in the DSA as a control needed to prevent or mitigate an accident scenario.
- The AC has a safety function that would be SC or SS if the function were provided by an SSC.
- The AC provides the main mechanism for hazard control.

In the context of Chapters 4 and 5, those administrative controls that are not specific (i.e., not designated as SACs), but are important in the HA, are selected as programmatic controls, with the attributed programmatic elements highlighted. These programmatic controls typically provide Defense-in-Depth (DID). A unique characteristic of the programmatic AC is that a single failure of the control does not affect the quantified frequency or consequences or the conclusions of the Safety Analysis, and would not warrant a Technical Safety Requirements (TSR) violation. Those SMPs that form the foundation of Integrated Safety Management Systems and result in effective operation of the facility are acknowledged in the programmatic AC in accordance with the requirements of these programs.

3.3.2 Hazard Analysis Results

This section presents the results of the HA. Section 3.3.2.1 presents the results of the Hazard ID, Section 3.3.2.2 presents the results of the hazard categorization, and Section 3.3.2.3 presents the results of the hazard evaluation. The detailed analysis tables and supporting discussions are provided in Appendix 3A. These tables include the hazard identification checklists, What-If Analysis tables, and HA tables. The supporting discussions include the bases for categorizing the frequencies and consequences of the postulated accident scenarios. The results of the unmitigated hazard evaluation are used as a basis for proceeding with the control selection and the mitigated hazard evaluation in Section 3.3.2.3.

3.3.2.1 Hazard Identification

3.3.2.1.1 Facility Sections

The processes and activities were subdivided into sections to provide a more manageable set of information and activities. As discussed in Section 3.3.1.2, the physical facility areas and major processes that are within the scope of the HA were grouped to facilitate hazard identification and evaluation. The first grouping was by physical facility area. The WCRRF processes and work activities were grouped into two physical locations: (1) those inside Building TA-50-69 and (2) those outside Building TA-50-69. This is a logical grouping of the site processes because a number of safety controls are unique to one of these two locations. The building structure and building systems apply to inside processes only. In addition, radioactive material quantity limits for these two locations are different, to the extent that the WCRRF total inventory in both the HA and AA is 1,800 PE-Ci. In the HA, if 800 PE-Ci is inside Building TA-50-69, then the maximum that can be outside is 1,000 PE-Ci. Corresponding to this grouping, two sets of hazard identification checklists are provided in Appendix 3A.

The second grouping was by process. The major processes performed at the facility were identified and are listed in the first column of Table 3-8. Then, as mentioned in Section 3.3.1.2, specific activities were linked to these processes. The specific activities performed at the WCRRF are listed in the heading row of Table 3-8. The matrix shows the specific activities that are associated with each process.

Table 3-8. Processes Correlated to Worker Activities

Activity / Process	Stage Waste Containers	Handle Waste Containers	Bag In/ Bag Out	Open/Close Waste Container	Unpack/ Repack	Process Activities
Receipt/Shipping	X	X				
Staging/Handling	X	X				
Visual Examination	X	X	X	X	X	X
Repackaging	X	X	X	X	X	X
Remediation	X	X	X	X	X	X
Miscellaneous Operations (decon and secondary waste)	X	X		X	X	X

The processes and activities were examined to determine how to organize the What-If Analysis in an efficient manner. The analysis was organized using the following sets of operations identifiers:

Outside Operations		Inside Operations	
Staging Outside	SO	Staging Inside	SI
Handling Outside	HO	Handling Inside	HI
		Waste Characterization Glovebox Operations	GB
		Glovebox Enclosure S&M	GE

Accident scenario development in the What-If Analysis followed this organization. The two-character designations were used in the scenario identification numbers. Waste container staging and handling were assessed for both locations because of possible differences in the safety controls and inventory at the two locations.

3.3.2.1.2 Facility Walkdowns

Major hazards present at the WCRRF are described in this section. For some hazards (e.g., radiological materials), additional data (beyond that provided on the hazard identification checklists) is presented in text form to provide more detailed descriptions. Then the hazards are evaluated against the screening criteria presented in Section 3.3.1 to eliminate less significant hazards from further consideration. For groups of hazards considered less significant, and thus screened out from further analysis, an appropriate explanation is provided to justify the screening. This section closes with a discussion of the facility operating history, with a special focus on past incidents that provide important insights into potential safety concerns.

Hazards throughout the facility were identified and documented on Hazard ID checklists. Two sets of Hazard ID checklists are provided in Appendix 3A, one for outside operations (i.e., outside staging area), and the other for inside operations (i.e., Building TA-50-69). The identification process included conducting facility walkdowns, interviewing subject matter experts, and reviewing procedures and hazard control plans. The checklists identify material sources, work areas, and quantities of significant hazardous materials.

3.3.2.1.3 Radioactive Materials

Transuranic Waste Containers

The primary mission of WCRRF operations is to characterize TRU wastes using invasive and noninvasive processes. The TRU waste is the primary hazard at the WCRRF. Other radioactive materials and sources are present, such as contamination in the WCRRF building and on equipment surfaces and in secondary wastes generated from the radionuclides found in the TRU waste. Secondary sources of radiological material present a minimal concern when compared to the radiological materials in the TRU waste containers and do not contribute significantly to the facility's hazards or nuclear hazard categorization. These secondary sources of radiological material are adequately addressed through standard LANL safety management programs (e.g., *as low as reasonably achievable* [ALARA]).

Many different radionuclides are present in the TRU waste containers, with the majority of the radioactivity present in plutonium radioisotopes and lesser amounts in other actinides. Radioactive wastes include metals, oxides, nitrates, and nitrides, in solid form or as contaminants in other waste items. The containers processed at the WCRRF contain solid TRU waste. Any liquid TRU waste must be eliminated in the packaging process at the generating facility by adsorption using solid media or by solidification using cement or other binders such as gypsum.

The TRU waste produces ionizing radiation, including alpha, beta, gamma, X-rays, and neutrons. The predominant radiation is from alpha particles that are shielded by the container and its contents. Accidents that release radioactive materials during facility operations could result in internal doses to workers, primarily from alpha radiation, or could result in external exposure from gamma radiation.

For each TRU waste container, the waste generator documents the radioactivity by radioisotope. To represent the relative hazards presented by the different radionuclides, the quantity of each must be converted into a single, common unit. The plutonium equivalent curie (PE-Ci), also referred to as the ^{239}Pu equivalent curie, is generally recognized as the standard unit for expressing radioactivity for TRU waste. Individual container data are routinely converted to PE-Ci, summed for each container, and entered into the waste container database. The data are converted as specified in Appendix 3B to the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC) (DOE 2006c). This methodology uses conversion data that were originally published in DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988). The WCRRF hazard and accident analyses use the PE-Ci data in the waste container database to represent the radioactivity in each waste container. The dose calculations for accidents that involve waste material dispersion are based on curies of ^{239}Pu.

The TRU waste containers are selected for processing at the WCRRF from containers received from TA-54, Area G. There is a continual turnover of containers as they are shipped to and from the WCRRF. The facility is not used for long-term storage.

A review of the PE-Ci values in the containers to be processed at the WCRRF indicates that the highest inventory container to be processed is approximately 800 PE-Ci in a noncombustible waste matrix. The unmitigated HA conservatively evaluated the bounding container as having 800 PE-Ci in a combustible waste matrix. The HA also considered 1,800 PE-Ci as the bounding inventory at the WCRRF (sum of inside and outside operations). The radiological inventory values used in the HA are listed in Table 3-9.

Table 3-9. WCRRF Inventory Limits Used in HA

Inventory (PE-Ci)	Inventory Applicability
≤ 800	Maximum inventory allowed in Bldg. TA-50-69. Maximum inventory in any single TRU waste container.
≤ 1,800	Maximum WCRRF inventory (sum of inside and outside)

The WCRRF handles three basic types of contaminated waste material. These are noncombustible solids, combustible solids, and filter media. Rather than establish and track inventory limits for each type of contaminated waste material, a conversion factor is developed that equates the inventory of the different types of waste matrices to a combustible waste form. The conversion factor is developed so that, for implementation, a radiological inventory limit of 800 PE-Ci of equivalent combustible waste is used. The combustible equivalency is based on the amount of TRU waste (e.g., noncombustible or filter media inventory, etc.) that would result in the same dose consequence resulting from an inventory of 800 PE-Ci combustible waste for the bounding accident scenario.

The analyses within the HA assume that the waste containers involved in any event contain the upper limit of activity to be processed (800 PE-Ci combustible waste). This results in a bounding analysis for the waste containers scheduled to undergo waste characterization at the WCRRF under this DSA. The upper bound WCRRF inventory limit of 1,800 PE-Ci (sum of inside and outside) allows the WCRRF to contribute to the Laboratory commitment to remove the TRU waste inventory from TA-54, Area G, in a timely manner.

The waste types known to be in the TRU waste containers were correlated to the material form categories used in DOE-HDBK-3010 (DOE 2000b) to facilitate assigning appropriate airborne release fraction/respirable fraction (ARF/RF) values for the source term (ST) calculations. The ARF/RF values were compared to the guidance provided in DOE-STD-5506 (DOE 2007) to ensure that bounding values were used. Chapter 5 of DOE-HDBK-3010, titled *Surface Contamination,* provides release fraction data for contaminated combustible and noncombustible solids. The general categories of waste types in the containers correspond to the DOE-HDBK-3010 categories *Combustible, Dispersible, Noncombustible,* and *Nondispersible, Noncombustible.* The category *Nondispersible, Noncombustible* correlates to composite solids, for example, concrete or cement, which are discussed in Chapter 4 of DOE-HDBK-3010 (DOE 2000b); this waste form is bound and identified as noncombustible material. The TRU waste that is stored outside at the WCRRF is typically contained in U.S. Department of Transportation (DOT) Type 7A (or equivalent, such as 17C, 17H, and/or UN1A2) 55-gal. drums or Standard Waste Boxes (SWBs). Section 2.6.1 provides a list of waste containers that might be brought to the WCRRF. Waste containers are inspected according to established criteria before shipment to the WCRRF, and damaged or otherwise unacceptable containers are not shipped to the WCRRF. Once

brought to the WCRRF, the TRU waste containers are placed within an all-metal transportainer until they can be processed. Once the TRU waste containers are brought inside Building TA-50-69, 55-gallon drums may be removed from overpacks or SWBs. These drums are removed from overpacks to perform repackaging for compliance issues with the WIPP WAC. Some of these drums may be degraded and may not meet all of the DOT Type 7A requirements. The Radiation Protection Program provides additional controls for these drums to protect workers.

Secondary Waste

As a by-product of the WCRRF TRU waste operations, small amounts of secondary waste are generated from the radionuclides found in the TRU waste; however, the low radioactivity levels of the secondary waste allow it to be classified as low-level waste (LLW) rather than TRU waste. This LLW is managed under the LANL LLW program. The LLW can be present at the WCRRF in several types of containers. Examples are described below:

- Low-level secondary waste (e.g., contaminated anti-Cs, contaminated Kimwipes,® etc.) might be found in laundry bags or other standard bags, or containers typically used for this purpose.
- Other LLW may be packaged inside cardboard boxes lined with plastic and transferred directly to Building TA-50-69. Such boxes are, however, temporary transfer boxes, and the waste will eventually be repackaged into authorized waste containers.

3.3.2.1.4 Hazardous Chemicals

Operations at the WCRRF infrequently use a few chemicals in small volumes, primarily for decontamination and routine maintenance. Chemicals such as surfactants, solvents, and lubricants are used in accordance with the Laboratory Chemical Management Program. No chemical processing or chemical research is conducted within the WCRRF, so there is no routine consumption of reagent chemicals.

The TRU waste containers are generally free of significant quantities of hazardous chemicals, and, if any are present, they are managed in accordance with the Hazardous and Mixed Waste Program. The following general characterization of the hazardous constituents in the waste accepted for characterization purposes is based on knowledge of the waste-generating processes. Trace quantities of organic solvents might be present in the solidified aqueous waste that was treated at the Radioactive Liquid Waste Treatment Facility. The solidified sludge also might contain trace amounts of metal hydroxides from the neutralization and precipitation treatment process. Heterogeneous waste forms do not contain spent solvents, but could contain rags with absorbed solvent.

Metals regulated by the Resource Conservation and Recovery Act (RCRA) are reported to be in the waste, but are not present in a respirable particulate form. Lead is the predominant metal, but it is present primarily in monolithic form. Other RCRA-regulated metals include cadmium, mercury, chromium, and arsenic; none of these metals is in respirable form. These heavy metals are usually constituents of tool rods, equipment, and metal containers. None of the metallic hazardous waste constituents associated with mixed waste accepted for processing should be of a particulate form or, if subjected to available energy sources, capable of generating a particulate form. Therefore, none of the hazardous chemicals in the TRU waste containers is considered a significant hazard.

3.3.2.1.5 Fire Hazards

Fire hazards include flammable and combustible fuels, combustibles in the TRU waste, flammables and combustibles associated with the processes, combustible aspects of the structures, vegetation, and transient combustibles.

Brief summary descriptions of the flammable material sources considered in the HA follow:

- TRU waste container delivery vehicles with diesel or gasoline fuel tanks with volumes up to 80 gal.
- Maintenance vehicles (typically pickup trucks or service vans, with gasoline tanks of approximately 25 to 50 gal. capacity).
- Liquid- and gas-powered vehicles exchanging cylinders and a service truck delivering full liquid propane gas (LPG) cylinders to the WCRRF.
- Refueling equipment. (The auxiliary generator has a double-wall diesel fuel tank located outside Building TA-50-69 on the NW corner of the WCRRF. Refueling this tank is accomplished with a long hose from a tanker truck parked on the roadway (Pecos Drive) along the north boundary of the WCRRF. The tank is located on the opposite side of the outside area containing the transportainers and does not pose a fire hazard to the transportainers.)
- Some processes and maintenance activities at the WCRRF use flammable materials. Maintenance workers occasionally use small volumes of flammable or combustible solvents for cleaning.

Other fire hazards present inside the TRU waste containers consist of various combustible waste materials, which include contaminated paper, plastic, and other cellulose materials, and similar materials used to wrap and package items. In addition, there are small quantities of waste materials that could be contaminated with organic solvent, or flammable (including combustible) liquids that could be discovered during prohibited item disposition. The quantities of flammable materials in the TRU waste containers are expected to be small relative to the quantity of cellulose combustible material. However, volatile organic compounds (VOCs) can generate flammable vapors. Because all TRU waste containers are metal drums and SWBs, and are placed within an all-metal transportainer, the combustible materials packaged inside them are not a fire hazard unless the containers are breached or fail due to overpressurization. If the containers are breached, the combustible material will contribute to the fire.

Based on the waste acceptance criteria and container characterization studies, Class 1 oxidizers such as nitrates and reactive flammables such as lithium metal or hydrides are not expected to be part of the waste stream and are prohibited items in the WCRRF. Because of limited uncertainty in the waste characterization, oxidizers, pyrophoric materials, and flammable liquids are considered as initiators to fire events during glovebox operations (considered *Unlikely* based on existing characterization data).

The TRU waste can generate flammable hydrogen gas through radiolytic decomposition of other materials in the waste. Based on gas generation testing results from other DOE sites, generation rates are expected to be low. Trace quantities of other flammable gases might be emitted from the waste materials. The metal TRU waste containers are vented to prevent hydrogen, or any other flammable gas, from reaching flammable concentrations inside the container. Before shipment from TA-54, Area G, a container's vent and filter will be verified to be free of obvious obstructions and the flammable vapors in the headspace measured. Containers that are verified to be <4% total amount of hydrogen gas and ≤ 8,000 ppm VOCs may be received at the WCRRF for processing. Receipt of an adequately vented TRU waste container (e.g., a drum or SWB) is credited at the WCRRF for reducing the frequency that a

TRU waste container presents a deflagration hazard. This control is implemented at the WCRRF facility through a receipt inspection process, which ensures that the waste container vents are present and obstruction-free, and that the flammable gas concentration in the headspace is < 4% for hydrogen or ≤ 8,000 ppm VOCs. This inspection and verification process minimizes the potential for a deflagration in the TRU waste containers shipped to the WCRRF. Flammable gas deflagrations are discussed in greater detail in the Appendix 3A, the HA.

Of the WCRRF structures, Building TA-50-69 is generally constructed of noncombustible materials (LANL 2010). Transportainers are constructed entirely of metal, with rigid metal siding. Most transportainers at LANL have steel floors, but a few have floors constructed of heavy wood planks. During the iterative HA process, it was determined that transportainers with wooden floors presented an unacceptable risk, and they have been precluded for use as TRU waste container staging units at the WCRRF. Some of the mobile units located within the WCRRF outside yard areas have an interior wall of partial wood construction and wood paneling. Office trailer TA-50-84, for example, is of wood construction. This trailer, however, is located far enough away from Building TA-50-69 and the outside transportainers that a potential fire involving office trailer TA-50-84 would not be a hazard to the TRU waste containers.

The WCRRF outside yard areas are mostly paved, although there are small grassy areas north and east of Building TA-50-69. These areas are maintained and kept free of excess vegetation. South of the site, the surface of Material Disposal Area (MDA) C is a field, which in the past was frequently overgrown with tall grasses. Since hazardous materials buried in this MDA are at a depth of approximately 1.2 m (4 ft), the vegetation is periodically cut back in an effort to lower the risk of fires. The combustible vegetation presents a hazard because wildfires involving this vegetation area can potentially spread out and threaten the WCRRF.

During walkdowns conducted by members of the HA team, accumulations of transient combustibles (e.g., packaging material or trash) were not observed. Combustible personal protective equipment (PPE) is kept in the change room and, in limited quantities, at other locations around the facility. No operations were identified as routinely using significant quantities of combustibles. All pallets used at the WCRRF for waste containers are fabricated metal. Wood pallets are not used except for delivering or storing some supplies, and these pallets are to be kept away from the TRU waste container staging and process areas.

Electrical Hazards

There are numerous electrical hazards present throughout the WCRRF. Electrical hazards typically present in these facilities are cable runs, wiring, electrical equipment, motors, and service outlets. Electrical hazards that may be found in the facility are portable generators, heaters, and power tools. Another electrical hazard that may be found in or near to the WCRRF is light fixtures. These electrical hazards may be initiators for fire and explosion events.

Thermal Hazards

Several thermal hazards were identified for the WCRRF as well. Thermal hazards typically present in the facility are heaters, electrical equipment, wiring, and engine exhaust. These thermal hazards may be initiators for fire and explosion events.

Spontaneous Combustion

The WCRRF may contain fuel, hydraulic fluids, oils, lubricants, and grease associated with equipment (e.g., forklift, drum lifts, compressors), soaps, detergents, cleaning and decontamination solvents, and stored waste material that is susceptible to spontaneous combustion (as the result of reactions between various constituents in the waste). The hydraulic fluids, oils, lubricants, grease, soaps, detergents, and cleaning solutions were screened as potential spontaneous combustion sources, since work activities and conditions in the facility will not cause the material to spontaneously ignite. If hydraulic fluid is released from a breach in a high-pressure containment vessel, it can result in an atomized spray or mist of droplets that can be ignited if the spray is close enough to an open flame or a metal surface heated to a temperature well above the fluid's flashpoint temperature, but the atomized spray is not spontaneously combustible. Class IIIB liquids such as these have an NFPA Flammability Rating of 1 or 0, a flashpoint greater than 200 °F, require considerable preheating of the fluid before ignition is possible, and were not considered further as potential fire initiators.

The remaining hazards, including flammable liquids and combustible Class II or IIIA liquids which have a Flammability Rating of 2, 3, or 4 and a flashpoint lower than 200 °F, are retained as contributors for fire events. Spontaneous combustion is considered possible for TRU waste containers with noncompliant waste.

Open Flame

There are no routine open flame sources identified for the WCRRF. Limited hot work may be performed to support site surveillance and maintenance activities.

3.3.2.1.6 Other Hazards

Vehicles, Forklifts, and Material Handling Equipment

Using motorized equipment is generally a SIH. However, because of the limited site space, the presence of TRU waste containers, and the frequency of handling them, vehicles and forklifts pose a physical hazard that can damage containers. Forklift tines or drum grapplers (used for lifting containers) can puncture or damage containers if not used properly. Containers can be dropped or overturned during vehicle loading and unloading, and during handling. In addition, vehicle fuels are fire hazards. Drum dollies, hand trucks, and other manually operated material handling equipment also present a potential hazard. Containers can be mishandled and dropped, for example, while transporting them using this type of equipment. Other mechanical insults to waste containers stem from container lifting operations.

Potential Energy (Pressure)

An additional hazard group considered involves sources of potential energy in the form of pressure. Hazards in this category, and identified for the waste storage facilities evaluated in this HA, include pressurized gas bottles (e.g., fire extinguishers), pressurized systems (e.g., hydraulic system on forklifts), and coiled springs associated with equipment. Additionally, there is the potential for containers to be pressurized (as the result of gas generation inside the container). These hazards may be initiators for loss-of-confinement events. The potential for these events is considered higher for TRU waste containers with noncompliant waste. The noncompliant wastes may contain, in addition to other hazards, aerosol cans,

compressed gas cylinders, or small quantities of reactive materials that are not permitted under the current WAC.

Standard size P10 or compressed air cylinders (a typical Size 1 cylinder contains approximately 250 ft^3) are used as a backup for operating the glovebox enclosure (GBE) doors. P10 cylinders are used for radiological monitoring equipment. Although TRU processing and storage operations within the GBE are not allowed in this document, the hazards associated with the presence of P10 or compressed air cylinders have been considered.

Potential Energy (Height/Mass)

In addition to the pressure hazards, there are also hazards related to elevated equipment that could contribute to accidents involving drops or falls. These include elevated doors and elevated work surfaces. Other hazards of this type that were identified include stacked material (e.g., TRU waste containers), containers located on a transport truck, and facility structure (e.g., facility ceiling). These hazards may be initiators for loss of confinement events.

Kinetic Energy

As a part of normal operation and maintenance, the WCRRF would be expected to contain multiple sources of kinetic energy as well. These include vehicles, motors, power tools, moving parts associated with equipment (e.g., belts, bearings), and movement of material via the forklift. Other kinetic energy hazards identified include gears grinders, fans, drills, presses, shears, and saws. These hazards may be initiators for loss of confinement events.

Physical Hazards

The waste storage facilities may also contain multiple sources of physical hazards, such as sharp edges, pinch points, tripping hazards, and temperature extremes. These physical hazards may result in an injury to the worker. Additional physical hazards are presented by the potential for an energetic lid ejection during drum deflagrations.

Explosive Materials

In addition to the hazards previously mentioned, the facilities evaluated in this HA may contain various explosive materials. These include fumes from vehicle fuel (e.g., gasoline), propane, hydrogen associated with facility equipment (e.g., lead-acid vehicle batteries), and generation of hydrogen or other explosive gas from reactions in the waste. These explosive materials may be contributors for various explosion events.

Internal Flooding Sources

Internal water sources found in the WCRRF include domestic water and fire suppression piping. Contributors can include: construction/other activities impact runoff, clogged/plugged drain (debris or trash), drain covered by container, insufficient drain capacity. These hazards were considered as potential contributors to events involving loss of contamination control.

Natural Phenomena Hazards

Natural phenomena events important to the WCRRF are discussed in Section 1.7. The natural phenomena hazards (NPHs) that are relevant and of particular concern to the WCRRF are earthquakes, high winds, wildfires, lightning, and precipitation (rain, snow, or ice), described as follows:

- Earthquakes can cause structural damage or failure, with debris impacting waste containers or gloveboxes and releasing radioactive material. They also might topple TRU waste containers, gloveboxes, or transportainers, impacting the radioactive material within. Seismic events can also initiate fires (i.e., electrical fire) or might cause other equipment failures (i.e., loss of power).
- High winds can damage structures that are not designed for the wind loading. In addition, high winds can generate missiles by picking up loose items in the yard or other locations around the site.
- Wildfires can potentially spread to the WCRRF from the MDA south of the site and impact staged waste containers. Building TA-50-69 is not readily susceptible to wildfires because of the defensible space between the wildfire area and the building. However, the building does not have a two-hour fire rating and is considered to be potentially involved in large wildfire events. The TRU waste containers stored in all-metal transportainers outside in the WCRRF yard may also be impacted.
- Lightning, besides being a significant worker hazard, can initiate fires. In addition, lightning strikes commonly cause power outages.
- A large amount of rain can potentially flood portions of the WCRRF if it is not graded properly. The Storm Water Pollution Prevention Plan for TA-50 discusses storm runoff, which is managed by contouring paved areas and collecting water into channels bordering them. Rain does not present a flooding or runoff hazard to the waste containers. Snow or ice does not present a structural loading hazard to the WCRRF structures.

Nonfacility Events

With regard to external hazards, there is typically little or no protection that would completely eliminate the potential for the WCRRF to be impacted by events that are initiated at a location external to the facility. The events of concern include aircraft crashes, nonfacility vehicle accidents, and fires. These may involve such mishaps as transportation accidents or events that occur in other facilities and propagate to the waste storage facilities. The potential for aircraft crash into the WCRRF is discussed in Appendix 3E. Appendix 3E determines that the aircraft crash frequency into the WCRRF Building is 2.85E-06 per year, based on the methodology of DOE-STD-3014-96 (DOE 2006b). As indicated in that standard, this event must be evaluated because the frequency is greater than 1E–06 per year. Because of the energy that may be imparted during an aircraft crash (and subsequent fuel fire), it is postulated that all TRU waste present at the WCRRF would be affected.

3.3.2.1.7 Screened Hazards

Identified hazards were assessed to screen or eliminate less significant hazards from further analysis. Hazards that were screened out most commonly were SIHs (events that are controlled and prevented by site-wide programs [e.g. radiation protection], national consensus standards [e.g. American National Standards Institute (ANSI), ASME, etc.] and U.S. Occupational Safety and Health Agency [OSHA] regulations). Those hazards that could initiate incidents leading to a radioactive material release were not screened.

Table 3-10 provides a list of hazard categories that were identified during the HA process review and facility walkdowns, but later screened out from further evaluation. Those hazards that are less significant, but could initiate accidents involving more significant hazards, were carried forward to hazard evaluation and addressed as accident initiators. For example, an electrical short was identified initially as an SIH; however, because it could ignite combustible material and initiate a fire, it was carried forward to hazard evaluation as an accident initiator. This case and other similar cases are noted in Table 3-10.

Table 3-10. Hazards Screened from Further Evaluation

Hazard	Reason for Screening*
Electrical equipment–low voltage (110 to 120 V electrical service)	In general, electrical equipment is considered an SIH and thus screened from further evaluation. However, it should be included when it is considered a potential fire (i.e., accident) initiator.
Compressed gas cylinders	In general, compressed gas cylinders are considered an SIH. Compressed gas cylinders that are punctured or that lose confinement are carried forward if they can cause a radioactive material release.
Slippery surfaces caused by lubricants or similar materials	Slippery surfaces are screened out because they are considered an SIH.
Internal flooding	Events were screened from detailed HA (in the What-If) due to the limited release of material from this initiator. **Note:** flooding of the GBE is considered as a potential initiator to a criticality.
Pinch points, sharp edges, cutting tools, and other mechanical situations that can cause injury	These mechanical hazards are screened out because they are SIHs. They are considered if the sharp edge can result in loss of containment (e.g., punctured glovebox glove) and release of radioactive material.
Hot surfaces, burns, hot work covered by LANL work control program	Hot items relative to burn hazards covered by LANL work control program are excluded because they are considered an SIH. However, they may be carried forward when considered an accident initiator (i.e., can initiate a fire that can impact radioactive or hazardous material).
Secondary LLW	Secondary LLW and loose/fixed contamination are generally screened from detailed hazards analysis because they are present in limited quantities (e.g., less than 10% of the HC-3 threshold) and are bounded by the inventory and hazards present in the TRU waste. LLW is considered as a combustible load, as appropriate.
Vehicles and other transportation equipment	Routine transportation hazards are screened, as these are SIHs. However, this hazard is considered as a potential initiator of scenarios that can cause a radioactive material release.
Forklift/vehicle battery recharging (hydrogen off-gassing)	Forklift battery recharging is an SIH that takes place outside to prevent interaction with nuclear material and is thus screened out. In the unlikely event that recharging was done inside the Main Process Area when MAR is present, the building exhaust ventilation change rate is far in excess of that needed to prevent hydrogen levels from reaching the lower explosive limit (LEL).
Class IIIB combustible liquids such as hydraulic fluids, lubricants, soaps, and cleaning solutions.	Class IIIB liquids such as these have an NFPA Flammability Rating of 1 or 0 and require considerable preheating before ignition is possible. These liquids are not exposed to temperatures that would permit ignition of vapors (i.e., > 200 °F) during normal operation, and, if exposed to an existing large fire, their contribution would be similar to that of ordinary combustibles.

Table 3-10. Hazards Screened from Further Evaluation

Hazard	Reason for Screening*
Hazardous chemicals—routine lubricants, solvents, and corrosives in quantities used for routine maintenance	No hazardous chemicals were identified in quantities that would be considered greater than SIHs.
Pneumatic and power hand tools	Pneumatic hand tools are considered an SIH. Their misuse or failure, however, can impact radioactive materials. When they are considered potential accident initiators, they are carried forward for further evaluation.

*In some cases, hazards are only partially screened and are carried forward if they can cause a radioactive material release.

*3.3.2.1.8 **Facility Operating History***

The WCRRF's operational history was investigated by reviewing occurrence reports submitted between 1990 and the present, and through discussions with the operations staff, some of whom have worked at the WCRRF since 1986. Issues identified by the operations staff were consistent with the events recorded in the occurrence reports; the operations staff identified no additional significant safety concerns. Twenty-five occurrence reports have been submitted. These occurrences did not have a significant impact on worker or public safety, but they prompted improvement of equipment and procedures.

There were 25 ORPS reports that involved or potentially affected operations at the WCRRF facility from 1990 to the present. The following nine reports are most representative of the types of concerns related to the WCRRF BIO requirements.

1. NA--LASO-LANL-WASTEMGT-2010-0008, *Positive USQ: Discovery of Inadequate Drum Lift Safety Analysis.* Management declared a positive USQ related to the WCRRF drum lift fixture which is required to meet PC-2 seismic design criteria. A seismic evaluation determined that the drum lift fixture has a high seismic capacity, assuming that the system is anchored to the concrete floor slab. During a recent CSE review of the anchoring configuration, it was determined that the drum lift fixture was not anchored to the floor. The finding invalidates the assumptions that the WCG drum lift fixture meets PC-2 seismic design criteria.
2. NA--LASO-LANL-WASTEMGT-2009-0007, *TSR Violation Associated with Fire Hydrant Testing.* A WCRRF Operations Center Operator was scheduling the required annual hydrant flow test when informed by Los Alamos Fire Department (LAFD) personnel that they had just conducted a flow test. WCRRF's surveillance procedure requires the facility (which was in Warm Standby at the time) to be placed in Cold Standby or for a Limiting Condition for Operation (LCO) to be entered when performing this test, because when this test is conducted the fire suppression system riser pressure drops below the TSR limit of 48 psig. A TSR violation occurred since the test was not conducted per the SR procedure, entry into the LCO was not recognized, and the corresponding required actions were not taken.
3. NA--LASO-LANL-MATWAREHS-2009-0008, *Onsite Shipment of Wrong Drum Results in a TSR Violation*. The wrong TRU Waste drum was transported from TA-54 Area G to WCRR. Several days later a subcontractor noticed that the wrong drum had been delivered to the WCRR facility and notified line management. Because this drum did not undergo appropriate analysis under the Transfer Evaluation Program, the transport of this drum resulted in a TSR violation of the P&T-SA-002, *Transportation Safety Document* (TSD) (LANL 2008).

4. NA--LASO-LANL-MATWAREHS-2009-0010, *TRU Waste Drum Shipped with a Hole in the Bottom*. During the receipt of a shipment of TRU waste drums at the WCRR facility, a worker identified that one of the drums in the shipment had a hole in the bottom of it. The OS-PT Facility Operations Director determined that a TSR has been violated.
5. NA--LASO-LANL-TA55-2008-0019, *Positive Wound Count Resulting from Injury Received While Performing Glovebox Work*. A glovebox technician (GBT1) received a puncture wound injury which was expected to result in a measurable dose to the worker from internal exposure to Pu-239. This event was initially listed as a management concern.
6. NA--LASO-LANL-MATWAREHS-2007-0001, *TSR Violation Associated with the Transport of 55-Gallon Drums*. LANL Packaging and Transportation workers transported eighteen 55-gallon drums along the Pajarito corridor from TA-50 to TA-54 that did not meet the quality assurance procurement requirements as specified in the Los Alamos TSD P&T-SA-002, R2.1, Appendix A Section A.6.1
7. NA--LASO-LANL-WASTEMGT-2007-0010, *Positive USQD: New Information Regarding Large Sealed Containers Within TRU Waste Drums.* Operations Manager for the TRU program identified a process concern related to new information regarding large sealed containers within TRU waste drums. A potentially inadequate safety analysis (PISA) was declared on October 4, 2007, because the potential for hydrogen deflagration inside the large sealed container and its potential effect on worker safety had not been previously analyzed. The event was dual categorized, at the direction of the Los Alamos Site Office (LASO), to reflect a TSR violation.
8. NA--LASO-LANL-WASTEMGT-2007-0012, *Receipt of Large Unvented Container Results in TSR Violation*. During the unpacking of the waste container, the operators discovered the drum had an unusual configuration in that there were three penetrations through the drum that appeared to be plugged with rubber buttons. In order to meet the WCRR TSR requirements, drums greater than 4 L must contain a WIPP-approved filter and have the headspace gas sampled.
9. NA--LASO-LANL-MATWAREHS-2005-0008, *TSR Violation of Transportation Safety Requirements Associated with Transfer of an Unfiltered TRU Waste Drum*. A violation of the Laboratory TSD and TSR was discovered and categorized based on TRU waste shipments from TA-54, Area G to WCRRF and back to Area G. On November 16, 2005, a TA-50-69 WCRRF technician began processing a TRU waste drum and noted that the drum lacked a vent filter as required by WCRRF procedures and TSRs. The drum was returned to Area G on November 23. This resulted in two reportable events, neither of which was WCRRF's responsibility.

3.3.2.2 Hazard Categorization

The DOE-STD-1027 (DOE 1997) describes the manner in which the final hazard categorization is determined for nonreactor nuclear facilities.

The maximum quantity of radioactive materials present at the WCRRF will be limited to a total of 1,800 PE-Ci (equivalent to approximately 28.6 kg ^{239}Pu). For the purpose of facility hazard categorization, the WCRRF is considered a single entity; facility segments are not established. Attachment 1 to DOE-STD-1027 (DOE 1997) lists the HC-2 TQs as 900 g ^{239}Pu or 3.6 g ^{238}Pu. Since the WCRRF can contain quantities of radioactive materials that exceed these TQs, the WCRRF is categorized as a HC-2 nuclear facility.

3.3.2.3 Hazard Evaluation

3.3.2.3.1 Unmitigated Hazard Evaluation

This section summarizes the results of the unmitigated hazard evaluation. The detailed evaluation is included in the What-If analysis and HA tables in Appendix 3A. The analysis followed the methodology described in Section 3.3.1. A summary of the hazards that impact the safety of the facility was given in Section 3.3.2.1.

The hazard analysis team identified scenarios with potential consequences to the public or workers. What-If analysis was used as the first step in identifying accident scenarios. As described at the beginning of Section 3.3.2, What-If analysis tables were developed for each facility section. The What-If analysis was used to prepare for the development of the HA tables by (1) ensuring a thorough identification of accident scenarios, and (2) assisting the team in identifying controls to prevent and mitigate the postulated accident scenarios. The What-If analysis serves as the basis for and is refined in the HA tables. The HA tables were developed by listing potential accident scenarios for each process or activity and organized by accident categories (e.g., fires, explosions, spills, natural phenomena events, and external events). Scenarios were selected if there was a potential for significant consequences. The HA tables were developed for each of the facility sections.

Sixty-four scenarios are evaluated for the WCRRF. For each accident scenario analyzed, the frequency of occurrence, public, collocated worker, and worker consequences, and risk ranking are estimated for the uncontrolled (or unmitigated) case using the matrices presented in Section 3.3.1. The controlled public, collocated worker, and worker risk levels are determined using the guidance in Table 3-7.

High consequence categories to the public and all postulated hazardous scenarios that resulted in unmitigated risk rank I or II are retained for further analysis and control selection. Risk rank III scenarios are also considered if the prevention or mitigation of the event requires unique controls.

Table 3-11summarizes sixty[1] scenarios, including twenty-five public High consequence categories and the public, collocated worker, and worker risk rank I and II unmitigated hazardous scenarios from the HA tables. The scenario numbers are based on the two-letter process/activity codes listed in Section 3.3.2.1. Preceding the process/activity designation code is an *H* that stands for HA. More detailed information (Hazard ID tables, What-If Analysis tables, HA tables, and supporting discussions) is provided in Appendix 3A. A text summary of the hazardous scenarios relative to the public, collocated worker, and worker receptors is presented after Table 3-11.

[1] From 65 originally evaluated hazard scenarios, three scenarios have been removed due to transformer relocation, and two new ones were added to address addition of a fire suppression system (FSS) in the WCG. Of the remaining 64 hazard scenarios, four had low unmitigated consequences to all receptors, credited no unique controls, and were not carried forward to the accident analysis. The remaining 60 hazard scenarios are summarized in Table 3-11.

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
Events Initiated Outside Building TA-50-69																	
Fire	HSO-4	Burning wooden floor and/or combustible/flammable material in transportainer.	Electrical failure of wiring or instruments in transportainer ignites fire or human error, hot work, maintenance, smoking, or unauthorized activities causes fire	A	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-5	Fire in the outdoor transportainer area involves TRU waste containers.	Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire	A	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-6	Vehicle impact and fire in the outdoor transportainer area.	Vehicle impacts containers, vehicle fuel tank leaks and ignites, or flammable or combustible liquids or pyrophorics in waste containers are ignited during accident.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-7	Fire spreads to staging area impacting TRU waste containers.	Vehicle or forklift accident breaches stored propane cylinders and ignites (forklift, maintenance, or delivery vehicle).	EU	H	H	H	II	II	II	BEU	M	M	M	IV	IV	IV
Explosion	HHO-1	Deflagration of flammable gases in TRU waste container during handling in the outside staging areas.	Forklift impact with TRU waste container initiates deflagration and/or fire.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-2	Explosion breaches waste containers Building TA-50-69 and contents burn.	Vehicle accident or fuel leak causes fuel to ignite and causes fuel tank to explode.	EU	H	H	H	II	II	II	BEU	M	M	M	IV	IV	IV
	HSO-3	Explosion and fire impacts TRU waste containers.	Vehicle accident involving fully loaded propane cylinder delivery truck causes propane cylinders to breach and explode.	EU	H	H	H	II	II	II	BEU	M	M	M	IV	IV	IV

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
Loss of Containment/ Confinement	HSO-25	Flammable gas deflagrates, ruptures container, and burns.	Hydrogen gas builds up in TRU waste container ignited due to impacts with vehicles operating in outside staging areas.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HHO-2	TRU waste container strikes ground.	TRU waste container is dropped from elevation during handling.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHO-3	Forklift tine punctures or cylinder or vehicle impacts TRU waste container.	Forklift, damaged cylinder, or vehicle impacts TRU waste container during handling.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHO-4	Damage to TRU waste container from overturning or falling off dolly or material spilled due to unsecured lids.	Operator mishandles TRU waste container	A	L	M	M	III	II	II	A	L	L	L	III	III	III
	HHO-5	Loss of TRU waste container confinement.	Degraded, corroded, or damaged TRU waste container fails during container handling.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHO-6	Loss of TRU waste container confinement.	Damaged or loose TRU waste container lid fails during handling.	A	L	M	M	III	II	II	A	L	L	L	III	III	III
	HHO-7	TRU waste container impacted.	Lifting device failure causes drop of container.	A	L	M	M	III	II	II	A	L	L	L	III	III	III
	HHO-8	TRU waste container impacted.	Inclement weather creates conditions leading to loss of vehicle control, slips, overturning, or other loss of control during container handling operations.	A	L	M	M	III	II	II	A	L	L	L	III	III	III
	HSO-10	Staged TRU waste containers impacted by moving mobile units or transportainers.	Accident occurs while positioning mobile units or transportainers.	U	L	M	M	III	II	II	EU	L	L	L	IV	IV	IV

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HSO-11	Forklift, maintenance, or delivery vehicle impacts TRU waste containers.	Operational vehicle/forklift impacts staged waste containers.	U	L	M	M	III	II	II	EU	L	L	L	IV	IV	IV
	HSO-26	Reaction products, flammable gas build-up, expansion of container contents due to weather.	Waste container vent failure causes gas build-up.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSO-9	Loss of waste container confinement.	Corrosion or container defect.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
Nuclear Criticality	HSO-1	Improper stacking of high fissile gram equivalent (FGE drums) causes inadvertent criticality.	Waste containers with significant fissionable material are stacked in a configuration that causes a criticality.	EU	L	L	H	IV	IV	II	BEU	L	L	H	IV	IV	III
External Event	HSO-13	Fire spreads to the WCRRF impacting TRU waste containers.	Vehicle (not facility related) or refueling truck accident adjacent to site causes fuel leak and spreads throughout WCRRF.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-15	TRU waste containers impacted.	Vehicle impacts staged containers (not facility related).	U	L	M	M	III	II	II	EU	L	L	L	IV	IV	IV
	HSO-16	Large fuel spill ignites, causing large fire that impacts TRU waste containers.	During refueling of auxiliary generator tank, mishap or accident spills fuel and fuel ignites.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSO-24	Aircraft crash.	Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.	EU	H	H	H	II	II	II	EU	H	H	H	II	II	II
Natural Phenomena	HSO-14	Grass/brush fire in fields impacts TRU waste containers.	Wildfire adjacent to site.	A	H	H	M	I	I	II	A	L	L	L	III	III	III

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HSO-17	Ignition of combustibles impacts TRU waste containers staged outside. Potential for fire to spread to the building.	Lightning causes fire in yard and/or transportainer.	A	H	H	H	I	I	I	U	L	L	L	III	III	III
	HSO-18	Overturning transportainer impacts staged TRU waste containers next to and inside transportainer.	Wind overturns transportainer.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSO-20	Missile impacts staged TRU waste containers.	Wind-driven missile.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSO-21	TRU waste containers impacted.	High winds topple stacked TRU waste containers.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSO-22	TRU waste containers toppled by seismic event.	Seismic event.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSO-23	TRU waste containers toppled by seismic event and impacted by fire.	Seismic event initiates a facility-wide fire.	EU	H	H	H	II	II	II	EU	M	M	M	III	III	III
Events Initiated Inside Building TA-50-69																	
Fire	HGB-3	Drum contents ignite, spreading fire to combustibles, impacting the glovebox confinement.	Pyrophoric, flammable (including combustible Class II or IIIA) liquid, gas, or oxidizer material ignites, or spontaneous combustion causes fire.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HGB-9	Any ignition source (e.g., power tools, hot work) ignites combustibles in the WCG.	Fire consumes rubber gloves or breaches high-efficiency particulate air (HEPA) filters or ductwork, causing loss of confinement. Potential for direct release path to exterior of building.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HGE-2	Any ignition source (e.g., power tools, hot work) ignites combustibles in the GBE or GBE airlock.	Fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement. Fire spreads to remainder of building.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HHI-2	Fire impacts TRU waste containers carried on pallet during offloading in the vehicle airlock.	Forklift fire caused by electrical short, human error, or other causes while carrying TRU waste containers.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSI-3	Fire spreads to TRU waste containers staged inside the vehicle airlock.	Leaking fuel from a truck parked near the building ignites and burns.	EU	H	H	H	II	II	II	EU	M	M	M	III	III	III
	HSI-4	Fire impacts staged TRU waste containers.	Forklift accident inside building, fuel system damage, fuel leaks cause a fire.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
	HSI-5	Building fire impacts gloveboxes or TRU waste containers.	Electrical short or operations cause fire.	A	H	H	H	I	I	I	U	L	L	M	III	III	II
Explosion	HGB-2	Built-up gas released while opening a TRU waste container results in deflagration, impacting the waste and glovebox.	Flammable gas build-up in TRU waste container resulting in deflagration.	A	H	H	H	I	I	I	U	L	L	M	III	III	II
	HHI-1	Deflagration of flammable gases in TRU waste containers during handling in the vehicle airlock.	Forklift impact with TRU waste container initiates deflagration and/or fire.	U	H	H	H	I	I	I	EU	M	M	M	III	III	III
Loss of Containment / Confinement	HGB-4	Radioactive material leaks from WCG confinement.	Loss of exhaust system or pressurization of the WCG or loss of power during container processing.	U	L	M	M	III	II	II	U	L	L	L	III	III	III

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HGB-6	Drum displaced from WCG, causing loss of confinement.	Worker error during bag-in or bag-out process or inadvertent activation of WCG drum lift.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HGB-7	Loss of confinement.	Drum lift fixture fails, dropping drums, breaching confinement, and releasing material.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HGB-8	Radioactive material leaks from WCG confinement. Container is in process in the WCG.	Upsets in the GBE result in overpressurization or loss of confinement in the WCG. Initiators can include fires in the GBE, impacts with the GBE structure or ductwork, airlock failures, or loss of power.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHI-4	TRU waste container strikes floor.	Drum falls from lifting device.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHI-5	Pallet of TRU waste containers overturned in the vehicle airlock.	Forklift failure or operator error drops TRU waste containers.	U	L	M	M	III	II	II	EU	L	L	L	IV	IV	IV
	HHI-6	TRU waste container impacted.	Forklift or damaged cylinder punctures or forcefully impacts SWBs, gloveboxes, or TRU waste containers during staging or handling.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HHI-7	Drum strikes floor.	TRU waste container is mishandled.	A	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSI-13	Building overpressurization leads to loss of confinement.	Failure of operator interface terminal (OIT) or loss of power.	A	L	M	M	III	II	II	A	L	L	L	III	III	III
	HSI-6	Loss of confinement from TRU waste container.	TRU waste container overturns or falls off dolly or unsecured lid leaks.	A	L	M	M	III	II	II	U	L	L	L	III	III	III

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HGB-10	Radioactive material is entrained in water from the activation of the WCG sprinkler head which fills the WCG and leaks onto the floor.	Actual fire response or inadvertent activation	U	M	L	L	II	III	III	EU	L	L	L	IV	IV	IV
	HGB-11	Water from the activation of the WCG sprinkler head either clogs the WCG outlet HEPA filter or pressurizes the WCG, causing a loss or decrease in the WCG vacuum and release of radioactive material.	Actual fire response or inadvertent activation of the WCG sprinkler head.	U	M	M	M	II	II	II	EU	M	M	M	III	III	III
Criticality	HGE-6	GBE fire sprinkler system water reflection and moderation inside GBE sump causes inadvertent criticality.	Fire sprinkler system actuates inside GBE and floods GBE liquid collection sump (water reflection and moderation). The criticality safety evaluation has determined that a criticality is not credible.	BEU	L	L	H	IV	IV	III	BEU	L	L	H	IV	IV	III
	HSI-1	Improper stacking of high FGE drums causes inadvertent criticality.	TRU waste containers with significant fissionable material are stacked in a configuration that causes criticality.	EU	L	L	H	IV	IV	II	BEU	L	L	H	IV	IV	III
Direct Exposure	HGB-1	Worker exposed to penetrating radiation from items in WCG	Unexpected radioactive source is removed from waste containers attached to WCG	U	L	L	M	III	III	II	U	L	L	M	III	III	II
Natural Phenomena	HGB-5	Structural damage and debris breach WCG confinement.	Seismic event causes building structural failure when TRU waste material is in WCG.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSI-10	Fire spreads through building and impacts gloveboxes or TRU waste containers.	Lightning initiates fire inside the building.	A	H	H	H	I	I	I	U	L	L	L	III	III	III

Table 3-11. Hazard Analysis Summary for the WCRRF

Event Type	HA-ID #	Scenario	Initiating Event or Cause	Unmitigated							Mitigated						
				Freq	Conseq			Risk			Freq	Conseq			Risk		
					P	C W	W	P	C W	W		P	C W	W	P	C W	W
	HSI-12	Fire and structural debris impact TRU waste containers WCG, or GBE.	Seismic event initiates electrical fire inside building.	EU	H	H	H	II	II	II	EU	M	M	M	III	III	III
	HSI-8	Structural damage to building, debris impacts TRU waste containers.	Seismic event.	U	L	M	M	III	II	II	U	L	L	L	III	III	III
	HSI-9	Structural damage to building and debris breach TRU waste containers.	High wind.	U	L	M	M	III	II	II	U	L	L	L	III	III	III

Off-Site Receptor

The off-site receptor of concern is the MEOI. The following text summarizes the unmitigated and mitigated scenarios by consequence and risk to the public as identified by the hazard analysis. These scenarios include fires, explosions, natural phenomena events, and external events.

Of the 64 accident scenarios evaluated, the HA team identified 25 scenarios with the potential for High consequences to the public, unmitigated (or uncontrolled); that is, consequences that could potentially exceed or challenge the EG . - These 25 scenarios are either initiated by or involve fires or explosions (with fire) that affect TRU waste inside or outside of Building TA-50-69. The major initiators include electrical failure, fuel leak/spill, flammable gas build-up/deflagration, self-ignition of waste (e.g., pyrophoric event), vehicle or forklift accident, human error, seismic event with fire, lightning, high wind (initiating electrical fire), and wildfire.

Eighteen high-risk scenarios (risk rank I), unmitigated, were identified with respect to the MEOI. All 18 risk rank I events were estimated to potentially result in High consequences to the public. The initiators for these events include equipment failure or operations (e.g., hot work) ignites combustible waste in transportainer; equipment failure or operations (e.g., hot work) initiates building fire; wildfire spreads to TRU waste staging areas; lighting-initiated fire involves building or outdoor transportainer area.

A total of 9 risk rank II (with High or Moderate consequences) accident scenarios, unmitigated, were identified with respect to the MEOI. These scenarios include fires and/or spills that involve several waste containers, the building limit, or the site limit. As the building limit can potentially exist in a single high-inventory container, in select events no distinction is made between the inventory in one container and the building limit. General initiators for the fire scenarios include vehicle or forklift accidents, fuel spills during refueling, equipment failure, high wind events, a seismic event that breaches waste containers and initiates a fire, vehicle or forklift accidents (with fire), aircraft crash, electrical short, and operations (e.g., hot work).

Of the 27 unmitigated accident scenarios involving the MEOI initially identified as risk rank I or II that are postulated to occur at the WCRRF, all but one event are mitigated to a risk rank of III or IV by safety controls. Aircraft crash (HSO-24) presents a mitigated risk of II to the public. It is important to note that the risk ranking in the HA is used as a tool to help understand which scenarios pose the greatest risk to the public and to ensure that adequate controls are provided for worker safety. Independent of risk, all scenarios with the potential to challenge the EG (i.e., High consequences to the public) are identified as candidates for formal Accident Analysis.

Collocated Worker Receptor

The following text summarizes the unmitigated and mitigated scenarios by consequence and risk to the collocated worker as identified by the hazard analysis. These scenarios include fires, explosions, spills, natural phenomena events, and external events.

A total of 25accident scenarios, unmitigated, were estimated to produce High collocated worker consequences. The high number of scenarios in this consequence category is because of the potential exposure above 100 rem TED caused by a release of TRU radioactive material. The radioactive material considered is located inside the waste containers or the WCG. Scenarios that can potentially impact the collocated workers include all accident types except criticality.

A total of 18 scenarios were identified as high risk (risk rank I, unmitigated) to collocated workers. These accidents are operational, initiated by workers, involve a fire or a breach of confinement (building or WCG overpressurization, waste containers, or a glovebox), and result in a release of radioactive material. A collocated worker at 100 meters is considered to evaluate the effects of exposure to radioactive material that becomes airborne. A total of 37 scenarios were identified as risk rank II, unmitigated, to collocated workers. These scenarios include every type of accident with the exception of a criticality. Several layers of DID are provided for these scenarios that reduce both their frequencies and consequences.

Of the 55 unmitigated accident scenarios involving the collocated worker initially identified as risk rank I or II that are postulated to occur at the WCRRF, all but one event are mitigated to a risk rank of III or IV by safety controls. Aircraft crash (HSO24) presents a mitigated risk of II to the collocated worker.

Local Worker Receptor

The following text summarizes the unmitigated and mitigated scenarios by consequence and risk to the worker as identified by the hazard analysis. These scenarios include fires, explosions, spills, criticalities, natural phenomena events, and external events.

Twenty-eight scenarios were estimated to produce High worker consequences unmitigated. Certain operational events such as the explosion/deflagration events in which a drum can energetically eject the drum lid, impacting any worker who is positioned above the drum, could result directly in immediate health effects or loss of life to workers. Three criticality accidents were estimated to produce High worker consequences, risk rank II, unmitigated (HSO-1, HSI-1, and HGE-6). Although no safety controls are capable of reducing the consequences to the worker, implementation of controls identified via the Nuclear Criticality Safety Management Program significantly reduces the frequency, resulting in a mitigated risk rank III to local workers for the criticality accidents. In addition, the CSE (SB-CS 2007) has determined that a criticality accident in the GBE is not credible as reflected in the assignment of a frequency BEU for the unmitigated hazard scenarios. Some radiological release scenarios have the potential for High consequences to the worker.

A total of 58 scenarios were identified as risk rank I or II, unmitigated, for the facility worker. All but four scenarios (HGB-1, HGB-2, HSO-24, and HSI-5) were reduced to risk rank III or IV with safety controls in place.

3.3.2.3.2 ***Mitigated Hazard Evaluation***

Table 3-11 identifies the events requiring further evaluation in the mitigated hazard evaluation. The mitigated hazard evaluation is performed to determine the controls required to protect the worker, collocated worker, and the off-site receptor from radiological hazards. For each accident scenario analyzed, the frequency of occurrence, public, collocated worker, and worker consequences, and risk ranking were qualitatively estimated for the uncontrolled (or unmitigated) case using the matrices presented in Section 3.3.1. Then safety controls that could reduce the scenario frequency or consequences were considered. The controls were evaluated for effectiveness, and those determined to be most important were identified. The final step was to estimate the controlled frequency and consequences considering the credited safety controls. The controlled public, collocated worker and worker risk levels are determined using the guidance in Table 3-7.

A summary of the controls that prevent or mitigate the evaluated scenarios is presented in the following DID section. The details of each control, its function as a preventer or a mitigator, and the accident scenarios that each control provides protection for, are summarized in the HA tables in Appendix 3A.

3.3.2.3.3 Defense-in-Depth

This section summarizes significant aspects of DID by accident type and identifies associated SS-SSCs, SACs and other items needed TSR coverage. These controls reduce the likelihood of an accident scenario or reduce its consequences. Both facility design and administrative features of DID are included. The collective layers of preventive and mitigative controls provide DID for postulated accident scenarios. Those safety controls required for public protection may also be designated as SC-SSCs as the result of the Accident Analysis in Section 3.4.

Defense-in-Depth: Loss of Confinement/Containment (Spill) Accidents

The controls that provide DID for releases of hazardous material from spills are listed beginning with the engineered controls and progressing through ACs. The controls are listed in short text form, with the unique control ID from the HA tables (Appendix 3A) following each control description. These controls provide the public, collocated worker and workers with adequate protection against exposure to hazardous materials in the event of a spill. The DID controls for spill events include the following:

SSCs (LCO or DF Candidates):

Abbreviated Control Description	Control ID from HA
Building TA-50-69 confinement ventilation system	FD-BCN
Building TA-50-69 structural integrity	FD-BSD
Transuranic waste containers (design integrity and filtered vent)	ED-TRU
Vehicle barrier	ED-BRR
WCG design integrity and confinement	ED-WCD
WCG drum lift fixture	ED-GBL

SSCs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Diesel Generator	ED-GEN
Transportainer	ED-TDI
Operator Interface Terminal	ED-VCC

ACs (SAC Candidates):

Abbreviated Control Description	Control ID from HA
Inventory limits	Analysis assumption
Critical lift plan	HR-LFT
TRU waste containers staged in transportainers	HM-TRU
Vehicle access system	VS-VAC
Vehicle Fuel Restrictions	FP-PRO
Waste container inspection	HM-WCI
Waste container staging practices	HM-WCS

ACs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Minimize Sharp Objects	CO-SHP
Two-Man Rule	CO-TMR
Airlock Door Usage Administratively Controlled	PR-GBA
Spotter required	HR-SPT

SMPs:

Abbreviated Control Description	Control ID from HA
Emergency Preparedness Program	EP-FAC
Fire Protection Program	FP-FPP
Hoist and Rigging Program	HR-LFT
Maintenance program	MP-INS
Radiation Protection Program	RP-RPP
Training and Qualification Program	TR-T&QP

Defense-in-Depth: Fires

Fires can have many different causes, each being a significant contributor to the risk and each requiring a unique set of controls. Initiators can include operationally induced events (e.g., hot work), electrical faults, vehicle impacts, NPH, and external events. The controls are listed in short text form, with the unique control ID from the HA tables (Appendix 3A) following each control description. These controls, in conjunction with common controls, provide the public, collocated worker, and workers with adequate protection against exposure to hazardous materials in the event of a fire. The DID controls for fires include the following:

SSCs (LCO or DF Candidates):

Abbreviated Control Description	Control ID from HA
Building TA-50-69 confinement ventilation system	FD-BCN
Building TA-50-69 structural integrity	FD-BSD
Building TA-50-69 and WCG Fire Suppression System (FSS)	FP-FSS
Transuranic waste containers (design integrity and filtered vent)	ED-TRU
WCG design integrity and confinement	ED-WCD
Vehicle barrier	ED-BRR

SSCs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Operator Interface Terminal	ED-VCC
Transportainer	ED-TDI
Site Perimeter Fence	FD-SPF

ACs (Candidates for SACs):

Abbreviated Control Description	Control ID from HA
Inventory limits	Analysis assumption
Combustible loading control	FP-CLP
Diesel generator refueling exclusion	FP-RFX
Hot work prohibition	FP-HOT
TRU waste containers staged in transportainers	HM-TRU
Vehicle access system	VS-VAC
Vehicle Fuel Restrictions	FR-PRO
Waste container inspection (including vent/head space gas analysis verification)	HM-WCI

ACs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Vegetation Exclusion Area	FP-VEG
Spotter required	HR-SPT

SMPs:

Abbreviated Control Description	Control ID from HA
Conduct of Operations Program	CO-COP
Emergency Preparedness Program	EP-FAC
Fire Protection Program	FP-FPP
Maintenance program	MP-INS
Training & Qualification Program	TR-TQP

Defense-in-Depth: Explosions/Deflagrations

A few hazards at the WCRRF create the potential for a deflagration. These hazards include the propane cylinders, vehicle fuels, and hydrogen and other flammable gases that might accumulate inside a TRU waste container. The controls are listed in short text form, with the unique control ID from the HA tables (Appendix 3A) following each control description. The specific controls, in conjunction with the common controls, provide the public, collocated worker and workers with adequate protection against exposure to hazardous materials in the event of deflagration. The DID controls for deflagrations and explosions include the following:

SSCs (LCO or DF Candidates):

Abbreviated Control Description	Control ID from HA
Building TA-50-69 confinement ventilation system	FD-BCN
Building TA-50-69 structural integrity	FD-BSD
Building TA-50-69 and WCG Fire Suppression System	FP-FSS
TRU Waste Containers (design integrity and filtered vent)	ED-TRU
Vehicle Barrier	ED-BRR
WCG design integrity and confinement	ED-WCD
WCG drum lift fixture	ED-GBL

SSCs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Operator Interface Terminal	ED-VCC
Transportainer	ED-TDI
Site Perimeter Fence	FD-SPF

ACs (Candidates for SACs):

Abbreviated Control Description	Control ID from HA
Inventory limits	Analysis assumption
Combustible loading control	FP-CLP
Vehicle fuel restrictions	FP-PRO
TRU waste containers staged in transportainers	HM-TRU
Vehicle access system	VS-VAC
Waste container inspection (including vent/headspace gas analysis confirmation)	HM-WCI
Waste Container Staging Practices	HM-WCS
Grounded, unvented drum	GU-FPP
Drum lid restraint	LR-FPP
Use of non-sparking tools/ De-energization of WCG electric receptacles when breaching unvented, sealed waste packages in the WCG .	FP-NST

ACs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Vegetation Exclusion Area	FP-VEG
Spotter required	HR-SPT

SMPs:

Abbreviated Control Description	Control ID from HA
Emergency Preparedness Program	EP-FAC
Fire Protection Program	FP-FPP
Maintenance program	MP-INS
Training & Qualification Program	TR-TQP

Defense-in-Depth: Radiation Exposure

Exposures can be caused by the ionizing radiation and contamination in the waste container contents. Potential exposures from inhaling contamination above personnel guidelines have been previously addressed in the *Defense-in-Depth: Spill Accidents* subsection. For routine operations, no unique DID controls for radiation exposure were identified. Protection is provided by routine implementation of the Radiation Protection Program (RPP) ALARA practices and through the application of appropriate PPE.

Defense-in-Depth: Criticality

The potential for a criticality at the WCRRF is limited by the configuration of the fissile material (i.e., distributed on contaminated waste material that is packaged in waste containers). The Laboratory's criticality safety program also supports operations at the WCRRF to ensure criticality safety.

The specific controls, in conjunction with the common controls, provide workers with adequate protection in the event of a criticality. The DID controls for criticality include the following:

ACs:

Abbreviated Control Description	Control ID from HA
Nuclear Criticality Safety Program	NC-CSP

Defense-in-Depth: Natural Phenomena Hazards

For the case of spills initiated by seismic events or high winds, the DID discussion for spill prevention (above) forms its basis. For the case of fires initiated by seismic events, the DID discussion for fire accidents (above) forms its basis. For the fixed engineered features, the *potential* NPH DID controls listed below are marked as appropriate based on their limitations. The controls are listed in short text form, with the unique control ID from the HA tables (Appendix 3A) following each control description. The performance limitations of the controls are considered in both the hazard analysis and accident analysis, as appropriate.

SSCs (LCO or DF Candidates):

Abbreviated Control Description	Control ID from HA
Building TA-50-69 confinement ventilation system	FD-BCN
Building TA-50-69 structural integrity	FD-BSD
Building TA-50-69 Fire Suppression System	FP-FSS
WCG design integrity and confinement	ED-WCD
WCG Drum Lift Fixture	ED-GBL
Transuranic waste containers (design integrity and filtered vent)	ED-TRU

SSCs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
Transportainer	ED-TDI

ACs (Candidates for SACs):

Abbreviated Control Description	Control ID from HA
Inventory limits	Analysis assumption
Combustible loading control	FP-CLP
TRU waste containers staged in transportainers	HM-TRU
Vehicle Fuel Restrictions	FP-PRO
Waste container staging practices	HM-WCS
Transportainer placement	HM-TSP

ACs (Uncredited contributor to defense-in-depth):

Abbreviated Control Description	Control ID from HA
TRU Waste Drum Confinement	CD-WCF
Vegetation Exclusion Area	FP-VEG
Yard Maintenance	PR-HKP

SMPs:

Abbreviated Control Description	Control ID from HA
Emergency Preparedness Program	EP-FAC
Fire Protection Program	FP-FPP
Maintenance program	MP-INS

The vegetation exclusion area separating the WCRRF from MDA-C provides defense-in-depth for wildland fires. Given the integrity of the TRU waste containers and the additional protection provided by the transportainers (LANL 2010), the vegetation exclusion area is considered defense-in-depth but is not elevated to safety-significant.

Defense-in-Depth: External Events

Controls contributing to DID for external events, such as vehicle impacts causing fires or spills, are given above for each respective accident type. For the case of externally initiated spills, the DID discussion for spill prevention (above) forms its basis. For the case of externally initiated fires, the DID discussion for fire accidents (above) forms its basis. Of these controls, vehicle barriers (ED-BRR) and vehicle access controls (VS-VAC) provide the primary means to protect the TRU waste containers from external events.

The double-walled fuel tank on the diesel generator is also a defense-in-depth feature for external fires. Given the location of the diesel generator away from the transportainers, a leak of the double-walled tank will not challenge the transportainers. The fuel tank holds about 127 gallons. If a diesel leak from the double-walled tank were to occur, the combination of the slope of the terrain around the diesel generator and the distance of the diesel generator from Building TA-50-69 (28 ft) means that a leak will not impact Building TA-50-69. The tank is considered defense-in-depth but is not elevated to safety-significant.

Identification of Safety-Significant SSCs and TSR ACs

Table 3-12 summarizes the SS-SSCs and ACs from the mitigated hazard evaluation for activities outside and inside Building TA-50-69. These features, or controls, can be engineered systems, SACs, or passive design features. Controls were considered if they had a discernible effect on the accident frequency (preventive controls) and/or consequences (mitigative controls). With the credited controls in place, the consequence and risk of each scenario were re-evaluated, and the adequacy of existing controls was assessed. This iterative process progressed until all events identified in the HA were addressed. The controlled risk columns in the HA Tables in Appendix 3A reflect the results of the iterative control selection process discussed in Section 3.3.1. The HA Tables also identify which specific controls are credited for each postulated event. Because of the length of the descriptions for all available controls identified in the HA, only a summary of those controls that have been credited as significant contributors to safety are presented in Table 3-12.

The controls presented in the HA tables and summarized in the DID discussions are re-evaluated in the Accident Analysis, Section 3.4, to assist in the identification of SC-SSCs and SC-ACs (e.g., Limiting Conditions for Operation [LCOs] and SACs).

3.3.2.3.4 Worker and Collocated Safety

The major features that protect workers and collocated workers from hazards involved in facility operations are discussed in the previous DID sections and summarized in Table 3-12. In general, safety controls that prevent a release of radioactive material from the waste containers or gloveboxes protect both workers, collocated workers, and the public. The only safety controls that are unique to the worker (credited for worker protection only) are the Nuclear Criticality Safety Program (NC-CSP) together with an SMP, the Radiation Protection Program.

Table 3-12. Controls Providing Significant Defense-in-Depth or Worker Safety[1]

Abbreviated Control Description	Control ID from HA	Safety Function
Building TA-50-69 structural integrity (DF and LCO)	FD-BSD	Provide structural integrity to support safety SSCs. Prevent insult to the MAR inside Building TA-50-69. Mitigates releases of MAR in conjunction with the confinement ventilation system.
Building TA-50-69 confinement ventilation system (and support system UPS) (LCO)	FD-BCN	Mitigates releases of MAR in conjunction with the WCG and Building TA-50-69 structural integrity.
Building TA-50-69 and WCG Fire Suppression System (LCO)	FP-FSS	Limit the size and duration of fires in the WCG and in Building TA-50-69 thereby protecting the TRU waste and the ventilation HEPA filters from overtemperature threats and minimizing the release of radioactive material from Building TA-50-69 to the environment.
Lightning Protection System (SMP element)	FD-LPS	Reduces probability of fires initiated by lightning strikes by a factor of 1/16th. Because the LPS cannot provide a full frequency bin (i.e., factor of 100) reduction, it is not credited as a design feature. Due to the defense-in depth contribution, LPS maintenance is identified as an element of the Maintenance Program.
Combustible loading control (Inside – SAC/LCO)	FP-CLP	Inside: Minimization of combustible loading prevents a fire from propagating and impinging upon TRU waste, and mitigates release of TRU waste by limiting fire size in Building TA-50-69. Outside: Ensures that combustible loading is minimized outside of Building TA-50-69 and properly located to limit fire growth and propagation.
(Outside – SAC/LCO)		
Critical Lift Plan (SAC)	HR-LFT	The use of a critical lift plan minimizes the probability of impacts and drops involving degraded or loss-of-integrity drums.
Diesel generator refueling exclusion (SAC)	FP-RFX	Prevents fuel pool fires associated with diesel generator refueling from affecting TRU waste inside Building TA-50-69.
Drum lid restraint (SAC)	LR-FPP	Provides physical protection in the WCG in case of a lid ejection and to minimize material release (e.g., prevents unconfined burning of material) when breaching an unvented, sealed 30- to 5-gallon waste package.
Grounded unvented drum (SAC)	GU-FPP	Reduces the probability for a spark during the opening of unvented 30- to 5-gallon waste package within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere with the WCG.
Use of non-sparking tools and processes / de-energization of WCG electric receptacles when breaching unvented, sealed waste packages in the WCG (SAC).	FP-NST	When breaching unvented, sealed waste package within the WCG, the use of non-sparking tools or processes and the de-energization of WCG receptacles, prevents the occurrence of sparks, thereby preventing the ignition of a potentially flammable atmosphere with the WCG.
Hot work prohibition (SAC)	FP-HOT	Reduces the probability of a fire igniting that could threaten TRU waste.
Inventory Limits (SAC/LCO)	Initial Condition	The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated (see Section 3.4).

Table 3-12. Controls Providing Significant Defense-in-Depth or Worker Safety[1]

Abbreviated Control Description	Control ID from HA	Safety Function
Prohibit storage, staging, and processing of inventory within the GBE	Initial Condition	Prohibiting the storage, staging, and processing of inventory within the GBE preserves an initial condition assumption for the hazard analysis that the radiological material inventory present in the GBE is limited to the residual contamination that remains from prior operations.
Training and qualification for forklift operators (TSR-AC/SMP-Element)	TR-FLT	Minimizes the probability of accidents caused by improper forklift operations.
Transportainer *(see Control ID: HM-TSP, HM-TRU and FP-CLP)*	ED-TDI	May reduce damage to TRU waste containers staged in outdoor staging areas, but is not credited with any reduction in damage ratio or other source term parameter, and is not considered a Design Feature. Control of combustibles inside and around transportainers, and the requirement for the use and placement of the transportainers are addressed by SACs.
Transportainer placement (SAC)	HM-TSP	Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.
Transuranic waste containers (design integrity and filtered vent) (DF)	ED-TRU	Provide primary confinement for TRU waste. Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents. Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents. Prevent accumulation of flammable gases inside the TRU waste containers.
TRU waste containers staged in transportainers (SAC)	HM-TRU	The requirement to stage TRU waste containers inside of secondary containment (i.e., transportainers) while in outdoor staging minimizes the release of TRU waste from external fires involving the TRU waste containers.
Vehicle access system (SAC)	FP-VAC	Prevents vehicle impacts and subsequent fuel pool fires that could impinge upon TRU waste in Building TA-50-69 and TRU waste containers staged in transportainers.
Vehicle barriers (DF)	ED-BRR	Prevent impacts between moving vehicles and the TRU waste containers staged inside Building TA-50-69 or in outdoor transportainers. Prevent subsequent vehicle fuel pool fires from involving TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.
Vehicle fuel restrictions (SAC)	FP-PRO	The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF prevents explosions and minimizes the potential for fires that will impact TRU waste.
TRU waste container inspection (SAC)	HM-WCI	TRU waste container inspections accomplish three functions: the container is confirmed to be of sound integrity; installation of a WIPP-approved vent is verified before receipt at WCRRF; independent headspace gas analysis is performed. These inspections prevent flammable gas fires and deflagrations and ensure that containers can mitigate other accidents involving containerized waste.

Table 3-12. Controls Providing Significant Defense-in-Depth or Worker Safety[1]

Abbreviated Control Description	Control ID from HA	Safety Function
TRU waste container staging practices (SAC)	HM-WCS	The restrictions of TRU waste container stacking and lift height prevents the release of material by reducing the likelihood of a container failure caused by a drop from an elevated position.
WCG design integrity and confinement (DF)	ED-WCD	The WCG must provide primary confinement for visual inspection, waste characterization, and repackaging operations.
WCG drum lift fixture (LCO)	ED-GBL	The drum lift fixture must prevent drum drops and mitigate the consequences from malfunction and/or seismic events..

[1] Require coverage in the TSRs

3.3.2.3.5 Environmental Protection

Protection of the environment is the result of the design and administrative features that control the release of radioactive waste to the environment. The preventative controls identified in the HA tables for protection of the public and the worker adequately address the impacts to the environment.

3.3.2.3.6 Accident Selection

This section discusses the process and criteria used in selecting bounding unique and representative accident scenarios (i.e., the Design Basis Accidents [DBAs]) for the Accident Analysis (Section 3.4) in this BIO. Unique accidents are those with sufficiently high-risk estimates that individual examination is needed (e.g., a single fire whose specific parameters result in approaching the Evaluation Guideline; situations of major concern). Representative accidents bound a number of similar accidents of lesser risk (e.g., the worst fire for a number of similar fires). Representative accidents are examined to the extent that they are not bounded by unique accidents. In any case, at least one bounding accident from each of the major types determined from the hazard analysis (e.g., fire, explosion, spill, etc.) should be selected unless the bounding consequences are *Low.*

The primary purpose of the DBA analysis is to identify SSCs that warrant SC designation. Comparison of the unmitigated consequences for a limited subset of potential accidents to the EG is performed to determine if the need for designation of SC-SSCs exists. If the EG value is approached by the unmitigated consequences of a release scenario, a need for SC-SSC designation is indicated. Any scenarios identified by the HA to result in High consequences to the collocated worker would also be candidates for AA even if the consequence to the public was not considered High.

Note that there is no predetermined frequency cutoff value, such as 1.0E-6 per year, for excluding low-frequency operational accidents (i.e., internally initiated). In fact, for operational accidents there is no explicit need for a frequency component to the unmitigated release calculations, since the determination of need is solely driven by the bounding consequence potential. In any case, at least one bounding accident from each of the major types determined from the hazard analysis (e.g., fire, explosion, spill, etc.) should be selected unless the bounding consequences are *Low.*

As such, frequency estimates, and thus risk, play a secondary role in the Accident Analysis selection process. The process for selecting events that were carried forward for formal accident analysis focused on events with the potential to challenge the EG (designated as events with public consequences of High). Moderate risk events with less than five rem consequences to the public are typically addressed adequately through the HA process. That is, formal controls for these events were selected in the HA and carried forward through the DSA to the TSRs.

The selection criteria include the following: Unique scenarios with (a) the highest consequences to the public for a given accident category (i.e., unmitigated consequences that challenge or exceed the DOE EG, or High consequences) and (b) sufficiently high risk estimates that require individual examinations. All public consequence High scenarios, by definition, can either exceed or challenge the EG. Thus, they are candidates for further analysis. Events that did not result in High consequences to the public are not required to be evaluated in formal accident analyses. However, for completeness, at least one bounding accident from each of the major event types (e.g., fire, explosion, spill, etc.) with the potential to impact the public (i.e., Moderate consequences or greater) is addressed.

The risk matrix is not the final decision for hazard scenarios being included or excluded from further evaluation. The risk matrix provides useful information to the analyst as part of the overall HA and accident analysis. This practice is encouraged so that there is high confidence that the accident analysis properly bounds the evaluated hazards in the facility.

The following accident scenarios, listed according to their event type, public consequence, and risk ranks, are potential candidates for Accident Analysis:

Fires

Risk Rank I Events

High Consequence:

- HSO-4: Burning wooden floor and/or combustible/flammable material in transportainer. Electrical failure of wiring or instruments in transportainer ignites fire or human error, hot work, maintenance, smoking, or unauthorized activities cause fire.
- HSO-5: Fire in the outdoor transportainer area involves TRU waste containers. Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire.
- HSO-6: Vehicle impact and fire in the outdoor transportainer area. Vehicle impacts containers, vehicle fuel tank leaks and ignites, or flammable or combustible liquids or pyrophorics are ignited during accident.
- HGB-3: Drum contents ignite, spreading fire to combustibles, impacting the glovebox confinement. Pyrophoric, flammable, or combustible (Class II or IIIA) liquids, or oxidizer material ignites, or spontaneous combustion causes fire.
- HGB-9: Any ignition source (e.g., power tools, hot work) ignites combustibles in the WCG. Fire consumes rubber gloves and/or breaches HEPA filters or ductwork, causing loss of confinement. Potential for direct release path to exterior of Building.
- HSI-4: Fire impacts staged TRU waste containers. Forklift accident inside building, fuel system damage; fuel leaks cause a fire.
- HSI-5: Building fire impacts gloveboxes or TRU waste containers. Electrical short or operational upsets cause fire.
- HHI-2: Fire impacts TRU waste containers carried on pallet. Forklift fire caused by electrical short, human error, or other causes while carrying TRU waste containers.
- HGE-2: Any ignition source (e.g., power tools, hotwork) ignites combustibles in the GBE airlock. Fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement. Fire spreads to remainder of building.

Risk Rank II Events

High Consequence:

- HSO-7: Fire spreads to staging area impacting TRU waste containers. Vehicle or forklift accident breaches stored propane cylinders and ignites (forklift, maintenance, or delivery vehicle).
- HSI-3: Fire spreads to TRU waste containers inside the vehicle airlock. Leaking fuel from a truck parked near the building ignites and burns.

Explosions

Risk Rank I Events

High Consequence:

- HSO-25: Flammable gas deflagrates, ruptures container, and burns. Hydrogen gas builds up in TRU waste container. Ignited due to mishandling, causing fire.
- HHO-1: Deflagration of flammable gases in TRU waste container. Forklift impact with TRU waste container initiates deflagration or fire.
- HHI-1: Deflagration of flammable gases in TRU waste container. Forklift impact with TRU waste container initiates deflagration or fire.
- HGB-2: Built-up gas released while opening a TRU waste container results in deflagration impacting the waste and glovebox. Flammable gas build-up in TRU waste container results in deflagration.

Risk Rank II Events

High Consequence:

- HSO-2: Explosion breaches waste containers outside of Building TA-50-69 and contents burn. Vehicle accident or fuel leak causes fuel to ignite and causes fuel tank to explode.
- HSO-3: Explosion and fire impacts TRU waste containers. Vehicle accident involving fully loaded propane cylinder delivery truck causes propane cylinders to breach and explode.

Loss of Containment/Confinement

Risk Rank I Events

High Consequence:

- None identified

Risk Rank II Events

High Consequence:

- None identified

Natural Phenomena Events

Risk Rank I Events

High Consequence*:*

- HSO-14: Wildfire adjacent to site. Grass/brush fire in fields impacts TRU waste containers.
- HSO-17: Lightning causes fire in yard and/or transportainer. Ignition of combustibles impacts TRU waste containers staged outside. Potential for fire to spread to the Building.
- HSI-10: Lightning initiates fire inside the building. Fire spreads through building and impacts gloveboxes and TRU waste containers.

Risk Rank II Events

High Consequence*:*

- HSO-23: Seismic event initiates a facility-wide fire. TRU waste containers toppled by seismic event and impacted by fire.
- HSI-12: Seismic event initiates electrical fire inside building. Fire and structural debris impact TRU waste drums, WCG, or GBE.

Note: A seismic event without a subsequent fire did not result in unmitigated *H* or *M* consequences to the public. Two events (one collapsing the building and one in the outside staging area) are considered for potential inclusion in the Accident Analysis.

- HSO-22: Seismic event. TRU waste containers toppled by seismic event.
- HSI-8: Seismic event. Structural damage to building, debris impacts TRU waste containers.

External Events

Risk Rank I Events

High Consequence*:*

- HSO-13: Vehicle (not facility-related) accident adjacent to site causes fuel leak that ignites. Fire spreads to the WCRRF, impacting TRU waste containers.
- HSO-16: During refueling of auxiliary generator tank, mishap or accident spills fuel and fuel ignites. Large fuel spill ignites, causing large fire that impacts TRU waste containers.

Risk Rank II Events

High Consequence*:*

- HSO-24: Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.

From the potential list of candidates, the bounding, representative, or unique accidents that were selected for further analysis are discussed in the following sections. Those HA events that are selected to be carried forward to the accident analysis are in bold.

Fire Events

For the purpose of the Accident Analysis, fires are grouped into (a) fires inside Building TA-50-69 and (b) fires outside Building TA-50-69. Further subsections are identified, as necessary.

Fires Outside Building TA-50-69

Fires occurring outside of Building TA-50-69 are grouped into operational fires (e.g., hot work) and vehicle impacts that result in fires. Both types of fire events have the potential to involve the entire outside storage area inventory (i.e., 1,800 PE-Ci).

Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles

- HSO-5: Fire in the outdoor transportainer area involves TRU waste containers. Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire.
- HSO-4: Burning wooden floor or combustible/flammable material in transportainer. Electrical failure of wiring or instruments in transportainer ignites fire or human error, hot work, maintenance, smoking, or unauthorized activities cause fire.

HSO-5 represents a common type of operational fire event for staging and handling activities in TRU waste storage areas. HSO-5 is selected as a bounding event to be carried forward for further Accident Analysis.

Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire)

- HSO-6: Vehicle impact and fire in the outdoor transportainer area. Vehicle impacts containers, vehicle fuel tank leaks and ignites, or flammable or combustible liquids or pyrophorics are ignited during accident.
- HSO-16: During refueling of auxiliary generator tank, mishap or accident spills fuel and fuel ignites. Large fuel spill ignites, causing large fire that impacts TRU waste containers.
- HSO-7: Vehicle or forklift accident breaches stored propane cylinders and ignites (forklift, maintenance, or delivery vehicle). Fire spreads to staging area, impacting TRU waste containers.
- HSO-13: Vehicle (not facility-related) or fuel truck accident adjacent to site causes fuel leak that ignites. Fire spreads to the WCRRF, impacting TRU waste containers.

HSO-6 involves a vehicle running into and breaching staged waste containers, causing a fuel leak, and igniting, or igniting flammable or combustible liquids or pyrophorics in waste containers. The vehicle impact may cause a breach of the TRU container (e.g., lid-loss) and the ejection of the contained TRU waste. A large fraction of the waste may burn, with the contaminant exposed to the ambient atmosphere. This scenario represents the most conservative case, is representative of the other scenarios in this class, and is selected as an event for further Accident Analysis.

Fires Inside Building TA-50-69

Fires occurring inside of Building TA-50-69 can occur from glovebox operations or supporting operations outside of the glovebox, but spread to impact TRU waste within the glovebox or staged waste containers.

- HSI-5: Building fire impacts gloveboxes or TRU waste containers. Electrical short or operational upsets cause fire.
- HHI-2: Fire impacts TRU waste containers carried on pallet during off-loading in the vehicle airlock. Forklift fire caused by electrical short, human error, or other causes while carrying TRU waste drums.
- HSI-3: Fire spreads to TRU waste containers staged inside the vehicle airlock. Leaking fuel from a truck parked near the building ignites and burns.
- HSI-4: Fire impacts staged TRU waste containers. Forklift accident inside building, fuel system damage, fuel leaks cause a fire.
- HGB-9: Any ignition source (e.g., power tools, hot work) ignites combustibles in the WCG. Fire consumes rubber gloves or breaches HEPA filters or ductwork, causing loss of confinement. Potential for direct release path to exterior of building.
- HGE-2: Any ignition source (e.g., power tools, hot work) ignites combustibles in the GBE. Fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement. Fire spreads to remainder of building.
- HGB-3: Drum contents ignite, spreading fire to combustibles, impacting the glovebox confinement. Pyrophoric or flammable or combustible (Class II or IIIA) liquids or oxidizer material ignites, or spontaneous combustion causes fire.

HSI-5 can impact both the glovebox and staged TRU waste containers and is selected as the bounding event.

Explosions (Deflagrations)

Potential causes of deflagrations include the build-up and ignition of hydrogen and other flammable gases in the TRU waste containers. A deflagration involving flammable gases can explosively release contaminated material and potentially initiate a facility-wide fire. In addition, the potential missiles (i.e., drum lid), overpressure, and flame front can result in significant physical consequences to the immediate worker. The unmitigated ignition of hydrogen during processing of a TRU waste container is typically considered to be an Anticipated event. However, given that all drums accepted by the WCRRF are vented at the originating facility, flammable gas build-up and ignition in a TRU waste container are considered to be Unlikely (unmitigated). This vented condition is considered in the HA and is verified before container processing through a waste container receipt inspection and verification process at the WCRRF. This inspection and verification process is conducted upon receipt of a TRU waste container at the WCRRF.

- HGB-2: Built-up gas released while opening a TRU waste container ignites, impacting the waste and glovebox. Flammable gas build-up in TRU waste container ignites, resulting in deflagration.
- HSO-2: Explosion breaches waste containers outside of Building TA-50-69 and contents burn. Vehicle accident or fuel leak causes fuel to ignite and causes fuel tank to explode.
- HSO-3: Explosion and fire impacts TRU waste containers. Vehicle accident involving fully loaded propane cylinder delivery truck causes propane cylinders to breach and explode.
- HSO-25: Flammable gas deflagrates, ruptures container and burns. Hydrogen gas builds up in TRU waste container. Ignited by impacts with vehicles operating in outside staging areas.

- HHO-1: Deflagration of flammable gases in TRU waste container during handling in the outside staging areas. Forklift impact with TRU waste container initiates deflagration or fire.
- HHI-1: Deflagration of flammable gases in TRU waste container during handling in the vehicle airlock. Forklift impact with TRU waste drum initiates deflagration or fire.

HGB-2, flammable gas (e.g., hydrogen) build-up while opening a TRU waste container, is selected as the representative event addressing the potential deflagration hazards during glovebox operations. HSO-2 and HSO-3 involve external explosions resulting in a fire impacting the TRU waste containers. Therefore, these two events are bounded by the analysis in Section 3.4.2.2, *Operational Fires Outside of Building TA-50-69 Involving Liquid Pool Fires (Spill and Fire)*. (It is worthwhile to note that the HA events HHO-1, HHO-25, and HHI-1 involve a vehicle (including forklift) impact with the drum that causes the drum to deflagrate, and are considered conservative. A test was performed during Idaho Drum H_2 Explosion Tests (EG&G 1983) to determine if puncturing a drum would ignite a gas mixture. A puncture of this type would simulate a forklift puncture, and possibly bound a vehicle impact. The test performed involved a drum with a stoichiometric concentration of 30% H_2, 15% O_2, and 55% N_2, which were considered to be the worst gas mixtures calculated to be reasonably expected in drums containing those contents (without overpressurizing the drum). The drum was air-punctured using a sharpened drill. The drum did not ignite; instead, gas escaped through the puncture. It was postulated that ignition did not occur partially as a result of the presence of a 90-millimeter polyethylene liner in the drum. From this test result, the HA events HHO-1, HHO-25, and HHI-1 are considered overly conservative.)

Loss of Confinement / Containment

No unmitigated High consequences to the public have been identified in the unmitigated HA for spill events (see Table 3-11). Pursuant to DOE-STD-3009 (DOE 2006a), Page 48, "…, at least one bounding accident from each of the major types determined from the hazard analysis (e.g., fire, explosion, spill, etc.) should be selected unless the bounding consequences are *Low* …" Although all the Loss of Containment / Confinement consequences are low to the Public, select spill events had sufficiently high frequencies to result in a High risk to the collocated worker (risk rank II).

From the unmitigated spill scenarios, the bounding events involve high energy impacts which involve multiple drums. Three spill events in the HA conservatively assume that the entire WCRRF site inventory is impacted (i.e., 1,800 PE-Ci):

- HSO-11: Operational vehicle/forklift impacts staged waste containers. Forklift, maintenance, or delivery vehicle impacts TRU waste containers.
- HSO-10: Accident while positioning mobile units or transportainers. Staged TRU waste containers impacted by moving mobile units or transportainers.
- HHI-5: Forklift failure or operator error drops TRU waste containers. Pallet of TRU waste containers overturned.

HSO-11 is viewed as the most bounding, as it may involve higher vehicle speeds and greater impact energies. **Note:** The HA also identifies events that occur more frequently than catastrophic impacts; however, these events typically involve much less inventory (≤ 800 PE-Ci), and, for the purpose of a quantitative dose estimation in the Accident Analysis, are adequately bounded.

The analysis of this bounding accident includes an evaluation of engineered and administrative controls that were identified earlier as providing DID in the event of spills or loss-of-confinement accidents.

Natural Phenomena

Seismic Event (without fire)

Seismic events that do not involve a fire component do not result in unmitigated High consequences to the MEOI and the collocated worker. For completeness, two potential events are considered, one event involving TRU waste stored in the outside staging area and a second event involving the collapse of the building. These events are bounded by the consequences from a seismic event and fire, do not present any unique controls, and are not evaluated as DBAs.

- HSO-22: Seismic event. TRU waste containers toppled by seismic event.
- HSI-8: Seismic event. Structural damage to building, debris impacts TRU waste containers.

Seismic Event (with fire)

- HSI-12: Seismic event initiates electrical fire inside building. Fire and structural debris impact TRU waste containers, WCG, or GBE.
- HSO-23: Seismic event initiates a facility-wide fire. TRU waste containers toppled by seismic event and impacted by fire.

HSI-12 assumes that the building fire has the potential to spread to the yard areas. At that point, the seismic event and fire would progress similarly and involve the same radiological inventory as HSO-23. Because of the potential to also involve the inventory within Building TA-50-69, and the additive effects of building debris impacting yard waste, **HSI-12** is selected as a representative and bounding event for seismically induced spills and fires, to include weather-related fires in the outside staging areas. **HSI-12** is carried forward for further analysis in the Accident Analysis.

Wildfire

HSO-14 involves a wildfire that spreads to the WCRRF outside staging areas and engulfs the TRU waste containers. This event can involve the entire facility inventory and is considered bounding.

Note: Building TA-50-69 is at a much greater distance from the MDA than the outside transportainer areas; however, for this analysis, its inventory is included.

- HSO-14: Wildfire adjacent to site. Grass/brush fire in fields impacts TRU waste containers.

Lightning Strike (with fire)

Two scenarios involving lightning strikes that result in fires have been identified that have unmitigated High consequences to the public and the collocated worker. One involves a lightning strike to the building (**HSI-10**) and a lightning strike to the outdoor staging area (**HSO-17**).

- HSI-10: Lightning initiates fire inside the building. Fire spreads through building and impacts gloveboxes and TRU waste containers.
- HSO-17: Lightning causes fire in yard or transportainer. Ignition of combustibles impacts TRU waste containers staged outside. Potential for fire to spread to the building.

External Events

External events can involve vehicle impacts with fires, refueling accidents, and aircraft crashes. Those events involving vehicle and refueling accidents have been considered earlier in other DBA selection sections. The remaining event, aircraft crash (HSO-24), is carried forward as a unique and bounding event for further Accident Analysis.

Aircraft Crash

- HSO-24: Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.

HSO-24 represents one of the bounding release mechanisms for the WCRRF. The HA did not identify any reliable preventers or mitigators for this event.

Accident Selection Summary

Nine accidents were identified for analysis in Section 3.4. The accident scenarios selected for the Accident Analysis are as follows:

- HSO-5: Fire in container storage areas involves TRU waste containers.
- HSO-6: Vehicle impact and fire in the outdoor transportainer. Vehicle impacts containers, vehicle fuel tank leaks and ignites, or flammable or combustible liquids or pyrophorics are ignited during accident.
- HSI-5: Building fire impacts gloveboxes or TRU waste containers. Electrical short or operational upsets cause fire.
- HGB-2: Built-up gas released while opening a TRU waste container results in deflagration, impacting the waste and glovebox. Flammable gas build-up in TRU waste container results in deflagration.
- HSO-11: Operational vehicle/forklift impacts staged waste containers. Forklift, maintenance, or delivery vehicle impacts TRU waste containers.
- HSI-12: Seismic event initiates electrical fire inside building. Fire and structural debris impact TRU waste containers, WCG, or GBE.
- HSO-14: Wildfire adjacent to site. Grass/brush fire in fields impacts TRU waste containers.
- HSI-10: Lightning initiates fire inside the building. Fire spreads through building and impacts gloveboxes and TRU waste containers.
- HSO-24: Aircraft crashes into staging area or building, causing a full facility (inside and outside) fire.

These accidents either bound and/or represent the scenarios of interest from the HA tables or are unique accidents warranting further evaluation in the Accident Analysis.

3.4 ACCIDENT ANALYSIS

The safe harbor for a limited-life facility or operation is DOE-STD-3011 (DOE 2002a), which requires the preparation of a BIO applying a graded approach consistent with DOE-STD-3009 (DOE 2006a). A DSA in the form of a BIO does not require an Accident Analysis (AA). However, for completeness, and due to the potential risk posed by the hazards at the WCRRF (Hazard Category 2 Facility), a detailed AA has been completed. This section describes the analysis of design basis operational, external, and natural phenomena events identified by the HA. Some of these accidents could have consequences to the public that approach, or potentially exceed, the EG. The accidents selected include DBAs for each major type of hazard identified in the HA.

The principal objectives of the AA are to identify SC-SSCs, if any are required, and TSRs needed for protection of the public. The AA also identifies the environments to which such SSCs will be exposed and defines the functional requirements for SC-SSCs and SS-SSCs. The Accident and Hazard Analyses together identify controls that define the operating envelope for the facility.

Safety-class SSCs are identified by determining the consequences of unmitigated accidents and comparing the results against the EG. For accidents that challenge the EG, credit is then taken for SSCs and ACs. These SSCs are then designated as SC or SS, requiring them and the ACs to be addressed by corresponding TSRs. Consideration is given to the survivability of the control during the control selection and functional classification process.

The AA examines (1) the frequency of occurrence of each accident and (2) its associated potential consequence (dose) to the MEOI and collocated worker. In addition, the AA considers the different inventories associated with the WCRRF, Building TA-50-69, or with the TRU waste containers. (The WCRRF includes both the outside area where TRU waste containers are stored in transportainers, and Building TA-50-69, where repackaging and remediation activities in the Waste Characterization Glovebox occur.) Estimates of accident sequence frequencies[1] are based on the facility's operating history, industry data (where available), and engineering judgment. The purpose of estimating the accident sequence frequencies is to illustrate the relative significance of various initiating events so that TSRs for preventive features, including ACs, can be determined. The accident sequence frequencies are order-of-magnitude estimates. Frequency estimation is not intended to screen or limit the examination of potential bounding accidents. No specific threshold is used for eliminating operational accidents from consideration. However, externally induced AA is limited to credible events (i.e., their estimated frequencies are greater than 1E-6/yr), and natural phenomena AA is limited to accidents with return periods associated with the facility's performance category (PC) (DOE 2005a).

Consequence assessment is performed using conservative methods, inputs, and assumptions for the different operational inventory limits. The intent is to provide conservative assessments of doses or consequences so that comparisons to the EG show significant margins of safety for most accident scenarios. The radiological consequences to the public from a given accident scenario are calculated and compared to the EG of 25 rem TEDE (Appendix A of DOE-STD-3009). If unmitigated consequences challenge or exceed the EG, SC-SSCs and SACs needed to reduce the unmitigated consequences are identified. It is important to note that, in many cases, preventive controls could be designated as SC-SSCs, if the unmitigated consequences challenge or exceed the EG. For those accident scenarios with unmitigated consequences that do not challenge the EG, the safety SSCs, and controls needed to protect the public (and collocated worker, worker) are identified as SS-SSCs and TSR ACs.

[1] Estimates are not required to be quantitative, according to DOE-STD-3009, Change Notice No. 3 (DOE 2006a).

Section 3.4.1 describes the AA methodology. Section 3.4.2 presents the analyses of DBAs. Section 3.4.3 discusses potential accidents that are beyond DBAs.

3.4.1 Accident Analysis Methodology

This section summarizes the methods that were used to analyze operational accident scenarios and external and natural phenomena events that were selected for further analysis in Section 3.3.2.3.6. This section discusses the approach and application of models and computer codes that support various phenomenological evaluations needed to analyze the selected postulated accident scenarios.

The description of the analysis for each accident scenario follows the format and content guidance provided in DOE-STD-3009 (DOE 2006a). The presentation consists of the following information: accident scenario development; scenario frequency estimation; source term (ST) determination; consequence analysis; comparison of the consequences to the EG; and identification of the SC- and SS-SSCs and ACs necessary to reduce the frequency and consequence of the accident.

The following sections describe the methods that were used to address each of the topics covered in the AA.

3.4.1.1 Scenario Development

This section of the AA identifies and describes each of the initiating events that could cause the accident scenarios. The initiating events and the associated controls that were identified in the HA are discussed in determining how each of these accidents develops and progresses. A number of models are developed to examine the effects of key parameters to ensure that a reasonable set of parameters is identified for each of these cases, including the worst-case scenario. The key parameters include the configuration of the inventory, the magnitude of the hazard, and the nature of the interaction of the hazard with the inventory. Models are also developed, where appropriate, to study mitigative features to determine their effects on the accident consequences.

Scenario frequencies are not required by DOE-STD-3009 to be quantitative. Each scenario frequency is estimated by considering the likelihood that the initiating event will cause the postulated scenario. For some events, the scenario frequency was assumed to be the same as the initiating event. For example, if a structure is not designed to withstand a postulated natural phenomena event, then the frequency of structural failure is assumed to be the frequency of that event. For other scenarios, where warranted by the physical configuration or by the characteristics of the initiating event, the scenario frequency was determined to be less than the initiating event. For example, the frequency of a vehicle accident breaching many waste containers is less than the frequency of a vehicle accident on-site. Many vehicle accidents will not occur in the vicinity of the waste containers, and not every accident in the vicinity of waste containers will cause a breach of many containers.

Evaluation basis natural phenomena events are based on the return periods and magnitudes (e.g., ground acceleration, wind speed, etc.) defined by DOE-STD-1020 (DOE 2002b), -1021 (DOE 2002c), -1022 (DOE 2002d), and -1023 (DOE 2002e), and associated site-specific evaluations. PC-2 natural phenomena events are evaluated in the HA. DOE-STD-1020 and -1021 indicate that PC-2 natural phenomena events are the appropriate evaluation basis for SSCs if their failure does not lead to consequences that exceed the EG. The AA evaluates natural phenomena events and identifies the appropriate final PC destination.

Source Term Analysis

The five-factor formula (see DOE 2000b) is used to derive the ST for each of the cases analyzed in the Accident Analysis. The five-factor formula is expressed as follows:

$$ST = MAR \times DR \times ARF \times RF \times LPF \qquad \text{[Eq. 3-2]}$$

The following paragraphs describe each of the five factors with respect to the accident scenarios evaluated in the Accident Analysis.

Material-At-Risk (MAR): The MAR is the amount of hazardous material available to be acted on by a given physical stress (DOE 2000b). The MAR for this AA is limited to the radioactive material in the waste containers that could be shipped to the WCRRF for processing. Although SWBs may be present at the WCRRF, the AA assumes that all the MAR is in 55-gal. drums or has been removed from 55-gal. drums inside a glovebox. This assumption is conservative and simplifies the analysis.

For this AA, all the MAR is assumed to be combustible material, except in the fire or seismic and fire accidents occurring in TA-50-69. In these accidents, dose consequences involving combustible material are compared against dose consequences for contaminated, noncombustibles or for HEPA filters, in order to determine a (contaminated, noncombustible or HEPA filter) combustible equivalency. In other accidents, assuming that all waste is combustible produces conservative results because the release fractions for accidents involving combustible waste material in drums are equal to or greater than the release fractions for accidents involving the other waste forms.

Upper bound material inventories have been established for the WCRRF and for certain areas or volumes on the site. These inventories are used to define MAR values for the AA. The MAR limits used in the source term analysis are 1800 PE-Ci of total WCRFF MAR (also defined as inventory), and 800 PE-Ci equivalent combustible waste inside Building TA-50-69. Note that the total WCRRF MAR of 1800 PE-Ci is the sum of the MAR outside of and inside Building TA-50-69.

To evaluate material holdup in the WCG, GBE, and associated ductwork, smear data was obtained from recent radiological surveys. The highest smear data sample was used as the average loading on the entire surface area inside the WCG, GBE, and associated ductwork. The facility holdup calculated in this manner was approximately one-tenth of the HC-3 threshold (0.52 PE-Ci). This demonstrates that holdup is negligible and can be excluded from the facility inventory limits.

Damage Ratio (DR): The DR represents the fraction of the MAR that is actually impacted by the energy generated by the postulated accident scenario. The unmitigated DR is conservatively assumed to be 1.0 for all accident scenarios analyzed in this AA. Note that DOE-STD-5506 (DOE 2007), Section 4.4, emphasizes the conservatism embedded in an assumed DR of 1.0.

Airborne Release Fraction (ARF) and Respirable Fraction (RF): The ARF represents the amount of radioactive material that becomes suspended in the air as an aerosol and thus becomes available for transport as a result of physical stresses from the accident. The RF represents the fraction of airborne radionuclides that can be

inhaled by humans. The DOE-HDBK-3010 (DOE 2000b) notes that the RF is commonly assumed to include particles of 10-mm aerodynamic equivalent diameter (AED)[1] and less.

The ARF and RF values are selected for each postulated physical stress based on the data and recommendations found in DOE-HDBK-3010. These values are also consistent with source term (ST) parameters found in DOE-STD-5506-2007 (DOE 2007). Table 3-13 lists some of the values used in the consequence analysis for combustible waste material with respect to physical stresses relevant to this Accident Analysis. The ARF/RF values are bounding values. Individual Accident Analysis descriptions identify specific ARF/RF values used in the Accident Analysis. Most waste containers include one or more layers of plastic used to package the waste material. These layers would reduce the fraction released, compared to loose material in a container. These plastic layers are not factored into any of the release estimates.

Leak Path Factor (LPF): The leak path factor is the fraction of material passing through some confinement deposition or filtration mechanism. For example, an LPF is typically associated with the fraction of material that can pass through a facility system such as a glovebox, through filtration, etc., and as such will reduce the overall ST. For the purposes of the unmitigated release calculation, the LPF is set to one. In addition, the contribution of the LPF (i.e., from the WCG glovebox) as a mitigative control is ignored. So in both the unmitigated and mitigated analyses, the LPF is equal to one.

Table 3-13. Release Fractions Data

Release Mechanism	DOE-HDBK-3010 Basis	Bounding ARF/RF	Remarks
Drum impacted; contents spilled	Contaminated, combustible solids packaged in a robust container that is spilled and subjected to shock and impact (vibration) during the spill (p. 4-9).	1E-3/0.1	
Fire causes drum lid loss or lid seal failure; waste material burns in drum	Contaminated, combustible solids, packaged mixed waste heated/burned in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, drums) (p. 5-1).	5E-4/1.0	
Waste material spills or is ejected from drum and burns	Contaminated, combustible solids, uncontained cellulosics or largely cellulosic mixed waste (burning of unpackaged, loosely strewn cellulosic materials, such as paper, cardboard, rags, and wood shavings).	1E-2/1.0	The recommended ARF for burning uncontained plastics is 5E-2 based on tests of powder piles on burning plastic material. A more representative configuration is listed in DOE-HDBK-3010, Tables A.51 and A.53 (DOE 2000b), using air-dried liquid on a plastic substrate (max. ARF of 0.006). The recommended bounding ARF for uncontained cellulosics bounds these results and will be used for both cellulosics and plastics.
Waste material out of drums in WCG burns	Same as previous.	1E-2/1.0	

Continued on next page

[1] The AED is the diameter of a sphere of density 1 g/cm^3 that exhibits the same terminal velocity as the particle in question.

Table 3-13. Release Fractions Data (cont.)

Release Mechanism	DOE-HDBK-3010 Basis	Bounding ARF/RF	Remarks
Drum bursts lid in fire and expels contents	Release for event is split into 3 components:		
	2/3 of contents burn in drum (p. 5-1)	5E-4/1.0	Same as waste burning in drum (above)
	1/3 of contents subject to shock/impact during ejection (p. 5-3)	1E-3/0.1	Same as impact/spill (above)
	Remaining ejected waste burns outside the drum (p. 5-1)	1E-2/1.0	Same as uncontained material fire (above)
Deflagration of drum	Release for event is split into 3 components:		
	60% of contents burn in drum	5E-4/1.0	Same as waste burning in drum (above)
	40% of contents ejected from drum	1E-3/0.1	Same as impact/spill (above)
	5% of ejected contents burns	1E-2/1.0	Same as uncontained material fire (above)

3.4.1.2 Dispersion and Consequence Calculations

This section identifies the methodology and computer codes that were used to determine the consequences of postulated accident scenarios. All DBAs for the WCRRF involve an airborne release of radioactive material.

Appendix A to DOE-STD-3009 (DOE 2006a) provides guidance on the calculation methods and assumptions that are needed to provide general consistency in dose estimation. It states that, for the purpose of comparing to the EG, the dose calculation location is taken to be the location of a theoretical MEOI standing at the site boundary. The MEOI may be located beyond the site boundary, if a buoyant or elevated plume release results in doses at locations beyond the site boundary that are greater than those predicted to occur at the site boundary. The 95th percentile of the distribution of doses to the MEOI, accounting for variations in both the distance to the site boundary and meteorological conditions as a function of direction, is the comparison point for assessment against the EG.

Dispersion and consequence calculations that support the AA must balance the use of conservative modeling assumptions with the need to consider accident-specific modeling parameters, such as release elevation or plume buoyancy, in order to calculate realistic doses for different accident scenarios. *LANL Guidelines for Performing Atmospheric Dispersion Analysis* (LANL 2004) provides detailed guidance for performing atmospheric dispersion analyses for LANL facilities using the MELCOR Accident Consequence Code System, Version 2 (MACCS2) (SNL 1997) and POSTMAX (LANL 2001) computer codes. The guidelines were developed to meet the requirements outlined in Appendix A of DOE-STD-3009. This guidance is followed for the atmospheric dispersion calculations supporting this BIO.

Calculation Tools: MACCS2 and POSTMAX

The MACCS2 code is a DOE/Nuclear Regulatory Commission-sponsored code that has been used widely in support of probabilistic risk assessments for the nuclear power industry and for consequence analyses for safety documentation throughout the DOE complex. POSTMAX was developed by LANL to facilitate calculating site-specific 95th percentile consequence metrics from MACCS2 output files. Software QA was performed on POSTMAX.

MACCS2 Dispersion Calculations

The MACCS2 code uses three separate calculation modules to perform transport, dispersion, and dose calculations: ATMOS, EARLY, and CHRONC. The ATMOS module performs all the calculations pertaining to atmospheric transport, dispersion, and deposition, as well as the radioactive decay that occurs after release. The EARLY and CHRONC dose calculation modules are not used for the WCRRF analyses. Doses are determined by hand calculation based on ground-level air concentration values calculated by the ATMOS module. The only other supporting input files needed for the WCRRF MACCS2 calculations are meteorological data files appropriate for the WCRRF.

Several MACCS2 runs simulating buoyant and nonbuoyant plume releases from ground-level release locations are carried out to support the AA. These calculations and assumptions are documented in detail in Appendix 3B.

LANL recently has had to address changes to the LASO Site Boundary Policy (DOE 2005c) because of land transfers and attendant changes in off-site doses to the public. The National Nuclear Security Administration (NNSA), as of October 17, 2006, approved the LASO Site Boundary Policy with respect to land transfers and the impact on the Safety Basis for the LANL Nuclear Facilities (NNSA 2006). Via this approval memo, NNSA approved an χ/Q for a ground-level release. In this BIO, Appendix 3B uses the same site boundary assumptions as the model NNSA approved to determine the χ/Qs for release during fires.

Definition of the TA-50 WCRRF Site Boundary Distances

The methodology referenced in Appendix A to DOE-STD-3009 maps the geometry of a site into 16 points. One point is identified for each nearest distance between the source and the site boundary that can be found within a 45° sector (arc) centered successively on each of the 16 compass points (compass points are numbered clockwise from the north). These distances were determined in Sartor 2006. These distances are provided in Appendix 3B.

Plume-centerline, ground-level air concentrations are computed for a range of distances from the release point using MACCS2 for all hourly observations from five full years of weather data. The MACCS2 output files serve as input files for the subsequent POSTMAX calculations of ground-level air concentrations at the site boundary.

POSTMAX Calculations for Determination of χ/Q

The POSTMAX code was developed to facilitate calculating site-specific χ/Q values following the methodology recommended in Appendix A of DOE-STD-3009. POSTMAX takes site-specific wind direction data, site boundary distances, and hourly ground-level air concentration values calculated by MACCS2, and computes a cumulative distribution function (CDF) of ground-level air concentrations to determine the representative χ/Q value. POSTMAX has the ability to calculate a CDF for multiple years of weather data (up to 6 years). This ability helps to ensure that weather data used for the analysis are representative (i.e., they are not extreme weather data collected during a period of particularly unusual weather conditions or patterns).

The result of interest is a set of ground-level air concentration values that conservatively represent the range of possible exposures that a person standing anywhere on the boundary might receive from an accident that occurred at a random time during the 5-year period. The 95th percentile value for the ground-level air concentration values is provided in the summary output listed at the end of the POSTMAX output file. This value is used in determining the 95th percentile χ/Q value using the following formula:

$$\chi/Q_{95\%} = \frac{GLCON_{95\%}}{\left(3.7\times10^{10}\ Bq/Ci\right)ST} \qquad \text{[Eq. 3-3]}$$

where

$\chi/Q_{95\%}$ = the 95th percentile plume-centerline dilution factor (s/m^3),

$GLCON_{95\%}$ = the 95th percentile plume-centerline ground-level air concentration from POSTMAX output file (Bq-s/m^3), and

ST = the source term for the accident sequence of interest (Ci).

In a special high-wind case providing a 95th percentile χ/Q value, a wind of 34 m/s (77 mph) [LANL 1990] was artificially defined into a straight-line Gaussian Plume equation. The distance of 1,187.03 meters was used as the distance to the MEOI, and a release height of 3 meters was used for the point release. The A-stability class (the classification of an extremely unstable meteorological condition) Tadmor and Gur analytic correlations to Pasquill-Gifford dispersion-coefficient data was applied for the standard deviation of concentration in lateral and vertical directions. The result χ/Q value for this special case is 2.51 E-8 s/m^3.

Calculation of Dose-to-Source Term Scaling Factor

After calculating the 95th percentile χ/Q value, dose-to-source term scaling factors (DSF) are determined for the various accidents analyzed according to the following formula:

$$\text{DSF} = \text{DCF} \times \text{BR} \times \chi/Q_{95\%} \qquad \text{[Eq. 3-4]}$$

where:

DSF = dose-to-source term scaling factors (rem/g or rem/Ci),

DCF = dose conversion factor (1.85E+08 rem/Ci for ^{239}Pu) (DOE 2007),

BR = breathing rate (3.33E-04 m^3/s) (DOE 2007), and

$\chi/Q_{95\%}$ = the 95th percentile plume-centerline dilution factor (s/m^3)

The effect of buoyancy was examined by modeling a spectrum of heat addition rates to the release plume. In addition to a nonbuoyant plume (zero heat addition), buoyant plumes with heat addition rates between 0.1 MW and 25 MW were modeled, as shown in Table 3-14. Where applicable to individual accidents involving fire, a conservatively low heat addition rate to the release plume was modeled. In determining the bounding unmitigated consequences for the public, due to uncertainties associated with canyon effects, the χ/Q value for a spill was used for all release mechanisms, with no credit for heat addition or plume meander for fire scenarios. Given the fact that there are no canyons between a release point at WCRRF and the collocated worker at 100 m away, fires were modeled with a low heat addition rate of 0.1 MW for determining the χ/Q for fire-related doses to the collocated worker.) The specifics are described in the individual AA sections.

The χ/Q values, and the DSF calculated using the DCF for ^{239}Pu derived from ICRP Publication 72 (ICRP 1996), are presented in Table 3-14. DOE-STD-5506 allows the use of ICRP-68 conversion factors for calculation of collocated worker inhalation dose. When the same 1 µm Activity Median Aerodynamic Diameter particle size is assumed for collocated worker inhalation as is used in ICRP-72 for the public, the collocated worker DCF (1.74E + 08 rem/Ci) is only 6% less than the ICRP-72 public (1.85E + 08 rem/Ci) conversion factor. Since the small reduction in calculated collocated worker dose would not change the consequence bin for any accidents or permit the elimination of any selected controls, the DCF value from ICRP-72 was used for dose calculations for both the public and the collocated worker.

Table 3-14. Dose-To-Source Term Scaling Factor and χ/Q Values for the WCRRF Accident Scenarios[1]

Accident Scenario	$\chi/Q_{95\%}$ Public	DSF based on 1.85E + 08 rem/Ci (rem/Ci) - Public	$\chi/Q_{95\%}$ CW	DSF based on 1.85E + 08 rem/Ci (rem/Ci) – CW
Spill Accident – Nonbuoyant release	5.74E-05	3.54	8.19E-03	504.54
Fire Accident – 0.10 MW smoldering release	4.95E-05	3.05	5.41E-04	33.33
Fire Accident – 0.25 MW plume	4.56E-05	2.81	4.02E-04	24.77
Fire Accident – 0.50 MW plume	4.11E-05	2.53	3.18E-04	19.59
Fire Accident – 1.0 MW plume	3.30E-05	2.03	2.37E-04	14.60
Fire Accident – 1.50 MW plume	2.72E-05	1.68	1.79E-04	11.03
Fire Accident – 2.0 MW plume	2.31E-05	1.42	1.51E-04	9.30
Fire Accident – 2.5 MW plume	1.97E-05	1.21	1.35E-04	8.32
Fire Accident – 3.0 MW plume	1.75E-05	1.08	1.22E-04	7.52
Fire Accident – 5.0 MW plume	1.43E-05	0.76	1.02E-04	5.34
Fire Accident – 10.0 MW plume	1.23E-05	0.47	8.67E-05	2.90
Fire Accident – 25.0 MW plume	3.95E-06	0.24	1.10E-05	0.68
High winds (77 mph) – 1187 m site boundary	2.51 E-8	1.55 E-3		

[1]These values are based on an assumed surface roughness of 38 cm, as recommended in DOE 2010.

The high wind case was analyzed to support the HA wind scenarios, which show a public consequence of *Low* based on a low χ/Q.

The base case for the WCRRF public χ/Q calculation is the nonbuoyant spill release of ^{239}Pu for all spill and fire-related events. For the collocated worker, the χ/Q and the DSF associated with a smoldering (0.10 MW) fire are used for fire-driven releases; for non-fire events, the collocated worker χ/Q is based on a nonbuoyant spill release, with the χ/Q and corresponding DSF decreasing for larger fires.

The heat from the fires tends to loft, i.e., increase the height of, the plume due to the buoyancy and rising of the hot air. At a given downwind location, the plume concentration is at a maximum at the centerline and monotonically decreases above and down the centerline. Plume lofting creates a downwind region where the ground-level concentration is zero because the plume is above the ground. After the plume touches the ground, plume lofting tends to dilute the plume for ground-level receptors; dilution tends to decrease the χ/Q value. However, the WCRRF analysis also includes a deposition velocity for the released ^{239}Pu. Plume lofting decreases the depletion of the plume because the ^{239}Pu must fall farther to reach the ground. Decreasing the plume depletion tends to increase the χ/Q values.

Therefore, the χ/Q behavior is the result of the two competing effects. For the smaller fires, the dominant effect is the decrease in plume depletion, resulting in a larger χ/Q at the closest receptor location. (The χ/Q results are generally dominated by the closest receptor.) For the larger fires, the dominant effect is the increased dilution before the plume reaches the closest receptor. It is recognized that the fire intensity, and thus the heat addition rate, is not a constant, but varies over time. Heat addition rate calculations are typically based on the time during which the fire is at its full intensity. Because the radioactive material in the waste is being driven airborne by the thermal energy from the fire, the majority of the ST is expected to become airborne during the time when the fire is at or near full intensity. Thus, it would be reasonable to assume that the majority of the ST will be buoyed by a heat addition rate that is based on the full intensity of the fire.

In general, some of the radioactive material could remain in the waste and be driven airborne as the fire lessens in intensity. The heat addition rate during this period would be less than when the fire is at full intensity. Developing a model that accounts for the time-dependent release and the time-dependent heat addition rate to the release plume is beyond the scope of this AA. To account for this effect, the collocated worker dose consequence calculations for fire scenarios conservatively assumed a low-buoyancy plume (0.1 MW), and public doses assumed a non-buoyant (spill) plume to offset uncertainty related to canyon effects on the plume. The low-buoyancy plume is equivalent to a small pile of trash burning. This buoyancy model results in overpredicting dose consequences. Radioactive material will be driven from the waste at higher rates when acted on by higher thermal energy addition rates. Thus, as noted above, most of the waste material is expected to be driven airborne while the fire is at or near full intensity. As the fire intensity lessens, radioactive material will continue to be driven airborne, but by lower thermal energy rates. Some heat addition is necessary because thermal energy is the mechanism that continues to drive the material airborne. Although it would be bounding to assume a zero heat addition rate for all fire scenarios, such an assumption represents a condition that is not physically possible. Radioactive material would not be driven airborne without the presence of thermal energy. For fire scenarios with very high consequences, the dose from both a bounding base case (a low-buoyancy plume for the collocated worker and a non-buoyant plume for the public) and a high-buoyancy plume is provided for comparison, with recognition that the actual plume behavior (and resultant dose to the receptors) would likely fall in between the low and high estimates. Control selection is based on the unmitigated consequences calculated with the conservative base case models.

The DSF ratios in Table 3-14 are conservative due to many factors, as noted in this section. The dose consequence calculations in this chapter also include conservative estimates of the STs for the various accident scenarios analyzed. Models and assumptions used to estimate the STs, and the inherent conservatism in these estimates, are discussed in the individual analysis sections.

3.4.2 Design Basis Accidents

This section presents the DBAs that are identified in Section 3.3.2.3.6, *Accident Selection,* for further analysis in this BIO. These DBAs were selected to include both representative and unique accident scenarios designed to bound or represent all accident scenarios in the HA with respect to the potential consequences and risks posed by such scenarios. Table 3-15 lists the DBA and its corresponding basis from the results of the HA.

Table 3-15. Design Basis Accident / Representative, Bounding HA Accident

Design Basis Accident	Representative, Bounding HA Accident
3.4.2.1 Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire)	HSO-5: Fire in the outdoor transportainer area involves TRU waste containers. Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire.
3.4.2.2 Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire)	HSO-6: Vehicle impact and fire in the outdoor transportainer area. Vehicle impacts containers, vehicle fuel tank leaks and ignites, or ignites flammable or combustible liquids or pyrophorics in waste containers.
3.4.2.3 Operational Fires Inside of Building TA-50-69 (Fire)	HSI-5: Building fire impacts gloveboxes or TRU waste containers. Electrical short or operational upsets cause fire.
3.4.2.4 Drum Deflagration (Explosion)	HGB-2: Built-up gas released while opening a TRU waste container results in deflagration impacting the waste and glovebox.
3.4.2.5 Loss of Confinement/Containment (Spill)	HSO-11: Operational vehicle/forklift impacts staged waste containers. Forklift, maintenance, or delivery vehicle impacts TRU waste containers.
3.4.2.6 Seismic Event with Fire (NPH)	HSI-12: Seismic event initiates electrical fire inside building. Fire and structural debris impact TRU waste container, WCG, or GBE.
3.4.2.7 Wildfire (NPH)	HSO-14: Wildfire adjacent to site. Grass/brush fire in fields impacts TRU waste containers.
3.4.2.8 Lightning-Strike-Induced Fire (NPH)	HSI-10: Lightning initiates fire inside the building. Fire spreads through building and impacts gloveboxes and TRU waste containers.
3.4.2.9 Aircraft-Crash-Induced Fire (External Event)	HSO-24: Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.

The following conservative assumptions apply to all accident scenarios: (1) For each of the inventory limits, at least one container has the maximum allowable inventory; and (2) to maximize the amount of material that can be impacted by the outside staging area postulated accident scenarios, the entire inventory in the outdoor transportainer staging area is considered. This is extremely conservative, because most accident scenarios are likely to impact a limited number of drums, each of which will contain only a fraction of the inventory.

3.4.2.1 Operational Fires Outside Building TA-50-69 Involving Ordinary Combustibles (Fire)

The AA for this scenario is based on the bounding HA scenario HSO-5 ("Fire in the outdoor transportainer area involves TRU waste containers. Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire."). As discussed in Section 3.3.2.3.6, *Accident Selection,* HSO-5 represents a common type of operational fire involving combustibles and is chosen as the bounding event carried forward for AA. The set of combustible fires involve those in which the initiating event is operationally induced (i.e., hot vehicle exhaust, human error, hot work, maintenance, electrical fault causes yard fire, combustible/flammable material in transportainer, etc.; see HSO-5 and HSO-4). While this scenario bounds the consequences of other ordinary combustible fires outside, its initiators do not. As such, controls for other scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.1.1 Scenario Development

The accident scenario is a fire in the outside yard caused by an initiator (i.e., hot vehicle exhaust, smoking, or electrical faults) causing ordinary combustibles (i.e., trash, wooden pallets and crates, dried vegetation, etc.) to catch on fire. The fire impinges the TRU waste containers, causing lid seal failure. All of the site inventory (1,800 PE-Ci) is involved in this accident.

The DOE–HDBK-3010 (DOE 2000b), p. 7-64, cites a study in which

Sealed 55-gal metal drums containing a mixture of combustible materials did not lose their lids when placed in a wooden structure burned to the ground with combustibles purposefully stacked around the drums to produce a high fuel loading and associated heat flux (reference Greenhalgh, Demiter, and Olson, May 1994). These drums exhibited more typical phenomena of lid seal failures producing torch flames from pyrolysis gases generated in the drums. After the fire consumed the entire building, examination of the drums revealed the majority of the contents to be uncombusted.

The cited study in DOE 2000b is similar to the accident scenario developed here. The postulated WCRRF outside yard combustible fire does not result in drum lid loss or ejection of drum waste contents. It is postulated that the flame impingement from the WCRRF outside combustible yard fire causes lid seal failure and containerized burning of the combustible waste.

3.4.2.1.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LPF).

MAR: The entire inventory allowed to be staged outside Building TA-50-69 (i.e., 1,800 PE-Ci) is the MAR considered in the accident scenario.

DR: A DR =1 is postulated for this accident. All drums are considered to experience lid seal failure.

ARF/RF: The ARF/RF for combustible waste that remains in the drum and burns within the drum is 5E-4/1.0 (DOE-HDBK-3010, DOE 2000b, pg. 5-1 and 5-13; these values are also consistent with source term [ST] parameters found in DOE-STD-5506-2007 [DOE 2007].). This ARF/RF for combustible waste bounds the ARF/RF for noncombustible waste (6E-3/0.01) and is used in the source term analysis.

LPF: The LPF is 1.0 for accident scenarios which occur outside the facility.

ST: The ST for waste contents that burn in the drum:

ST = 1,800 × 1.0 × 5E-4 × 1 × 1 = 0.9 PE-Ci

3.4.2.1.3 Consequence Analysis

The DSF value (based on the conservative use of a spill-related X/Q value) is 3.54 rem/PE-Ci for the public receptor, and 33.3 rem/PE-Ci (for a 0.1 MW smoldering fire) for collocated workers:

Dose (public) = 0.9 PE-Ci × 3.54 rem/PE-Ci = 3.2 rem

Dose (collocated worker) = 0.9 PE-Ci × 33.3 rem/PE-Ci = 30.0 rem

3.4.2.1.4 Comparison to Guidelines

The dose to the MEOI for this postulated accident scenario does not challenge the EG of 25 rem for public or the threshold value of 100 rem for collocated workers, and is in fact considered conservative, since it presumes all drums experience seal failure. The selection of SS controls for worker protection and defense-in-depth is warranted, however, and is discussed in the hazards analysis.

3.4.2.1.5 Summary of TSR Controls

The consequences of this scenario do not challenge the EG; therefore, there are no SC controls identified or selected to mitigate consequences to the MEOI.

3.4.2.2 Operational Fires Outside Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire)

The AA for this scenario is based on the bounding HA scenario **HSO-6** ("Vehicle impact and fire in the outdoor transportainer staging area. Vehicle impacts containers, vehicle fuel tank leaks and ignites, or ignites flammable or combustible liquids or pyrophorics in waste containers."). As discussed in Section 3.3.2.3.6, *Accident Selection*, HSO-6 involves a vehicle running into and breaching staged waste containers, causing a fuel leak, and igniting, or igniting flammable or combustible liquids or pyrophorics in waste containers. The vehicle impact may cause a breach of the TRU container (e.g., lid loss) and the ejection of the contained TRU waste. A large fraction of the waste may burn, with the contaminant exposed to the ambient atmosphere. This scenario represents the most conservative case, and is representative of the other scenarios in the class of accidents involving a liquid fuel pool fire, hence its selection in this AA. HSO-2 and HSO-3 involve external explosions resulting in a fire impacting the TRU waste containers. Therefore, these two events are bounded by the analysis in this section. While this scenario bounds the consequences of other outside fires involving a liquid fuel pool fire, its initiator does not. As such, controls for other scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.2.1 Scenario Development

The accident scenario is an errant vehicle which impacts staged waste containers. The total site inventory of 1800 PE-Ci is presumed to be within the drums that are impacted. The vehicle impact imparts enough energy that all drums completely lose their waste contents. The vehicle impact also results in a fuel leak; the fuel leak is ignited, and the subsequent fuel pool fire engulfs the uncontained waste.

Although container impacts due to forklift or vehicle accidents are likely to occur, a vehicle crash and subsequent fuel leak and fire involving containers or impacting a high PE-Ci container is considered unlikely.

The sequence of events leading to a spill and fire involving uncontained waste bounds other similar HA events, such as those that occur during refueling of the auxiliary generator tank, a mishap or accident spills fuel, and fuel ignites – the large fuel spill ignites, causing a fire that impacts TRU waste containers (HSO-16); vehicle or forklift accident which breaches propane cylinders, which ignites the fuel in fuel-powered vehicles near the staged waste (HSO-7); and any other fuel powered nonfacility-related vehicles which strike the waste containers and leak their fuel as a result of the impact (HSO-13).

3.4.2.2.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LF).

MAR: The entire inventory allowed to be staged outside Building TA-50-69 (i.e., the total site MAR limit of 1,800 PE-Ci) is the MAR considered in the accident scenario.

DR: All of the contents are assumed to be ejected from the drum by the impact, so the DR = 1. The conservatism in this presumption is discussed at the end of this section.

ARF/RF: An ARF/RF of 1E-3/0.1(DOE 2000b, pg. 5-20; this value is also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007].) is considered bounding for contaminated, combustible solids packaged in a robust container that are spilled and subjected to shock and impact; the ARF/RF for combustible waste that is ejected from a drum and burns outside the container is 1E-2/1.0 (DOE 2000b, pg. 5-15.*LPF:* The LPF is 1.0 for accident scenarios which occur outside the facility.

ST: The ST for spill and fire components in the consequence analysis is as follows:

<u>Spill Contribution:</u> The entire MAR contained in containers is directly impacted by the vehicle completely spilling their waste.

ST = 1,800 PE-Ci × 1.0 × 1E-3 × 0.1 × 1.0 = 0.18 PE-Ci

<u>Uncontained Fire:</u> The ST for the spilled/expelled material that burns uncontained is calculated here. The MAR that becomes airborne and respirable during the spill of waste from the containers was subtracted from the MAR that burns uncontained on the ground:

ST = [1,800 – (1,800 × 1E-3 × 0.1) PE-Ci] × 1.0 × 1E-2 × 1.0 × 1.0 = 18 PE-Ci.

3.4.2.2.3 Consequence Analysis

This section discusses the major parameters that impact the dispersion of radioactive materials and the potential doses from such releases.

Spill Contribution: The DSF value used for the nonbuoyant release is 3.54 rem/PE-Ci for the public, and 504.5 rem/PE-Ci for collocated workers. The dose calculation is as follows:

Dose (public)= 0.18 PE-Ci × 3.54 rem/PE-Ci = 0.64 rem

Dose (collocated worker)= 0.18 PE-Ci ×504.5 rem/PE-Ci = 90.8 rem

Uncontained Fire Contribution:

The dose for the ST involving burning of the uncontained waste, conservatively modeled as a non-buoyant spill release for the public and for a 0.1MW smoldering fire release for collocated workers, is calculated as follows:

Dose (public) = (18 PE-Ci) × (3.54 rem/PE-Ci) = 63.6 rem

Dose (collocated worker) = (18 PE-Ci) × (33.3 rem/PE-Ci) = 599.9 rem

For comparison only, the dose for the ST involving the same uncontained waste and subjected to a high-buoyant, 10 MW plume would be:

Dose (public) = (18 PE Ci) × (0.47 rem/PE-Ci) = 8.5 rem

Dose (collocated worker) = (18 PE Ci) × (2.9 rem/PE-Ci) = 52.1 rem

The dose from the *spill* contribution is 0.64 rem (public) and 90.8 rem (collocated worker).

The dose from the *fire* contribution is 54.9rem (public) and 599.9 rem (collocated worker).

The total dose unmitigated dose to the public for this accident analysis is the spill + fire contribution = 64.3 rem.

The total dose to the collocated worker for this accident analysis is the spill + fire contribution = 690.7 rem.

3.4.2.2.4 Comparison to Guidelines

The calculated dose to the MEOI fire exceeds the EG of 25 rem, so the selection of SC-level controls (SSCs or ACs) are required to prevent or mitigate the dose consequences for the protection of the public. Similarly, the calculated dose to the collocated worker exceeds the 100 rem threshold and evokes the need for SS level controls to prevent or mitigate the dose consequences for the collocated worker.

It is worthwhile to note that the 64.3rem dose to the public can be considered very conservative due to presuming that 100 % of the allowable inventory is in the impacted containers and, for all waste containers impacted, 100% of the drum contents are ejected, spill, and burn uncontained.

Results of a study involving 17 single-drum free-fall impacts from 44 ft (13 m) at Sandia National Lab (SNL) indicated that only 1 drum experienced 5% drum content loss, and 4 drums experienced drum lid loss. The drum was impacted laterally (sideways). No lid failures, and hence no drum content loss, occurred for the resultant impact velocity of less than around 36 mph. In all tests, the waste matrix was placed within a light polyethylene

container, which was in turn placed within a rigid liner. Including the outer drum, the waste matrix in the test drums was within 3 layers of confinement (SNL 1983).

Other tests performed by Westinghouse Hanford Corporation (WHC) involved 3-17C and 3-17H drums, directly loaded with sand or heavy bricks, for a total of six drum drop tests. No liner or bags were used, so the drum comprised the only confinement. WHC concluded that single 1,000-lb drums dropped from 11 ft and impacting the locking ring at 45° to horizontal are likely to spill some of their contents. For Type 17C drums, the maximum spill was 250 lbs (27% of the drum contents) and the average for three tests was 103 lb (11% of the drum contents). The Type 17C test with the smallest void volume produced the greatest spill. For Type 17H drums, the maximum spill was 500 lb (53% of the drum contents) and the average was 170 lb (18% of the drum contents). The lid stayed attached to the drum in each of the six single-drum tests (Hanford 1995).

The likelihood that a vehicle can travel more than 35 mph within the confines of the WCRRF outside container storage area is considered highly unlikely. DOE-STD-5506 (DOE 2007) recommends a DR of .1 for "multiple containers impacted by a vehicle whose speed may be restricted by physical layout of the facility/site and associated obstacles, but whose speed can't reasonably be assumed to be <10 mph." Also, a vehicle impact is presumed to involve a lateral impact to a drum, so a DR = 5%, based on the SNL studies, may be considered in the unmitigated case for waste matrices that have some level of additional confinement within the drum containment. However, if the DR = 53% from the maximum drum content loss shown in the WHC study is used in the consequence analysis, dose would be reduced by approximately half.

3.4.2.2.5 Summary of TSR Controls

The implementation of controls to prevent a vehicle impact with loss of waste container contents and subsequent fuel pool fire resulting in the consequences described in this accident scenario will significantly reduce the frequency of this accident (i.e., prevent the occurrence of this accident). Vehicle barriers are SC design features. Their placement at specific points outside TA-50-69 defines the Vehicle Access System. The outdoor transportainer areas are located within the Vehicle Access System. An SC-level SAC requires that the vehicle barriers are in place when TRU waste is present within the Vehicle Access System. The vehicle barriers prevent vehicles from entering the Vehicle Access System to the extent that the vehicles cannot impact waste containers, and any fuel leaks from a vehicle accident cannot come close enough to the waste containers to involve the waste containers in the postulated fuel pool fire. The prohibition of fuel powered vehicles both outside and inside Building TA-50-69 when MAR is within the Vehicle Access System or in Building TA-50-69 also reduces the frequency for the postulated vehicle accident/fuel leak/fuel pool to occur (prevents it), as does the SC-SAC precluding refueling of the diesel generator while TRU waste is in Building TA-50-69 (Table 3-16).

The listed controls significantly reduce the likelihood of the accident scenario, significantly mitigate or significantly reduce the likelihood of scenarios within the hazards analysis bounded by this accident scenario, or protect the assumptions of the hazards and accident analysis. The combination of the Vehicle Fuel Restrictions, the Vehicle Barriers, and the Vehicle Access System is sufficient to prevent this accident from occurring by eliminating fuel pool fires. This makes the frequency of this accident BEU.

NOTE: The *Credited Control for AA / HA Scenarios* column only identifies the HA scenarios from the potential list of candidates.

Table 3-16. Summary of SC TSR Controls for Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire)

Abbreviated Description	Credited Control for AA / HA Scenarios	Level	Safety Function
Vehicle Barriers	HSO-2 HSO-3 HSO-6 HSO-7 HSO-13	SC-DF	Prevent impacts between moving vehicles and the TRU waste containers staged inside Building TA-50-69 or in outdoor transportainers. Prevent subsequent vehicle fuel pool fires from involving TRU waste via separation distance between vehicle barriers and the TRU waste containers.
TRU Waste Containers (applies to outdoor staging only)	HSO-2 HSO-3 HSO-6 HSO-7 HSO-13 HSO-16	SC-DF	Provide primary confinement for TRU waste. Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents. Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents. Prevent accumulation of flammable gases inside the TRU waste containers.
Diesel Generator Refueling Exclusion	HSO-16	SC-SAC	Prevents fuel pool fires associated with diesel generator refueling from affecting TRU waste inside Building TA-50-69.
Vehicle Access System	HSO-2 HSO-3 HSO-6 HSO-7 HSO-13	SC-SAC	Prevents vehicle impacts and subsequent fuel pool fires that could impinge upon TRU waste within Building TA-50-69 and TRU waste containers staged in transportainers.
Vehicle Fuel Restrictions	HSO-2 HSO-3 HSO-6 HSO-7 HSO-16	SC-SAC	The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF while TRU waste is present prevents explosions and minimizes the potential for fires that will impact TRU waste.
Inventory Limits	All (Initial Condition)	SC-SAC	The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated.

3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire)

The accident analysis for this scenario is based on the bounding HA scenario **HSI-5** ("Building fire impacts gloveboxes or TRU waste containers. Electrical short or operational upsets cause fire."). Fires occurring inside of Building TA-50-69 can occur due to glovebox operations or supporting operations outside of the glovebox, but spread to impact TRU waste within the glovebox or staged waste containers. **HSI-5** can impact both the glovebox and staged TRU waste containers, and was thus selected as the bounding HA event. While this scenario bounds the consequences of other inside fires, its initiators do not. As such, controls for other scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.3.1 Scenario Development

The accident scenario involves two cases:

Case 1: A fire is initiated within the main operations area of Building TA-50-69, where waste containers are stored, which is initiated by a fuel spill that is ignited, resulting in a fuel pool fire. The fire engulfs the stored waste containers. The heat of the fire causes 25% of the waste containers to lose their lids and eject 1/3 of their contents (per DOE-STD-5506, Section 4.4.3.1 [DOE 2007]). The ejected contents spill and burn uncontained. The remaining waste contents burn within the containers. This fire bounds other initiators for the indoor fire, such as those described in the HA and labeled HHI-2 (fire impacts TRU waste containers carried on pallet during off loading in the vehicle airlock; forklift fire caused by electrical short, human error, or other causes while carrying TRU waste containers); HSI-3 (fire spreads to TRU waste containers staged inside the vehicle airlock. Leaking fuel from a truck parked near the building ignites and burns); and HSI-4 (fire impacts staged TRU waste containers; forklift accident inside building, fuel system damage, fuel leaks cause a fire).

For the building fires modeled in Appendix 3D, the magnitude of the fires ranged from 2.2 to 27.6 MW, corresponding to a burning surface area equivalent ranging from approximately 4% to 50% of the available floor area.

Within Appendix 3D, maximum upper layer gas temperatures as well as sprinkler actuation times were estimated for Room 102 (see Appendix 3D for results). (Room 102 is the main process area of Building TA-50-69.) If a fire occurred in these areas, it is expected that the FSS would cool, if not extinguish, a fire, thereby reducing the amount of MAR impacted by the fire. It is estimated that, at a minimum, a ~937 kW fire located in the building would be necessary to actuate the sprinklers at approximately 280 seconds into the growth phase of a medium-growth fire.

For the building fire, these estimates indicate that the FSS will be effective in reducing the potential MAR that may be impacted by a fire in the building, limiting this value to that affected until sprinkler actuation occurs. The building fire could burn the gloves of the WCG before the building sprinklers actuate, initiating the WCG fire. Activation of the WCG portion of the FSS may compromise containment/confinement due to the release of fire water from the WCG to the building, and loss of vacuum by overpressurization of the WCG or clogging of the WCG HEPA filters. Although not credited with reducing the accident source term, rapid fire suppression should help to minimize consequences due to airborne releases by releasing radioactive material into the building that is entrained with the firewater.

Case 2: A fire is initiated within the WCG with waste contents emptied onto the glovebox floor and containing the Building MAR. The waste contents are considered to burn uncontained. The WCG fire bounds other initiators in similar HA scenarios such as HGB-9 (any ignition source (e.g., power tools, hot work) ignites combustibles in the WCG; fire consumes rubber gloves or breaches HEPA filters or ductwork, causing loss of confinement; potential

for direct release path to exterior of building); HGE-2 (any ignition source (e.g., power tools, hot work) ignites combustibles in the GBE; fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement; fire spreads to remainder of building); and HGB-3: pyrophoric, flammable or combustible (Class II or IIIA) liquids or oxidizer material ignites, or spontaneous combustion causes fire, drum contents ignite, spreading fire to combustibles, and impacting the glovebox confinement.

Should the pyrophoric material or TRU waste ignite, a fast growth fire within the WCG could occur due to the forced ventilation provided by the GBE and WCG exhaust ventilation system. The WCG and GBE HEPA filter unit is located on the mezzanine above the WCG, with approximately 30 ft of substantial heavy-duty exhaust piping for the WCG exhaust flow before the WCG exhaust piping connects with the GBE exhaust flow. The WCG/GBE HEPA filter unit is also protected with a spark-arresting fire screen on its intake, providing an additional layer of defense.

The criterion for the fire rating of the FE-003 HEPA filters is based on a 1649°C (3000°F) fire. Previous evaluation performed for glovebox systems in TA-55, LA-UR-99-2677, *Mechanistic Analysis of Glovebox Fire Propagation* [LANL 1999], concludes that glovebox fires would stabilize at temperatures between 871 – 982ºC (1600 – 1800ºF). Figure 3-6.9, *Average temperature during fully developed period measured in experimental fires in compartments*, in the Society of Fire Protection Engineers Handbook of Fire Protection Engineering 4th Edition [NFPA 2008] shows a maximum temperature of about 1200°C (2192°F). A report on glovebox fire experiments at Rocky Flats, *Evaluation of the Consequences of Combustible Solvent Glove Box Fires* [Beyler1992], discusses a maximum temperature of 1100°C (2012°F). These studies indicate that the 1649°C (3000°F) temperature assumed for a fire within the WCG is conservative.

Calculation of the maximum temperature of air contacting the FE-003 HEPA filters given a maximum fire in the WCG is documented by CALC-11-TA50-0069-006 [LANL 2011]. The calculation assumes a ratio of 10% air flow from the WCG at 1649°C (3000°F) and 90% air flow from the GBE at 68°C (155° F). Data collected on the confinement ventilation system confirms that this assumed ratio is conservative. Loss of confinement in the WCG through compromise of the glove ports during a fire event would likely result in increased overall system flow as a result of unrestricted airflow into open WCG glove ports. The additional air admitted to the system would be the cooler, 68° C (155° F) room air, which would further reduce the mixed air temperature admitted to the filter plenum. Uniform air mixing is assumed due to the length of duct, the large number of duct fittings, and the presence of a spark arrestor upstream HEPA filters in the plenum. The analysis concludes that in the event of an unmitigated fire in the WCG, air entering the FE-003 filter plenum will not exceed 99 °C (211° F).

HEPA filters are rated for exposure to 402º C (756º F) hot air for 5 min (DOE-STD-1066) (DOE 1999). For 12 hours of continuous service, these filters are rated for 121º C (250º F).

Should a relatively fast growth fire occur, it is possible that all combustible material within the WCG could be involved in the event. In this case, the WCG gloves would be destroyed by the fire and WCG confinement lost. Due to the loss of the WCG glove ports, some fire products could backflow from the WCG into the general building exhaust ventilation. The general building ventilation is also equipped with HEPA filters and a spark-arresting fire screen on its intake. The substantial steel construction of the WCG would provide significant shielding of the fire and also prevent significant radiant heat emanating from the fire. The lack of a continuity of combustible material, and the transient combustible controls to be enforced around the WCG, prevent a fire in the glovebox from spreading to the building proper. This fire would be limited to the WCG and is not expected to compromise the building integrity.

3.4.2.3.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LF).

MAR: The MAR considered in both Case 1 (Building TA-50-69 main process area fire) and Case 2 (WCG fire) is the highest allowable MAR, 800 PE-Ci of combustible waste. Because relatively few (approximately 100) of the drums to be processed in the WCG contain a high MAR inventory of > 300 PE-Ci equivalent combustible waste, Case 2 also examines the consequences of a fire during the WCG processing of a more typical drum (300 PE-Ci equivalent combustible waste) drum.

DR: For the unmitigated accident scenarios in both Case 1 and Case 2, the DR is assumed as 1.0.

ARF/RF:

Waste Form		ARF		RF	
		Spill	Fire	Spill	Fire
Combustible	Unpackaged	1E-3[a]	1E-2[b]	1E-1[a]	1[b]
	Packaged		5E-4[c]		1[c]

[a]DOE 2000b, p. 5-20; [b]DOE 2000b, p. 5-15; [c]DOE 2000b, pp. 5-1 and 5-13; these values are also consistent with source term parameters found in DOE-STD-5506-2007 (DOE 2007).

LPF: An LPF of 1.0 is used for the unmitigated case.

ST calculations follow:

Case 1:

ST of waste contents that are ejected and spilled from 25% of containers due to being exposed to the building fire:

ST = (0.25 × 1/3 × 800 PE-Ci) × 1 × 1E-3 x 0.1 × 1 = 0.007 PE-Ci

ST for ejected waste contents that spills and burns uncontained (ARF and RF from spill are subtracted):

ST = (.25 × 1/3 × (800-PE-Ci -(800PE-Ci × 1E-3 × 0.1))) × 1 × 1E-2 × 1 × 1 = 0.66 PE-Ci

ST for remainder of waste contents that experiences contained burning:

ST = ((1 – (.25 × 1/3)) × 800 PE-Ci) × 1 x 5E-4 × 1 × 1 = 0.37 PE-Ci

Total ST for inside building fire component is .0.66 + 0.37 = 1.03 PE-Ci

Case 2:

ST of waste contents emptied in WCG that burns uncontained:

ST = 800 PE-Ci × 1 × 1E-2 × 1 × 1 = 8.0 PE-Ci (if processing one of the high-MAR drums)

ST = 300 PE-Ci × 1 × 1E-2 × 1 × 1 = 3.0 PE-Ci

3.4.2.3.3 Consequence Analysis

Case 1:

For the ejected spill component, a DSF of 3.54 rem/PE-Ci for public and 504.5 rem/PE-Ci for collocated worker for a nonbuoyant release is used to calculate the dose. For the waste that burns, a DSF of 3.54 rem/PE-Ci (nonbuoyant release for public) and 33.3 rem/PE-Ci (for a 0.1 MW smoldering fire for collocated worker) is presumed.

Dose (public - spill) = ST × DSF = 0.007 PE-Ci × 3.54 rem/PE-Ci = 0.02 rem

Dose (CW - spill) = ST × DSF = 0.007 PE-Ci × 504.5 rem/PE-Ci = 3.53 rem

Dose (public - fire) = ST × DSF = 1.03 PE-Ci × 3.54rem/PE-Ci = 3.63 rem

Dose (CW - fire) = ST × DSF = 1.03 PE-Ci × 33.3 rem/PE-Ci = 34.23 rem

Total Dose (public) = 3.63 + 0.02 rem = 3.65 rem

Total Dose (collocated worker) = 3.53 + 34.23 = 37.76 rem

For comparison, the fire involving only *contained* burning of combustibles (800 PE-Ci x ARF×RF of 5E-4/1), the dose = 0.4 PE-Ci × 3.54 rem/PE-Ci = 1.41 rem for public and 0.4 PE-Ci × 33.3 rem/PE-Ci = 13.3 rem for collocated worker.

Case 2:

For the waste contents that burn uncontained within the WCG, the same DSFs, 3.54 and 33.3 rem/PE-Ci, as in Case 1, is used to calculate the dose.

If processing one of the high-MAR drums:

> Dose (public) = ST × DSF = 8.0 PE-Ci × 3.54 rem/PE-Ci = 28.3 rem Dose (collocated worker) = ST × DSF = 8.0 PE-Ci × 33.3 rem/PE-Ci = 266.6 rem

If processing a typical drum with < 300 PE-Ci:

> Dose (public) = ST × DSF = 3.0 PE-Ci × 3.54 rem/PE-Ci = 10.6 rem
>
> Dose (collocated worker) = ST × DSF = 3.0 PE-Ci × 33.3 rem/PE-Ci = 99.9 rem

The Case 2 combustible waste fire dose consequence of 28.3 rem to the public involving a high-MAR drum of combustible waste, or 10.6 rem for a typical drum with no more than 300 PE-Ci combustible waste, compels a rigorous review of the over-conservatisms used in the ST and consequence analysis; specifically, that a fire involving waste contents in the WCG fire is an uncontained fire. This presumption does not consider the glovebox confinement.

DOE-HDBK-3010-94, Section 5.2.1.1 *(Thermal Stress of Surface Contaminated, Combustible Solids) Packaged Waste,* DOE 2000b, p. 5-10, states the following:

Current requirements have led to the packaging of contaminated, combustible waste in relatively substantial packages such as metal containers and drums. The material that is placed in these containers often consists of less robust waste packages in the form of single- or double-wrapped plastic packages bagged out of glovebox lines. Even waste placed together in a pile without even bag containment forms a loosely agglomerated package of sorts.

In addition, in the same reference, p. 5-11,

... a bounding ARF is assessed to be 5E-4 for packaged waste. For this purpose, even waste in taped plastic bags or pails is considered packaged. In lieu of a measured size distribution for the airborne materials, a conservative RF of 1.0 is assessed to be bounding.

Also, according to DOE-STD-3009, CN3, Section 3.4.2, *Design Basis Accidents,* second paragraph (DOE 2006a),

Quantification methods are typically limited to calculating the dose profile of a release. The process is iterative, starting by taking no credit for mitigative features and comparing results to the Evaluation Guideline. Continue taking credit for additional mitigative features incrementally and comparing the results to the Evaluation Guideline until below the guideline. This iterative process, however, does not require denying the physical design of facility structures, systems, and components. For example, if liquid hazardous material is brought into a facility in steel piping and stored in steel tanks, it is not meaningful to disregard the existence of these physical features in analysis. Simply admitting they exist does not require SC-SSC designation either. Stated another way, facilities should be analyzed as they exist when quantifying meaningful release mechanisms.

The difference between a fire burning in a glovebox, versus in a pail or drum, is related to the amount of surface area and availability of air that can flow through the combustible material. Since the glovebox does provide a larger surface area and more air flow than an open drum, basing the source term analysis on the lower ARF/RF of 5E-4/1 is not defensible. However, the ARF/RF used in the source term analysis is based on experiments where the air is passed over and around the material, and does not consider burn residue that could attenuate the ARF from large piles of waste material. The "experimental configuration did not allow the contaminant material to attain the degree of adhesion and packing expected for real stored wastes" (DOE 2000b, p. 5-13).

By taking some credit for the glovebox and building confinement, it is reasoned that, although we should use the ARF/RF of 1E-2/1.0 to determine the ST resulting from the uncontained burn, the calculated dose to the MEOI should be considered overly conservative, since the parent drum, the glovebox, and the attached daughter drums into which waste is being transferred will provide some level of confinement for the burn and reduce the consequence, though this cannot be quantified.

3.4.2.3.4 Comparison to Guidelines

For Case 1, the public dose of 3.65 rem does not challenge the EG of 25 rem, so the selection of SC controls for the protection of the public are not required. However, several SS controls have been selected to prevent or mitigate the consequences for the protection of the collocated worker and worker. Controls that eliminate liquid fuel pool fires reduce the consequences to less than 1.5 rem to the public and 15 rem for the collocated worker. Additional controls provide further defense-in-depth.

For Case 2, the unmitigated dose of 28.3 rem to the public for a high-MAR scenario, is considered conservatively bounding and exceeds the EG, if no credit is given for the glovebox or building confinement. The ARF/RF of 1E-2/1.0 is applicable to an uncontained burning scenario (exposure to the ambient environment; air passed over and around material; no attenuation due to burn residue). Though it is appropriate to use these parameters since the ARF/RF of 5E-4/1 may not be bounding, the use of the ARF/RF for uncontained burning is overly conservative because the burning waste can be argued to be somewhat packaged or contained by the glovebox (and the attached parent and daughter drums), and enclosed in a building with an associated LPF less than the 1.0 value conservatively assumed, given the physical features of the facility. So, even if the glovebox fire were to breach the glovebox confinement through the gloves, the fire would be somewhat contained. For a fire involving a more typical MAR (< 300 PE-Ci), the conservatively calculated dose of 10.6 rem for a more typical scenario is not considered to challenge the EG.

The *actual* dose would be higher than the dose calculated using an ARF/RF of 5E-4/1 [1.41 rem] for contained burning, but lower than the dose calculated using an ARF/RF of 1E-2/1 [28.3 rem for high MAR, or 10.6 for 300 PE-Ci combustible waste] for completely uncontained burning.

If the actual configuration included 1/3 of the allowable MAR spread out over the floor of the glovebox and burning as uncontained, while the other 2/3 remained contained within the attached parent and daughter drums and subject to the lower ARF/RF for packaged or contained waste, the public dose would be 10.4 rem for high-MAR inventory, or 3.9 rem for a more typical WCG loading of 300 PE-Ci or less (without considering a reduced LPF). The high-MAR accident still challenges the EG, so at least one safety class control is required for this bounding dose consequence.

The selection of SS controls for worker and collocated worker protection and defense-in-depth is also warranted, and these controls are identified in the HA.

3.4.2.3.5 Summary of TSR Controls

Table 6.4.1-1 of DOE-STD-5506 (DOE 2007) identifies preferred and alternate controls for minimizing initiators or limiting fire size for a fire in a glovebox during repackaging. The suggested controls include an automatic fire suppression system, flammable and combustible limits, and hotwork restrictions. Because the building and WCG fire suppression systems could not meet expectations (e.g., redundancy) for a safety class SSC, two alternative controls were selected for this accident scenario:

1) A SAC for combustible and flammable material control limits, and
2) A SAC for extra fire controls for high-MAR processing in WCG

These two safety-class TSR controls are sufficient to limit the likelihood of an exterior fire from spreading to the WCG. The Extra Fire Controls for High-MAR processing in the WCG will allow a stationary fire watch to use fire control agents and mitigate the consequences of a fire intiated within the WCG to below the EG.

Safety-Class Controls:

Abbreviated Description	Level	Safety Function
Combustible Loading Control Control	SC-SAC	Minimization of combustible loading prevents a fire from propagating and impinging on TRU waste and mitigates release of TRU waste by limiting fire size.
Extra Fire Controls for High-MAR Processing in WCG	SC-SAC	A stationary fire watch and the use of fire control agents by trained operators mitigate the effects of a fire in the WCG during the processing of a parent drum containing > 300 PE-Ci.

3.4.2.4 Drum Deflagration

The AA for this scenario is the build-up of a hydrogen-air mixture in a TRU waste container, resulting in a deflagration. This accident analysis will bound the following HA scenarios with high or moderate consequences carried forward for accident analysis consideration: **HGB-2** ("Built-up gas released while opening a TRU waste container results in deflagration impacting the waste and glovebox. Flammable gas build-up in TRU waste container resulting in deflagration.") As discussed in Section 3.3.2.3.6, *Accident Selection*, HGB-2 was chosen as the representative event addressing potential deflagration hazards during glovebox operations. Other HA scenarios represented by **HGB-2** are as follows: HSO-25: flammable gas deflagrates, ruptures container and burns; hydrogen gas builds up in TRU waste container; ignited due to impacts with vehicles operating in outside staging areas; HHO-1: deflagration of flammable gases in TRU waste container during handling in the outside staging areas; forklift impact with TRU waste container initiates deflagration and/or fire; and HHI-1: deflagration of flammable gases in TRU waste container during handling in the vehicle airlock; forklift impact with TRU waste container initiates deflagration or fire. HSO-2 and HSO-3 involve external explosions resulting in a fire impacting the TRU waste containers. Therefore, these two events are bounded by the analysis in Section 3.4.2.2, *Operational Fires Outside of Building TA-50-69 Involving Liquid Pool Fires (Spill and Fire).* While this accident scenario specifically bounds the consequences of a drum deflagration accident scenario due to the build-up of a hydrogen-air oxygen mixture, controls for the listed HA scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.4.1 Scenario Development

This scenario involves an explosive mixture forming inside a drum that is then ignited during handling. Hydrogen gas is generated by radiolysis to varying degrees in the waste drums, depending on their content, and VOCs, if present, can off-gas from the waste matrix. The deflagration is postulated to expel some of the drum's contents, which are assumed to be ignited and to burn outside the drum. No pipe-overpacks can experience this phenomenon, and therefore they cannot contribute to the consequences.

A drum deflagration accident requires the following progression of events: generation of flammable gas inside a drum, no vent in place or failure of the drum's venting capability, build-up of flammable gas and formation of a

flammable gas mixture, and exposure of the mixture to an ignition source. Appendix 3A discusses each of these phenomena and develops an estimated frequency for this scenario to be approximately $10E^{-2}$/yr to $10E^{-4}$/yr (Unlikely), assuming that the containers arrive vented.

A dose consequence calculation for a single drum deflagration in Building TA-50-69 is performed in this section. This will bound the consequences from any on-site location at the WCRRF.

Multiple drum deflagration is not considered in this accident analysis. A cascading deflagration event requires two or more suspect containers of poor container integrity to be stored or staged in a single location. Given the requirement that all drums received at the WCRRF are received in a vented condition, and are visually inspected to ensure that they are structurally sound, there is little potential for a cascading deflagration event. The likelihood of a single drum having an atmosphere that would deflagrate was considered to have an unmitigated frequency of Unlikely. The possibility of two adjacent TRU waste containers having high inventory, poor container integrity, simultaneous filter failures, and being subject to an ignition source is considered to be overly conservative and not requiring further analysis. A multiple drum deflagration was also not analyzed as a unique event, since no unique controls have been identified for a sympathetic deflagration beyond what is required for the mitigation of a single drum deflagration (e.g., TRU waste containers are in good condition and vented).

A fire within the WGC could result from the deflagration impacting combustible waste. Should the combustible material ignite, a fast-growth fire within the WCG could occur due to the forced ventilation provided by the GBE and WCG exhaust ventilation system. The WCG and GBE HEPA filter unit is located on the mezzanine above the WCG, with approximately 30 ft of substantial heavy-duty exhaust piping for the WCG exhaust flow before the WCG exhaust piping connects with the GBE exhaust flow. The WCG/GBE HEPA filter unit is also protected with a spark-arresting fire screen on its intake, providing an additional layer of defense.

As a result of the deflagration, the WCG integrity may be compromised. Due to the loss of the WCG confinement, some fire products could backflow from the WCG into the general building exhaust ventilation. The general building ventilation is also equipped with HEPA filter unit and a spark-arresting fire screen on its intake. The lack of a continuity of combustible material and the transient combustible controls to be enforced around the WCG prevent a fire in the glovebox from spreading to the building. This fire would be limited to the WCG and is not expected to compromise the building structure.

3.4.2.4.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LF).

MAR: One drum containing 800 PE-Ci of combustible waste is considered.

DR: A DR of 1.0 will be assumed for this drum deflagration.

ARF/RF: The ARF/RF values for this scenario were based on deflagration of a drum containing combustible waste. This provides conservative consequence estimates, because the release fractions are much higher for combustible waste than for noncombustible waste forms. For the purposes of ST calculations, two components of the waste are identified: the material that stays in the drum and the material that is expelled from the drum. The material that stays in the drum is assumed to burn as in an open container. ARF/RF values of 1E–03/0.1 (DOE 2000b, p. 5-3; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]) are used for the material that is initially expelled. Material expelled is assumed to be ignited and burn on the ground uncontained. Forty percent (EG&G 1983) of the waste material is assumed ejected from the drum, of

which 5% of that ejected is postulated to burn uncontained (Hanford 2004). An ARF/RF of 1E-2/1.0 (DOE 2000b, p. 5-1) for the ejected amount that burns uncontained is applied (see discussion following).

The ARF/RF values for the 60% of the material that remains in the drum (and is assumed to be ignited and burn) are 5E–04/1.0 (DOE 2000b, p. 5-1; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]). For the material that is expelled from the drum, two mechanisms will cause radioactive material to become airborne: loss of surface contamination in the process of being expelled, and the subsequent release while the material burns on the ground.

For the expelled material that falls to the ground and burns, two ARF/RF values may be used for burning uncontained cellulosic mixed waste, 1E–02/1.0, and uncontained plastics, 5E–02/1.0 from DOE-HDBK-3010 (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]). Because the ARF for plastic is relatively high (5E–02) and is one of the dominating parameters in this analysis, the basis for this value in DOE-HDBK-3010 (DOE 2000b) is examined.

The recommended bounding ARF for burning of contaminated, uncontained plastics in Section 5.1 of the Handbook is based on the experimental data provided in Tables A.51 through A.53 of the Handbook. The highest release for all plastics was measured for burning contaminated polymethylmethacrylate (PMMA). Run #32 measured that 4.5% of a depleted uranium oxide powder pile became airborne (Table A.53). Other experiment runs for powder piles gave similar but slightly lower results. The recommended bounding ARF of 0.05 provides a 10% margin over the highest measured value.

A powder pile on plastic material is not representative of the waste forms present in the drums at LANL. Significant amounts of TRU material in loose powder form would have been recovered and not processed as contaminated waste. A more representative configuration that was tested in the same experimental program is air-dried liquid on a plastic substrate. Several tests were performed for this configuration: Run #24 for burning contaminated polychloroprene (Table A.51 of DOE 2000b) and Run #14 for burning contaminated PMMA (Table A.53 of DOE 2000b). These tests resulted in the airborne release of 0.42% and 0.6% of the radioactive contamination, respectively.

The experimental results indicate that contamination in the form of a coating on a substrate has a release fraction approximately one order of magnitude less than a pile of loose powder on top of the substrate. An ARF that is based on the air-dried liquid test results is more representative of the expected behavior of the contaminated waste material in the TRU waste containers at LANL. Therefore, an ARF/RF of 1E-02/1 was chosen to bound the experimental results for uncontained burning of this waste form (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]).

LPF: An LPF of 1.0 was assumed as discussed in Section 3.4.1.2.

ST: ST calculations are as follows:

Waste that is ejected into the air (40%), with loose material coming off in the air:

$$ST = 40\% \times 800 \text{ PE-Ci} \times 1 \times 1E\text{-}3 \times 0.1 \times 1 = 0.032 \text{ PE-Ci}$$

Waste that is ejected into the air (40%) and falls to the ground and burns (5%) (ARF and RF from spill subtracted from MAR):

ST = 40% × 5% × (800-(800 × 1E-3 × 0.1)) × 1 × 1E-2 × 1 × 1 = 0.16 PE-Ci

Waste that remains in drum and burns:

ST = 60% × 800 PE-Ci × 1 × 5E-4 × 1 × 1 = 0.24 PE-Ci

For the deflagration accident, the ST for the material that spills during the initial ejection is 0.032 PE-Ci.

The ST for the material that burns is (0.16 + 0.24) PE-Ci = 0.4 PE-Ci

3.4.2.4.3 Consequence Analysis

The release from the burning waste material will be elevated by the heat added by the fire. For the public, buoyancy is conservatively neglected and the fire release treated the same as the spill component. For the collocated worker, the release is modeled as a smoldering fire (0.10 MW). The DSF values for the fire are 3.54 rem/PE-Ci for public and 33.3 rem/PE-Ci for collocated worker. For the spill component, Table 3-14 indicates a public and collocated worker DSF for a nonbuoyant release as 3.54 and 504.5 rem/PE-Ci, respectively. The total dose is calculated as follows:

Dose from ST in spill component (public) = 0.032 PE-Ci × 3.54 rem/PE-Ci = 0.11 rem

Dose from ST in spill component (CW) = 0.032 PE-Ci × 504.5 rem/PE-Ci = 16.14 rem

Dose from ST involved in non-buoyant fire (public) = 0.4 PE-Ci × 3.54 rem/PE-Ci = 1.42 rem

Dose from ST involved in smoldering fire (CW) = 0.4 PE-Ci × 33.3 rem/PE-Ci = 13.32 rem

Total unmitigated dose for deflagration of 1 drum containing 800 PE-Ci of combustible waste (public) = (0.11 + 1.42) rem = 1.53 rem

Total unmitigated dose for deflagration of 1 drum containing 800 PE-Ci of combustible waste (CW)= (16.14 + 13.32) rem = 29.46 rem

3.4.2.4.4 Comparison to Guidelines

The 1.53 rem public dose consequences for a deflagration accident inside or outside Building TA-50-69 involving 800 PE-Ci does not challenge the EG of 25 rem, so the selection of SC controls is not required. Although the collocated worker dose does not exceed the 100 rem threshold, the selection of SS controls for worker and collocated worker protection and defense-in-depth is warranted and is discussed in the HA.

Note that in the case of a two-drum deflagration event that is considered overly conservative, the MAR is 1600 PE-Ci, and the source term and consequence analysis are treated as for the single-drum case. In this case, the dose to the public is 3.06 rem, and SC controls again would not be required. Idaho drum deflagration tests (EG&G 1983) indicated that sympathetic deflagration of a drum on top of the initial deflagration occurred; however, the lower drum did not lose its lid because of the weight of the drum on top. No experimentation has been conducted on sympathetic deflagration of horizontally adjacent drums. Therefore, it is suggested that sympathetic deflagration is possible involving two unvented drums for TRU waste being retrieved from burial sites, which is not the case for the drums destined for the WCRRF.

3.4.2.4.5 Summary of TSR Controls

The consequences of this scenario do not challenge the EG; therefore, there are no safety-class controls identified or selected to mitigate consequences to the MEOI.

3.4.2.5 Loss of Confinement / Containment (Spill)

The AA for this scenario is based on the bounding HA scenario HSO-11 ("Operational vehicle/forklift impacts staged waste containers. Forklift, maintenance, or delivery vehicle impacts TRU waste containers.") As discussed in Section 3.3.2.3.6, *Accident Selection*, HSO-11 was chosen as the representative event addressing vehicles traveling at high speeds and with greater impact energies. Other HA scenarios represented by HSO-11 are as follows: HSO-10 – accident while positioning mobile units or transportainers; staged TRU waste containers impacted by moving mobile units or transportainers; and HHI-5 – forklift failure or operator error drops TRU waste containers; pallet of TRU waste containers overturned. While this scenario bounds the consequences of loss of confinement or containment accident scenarios, its initiators do not. As such, controls for other scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.5.1 Scenario Development

A vehicle crash is assumed to bound all WCRRF spills and potential consequences because of the magnitude of the spill. Container impacts as a result of forklift or vehicle accidents are likely to occur when numerous vehicles are assumed to have unrestricted access to the staging area. A forklift accident rupturing four drums or 1 high PE-Ci drum, however, is considered unlikely. Although a bounding or worst-case accident involves a forklift impacting four drums on a pallet, the entire WCRRF inventory is considered in order to envelop the consequences for this scenario.

The scenario involves a forklift moving around the staging area and overturning or impacting staged waste containers, causing drums to spill. Waste containers (including drums and SWBs) are staged in transportainers in a protected area immediately outside the facility. Thus, this scenario represents a very conservative assumption with respect to the potential accident conditions (unprotected containers). Therefore, the magnitude of the ST and consequences are also conservative.

3.4.2.5.2 Unmitigated Source Term Analysis

Section 3.4.1.1, Scenario Development, discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LPF).

MAR, DR, LPF: The MAR is 1,800 PE-Ci. Both the DR and LPF are 1.0.

ARF/RF: The ARF/RF for contaminated, combustible solids packaged in a robust container that is spilled and subjected to shock and impact during the spill is 1E-3/0.1 (DOE 2000b, pg. 5-20; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]).

ST: The ST for this postulated accident scenario is calculated as follows:

$$ST = 1{,}800 \text{ PE-Ci} \times 1.0 \times 1E\text{-}3 \times 0.1 \times 1.0 \times 1.0 = 0.18 \text{ PE-Ci}$$

3.4.2.5.3 Consequence Analysis

The public and collocated worker DSF for the nonbuoyant spill release, 3.54 and 504.5 rem/PE-Ci are used to calculate the doses for this accident scenario as follows:

Dose (public) = 0.18 PE-Ci × 3.54 rem/PE-Ci = 0.6 rem

Dose (CW) = 0.18 PE-Ci × 504.5 rem/PE-Ci = 90.8 rem

3.4.2.5.4 Comparison to Guidelines

The dose to the MEOI for this accident scenario does not challenge the EG of 25 rem, so the selection of SC controls is not necessary. The selection of SS controls for collocated worker and worker protection and defense-in-depth is warranted, however, and is discussed in the HA.

3.4.2.5.5 Summary of TSR Controls

The control functions of the safety-significant-level controls are listed in the Hazard Analysis, Section 3.3.

3.4.2.6 Seismic Event and Fire

The AA for this scenario is based on the bounding HA scenario **HSI-12** ("Seismic event initiates electrical fire inside building. Fire and structural debris impact TRU waste containers, WCG, or GBE.") As discussed in Section 3.3.2.3.6, *Accident Selection*, **HSI-12** was chosen as the representative and bounding event for seismically induced fires and was selected as an event for further analysis in this section. A listing of the HA scenarios represented by HSI-12 are as follows: HSO-23 – seismic event initiates a facility-wide fire; TRU waste containers toppled by seismic event and impacted by fire; HSO-22 – TRU waste containers toppled by seismic event; HSI-8 – structural damage to building, debris impacts TRU waste containers; electrical arcing ignites combustibles in yard, impacting TRU waste containers. While HSI-12 bounds the consequences of the seismic and postseismic fire accident scenarios, controls for other HA scenarios that are bounded by this accident will be selected based on the consequences of this accident.

3.4.2.6.1 Scenario Development

This accident scenario involves a fire (a secondary event) initiated by a seismic event. The fire may be initiated by electrical sparks or arcing due to downed electrical lines and fueled by exposed combustible waste as a result of breached containers.

The unmitigated frequency of the seismic event leading to a fire is estimated to be unlikely, or in frequency category III. The frequency of this scenario is reduced one frequency bin, to frequency category IV, in consideration of the conditional probability that a flammable condition could impact the inventory.

This accident scenario bounds a wind event that results in fire because of the low χ/Q for high winds. As indicated previously, Building TA-50-69 and the WCG can withstand a seismic event as severe as a PC-2.

Three cases are considered.

Case 1: All of the inventory is presumed to be outside in WCRRF staging areas and could be in the transportainers. The seismic event causes the building to sway and collapse. Heavy building seismic debris impacts and covers the containers; waste contents spill out of the waste containers due to the impact. A fire starts due to electrical sparks, which causes combustible seismic debris to catch on fire. The fire spreads to the waste containers, causing spilled waste to burn.

Case 2: Waste containers are inside Building TA-50-69 with up to 800 PE-Ci combustible waste. During the seismic event, the containers are impacted and covered by falling building debris. An electrical spark causes a fire to occur, which causes combustible seismic debris inside the building to catch on fire. Buried spilled waste contents are involved in the postseismic fire. Waste containers outside are impacted by heavy seismic debris, causing the waste contents to spill out of the waste containers; a building fire propagates to the outside waste staging area, causing any buried, spilled waste contents to burn. A secondary fire outside (such as from a downed power line) may also cause the outside waste contents to burn.

Case 3: The entire building inventory is presumed to be emptied into the WCG, and the balance of the site inventory is outside in the staging area in packaged containers. Falling building debris and seismic vibrations cause the WCG to spill the waste contents. Electrical sparks cause a fire to occur in the WCG, which spreads to the building confines. Containers outside are also impacted by heavy debris; all of their contents are spilled and become involved in the fire that spreads from the building or from a second fire that occurs outside.

In all three cases, the seismic event is presumed to impact the containers, causing their breach and resulting in a spill of waste contents. The postseismic fire burns the spilled waste contents.

3.4.2.6.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LPF).

MAR: The total site inventory of 1800 PE-Ci is considered. The total site inventory may be all outside (Case 1), or some of the MAR may be inside Building TA-50-69 (800 PE-Ci), with the balance of the site inventory (1000 PE-Ci) outside. All of the MAR is considered as combustible waste.

DR: DOE-STD-5506 [DOE 2007] indicates the use of a DR=0.1 for a substantially constructed building; DR=0.01 for a medium constructed building; and a DR=0 for a light constructed building. The WCRRF is conservatively presumed to be a substantially constructed building, so DR = 0.1 is considered. However, DR=1 is used for the unmitigated case, and, as a comparison, the consequence analysis results will also show dose to the MEOI using DR = 0.1. (Final selection of SC controls will be based on DR=1 unmitigated consequence analysis.)

ARF/RF: A discussion on the selection of the ARF/RF for the building seismic debris impact of waste containers and subsequent fire is warranted at this point. DOE 2000b, pp. 4-85 to 4-87, Section 4.4.3.3.2, *Large Falling Object Impact or Induced Air Turbulence,* discusses the derivation of ARF/RF in the case where substantial portions of structural features and equipment may fall on radionuclide-bearing-powders released from confinement, as could result from a seismic event. Several studies are cited involving rocks dropped directly onto powders. From these studies, it is postulated that the release mechanism appears to be air turbulence and shock-vibration, both of which can increase with mass and size of debris and fall height. Also considered is that, as debris size increases, the impact effect is less likely to be fully concentrated in one area, and debris will provide cover for material that could limit releases. A conservatively bounding ARF/RF value of 1E-2/0.2 is assessed as applicable

to loose powders directly impacted by debris. Further studies (pg. 4-87 of DOE 2000b) considered that "powders are contained in cans, cans in gloveboxes, cans in cans, etc.," and also that, in a total building collapse, remains would be buried under the falling debris. From these studies, an ARF/RF value of 1E-3/0.1 is assessed as bounding for powder held in cans failed by debris. This decrease in the overall respirable release is postulated as being due most likely to some combination of shielding of powder and interaction between the powder and confining surfaces, as would be expected with debris-covered powder.

The situation described above is applied in the seismic event analyzed here, involving building debris impacting waste containers, causing the release of waste contents. Accordingly, ARF/RF = 1E-3/0.1 is used for the impact/spill release mechanism analysis below (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]).

The same discussion can somewhat be applied to the ARF/RF selected for the postseismic fire event. That is, following the impact/spill of waste contents, the first presumption is that the combustible waste will experience uncontained burning – an ARF/RF = 1E-2/1 is assigned according to DOE 2000b, pg. 5-13. This ARF/RF is noted as conservative from the experimental data, which indicated measured ARFs ranging from 7E-5 to 1E-2 and two RF values of 0.5 and 1. The experimental data, pg. 5-14 of DOE 2000b, also indicates that the ARFs close to 1E-2 involved experiments where an airflow around and over the burning contaminated materials (at 0.06 m/s velocity) occurred, contributing to its combustion potential and hence the measured ARFs. The experimental data shown on pg. 5-14, involving no airflow but uncontained burning, reported ARFs ranging from 7.0E-5 to 1.53E-3 for burning combustibles.

Since the waste contents in Case 1 through Case 3 are more appropriately described by the experimental data involving waste contents that may burn but experience no airflow around and over the burning contaminated materials, values for an ARF = 1.0E-3 and RF = 1 are used and are considered to bound the experimental data shown on p. 5-14 of DOE-HDBK-3010-94 (DOE 2000b), again for material that burns with no airflow applied (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]).

LPF: The LPF is presumed to be 1.0.

ST: <u>It is important to note that, in the following ST analysis, individual STs are developed for the following</u>:

ST (seismic impact on waste containers in Building TA-50-69) (not applicable for Case 1)

ST (postseismic fire involving impacted waste containers in Building TA-50-69) (not applicable for Case 1)

ST (seismic impact on waste containers outside of Building TA-50-69)

ST (postseismic fire involving impacted waste containers outside of Building TA-50-69).

The *total* source term for Cases 1 through 3, developed below, is the summation of the individual source terms.

Case 1: Total site MAR of 1800 PE-Ci is outside; seismic debris causes waste contents to spill; post seismic fire involves buried spilled waste contents.

ST for the amount of waste contents (all combustible waste contents) that is impacted due to seismic debris:

$$ST = 1800 \text{ PE-Ci} \times 1 \times 1E\text{-}3 \times 0.1 \times 1 = 0.18 \text{ PE-Ci}$$

ST for the amount of waste contents that is spilled due to being impacted and buried by the seismic debris and is thus considered as burning in a contained environment. The postseismic fire is a combustible fire. The ARF and RF from the spill are subtracted from the total MAR.

ST = (1800 - (1800 × 1E-3 × 0.1)) PE-Ci × 1 × 1E-3 × 1 × 1 = 1.8 PE-Ci

Case 2: The total site MAR of 1800 PE-Ci is at the WCRRF site. The MAR inside the building is 300 PE-Ci in waste containers staged in drums inside Building TA-50-69; the balance of the total site MAR is outside. Seismic debris from the building swaying and falling onto waste containers causes waste container contents to spill; a (combustible) postseismic fire occurs both inside and outside and involves the buried spilled waste.

MAR Inside Facility = 800 PE-Ci combustible waste inside Building TA-50-69

MAR Outside = (1800-800) PE-Ci = 1000 PE-Ci combustible waste outside in transportainers

Spilled/impacted packaged material inside Building TA-50-69:

ST for waste contents inside building that spills due to impact by falling building debris due to seismic event:

ST = 800 PE-Ci × 1 × 1E-3 × 0.1 × 1 = 0.08 PE-Ci

ST for waste contents inside the building that burn is shown below. In the ST calculation below, the ARF and RF from the impact/spill are subtracted from the MAR involved in the burning waste contents:

ST = (800 - (800 × 1E-3 × 0.1)) PE-Ci × 1 × 1E-3 × 1 × 1 = 0.8 PE-Ci

Spilled/impacted packaged material outside:

ST for the amount of waste contents (all combustible waste contents) that is impacted due to seismic debris:

ST = 1000 PE-Ci × 1 × 1E-3 × 0.1 × 1 = 0.10 PE-Ci

ST for the amount of waste contents that is spilled due to being impacted and buried by the seismic debris, and is thus considered as burning in a contained environment. The postseismic fire is a combustible fire. The ARF/RF from the impact/spill are subtracted from the MAR.

ST = (1000 - (1000 × 1E-3 × 0.1)) PE-Ci × 1 × 1E-3 × 1 × 1 = 1.0 PE-Ci

Case 3: Building MAR is within waste contents emptied into WCG; WCG is considered a confinement layer, so waste contents do not experience direct impact by building seismic debris but do experience seismic vibrations which could break glovebox windows, causing waste to spill. A fire burns waste contents.

MAR Inside Facility = 800 PE-Ci combustible waste inside the WCG

MAR Outside = (1800-800) PE-Ci = 1000 PE-Ci combustible waste outside in transportainers

Spilled/impacted packaged material inside Building TA-50-69 within the WCG:

ST for waste contents inside the WCG that spills out of the glovebox due to glovebox being impact by seismic debris:

ST = 800 PE-Ci × 1 × 1E-3 × 0.1 × 1 = 0.08 PE-Ci

ST for waste contents inside the WCG that burn. It is important to note that the seismic debris that impacted the WCG, causing the waste contents to spill out of the WCG, is not considered to cover the spilled waste contents. That is, the seismic debris is sufficient to impact and vibrate the WCG and cause its contents to spill, but not necessarily cause the spilled waste to be buried. However, since the WCG is downed, it is unrealistic to presume that any airflow would be occurring through the WCG, so the burning waste contents could be compared to the experiments involving combustible material with no air flow, DOE-HDBK-3010, DOE 2000b, p. 5-14; so the ARF/RF of 1E-3/1 is also used in this Case 3 (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]). Again, the ARF and RF from the impact/spill are subtracted from the MAR involved in the uncontained burning:

ST = (800 - (800 × 1E-3 × 0.1)) PE-Ci × 1 × 1E-3 × 1 × 1 = 0.8 PE-Ci

Spilled/impacted packaged material outside:

ST for the amount of waste contents (all combustible waste contents) that is impacted due to seismic debris:

ST = 1000 PE-Ci × 1 × 1E-3 × 0.1 × 1 = 0.1 PE-Ci

ST for the amount of waste contents that is spilled due to being impacted and buried by the seismic debris, and is thus considered as burning in a contained environment. The postseismic fire is a combustible fire. The ARF and RF from the impact/spill are subtracted from the MAR.

ST = (1000 - (1000 × 1E-3 × 0.1))PE-Ci × 1 × 1E-3 × 1 × 1 = 1.0 PE-Ci

3.4.2.6.3 Consequence Analysis

For the impacted/spill component, a DSF of 3.54 (public) and 504.5 (collocated worker) rem/PE-Ci for a nonbuoyant release is used to calculate the dose. For the waste that burns, a DSF of 3.54 rem/PE-Ci is used for the public (representing a nonbuoyant release) and 33.3 rem/PE-Ci representing a 0.1-MW smoldering fire is presumed for the collocated worker.

Case 1: All MAR outside; seismic debris causes waste contents to spill; postseismic fire involves waste contents

Dose from spill component (public): 0.18 PE-Ci × 3.54 rem/PE-Ci = 0.6 rem

Dose from spill component (CW): 0.18 PE-Ci × 504.5 rem/PE-Ci = 90.8 rem

(Public Dose *using DR = 0.1*: 0.1 × 0.6rem = 0.06 rem)

Dose from buried spilled component / contained burning (public): 1.8 PE-Ci × 3.54 rem/PE-Ci = 6.4 rem

Dose from buried spilled component / contained burning (CW): 1.8 PE-Ci × 33.3 rem/PE-Ci = 60 rem

(Public Dose *using DR = 0.1*: 0.1 × 6.4rem = 0.64 rem)

The **total dose** for Case 1 is the sum of the spill + fire (public) : (0.6 + 6.4) rem = 7.0 rem.

The **total dose** for Case 1 is the sum of the spill + fire (CW) : (90.8 + 60) rem = 150.8 rem.

(Dose *using DR = 0.1*: 0.7 rem (Public) and 15 rem (CW))

This calculated dose, using a DR=1, is conservative given that the DR=0.1 for a substantially constructed building is ignored. If the DR=0.1 is applied, shown in bold above, the dose consequences do not challenge the EG nor the threshold of 100 rem for the collocated worker.

Case 2: The total site MAR of 1800 PE-Ci is at the WCRRF site. The MAR inside the building is 300 PE-Ci in waste containers staged in drums inside Building TA-50-69; the balance of the total site MAR is outside. Seismic debris from the building swaying and falling onto waste containers causes waste container contents to spill; a (combustible) postseismic fire occurs both inside and outside and involves the buried spilled waste.

Inside Building TA-50-69:

Dose from spill component (public): 0.08 PE-Ci × 3.54 rem/PE-Ci = 0.28 rem

Dose from spill component (CW): 0.08 PE-Ci × 504.5 rem/PE-Ci = 40.36 rem

Dose from buried spill component / contained burning (public): 0.80 PE-Ci × 3.54 rem/PE-Ci = 2.8 rem

Dose from buried spill component / contained burning (CW): 0.80 PE-Ci × 33.3 rem/PE-Ci = 26.66 rem

The **total dose for Inside Building TA-50-69** for Case 2 is the sum of the spill and fire:

Total Dose for Inside Building TA-50-69 (public): (0.28 + 2.8) rem = 3.11 rem

Total Dose for Inside Building TA-50-69 (CW): (40.36 + 26.66) rem = 67 rem

Outside Building TA-50-69:

Dose from spill component (public): 0.1 PE-Ci × 3.54 rem/PE-Ci = 0.35 rem

Dose from spill component (CW): 0.1 PE-Ci × 504.5 rem/PE-Ci = 50.45 rem

Dose from buried spill component / contained burning (public): 10 PE-Ci × 3.54rem/PE-Ci = 3.54 rem

Dose from buried spill component / contained burning (CW): 1.0 PE-Ci × 333 rem/PE-Ci = 33.33 rem

The **total dose for Outside Building TA-50-69** for Case 2 is the sum of the spill and fire:

Total Dose for Outside Building TA-50-69 (public): (0.35 + 3.54) rem = 3.89 rem

Total Dose for Outside Building TA-50-69 (CW): (50.45 + 33.33) rem = 83.78 rem

The sum of the dose from Inside Building TA-50-69 and Outside Building TA-50-69 for this accident is

Grand Total Dose for Case 2 (public)= (3.11 + 3.89) rem = 7.0 rem

(Dose *using DR = 0.1*: 0.1 × 7.0 rem = 0.7 rem)

Grand Total Dose for Case 2 (CW)= (67 + 83.78) rem = 150.8 rem

(Dose *using DR = 0.1*: 0.1 × 150.8 rem = 15rem)

Case 3: Building MAR is within waste contents emptied into WCG; WCG is considered a confinement layer, so waste contents do not experience direct impact by building seismic debris but do experience seismic vibrations which could break glovebox windows, causing waste to spill. A fire burns waste contents. No upflow of air through waste contents is possible.

Inside Building TA-50-69 – MAR inside WCG:

Dose from spill component (public): 0.08 PE-Ci × 3.54 rem/PE-Ci = 0.28 rem

Dose from spill component (CW): 0.08 PE-Ci × 504.5 rem/PE-Ci = 40.36 rem

Dose from buried spill component / contained burning (public): 0.80 PE-Ci × 3.54 rem/PE-Ci = 2.8 rem

Dose from buried spill component / contained burning (CW): 0.80 PE-Ci × 33.3 rem/PE-Ci = 26.66 rem

The **total dose for Inside Building TA-50-69** for Case 3 is the sum of the spill and fire:

Total Dose for Inside Building TA-50-69 (public): (0.28 + 2.8) rem = 3.11 rem

Total Dose for Inside Building TA-50-69 (CW): (40.36 + 26.66) rem = 67 rem

Outside Building TA-50-69:

Dose from spill component (public): 0.1 PE-Ci × 3.54 rem/PE-Ci = 0.35 rem

Dose from spill component (CW): 0.1 PE-Ci × 504.5 rem/PE-Ci = 50.45 rem

Dose from buried spill component / contained burning (public): 1.0 PE-Ci × 3.54 rem/PE-Ci = 3.54 rem

Dose from buried spill component / contained burning (public): 1.0 PE-Ci × 33.3 rem/PE-Ci = 33.33 rem

The **total dose for Outside Building TA-50-69** for Case 3 is the sum of the spill and fire:

Total Dose for Outside Building TA-50-69(public): (0.35 + 3.54) rem = 3.89 rem

Total Dose for Outside Building TA-50-69 (CW): (50.45 + 33.3) rem = 83.78 rem

The sum of the dose from Inside Building TA-50-69 and Outside Building TA-50-69 for this accident is

Grand Total Dose for Case 3(public) = (3.11 + 3.89) rem = 7.0 rem

Grand Total Dose for Case 3(CW) = (67 + 83.78) rem = 150.8 rem

3.4.2.6.4 Comparison to Guidelines

In all three cases involving combustible waste, the total dose consequences from the seismic and fire event, both inside and outside of Building TA-50-69, may be viewed as challenging the EG of 25 rem. The threshold of 100 rem to the collocated worker is also exceeded. The table below sums the contributions to the dose consequences from the Inside Building TA-50-69 and Outside Building TA-50-69 consequence analyses, for DR=1.

The rest of this discussion will focus on the unmitigated consequence results for DR=1 for the combustible waste stream.

The building structure and WCG are PC-2 rated and will be able to survive a PC-2 earthquake, PC-2 wind, and PC-2 snow loading. The accident analysis presumes, however, that a significant (> PC-2) earthquake occurs, causing the complete collapse of the facility.

While focusing on the unmitigated consequences (DR=1), in order to select appropriate SC or SS controls, it is worthwhile to analyze the different components of the dose consequences (i.e., spill(outside) + spill(inside) + fire(inside) + fire(outside)) that contribute to the total dose.

The following table shows all the components that make up the total dose for each case.

Table 3-17. Total Dose for Seismic and Fire

	Seismic and Fire -- Unmitigated Dose to MEOI (rem) (DR=1)						
Case No. (Combustible Waste Only)	**Seismic Impact Outside**	**Post-Seismic Fire Outside**	**Total Outside Dose**	**Seismic Impact Inside**	**Post-Seismic Fire Inside**	**Total Inside Dose**	**Total Dose**
1	0.6	6.4	7.0	0	0	0	7.0
2	0.35	3.54	3.89	0.28	2.8	3.11	7.0
3	0.35	3.54	3.89	0.28	2.8	3.11	7.0

This data shows that the spill and fire component from inside the building is small.

The majority of the dose is from the postseismic fire outside, which first initiates when building debris impacts waste containers staged outside. The dose consequences shown could still be seen as challenging the EG. So, an SC to prevent the building structure from impacting the waste containers staged outside should be selected.

The TRU waste containers, when staged outside, are designated as SC design features, to mitigate against the consequences for the outside seismic and fire event. A SC-level SAC to prevent impact of building debris on the waste containers is the requirement that the outdoor transportainer areas are of a sufficient distance from Building TA-50-69 so that in a seismic event, if the building is to sway and fall, its debris does not fall on the waste containers. From the combination of the SC-DF TRU waste containers staged outside, and the SC-SAC for waste container distance from the building, the mitigated dose consequences (for outside Building TA-50-69) for a PC-3 seismic event are concluded to be as follows:

Table 3-18. Mitigated Dose for Seismic and Fire

	Seismic and Fire -- Mitigated Dose to MEOI (rem)*						
Case No.	**Seismic Spill Outside**	**Post-Seismic Fire Outside**	**Total Outside Dose**	**Seismic Spill Inside**	**Post-Seismic Fire Inside**	**Total Inside Dose**	**Total Dose**
1	0	0	0	0	0	0	0
2	0	0	0	0.28	2.8	3.11	3.11
3	0	0	0	0.28	2.8	3.11	3.11

*Mitigated *outside* dose consequences via SC-SAC for waste container staging and SC-DF for drum confinement and integrity.

For a PC-2 seismic event, the mitigated consequences inside the building are zero since the building, WCG, and drums can all withstand a PC-2 event. However, the data shows that even with a > PC-2 event, given the SC-SAC for waste container staging and SC-DF for drum confinement and integrity, the dose from seismic impact and postseismic fire originating from inside Building TA-50-69 does not challenge the EG, so further SC controls are not required. This means that the Building TA-50-69 structure does not need to be considered SC for structural failure events; SS categorization from the HA is sufficient. For SS structures, DOE-STD-1020 (DOE 2002b states that the design requirement is PC-2, which Building TA-50-69 and the WCG meet for seismic, wind, and snow loading.

This accident scenario results in the identification of SC controls for the 7.0-rem dose consequence for the outside seismic and fire scenario. The difference between challenging and not challenging the EG is primarily based on the layers of conservatisms in the available ARF/RF applied to the ST calculations for the two different cases. The seismic and fire source term analysis for the postseismic fire event utilizes empirical data from DOE-HDBK-3010-94 (DOE 2000b) that allows for the selection of an ARF/RF (1E-3/1) for the impact spill and fire event which considers lack of air flow around the exposed waste contents, consistent with what is expected for waste contents buried under building debris from a seismic event. In comparison, the ARF/RF (1E-2/1) selected for the WCG fire is judged overly conservative, since it *"reflects experimental data which was limited by the space available and tended to be very small (with respect to what is anticipated in facilities),"* and so did *"not provide the depth of burn-residue that could attenuate airborne release from large piles of material. The radionuclides (such as*

plutonium solutions) were freshly applied and emphasized the goal of maximizing release. The experimental configuration did not allow the contaminant material to attain the degree of adhesion and packing expected for real stored wastes. Accordingly, the values may be very conservative for most, if not all, applications" (DOE-HDBK-3010-94, pg 5-14). Finally, the selected ARF/RF for the WCG fire represents a situation where highly contaminated materials are uncontained, which is not the case at WCRRF because the waste material will be inside a glovebox with burned-out gloves. Finally, no LPF reduction was applied to the WCG Operational Fire. In an actual event, even without considering the ventilation system, the structure would provide mitigation through an LPF. **Summary of TSR Controls**

The SC controls listed in Table 3-19 prevent or mitigate the potential dose, reduce the likelihood of the accident scenario, or protect the assumptions of this analysis. Other controls that have been specifically identified for collocated worker and worker protection and defense-in-depth are listed in the HA (Section 3.3 and Appendix 3A).

Table 3-19. Summary of SC TSR Controls for Seismic Event and Fire (Spill and Fire)

Abbreviated Description	Credited Control for AA / HA Scenarios	Level	Safety Function
TRU Waste Containers (when outside TA-50-69)	HSI-12 HSO-23	SC-DF	Provide primary confinement for TRU waste. Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents. Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents. Prevent accumulation of flammable gases inside the TRU waste containers.
Transportainer Placement	HSI-12 HSO-23	SC-SAC	Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.
Inventory Limits	All (Initial Condition)	SC-SAC	The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated (see Section 3.4).

3.4.2.7 Wildfire (NPH)

The AA for this scenario is carrying forth the HA scenario HSO-14 ("Wildfire adjacent to site. Grass/brush fire in fields impacts TRU waste containers."). This accident scenario involves a fire accident initiated by a brush or wildfire that spreads to the WCRRF and impacts the waste containers staged inside the transportainer.

3.4.2.7.1 Scenario Development

An open grass field (environmental restoration site) is located immediately east (next to the fence line) of the transportainer. This scenario postulates that a brush fire occurs in this field and propagates to the transportainer due to operational, external, or natural phenomena initiating events. Operational initiating events include vehicle-related incidents (e.g., misfiring, fuel leaks) or events caused by human ignition sources. External initiating events

are events that are initiated by activities external to the facility operations and that occur outside the WCRRF boundaries (e.g., forest fires that propagate to the environmental restoration area). The most likely natural phenomenon initiating the event is lightning. The accident analysis assumes that the amount of brush or vegetation has grown out of control. The open grass field is close to the WCRRF staging area, and transient combustibles are staged between the field and the transportainer. The postulated wildfire impinges on the TRU waste containers. All of the site inventory (1800 PE-Ci) is involved in this accident.

The wildfire is postulated to be similar if not the same as the DBA in Section 3.4.2.1, *Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire)* in that the (combustible) wildfire impinging on the waste containers would cause lid seal failure, and containerized burning of the combustible waste.

3.4.2.7.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR × ARF × RF × LPF).

MAR: The entire inventory allowed to be staged outside Building TA-50-69 (i.e., 1800 PE-Ci) is the MAR considered in the accident scenario.

DR: A DR =1 is postulated for this accident. All drums are considered to experience lid seal failure.

ARF/RF: The ARF/RF for combustible waste that remains in the drum and burns within the drum is 5E-4/1.0 (DOE 2000b, pg. 5-1 and 5-13; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]). This ARF/RF for combustible waste bounds the ARF/RF for noncombustible waste (6E-3/0.01) and is used in the source term analysis (these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]).

LPF: The leak path factor (LPF) is 1.0 for accident scenarios which occur outside the facility.

ST: The ST for waste contents that burn in the drum:

ST = 1,800 × 1.0 × 5E-4 × 1 × 1 = 0.9 PE-Ci

3.4.2.7.3 Consequence Analysis

The public and collocated worker DSF values used, are 3.54 and 33.3 rem/PE-Ci

Dose (public)= 0.9 PE-Ci × 3.54 rem/PE-Ci = 3.2 rem

Dose (CW) = 0.9 PE-Ci × 33.3 rem/PE-Ci = 30.0 rem

3.4.2.7.4 Comparison to Guidelines

The dose to the MEOI for this postulated accident scenario does not challenge the EG of 25 rem, and is in fact considered conservative, since it presumes all drums experience seal failure. Although the collocated worker dose does not exceed the 100 rem threshold for collocated workers, the selection of SS controls for collocated worker and worker protection and defense-in-depth is warranted, and is discussed in the HA.

3.4.2.7.5 Summary of TSR Controls

The consequences of this scenario do not challenge the EG; therefore, there are no SC controls identified or selected to mitigate consequences to the MEOI. The control function of the safety-significant-level controls is listed in the Hazard Analysis, Section 3.3.

3.4.2.8 Lightning Strike and Fire (NPH)

Lightning in Los Alamos can be frequent and intense during some thunderstorms. Because lightning can cause occasional brief power outages, lightning protection is an important design factor for most facilities at LANL.

The following HA events are considered in this section: HSO-17: Lightning strike impacts site (e.g., staging area), causing fire; HSI-10: Lightning strike impacts Building TA-50-69, causing fire.

3.4.2.8.1 Scenario Development

This scenario presents an estimate of the lightning strike frequency at the WCRRF. It uses the following process to develop these estimates.

1. Establish the number of lightning strikes to the ground per unit area per year for the Los Alamos area; and
2. Calculate the total attractive strike area and the lightning strike frequency for the WCRRF (i.e., Building TA-50-69).

These two steps are described and developed in Appendix 3C. It was determined that 6 strikes per year per km^2 is an appropriate estimate of the lightning strike impact frequency at LANL. The total attractive strike area was also developed in Appendix 3C for Building TA-50-69. Based on these values, the total lightning strike frequency for Building TA-50-69 is estimated to be 0.14 strikes per year. This is well above the 1E-6 threshold for which external events must be analyzed.

There are several variations of this scenario, depending on exactly where at the WCRRF the lightning actually strikes. The lightning could strike the ground in the near vicinity of the facility, or could actually hit Building TA-50-69. The results can vary as well. The lightning strike could initiate a fire or result in physical damage to the structure (or other items) without starting a fire.

3.4.2.8.2 Unmitigated Source Term Analysis

As explained previously, the results of a lightning strike could be physical damage, a fire, or both. Therefore, the lightning strike is an initiator of, or bounded by, several other DBAs evaluated in this BIO.

An outside strike could result in a wildfire near the facility, or a fire that involves other combustibles in the vicinity of staged material in the transportainers. These are the subjects of the scenarios evaluated in Sections 3.4.2.7 and 3.4.2.1, respectively. The ST would be no different for each of these fires, as the only difference would be that they are initiated by a lightning strike. Similarly, a building fire resulting from a lightning strike would be subject to, and bounded by, the same ST developed in Section 3.4.2.3 of this BIO. Section 3.4.2.3 evaluates building and glovebox fires at TA-50-69.

A lightning strike to the facility could result in damage that might ultimately impact staged material (inside or outside), either with or without a subsequent fire. However, the damage that might occur is bounded by that postulated inside building TA-50-69 in Section 3.4.2.3, *Operational Fires Inside of Building TA-50-69 (Fire)* of this BIO, as is the associated ST.

While the lightning strike is a unique initiator, the release mechanisms are the same as those for the aforementioned scenarios that have each been evaluated separately. Therefore, the maximum MAR limits, and the ARFs/RFs for each of those scenarios, also apply to these postulated lightning-induced scenarios. In the unmitigated case, the LPF and DR are taken to be 1, as was done for each of the other accidents. As a result, the STs for all the various lightning-induced scenarios that may be postulated are no different from what was evaluated previously.

3.4.2.8.3 Consequence Analysis

As described above, in the source term analysis, the other DBA scenarios evaluated in this BIO bound all the possible dose consequences that might result from lightning-induced scenarios. Of the *non-lightning* scenarios mentioned above, the highest potential MEOI dose that could result is 28.3 rem (*Inside Building Fire involving WCG* – Case 2 of Section 3.4.2.3, *Operational Fires Inside of Building TA-50-69 [Fire]*). The collocated worker dose for this scenario is greater than 100 rem. These doses were the result of uncontained burning within the WCG and are therefore appropriate for a lightning strike at WCRRF.

3.4.2.8.4 Comparison to Guidelines

The releases from the building fire, initiated by a lightning strike, yield a conservatively calculated dose that exceeds the EG of 25 rem to the MEOI, and a safety-class control is required.. The dose to the collocated worker exceeds the threshold value of 100 rem. Therefore, the selection of SS controls for collocated worker and worker protection and defense-in-depth is also warranted and is discussed in the HA.

3.4.2.8.5 Summary of TSR Controls

As for the WCG fire scenario, the combustible and flammable material control limit is selected as the safety-class control for this accident scenario. The control functions of the safety-significant-level controls are listed in, Section 3.3, Table 3-12, and in the HA tables in Appendix 3A.

3.4.2.9 Aircraft Crash (External Event)

The following accident scenario is addressed in this section:

- **HSO-24**: Aircraft crashes into building and waste staging area, with ensuing fire.

3.4.2.9.1 Scenario Development

If the MAR were staged both inside and outside the building, the aircraft could not directly impact both locations. It would be possible for a crash into the building to cause a fuel fire that would propagate to the outside drums, or vice versa. However, the worst-case configuration for this event is when all the MAR (assuming the maximum allowable site inventory of 1,800 PE-Ci) is located outside. The postulated scenario is an aircraft crash directly into the containers staged outside, breaching and spilling every container and initiating a fuel fire.

Appendix 3E determines the aircraft crash frequency into the WCRRF is 2.85E-06 per year, based on the methodology of DOE-STD-3014 (DOE 2006b). As indicated in that standard, this event must be evaluated because the frequency is greater than 1E–06 per year. According to DOE-STD-3014, when the probability threshold is exceeded, structural response to general aviation impacts should be evaluated. Given that the construction of the WCRRF (the roofing consists of a fire-retardant, 4-ply membrane roofing with bitumen and gravel), aircraft impacts are expected to penetrate the walls and roof of the WCRRF. Due to the energy that may be imparted during an aircraft crash (and subsequent fuel fire), it is postulated that all of the waste inside the staged containers would be affected.

No safety controls present at the WCRRF can reduce the likelihood or mitigate the consequences of this accident.

3.4.2.9.2 Unmitigated Source Term Analysis

Section 3.4.1.1, *Scenario Development,* discussed the use of the five-factor formula to determine the ST for this accident scenario (ST = MAR × DR ×ARF × RF × LPF).

MAR: Assuming the maximum allowable site inventory, the MAR = 1800 PE-Ci.

DR: Assuming that the aircraft crash impacts and breaches all containers, spilling all the waste material, the DR=1.0.

ARF/RF: The waste material is assumed to first spill from the containers and then burn uncontained on the ground. The ARF/RF for this scenario are 1E-03/0.1 (DOE 2000b, pg. 4-87; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]) for the spill release that is subjected to shock and impact during the spill and 1E-2/1.0 (DOE 2000b, pg. 5-15; these values are also consistent with source term parameters found in DOE-STD-5506-2007 [DOE 2007]) for the uncontained burn release.

LPF: This accident is evaluated to occur outside and the drums are assumed to breach. Therefore, an LPF of 1.0 is assumed.

ST: Separate STs are calculated for the release from the spill from the initial impact and for the release from the resulting fire. Different DSF ratios apply to each of these release components. The STs are as follows:

$$ST_{spill} = 1800 \text{ PE-Ci} \times 1.0 \times 1E{-}03 \times 0.1 \times 1.0 = 0.18 \text{ PE-Ci}$$

$$ST_{burn} = (1800 - (1800 \times 1E{-}03 \times 0.1)) \text{ PE-Ci} \times 1.0 \times 1E{-}02 \times 1.0 \times 1.0 = 18 \text{ PE-Ci}$$

Note that, although the effect is small, the quantity of radioactive material that is driven airborne from the initial impact is subtracted from the amount that is available for the fire. There are no controls at the WCRRF that can effectively prevent or mitigate the postulated scenario. Therefore, no mitigated version of this accident will be presented.

3.4.2.9.3 Consequence Analysis

Based on a public DSF of 3.54 rem/PE-Ci and a collocated worker DSF of 504.5 rem/PE-Ci for a nonbuoyant spill, and a collocated worker DSF of 33.3 rem/PE-Ci (DOE 1998) for a smoldering fire, the unmitigated consequences of this accident are 64.3 rem for the public and 690.7 rem for the collocated worker.

For comparison, if lofting of the plume from a 10-MW fire is assumed for the burning aircraft fuel, the public consequences of this accident total 9.1 rem. Total dose to the collocated worker is 142.9 rem.

3.4.2.9.4 Comparison to Guidelines

The dose consequence to the MEOI challenges or exceeds the EG. The following section describes controls that were considered for the prevention or mitigation of the consequences of this event.

3.4.2.9.5 Summary of TSR Controls

The combined consequences of the spill and fire-related components of this accident exceed the evaluation guidelines. The preferred control would be prevention of the aircraft impact, eliminating both the spill and fire-related dose components. The airspace over the WCRRF facility is already restricted, so there is no additional control that is more likely to prevent a pilot error or aircraft malfunction leading to a crash. If the extremely unlikely crash cannot be prevented, the potential controls can only seek to limit the effect of the impact and/or the aviation fuel spill and fire. The following controls were considered:

- Erection of a containment structure robust enough to (1) resist penetration by a crashing or skidding aircraft and (2) withstand a resulting aviation fuel pool fire is the only control that could fully mitigate the effects of an aircraft crash. Design and construction of such a structure to fully enclose the existing facility and operations is not considered fiscally or operationally feasible for a limited-life facility.
- Installation of berms or dikes sufficient to impede the flow of burning aviation fuel from one area to another could decrease the amount of MAR affected by a pool fire, but may also increase the likelihood of low-consequence material spills due to drops or impacts while moving waste containers during normal operation, and is not proposed.
- Installation of additional robust barriers (such as the vehicle barriers already in place) around the site perimeter could reduce the impact energy from an aircraft crashing near the edge of the site and skidding into the stored containers, but would offer no benefit for a direct strike, and is not proposed.
- A significant reduction in allowable MAR inventory could reduce the spill- and fire-related consequences of this unlikely event, but is not operationally feasible, given the short time frame for completion of the facility mission.
- Segregation of the TRU waste in widely separated, multiple transportainers and within Building TA-50-69 may limit the amount of MAR that is acted upon during an aircraft impact, depending on the angle and speed of impact, such that only the building or only one transportainer is impacted. However, the WCRRF site is not large enough to efficiently allow a separation distance in excess of 60 ft (the assumed skid distance and wing span of a general aviation aircraft) between transportainers. Putting in place a segregation control on inventory placement would be of low reliability, could not be defendably credited with reducing the amount of material at risk in the aircraft crash and fire consequence analysis, and is not proposed.

Although no controls can be implemented at the WCRRF to reduce the risk of an aircraft impact to the WCRRF from what was evaluated, the assumption of the maximum facility inventory is a key assumption to this analysis. The site inventory limit ensures that the consequences are limited to what has been considered in this evaluation. The initial low probability of an airplane crash provides the sole risk limiting factor. LANL has institutional restrictions on aircraft overflights that are accounted for in the frequency estimates discussed in Section 3.4.2.9.1. Safety management programs, especially the Emergency Response Program, would undoubtedly mitigate the consequences of an aircraft crash to a certain degree. There are no other preventative controls or mitigative controls reasonably available to the WCRRF to protect against the effects of an aircraft crash. Since the probability

of an aircraft crash at the WCRRF is very near the 1E-6 threshold, beyond which external events do not have to be evaluated in the Accident Analysis, acceptance of the overall risk associated with this accident is recommended.

3.4.3 Beyond Design Basis Accidents

Accident scenarios beyond the evaluation basis of the facility need to be considered to gain a perspective on the residual risk associated with the facility operation. These beyond DBAs do not have to be evaluated to the detail provided in the AA sections. However, the evaluation must be sufficient to determine the magnitude of their consequences.

There are no accident scenarios that could cause a significant increase in potential incremental risks beyond those already evaluated in the AA. The dose consequence analysis for a seismic and fire event assumes that the maximum allowable facility inventory is impacted, spilled, and burns in an uncontained manner. This scenario produces the highest ST possible for an accident at the WCRRF. The resulting dose consequence would not be increased by any more severe accident conditions or additional equipment failures. The worst-case configuration for this event is when the entire inventory (assuming the maximum allowable site inventory) is located outside, which is the case for the postulated seismic and fire accident scenarios. The accidents analyzed in Section 3.4.2 include bounding scenarios for the inventory quantities assumed in the analysis and the energy sources that will be present at the WCRRF for the operations described in this BIO. Beyond DBA scenarios will not result in dose consequences greater than those calculated for the bounding scenarios in Section 3.4.2.

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APPENDIX 3A

Hazards Analysis Tables

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3A.1 INTRODUCTION

This appendix presents a summary of the Hazards Analysis (HA) methodology and the detailed HA tables that were developed for Los Alamos National Laboratory (LANL)'s Waste Characterization, Reduction, and Repackaging Facility (WCRRF). The primary mission of WCRRF operations is to characterize transuranic (TRU) wastes using invasive and noninvasive processes. The TRU waste is the primary hazard at the WCRRF. The WCRRF includes both the outside area where TRU waste containers are stored in transportainers, and the inside of Building TA-50-69, where repackaging and remediation activities in the Waste Characterization Glovebox occur.

Personnel participating in the hazards analysis included personnel from the WCRRF waste handling and facility operations organization, the radiological control organization, nuclear safety, system engineers, and consultants with experience in TRU waste processing. As part of the unmitigated hazards analysis, events requiring mitigation and further quantitative Accident Analysis (AA) are identified. Potential preventive and mitigative features that are candidates for control selection are also identified. In the AA and mitigated hazard evaluation, those events requiring further analysis are quantitatively or qualitatively analyzed as appropriate, and, ultimately, the controls are selected for protection of the public, collocated workers, and workers. A summary of the information developed in this appendix is presented in Section 3.3.1 of Chapter 3.

A team of safety analysts with backgrounds in fire protection engineering, nuclear engineering, health physics, mechanical engineering, and other related technical disciplines performed the HA. Facility and operations personnel participated in each step of the HA process. The analysts and personnel held meetings on a regular basis to discuss background information, identify hazards, develop potential accident scenarios, and review and evaluate safety controls. The meetings enabled facility and operations personnel to actually participate in the analysis, not just to review the end products.

NOTE: Significant information is presented in Appendix 3A regarding the glovebox enclosure (GBE). At this time, the GBE will not be used (or required) to stage or process TRU waste containers. The information regarding the GBE is retained in Appendix 3A because of the contamination present in the GBE and the communication between the GBE and waste characterization glovebox (WCG) operations ventilation systems. The GBE will also be a part of routine surveillance and maintenance (S&M) activities associated with Building TA-50-69.

3A.2 HAZARDS ANALYSIS METHODOLOGY

A brief summary of the HA methodology is presented in this Appendix. The detailed HA methodology is presented in Chapter 3. Hazards analysis provides a comprehensive assessment of facility hazards and accident scenarios that could produce undesirable consequences for workers and the public. Hazards analysis is divided into three main parts: (1) Hazard identification (ID) of the potential hazards associated with the WCRRF waste handling operations; (2) an unmitigated hazard evaluation; and (3) a mitigated hazard evaluation. The Hazard ID and unmitigated hazard evaluation present a comprehensive evaluation of potential process-related, natural events, and man-made external hazards that can affect the public, workers, and the environment.

3A.2.1 Hazard Identification

Hazard ID involves identifying all facility and process hazards and energy sources. Hazard ID is a comprehensive, systematic process by which all known facility hazards (hazardous materials and energy) are identified, recorded, and screened. Hazard ID for the WCRRF was divided into three steps: (1) division of the facility into *facility sections*, (2) facility walkdowns, and (3) screening for Standard Industrial Hazards (SIHs).

Division of the Facility—The facility is divided or grouped into *sections* to facilitate Hazard ID and evaluation. These sections may be individual unit operations, individual or grouped facility systems, specific functions, or physical boundaries inside the facility. The term *facility section* is used in the HA process to distinguish from *facility segments* as defined in DOE-STD-1027-92.

Facility Walkdowns—Facility walkdowns include both physical walkdowns and informational walkdowns to identify hazardous materials and energy sources for each facility section. Physical walkdowns permit first-hand familiarization with actual facility systems, processes, practices, equipment, and inventory. The informational walkdown includes a review of available documents such as the facility description, inventory, existing safety documentation [e.g., Fire Hazards Analyses (FHAs)], and consultations with facility system and process experts.

As part of the information-gathering process, an inventory list is developed to identify all known radiological and chemical hazards. The inventory includes the material quantity, location, form, and other pertinent information regarding the material (e.g., concentration). Additional hazards that are a byproduct of the process, or that are due to potential chemical interactions, are identified. A Hazard ID Table (see Table 3-1 in Chapter 3) is a useful aid in conducting Hazard ID and lists generic facility hazards.

Screening of SIHs—After the hazards and energy sources are identified, the hazards analysis team determines whether any potential hazards can be screened from further consideration. Insignificant, or common, everyday hazards are not addressed in this HA. Examples of hazards common to everyday activities include trips and falls while walking or climbing stairs. The SIHs are defined as hazard sources (material or energy) or events that involve hazards that are routinely encountered by the general public or in general industry and construction, and for which national consensus codes or standards exist to govern handling or use without the need for special analysis to define safety design and operational parameters. These types of hazards were carried forward only if they can lead to additional consequences. If there was uncertainty as to whether a hazard should be screened, it was carried forward to be evaluated more thoroughly. Hazards screened from further consideration are identified in the *Process or Area* column of the Hazard ID table (see Table 3-1 in Chapter 3).

3A.2.2 Unmitigated Hazard Evaluation

The unmitigated hazard evaluation follows the Hazard ID process described in Chapter 3. The purpose of the unmitigated hazard evaluation is to ensure a comprehensive assessment of facility hazards and to focus attention on those events that pose the greatest risk to the public, collocated workers, and workers. Event categorization, identification of event causes, assignment of event frequency and unmitigated consequence level, and identification of potential mitigative and preventive features are tasks performed during the unmitigated hazard evaluation.

Using the Hazard ID as a basis, What-If scenarios are postulated without regard for frequency or consequence. These scenarios are evaluated preliminarily to determine the *scenarios of interest* requiring further evaluation. For each hazard, the team reviewed a list of standard accident types such as fire, spill, explosion, criticality, direct exposure, external event, and natural phenomena, and developed possible accident scenarios. Each postulated accident scenario was assigned a number and listed on a simple What-If Analysis form with the hazard, accident type, initiating event, and the accident scenario description (see Table 3-2 in Chapter 3). The last column on the What-if form is used to document those scenarios that were identified as scenarios of interest. For scenarios not identified as such, the basis of this determination is provided in the Notes column.

From the What-if analysis, a separate hazard evaluation table is developed for each facility section. The HA tables are used to capture information relating to both the unmitigated hazard evaluation and the subsequent mitigated hazard evaluation. Events in the HA tables are numbered to provide each with a unique mnemonic sequential reference. The event numbering follows a simple mnemonic sequence based on the facility sections. Haa-## is the format for the unique accident scenario identification number. The *H* indicates that the scenario is a Hazard Analysis scenario (not a What-If Analysis scenario). The H is followed by a two-letter designation, such as *GB* for glovebox. The two-letter designation refers to the What-If table event that prompted the detailed hazard analysis.

Events in the HA tables are categorized according to the nature of the event, with the exception of events initiated by External Events or Natural Phenomena Hazards (NPHs). The event description includes a description of the event (including event progression information) and the release mechanism (e.g., fire, pressurized release, spill, etc.) or other consequence mechanism (e.g., direct exposure). Causes are identified to support frequency evaluation.

Existing controls that the HA team determined can be effective in preventing or mitigating the accident are comprehensively listed in the HA tables. A √ denotes controls that are judged to give the most effective reduction of the frequency or consequence category. *Uncontrolled* means that the scenario frequency and consequences are unmitigated, while *Controlled/Residual Risk* is the risk level determined after taking appropriate credit for the listed or any common controls.

Unmitigated and mitigated frequency estimates are provided as an important step in identifying controls important to safety. Table 3A-1 identifies the frequency bins that were used in the hazard analysis.

Table 3A-1. Qualitative Frequency Bins

Frequency	Descriptor	Description
I (10^{-1}/yr to10^{-2}/yr)	**ANTICIPATED (A)**	**Likely to occur often to several times during the life of the facility.** (Incidents that may occur during the lifetime of the facility; these are incidents with a mean expected likelihood of once in 50 years)
II (10^{-2}/yr to 10^{-4}/yr)	**UNLIKELY (U)**	**Should not occur during the life of the facility.** (Incidents that are not anticipated to occur during the lifetime of the facility but could; these are incidents having a likelihood of between once in 100 years to 10,000 operating years)
III (10^{-4}/yr to 10^{-6}/yr)	**EXTREMELY UNLIKELY (EU)**	**Unlikely but possible to occur during the life of the facility.** (Incidents that will probably not occur during the lifetime of the facility; these are incidents having a likelihood of between once in 10,000 years and once in a million years)
IV (Below 10^{-6}/yr)	**BEYOND EXTREMELY UNLIKELY (BEU)**	**Should not occur during the life of the facility.** (All other incidents having a likelihood of less than once in 1,000,000 operating years)

The unmitigated frequency estimates do not take credit for safety controls that could lower the frequency. These estimates are based on an interpretation of *unmitigated* to mean that no special safety controls are implemented above and beyond standard industrial practices, and do not credit many of the Laboratory's institutional procedures.

The controlled or mitigated frequency is based on how the controls lower the scenario frequency by reducing either the initiator frequency or the enabling event frequency. In the earthquake scenario example, controls cannot lower the frequency of the postulated initiating event, the earthquake; but if electrical equipment is designed to withstand the earthquake, or if there are no combustibles present to support a fire, then the frequency estimate for this enabling event and the subsequent fire would be lower. Thus, the overall scenario frequency would be lower.

As with the frequency categories, quantitative consequence severity categories are assigned to each of the postulated accident scenarios. These consequence severity categories are qualitatively assessed and consider radiological factors such as inventory, material form, and energy of release; toxic factors include toxicity, inventory, and volatility.

Consequence Categories for the Public, Collocated Worker, and Worker: Table 3A-2 identifies the consequence categories for the public, collocated worker, and worker used to assess the various consequence categories for the postulated accident scenarios.

Table 3A-2. Consequence Levels and Risk Evaluation Guidelines

Consequence Level (Abbreviation)	Public (P)	Collocated Worker (CW) (at 100 m)	Worker (W) (Involved worker within facility boundary)
High (H)	Considerable offsite impact on people or the environs. CHALLENGE 25 rem EG *	Significant onsite impact on people or the environs. > 100 rem TED	For SS designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, must be considered.
Moderate (M)	Only minor offsite impact on people or the environs. ≥ 1 rem TED	Considerable onsite impact on people or the environs. ≥ 25 rem TED	No distinguishable threshold
Low (L)	Negligible offsite impact on people or the environs. < 1 rem TED	Minor onsite impact on people or the environs. < 25 rem TED	No distinguishable threshold

* Per DOE-STD-3009, the EG for the public is 25 rem. As stated in Section 6.3 of DOE-STD5506, a public dose greater than 10 rem should be considered sufficient to *challenge* the EG.

Although the hazard analysis is mostly a qualitative process, the radiological consequences (doses) to the public are estimated using a simplified quantitative determination. The dose to the maximally exposed off-site individual (MEOI) and the collocated worker for each postulated accident scenario is estimated by the product of the source term and the dose-to-source-term ratio. To estimate the consequence category, these parameters are conservatively estimated using simplifying assumptions. For the limiting and representative accident scenarios that are carried forward into the accident analysis (Section 3.4), the dose consequences to the public and collocated worker will be calculated more precisely based on detailed scenario development and quantitative models of the physical phenomena.

For some accident scenarios, it is expected that the dose consequence analysis in Section 3.4 will result in calculated doses that are less than the consequence category assigned in this hazard analysis. These apparent differences are a result of the conservative simplifying assumptions used herein. These situations are expected and will not invalidate the results of the hazard analysis.

Quantitative methodology exists for estimating the public and collocated worker consequences for radiological releases. There have been attempts to provide similar guidance for calculating worker consequences; however, this guidance is limited in value. Senior analysts recognize the difficulty and, too often, the errors in calculating worker consequences. A qualitative assessment by the safety analysts and operational team members of worker consequences is considered much more appropriate than calculations. The predominant exposure pathways for workers from accidents involving TRU waste handling activities are direct exposure to external penetrating radiation or inhalation of airborne radioactive material generated during release events. The radiogenic health effects associated with TRU waste are due primarily to alpha and gamma radiation. External exposure to plutonium poses very little health risk, since plutonium isotopes emit alpha radiation, and almost no beta or gamma radiation. Because of the emission of alpha particles, the WCRRF waste streams pose a significant risk if sufficient quantities are swallowed or inhaled.

Plutonium and other TRU radionuclides that are absorbed from the lungs deposit into the bones, liver, and other body organs. Plutonium that reaches body organs is retained in the body for decades and continues to expose the surrounding tissue to radiation. This may eventually increase a person's chance of developing cancer.

Based on the application of a graded approach (DOE-STD-3009, Chapter 3, pp. 26-27) (DOE 2006), and on the definition of SS-SSCs (pg. xxii, DOE 2006), it is apparent that only qualitative evaluation of the unmitigated consequences to the worker is appropriate. Based on the inventory limits in place at the WCRRF (i.e., 1,800 PE-Ci total site and 800 PE-Ci inside Building TA-50-69), some slowly evolving events that would allow time to flee from the immediate area are qualitatively judged to have Moderate to Low consequence to the worker. However, most events that are quantitatively determined to have High consequences to the collocated worker would, by inference, also result in High consequences to the worker.

The HA team also estimated a High consequence category for workers from accidents involving direct exposure or criticality events. A High consequence was assumed for deflagrations, where severe physical injury is a potential.

After developing frequency and consequence estimates, the risk rank of each scenario is determined using the matrix given in Table 3A-3, and then listed in the HA tables. The risk rank is listed for the Public, Collocated Worker, and Workers, for both the uncontrolled and controlled cases.

Table 3A-3. Qualitative Risk Ranking Bins

Consequence Level	BeyondExtremely Unlikely (BEU) Below 10^{-6}/yr	Extremely Unlikely (EU) 10^{-4} to 10^{-6}/yr	Unlikely (U) 10^{-2} to $10^{-4/}$yr	Anticipated (A) 10^{-1} to 10^{-2}/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	II
Low Consequence	IV	IV	III	III

[1] **Industrial events that are not initiators or contributors to postulated events are addressed as SIHs.**

3A.2.3 Mitigated Hazard Evaluation

Any events with risk to the public, collocated worker, or worker that fall in Risk Ranks I or II are considered for further qualitative evaluation and control identification. Worker events that fall in Risk Rank III are generally protected by Safety Management Programs (SMPs), but are considered on an individual basis by the HA Team. The control features that are most significant in reducing the scenario frequency were noted in the HA tables (√) to identify those controls that are major contributors to defense-in-depth. The amount of frequency reduction is based on the individual control and evaluated as such. For determining the amount of *credit* given to a control, the following general guidance was used as a starting point:

- Specific Administrative Controls (SACs) may reduce the scenario frequency by one or more bins, if technically justified..
- Engineering controls that have surveillance requirements or are passive may reduce the frequency by a factor of 100 (one frequency bin), unless specific data available for the control indicates otherwise.
- The accident scenario frequencies are qualitative and based primarily on engineering judgment. When available, site-specific data may be used if it provides added insight.

The same logic may be applied in determining the effect of mitigative controls, assuming that a decrease in consequence bin is equivalent to a decrease in two orders of magnitude in frequency. The actual amount of consequence reduction is based on the effectiveness of the individual SAC or engineered control and evaluated as such..

NOTE: In the context of Chapters 4 and 5, those administrative controls that are not specific (i.e., not designated as SAC), but are important in the HA, are selected as programmatic controls, with the attributed programmatic elements discussed. These programmatic controls typically provide significant Defense-in-Depth (DID). A unique characteristic of the programmatic AC is that a single failure of the control does not affect the quantified frequency or consequences or the conclusions of the Safety Analysis, and would not warrant a Technical Safety Requirements (TSR) violation. Those SMPs that form the foundation of ISMS and result in effective operation of the facility are given general credit in the

programmatic AC in accordance with the requirements of these programs. The logic for the selection of individual controls is derived from this HA, with additional discussion in Chapters 4 and 5.

3A.3 HAZARDS ANALYSIS RESULTS

3A.3.1 Hazard Identification

Facility Sections: The processes and activities were subdivided into sections to provide a more manageable set of information and activities. For the purpose of Hazards Analysis, the operations at WCRRF were first divided into (1) those inside Building TA-50-69, and (2) those outside Building TA-50-69.

The second grouping was by process. The major processes performed at the facility were identified and are listed in the first column of Table 3A-4. Then, as mentioned in Section 3.3.1.2, specific activities were linked to these processes. The specific activities performed at the WCRRF are listed in the heading row of Table 3A-4.

Table 3A-4. Processes Correlated to Worker Activities

Activity / Process	Stage Waste Containers	Handle Waste Containers	Bag In/ Bag Out	Open/Close Waste Container	Unpack/ Repack	Process Activities
Receipt/Shipping	X	X				
Staging/Handling	X	X				
Visual Examination	X	X	X	X	X	X
Repackaging	X	X	X	X	X	X
Remediation	X	X	X	X	X	X
Miscellaneous Operations (decon and secondary waste)	X	X		X	X	X

The processes and activities listed in Table 3A-4 were examined further to determine how to organize the Hazard ID and What-If Analysis in an efficient manner. As a result, the analysis was organized using the following sets of general operations identifiers:

Outside Operations		Inside Operations	
Staging Outside	SO	Staging Inside	SI
Handling Outside	HO	Handling Inside	HI
		Waste Characterization Glovebox Operations	GB
		Glovebox Enclosure S&M	GE

Accident scenario development in the What-If Analysis followed this organization, with the two-character designations used as the scenario identification numbers. Waste container staging and handling were assessed for both locations because of differences in the safety controls and Material-at-Risk (MAR) at the two locations. In instances where sectioned processes share common equipment, such as in the waste characterization glovebox (GB) and glovebox enclosure (GE) ventilation systems, the processes were grouped together for evaluation.

Facility Walkdowns

Major hazards present at the WCRRF are described in this section. For some hazards (e.g., radiological materials), additional data (beyond that provided on the hazard identification checklists) are presented to provide more detailed descriptions. Then the hazards are evaluated against the screening criteria presented in Section 3.3.1 to eliminate less significant hazards from further consideration. For each hazard considered less significant, and thus screened out from further analysis, an appropriate explanation is provided to justify the screening.

To remove repetitiveness between the text of the BIO (e.g., Chapter 3), other appendices, and this appendix, only select information regarding the radiological and chemical inventories is presented below. The Hazard ID checklists themselves are presented in conjunction with the What-if and hazard evaluation tables at the end of this appendix.

Radioactive Materials

A review of the PE-Ci content of the TRU waste containers provides the following analysis assumptions.

- The highest content container (in terms of PE-Ci) is slightly below the WCRRF Building (TA-50-69) administrative limit of 800 PE-Ci which is based on a combination of combustible and non-combustible waste forms. (In the accident analysis in Chapter 3 and in the TSRs, this bounding value is converted to an appropriate *equivalent combustible* waste limit. The combustible equivalency is based on the amount of TRU waste (e.g., noncombustible or filter media inventory, etc.) that would result in the same dose consequence as the specified inventory in combustible form in the bounding accident scenario.)

The types of waste in the TRU waste containers are as follows:

- Combustible – laboratory trash, filter waste, plastics, rubber, and other materials specifically identified as combustible

- Dispersible, Noncombustible – metal, glass, concrete, or other noncombustible materials with surface contamination
- Nondispersible, Noncombustible – solidified or process waste with radioactive contaminants distributed uniformly within the carrier material, such as dewatered sludge, slurry, precipitates, and cemented waste

Secondary Radiological Waste

As a by-product of the WCRRF TRU waste operations, small amounts of secondary waste are generated from the radionuclides found in the TRU waste; however, the low radioactivity levels of the secondary waste allow it to be classified as low-level waste (LLW) rather than TRU waste. This LLW is managed under the LANL LLW program. LLW can be present at WCRRF in several types of containers. Examples are described below:

- Low-level secondary waste (e.g., contaminated anti-Cs, contaminated Kimwipes,® etc.) might be found in laundry bags or other standard bags, or in containers typically used for this purpose.

- Other LLW may be packaged inside cardboard boxes lined with plastic and transferred directly to Building TA-50-69. Such boxes are, however, temporary transfer boxes, and the waste will eventually be repackaged into authorized waste containers.

Hazardous Chemicals

Operations at the WCRRF infrequently use a few chemicals in small volumes, primarily for decontamination and routine maintenance. Chemicals such as surfactants, solvents, and lubricants are used in accordance with the Laboratory Chemical Management Program. No chemical processing or chemical research is conducted within the WCRRF, so there is no routine consumption of reagent chemicals.

The TRU waste containers are generally free of significant quantities of hazardous chemicals, and, if present, these chemicals are managed in accordance with the Hazardous and Mixed Waste Program. The following general characterization of the hazardous constituents in the waste accepted for characterization purposes is based on knowledge of the waste-generating processes.

Trace quantities of organic solvents might be present in the solidified aqueous waste that was treated at the Radioactive Liquid Waste Treatment Facility. The solidified sludge also might contain trace amounts of metal hydroxides from the neutralization and precipitation treatment process. Heterogeneous waste forms do not contain spent solvents, but could contain rags with absorbed solvent. Metals regulated by the Resource Conservation and Recovery Act (RCRA) are reported to be in the waste, but are not present in a respirable particulate form. Lead is the predominant metal, but it is present primarily in monolithic form. Other RCRA-regulated metals include cadmium, mercury, chromium, and arsenic; none of these metals is in respirable form. These heavy metals are usually constituents of tool rods, equipment, and metal containers. None of the hazardous waste constituents associated with mixed waste accepted for processing should be of a particulate form or, if subjected to available energy sources, capable of generating a particulate form. Therefore, none of the hazardous chemicals in the TRU waste containers is considered a significant hazard.

3A.3.2 Unmitigated and Hazard Evaluation Results

This section presents the results of the unmitigated and mitigated hazard evaluations in tabular form. Also presented is an expanded basis for the frequency and consequence estimates used in the hazard evaluation.

Bases for Frequency Estimates

This section provides the rationale and nominal values for frequency categories for the accident scenarios evaluated in the hazard analysis tables. Frequency categories are defined in Table 3A-1. The unmitigated frequency estimates do not take credit for safety controls that could lower the frequency. These estimates are based on an interpretation of *unmitigated* to be no special safety controls implemented above and beyond standard industrial practices. These frequency estimates do not credit LANL's institutional procedures.

The frequency of an accident scenario is a function of the frequency of the initiating event and the frequency of enabling events. Enabling events are those events that must occur following the initiating event to cause the postulated accident. For example, in the scenario of an earthquake resulting in a fire in a building, the initiating event is the earthquake and an enabling event could be some type of electrical equipment failure that starts the fire. Unmitigated frequency estimates for accident scenarios are generally taken to be the frequency of the initiating event only, with the probability of the enabling event assumed to be 1.0, i.e., the event happens. The unmitigated frequency estimate would typically be the frequency of the earthquake. However, under certain circumstances, where the probability of the enabling event is clearly less than 1.0, the overall scenario frequency estimate could be less than the initiating event frequency.

The controlled or mitigated frequency is based on how the controls lower the scenario frequency by reducing either the initiator frequency or the enabling event frequency, or both. In the earthquake scenario example, controls cannot lower the frequency of the postulated initiating event, the earthquake; but if electrical equipment is designed to withstand the earthquake, or if there are no combustibles present to support a fire, then the frequency estimate for this enabling event would be lower. Thus, the overall scenario frequency would be lower.

Frequency estimates for specific types of accident scenarios are based on the general concepts described in the following paragraphs. Frequency estimates were developed for each accident scenario postulated in the hazard analysis tables using these general concepts as guidelines, not as absolute criteria. The hazard analysis team adjusted the guideline frequencies for any particular scenario to reflect as accurately as possible the accident frequency expectations for particular facilities and operations. In addition, the following paragraphs are intended to address typical accident scenarios for a waste facility, and might not include every postulated scenario.

<u>Loss of Containment / Confinement</u>

Loss of Containment / Confinement accidents initiated by human error during operations that result in a *significant* release of radioactive material are generally considered to be in frequency category Anticipated (once every 1 to 100 yr) for the *unmitigated* case. Such accidents include container mishandling accidents, vehicle accidents, and accidents caused by operating equipment incorrectly in which the container is breached and a significant amount of radioactive material is released. Lesser events are expected to occur more frequently than once every 1 to 100 yr, but most will be of minimal

significance (e.g., a minor vehicle accident, or *fender-bender,* that does not harm waste containers carried by the vehicle). Such mishandling accidents are expected to be more frequent with routine activities when operator attention is expected to be less concentrated (i.e., TRU waste container with ≤ 56 PE-Ci), and even less frequent with higher activity content containers because, due to the extra hazard, human operator attentions will be more concentrated and deliberate. Accidents caused by human error are expected to occur several times during the life of the facility.

The unmitigated frequency for accident scenarios initiated by human error that impact several containers that contain close to the site limit (e.g., population reflects the few highest inventory containers) is estimated to be in frequency category Unlikely (once every 100 to 10,000 yr). For example, a container mishandling accident or a vehicle accident that impacts one or two average inventory waste containers is estimated to be a an anticipated event, but such events that would impact many more containers at the highest inventory would be much less likely (Unlikely). Mishandling accidents, or vehicle accidents that significantly impact multiple containers (say 10 to 20 containers), would also be estimated to be Unlikely. For accidents involving vehicles that are not facility-related, a single frequency bin reduction is estimated.

Frequency estimates for some *mitigated* accident scenarios will remain the same as the unmitigated frequency category (Anticipated or Unlikely), but the estimates for other scenarios could be reduced to the next lower frequency category depending on the controls that are implemented. In general, the mitigated frequency estimates for accidents that are caused by a single human error that does not allow for correction or recovery, such as a vehicle accident, generally will remain the same as for the unmitigated case. Controls such as rigorous training and enhanced equipment and operations design might reduce the frequency estimates for these types of accidents to a lower frequency category, but such reductions are often not great enough to change the frequency to a lower bin. The frequency estimates for accidents caused by human error that allow time for recovery could be mitigated to a lower frequency category by means of controls targeted directly at identifying, preventing, or correcting such errors.

Equipment failures that lead to significant releases are generally considered to have an *unmitigated* frequency of category Anticipated (once every 1 to 100 yr) or Unlikely (once every 100 to 10,000 yr) depending on the particular piece of equipment. Similar to human error initiators, equipment failures are expected more frequently than the aforementioned frequency estimates, but most will not lead to a significant release. Types of equipment failures considered include forklift/vehicle breakdowns, rigging failures, electrical faults, and significant degradation of a waste container. For accidents involving vehicles that are not facility-related, a single frequency bin reduction is estimated.

Estimates for *mitigated* frequencies of accident scenarios initiated by equipment failures could be lowered one frequency category if controls are identified to significantly improve the reliability of the particular item. Although typical controls such as equipment inspections and preventive maintenance will improve equipment reliability, in many cases such controls will not reduce the failure frequency by an entire category.

Fires

Operational fires (i.e., fires initiated on-site by accidents involving routine operations) are generally considered to be in frequency category Anticipated (once every 1 to 100 yr) for the *unmitigated* case. This is the frequency range for fires at typical industrial facilities.

Mitigated frequency estimated for operational fires could be reduced to Unlikely if strict fire safety controls are identified, and if the operation does not involve inherent ignition sources (i.e., hot work) and significant quantities of combustible or flammable materials. In general, the frequency of operational fires

for activities that involve ignition sources and combustible or flammable materials cannot be reduced to a lower frequency category. *Fire suppression system*s typically mitigate the consequences of these types of accidents, but not their frequency.

The unmitigated frequency of a fire caused by a vehicle that ignites combustible material is estimated to be in frequency category Unlikely (once every 100 to 10,000 yr). Such events are, therefore, possible but improbable. Electrical system safety features could reduce the frequency, but not likely to a lower category. The mitigated frequency is assumed to be in frequency category Extremely Unlikely, based on strict combustible (prevents fire spread) and vehicle access controls within the WCRRF.

Explosions

Explosions or deflagrations of flammable gases on-site could involve forklift propane fuel cylinders. (A potential deflagration of hydrogen generated inside waste containers is discussed below.) The postulated accident scenarios of interest require a leak and ignition of flammable fuel in a location near waste containers. An explosion or deflagration near the TRU waste containers can affect the radioactive material.

To estimate the frequency of a forklift fuel leak and fire, an Internet search was performed to research forklift accidents. Information was found on a number of websites, including a summary of forklift fatalities investigated by the Occupational Safety and Health Administration (OSHA)[1] and a comprehensive report of forklift accidents around the United States and in Canada generated from newspaper reports.[2] Although the information was limited to recent reports and might not include all forklift accidents, these reports provide information over several years on several dozen serious accidents.

Neither of these reports included a fuel leak from the forklift's fuel system. A number of accidents involved a fire, but all involved external fuel (e.g., dropping a propane fuel tank, etc.). The accident data included several forklift toppling events; however, none of these cases occurred in conjunction with a forklift fuel tank leak.

Anecdotal evidence provided by these accident reports cannot replace carefully collected and studied statistical evidence; however, they provide valuable insights into accident scenarios involving forklift operations. The accident data strongly suggest that forklift fuel systems are very robust and reliable components and that a fuel leak during controlled operations is actually extremely unlikely. The data examined represent the operating experience from hundreds of thousands of forklifts operating over several years under a wide range of uses and conditions; however, there were no reports identified of an accident involving a fuel leak and fire. From this, it can be inferred that an accident involving a forklift fuel leak and fire is extremely unlikely when the scale of forklift operations is relatively small and the operations carefully controlled. The *unmitigated* frequency of an event involving a forklift fuel leak and fire happening at the WCRRF is conservatively estimated to be in category Unlikely (once every 100 to 10,000 yr).

Standard sized gas cylinders, such as P10 and compressed air, are in Building TA-50-69. The P10 is used as a component of personnel radiation monitoring equipment. (Compressed air is used for the GBE airlock doors.) Because of the small volume (10%) of methane in the P10 mixture (90% argon/10% methane), a leak of the cylinder would quickly dilute to a non-flammable mixture in the large volume of

[1] http://www.osha-slc.gov/Training/PIT/fatalities_sum.htm.
[2] http://www.liftlink.com/Industry/News/accidents/index2.cfm.

Building TA-50-69. Therefore, an accident involving a leak and ignition of the flammable gas (methane) in the P10 cylinder in a location that would affect one or more TRU waste containers is considered Extremely Unlikely, that is, in frequency category III.

The *mitigated* frequency of these scenarios is estimated based on the identification of safety controls that would reduce the frequency to the next lower category (i.e., prohibition on the use of liquid-fueled forklifts, and other fueled vehicles, in the outside staging areas when TRU waste is at the WCRRF).

The *unmitigated* frequency of a fire at the WCRRF initiated by a wildfire is considered to be in frequency category Anticipated (once every 1 to 100 yr). The *Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory* (LANL 1999) estimates the likelihood of a significant wildfire somewhere on Laboratory property to be about once every 10 yr. Given the size of the Laboratory site, the likelihood of one of these fires affecting the WCRRF would be lower. However, given the experience of the Cerro Grande Fire of May 2000, a large forest fire could impact a significant portion of the Laboratory property, so the unmitigated frequency is not further reduced. Therefore, the unmitigated frequency of this accident scenario is estimated to be in frequency category Anticipated.

The *mitigated* frequency of this accident scenario is based on the assessment that the identified safety controls (such as removing vegetation and other combustible materials from the site) would reduce the frequency to the next lower category.

Explosions (Hydrogen Deflagrations)

The bases for the frequency of a hydrogen deflagration during glovebox operations or during TRU waste container handling/staging are described below.

A drum deflagration during glovebox operations would require introducing a drum that contains a flammable gas concentration above the lower flammability limit (LFL), 4% hydrogen. Removal of the drum lid might produce a sufficient spark that could ignite a flammable hydrogen mixture. For a deflagration to occur during glovebox operations, the following conditions must exist: (1) generation of hydrogen gas inside a drum at a rate sufficient to reach an explosive concentration; (2) lack of venting (e.g., the existing vents are plugged or container is not adequately vented); and (3) the presence of sufficient oxygen inside the drum to support combustion. These conditions, present with an ignition source, or a handling accident that breaches the drum, allowing the hydrogen to mix with air to form an explosive mixture, can lead to a deflagration. Because of the activities associated with repackaging, it is conservatively assumed that there is sufficient energy to result in an ignition source during glovebox operations, and thus that a deflagration is possible.

Each of the conditions that can contribute to a drum deflagration is discussed below.

Generation of flammable gas inside a drum: The flammable gas of concern, hydrogen, is generated in a drum, mainly due to radiolysis, to varying degrees depending on the waste form and the fissile material content of the waste. Data from venting drums during TWISP operations indicate that 4.3% of unvented barrels have hydrogen concentrations above the LFL of about 4%. It is conservatively estimated that about 5.2% of all the drums (based on statistical error associated with a sample size of 12,315 drums) to be processed at the WCRRF (currently stored at Area G) are capable of producing quantities of hydrogen significant enough to cause a deflagration concern (i.e., concentrations of hydrogen greater than the LFL of about 4%).

Failure of the drum's venting capability: All the TRU waste containers to be processed at the WCRRF have been previously vented and fitted with filters or vents. Therefore, a mechanism by which a flammable gas mixture can accumulate includes a failure of the drum vent or filter (note that unvented drums being prohibited from the WCRRF is an initial condition to be verified in the analysis). The results of filter tests at Rocky Flats show a failure rate of vents or filters of 1.2% for drums in storage at least ten years (some drums in the test had been in storage for more than 20 years). The error associated with this failure rate is 2.9%, so a value of 4.1% is conservatively estimated for the failure rate of filters. Most of these failures occurred at Rocky Flats due to the presence of chemicals (such as CCl_4); this chemical is not used at LANL. Through the end of calendar year 2005, there have not been any reports of drums with plugged filters at LANL. Based on the above information, it is reasonable to conclude that the filter failure rate at Area G is at least one order of magnitude less than the Rocky Flats rate, or approximately 0.4% (4E-3).

Buildup of flammable gas and formation of an explosive gas mixture: Sufficient quantities of hydrogen have to be present in a drum or glovebox to enable a deflagration. Analyses performed at Rocky Flats show that there must be at least 15% hydrogen and 7.5% oxygen for a deflagration to have sufficient energy to compromise a TRU waste container. Data from venting drums during TWISP operations indicate that 1.93% of unvented barrels have hydrogen concentrations above 15%. It is conservatively estimated that about 2.83% of all the drums (based on statistical error associated with a sample size of 12,315 drums) have sufficient hydrogen to threaten drum integrity. Experiments conducted at Rocky Flats have shown that 1 of 6 drums with hydrogen above the LFL has gas concentrations with the capability of failing drum confinement if ignited. However, these data are from unvented drums. The data also indicate that oxygen depletion is very likely in drums that experience filter plugging, and that very few drums with plugged filters will have sufficient oxygen to support an explosive mixture. This data is based on drums containing chemicals (such as CCl_4).

Assuming an upper bound throughput of drums at the WCRRF of approximately 1,000 to 2,000 drums per year, this represents five to ten percent of 20,000 drums. The unmitigated frequency of a drum deflagration during drum repackaging is found by taking the product of all the conditional probabilities. Taking propagation of error into account, the probability that a drum susceptible to deflagration upon opening is brought to WCRRF is on the order of 4.2E-1 (0.4% x 5.2% x 2000 drums/yr). This corresponds to frequency category Anticipated for the *unmitigated* case. The receipt of unvented drums at WCRRF is prohibited as an initial assumption of the analysis (because it is an initial condition for operations at the WCRRF). The unmitigated frequency assumes that the vent path has failed. The requirement to inspect drums and standard waste boxes (SWBs) before receipt reduces the likelihood that a container will be processed with a plugged or missing filter. Also, container-handling practices and the control of ignition sources reduce the likelihood that hydrogen will be present and ignite during glovebox operations. Taken together, these controls reduce the mitigated frequency of this event to one category lower than the unmitigated frequency estimate.

The frequency of a drum deflagration accident during handling at the WCRRF is estimated from the likelihood that a drum vulnerable to such an accident is brought to the facility, and the likelihood that the drum is mishandled in a manner that would breach the drum and ignite the explosive mixture. The frequency of a container mishandling accident that breaches a drum is estimated to be on the order of 0.1 per year (or once every 10 years). Many waste drums have been handled at Area G for a longer period of time, with only one small puncture reported. However, other DOE sites have reported a number of forklift punctures of radioactive waste drums. The likelihood that any one specific drum is mishandled and breached (based on an order of magnitude estimate of 1000 to 2000 drums passing through the WCRRF in a year) is on the order of 5E-5 per year. The frequency that a single drum that is vulnerable

to a drum deflagration accident is mishandled and breached is on the order of 8E-6 per year. For conservatisms, this event is evaluated in the frequency category Unlikely (vs. Extremely Unlikely).

The *mitigated* frequency is assumed to be in frequency category Extremely Unlikely. Before shipment, and once received, there are requirements to inspect drums, reducing the likelihood that the filter on a drum will be plugged and a hydrogen mixture will form that is above the LFL. Also, container-handling practices reduce the likelihood that a mishandling accident will breach a drum and ignite the resulting hydrogen-air mixture. Taken together, these controls reduce the mitigated frequency of this event to one category lower than the unmitigated frequency estimate.

Multiple drum deflagration: A cascading deflagration event requires two or more suspect containers of poor container integrity to be stored or staged in a single location. Given the requirement that all drums received at the WCRRF are received in a vented condition, and are visually inspected to ensure that they are structurally sound, there is little potential for a cascading deflagration event. The likelihood of a single drum having an atmosphere that would deflagrate was considered to have an *unmitigated* frequency of Unlikely. The probability of two adjacent TRU waste containers having high inventory, poor container integrity, simultaneous filter failures, and being subject to an ignition source is considered to be incredible. A multiple drum deflagration was also not analyzed as a unique event, since no unique controls have been identified for a sympathetic deflagration beyond what is required for the mitigation of a single drum deflagration (e.g., TRU waste containers are in good condition and vented).

Idaho drum deflagration tests (Idaho 1983) indicated that sympathetic deflagration of a drum on top of the initial deflagration occurred; however, the lower drum did not lose its lid due to the weight of the drum on top. No experimentation has been conducted, nor observed, on sympathetic deflagration of horizontally adjacent drums. Therefore, it is suggested that sympathetic deflagration is possible involving two unvented drums for TRU waste being retrieved from burial sites, which is not the case for drums destined for the WCRRF.

External Events

External fires and explosions that could affect the TRU waste containers are generally considered to be in frequency category Unlikely (once every 100 to 10,000 yr) for the *unmitigated* case. These events include fires and explosions involving vehicles or other flammable gas/liquid sources on nearby roads and not directly involved in a site operation. These types of events are unlikely events in themselves, and enabling events that would cause the fire or explosion to affect the waste containers are even less likely.

The *mitigated* frequency estimates for external events initiating a fire are based on the identification of safety controls that would reduce the frequency to a lower category.

Natural Phenomena Hazards

The evaluation basis earthquake for this hazard analysis is a Performance Category (PC)-2 earthquake (0.22 g) with a return period of 1000 yr. The Building TA-50-69 and the WCG are designed to withstand a PC-2 earthquake (LANL 2007). However, in the unmitigated case, these structures are conservatively assumed to fail. Thus, the frequencies of these accidents are in the same category as a seismic event, which is frequency category Unlikely (once every 100 to 10,000 yr).

The unmitigated frequency of a fire in the staging area caused by a seismic event is estimated to be in frequency category Extremely Unlikely, one category lower than the seismic event itself. This estimate is based on the lack of a large number of potential fire initiators and combustible materials in the staging

area. The mitigated frequency is estimated to be the same; however, administrative controls may lower the frequency of an incipient fire growing to a full facility or staging yard fire.

The unmitigated frequency of accident scenarios involving staged TRU waste containers toppling during a seismic event is estimated assuming that the containers are stacked. The frequency category of these scenarios is estimated to be the same as the seismic event: frequency category Unlikely.

The *unmitigated* frequency of fire initiated by a lightning strike is estimated to be in frequency category Anticipated. The basis for this estimate is the 1.4E-1 lightning stikes per year documented in Appendix 3D.

Lightning protection systems (LPSs) installed on Building TA-50-69 and the outside transportainers do not reduce the frequency of lightning strikes, but they reduce the likelihood of a resultant fire by dissipating the energy of the strike. Data shows that National Fire Protection Association (NFPA) 780-type LPSs do a reasonably good job of excluding the continuing current component of lightning from the interior of buildings. The data indicate that only 1/16 as many lightning-caused fires occur in NFPA 780 protected structures as in unprotected structures. For a credited SSC, a reduction in one bin frequency (a factor of 100) should be attained. Based on this data, the LPS system at WCRRF is appropriately classified as defense-in-depth instead of a design feature because it does not provide a factor of 100 frequency reduction for a credited SSC. Therefore, the *mitigated* frequency of a lightning-initiated fire inside the building is estimated to be in frequency category Unlikely (i.e., 1.4E-1/yr x 1/16 = 8.73E-3/yr). Without the protection of the LPS, both the *unmitigated* and *mitigated* frequencies of a lightning-initiated fire outside the building are assumed to be the same as the unmitigated frequency inside the building, or frequency category Anticipated. Programmatic maintenance of the LPS helps to ensure its continuing ability to provide the defense-in-depth function.

Three types of accident scenarios are postulated to be caused by high winds: (1) damage to the facility, up to a catastrophic structural failure; (2) a wind-driven missile that impacts waste containers and causes a spill of radioactive or hazardous material; and (3) wind causes containers to fall and spill radioactive or hazardous material.

Building TA-50-69 is designed to meet structural standards for PC-2 wind loads. The building structural design prevents damage from PC-2 winds (1000-yr return period). Thus, the frequency of structural damage is in frequency category Unlikely (once every 100 to 10,000 yr).

Wind-driven missiles could be generated from loose items outside the building that are picked up by the wind. Waste containers staged outside are not protected by the building structure and thus are more susceptible to being struck by a wind-driven missile than waste containers inside the building. The overall scenario frequency is a function of both the frequency of such a missile being generated and the probability that such an item would impact and breach waste containers. The frequency of a missile being generated by high winds is estimated to be in frequency category Anticipated (once every 1 to 100 yr). Based on the small number of waste containers staged in the yard, the probability that such a missile will impact and breach staged waste containers is estimated to be on the order of 0.01, resulting in an overall *unmitigated* accident frequency in frequency category Unlikely (once every 100 to 10,000 yr). It should also be noted that PC-2 structures do not need to withstand wind-generated missiles per DOE-STD-1020.

The *mitigated* frequency can be reduced by a control to limit accumulation of items in the yard that could become windborne. However, because of the proximity of other facilities that would not be controlled by WCRRF requirements, this control would not reduce the frequency to a lower frequency category.

The unmitigated frequency of a spill caused by strong winds toppling storage containers is estimated to be in frequency category Unlikely (once every 100 to 10,000 yr), which is the same frequency as the initiating event itself. The mitigated frequency is assumed to be in frequency category Extremely Unlikely; however, additional controls may lower the mitigated frequency.

Nuclear Criticality

The *unmitigated* frequency of an inadvertent criticality during TRU waste container staging must consider the likelihood that some new containers exceed the LANL waste acceptance criteria (WAC) quantities of fissile material. The unmitigated frequency of an inadvertent criticality during TRU waste staging is considered being in the extremely unlikely category, or in frequency category Extremely Unlikely, since TRU waste will not contain significant amounts of fissionable material.

The *mitigated* frequency of an inadvertent criticality during staging is less than the unmitigated frequency because administrative controls reduce the likelihood of such an event. These controls, provided by the Nuclear Criticality Safety Program, prevent a waste container configuration from resulting in an inadvertent criticality. Therefore, the mitigated frequency of an inadvertent criticality is approximately two orders of magnitude less than the mitigated frequency, placing it in frequency category Beyond Extremely Unlikely.

The *unmitigated* frequency of an inadvertent criticality caused by the fire sprinkler system actuation inside the GBE and subsequent flooding of the GBE liquid collection sump is considered beyond extremely unlikely.

The *mitigated* frequency of an inadvertent criticality caused by the fire sprinkler system actuation and the liquid collection sump flooding in the GBE is the same as the unmitigated frequency because the criticality safety evaluation has determined that a criticality is not possible. Therefore, the unmitigated and mitigated frequency is in frequency category Beyond Extremely Unlikely. (**NOTE:** The GBE will not be used for the staging, characterization, or repackaging of waste.)

Bases for Consequence Estimates

As with the frequency categories, qualitative consequence severity categories were assigned to each of the postulated accident scenarios. Estimating the consequence category is based on a qualitative assessment of the radiological effects of the postulated release, considering factors such as inventory and the energy sources involved with the release. The HA conservatively uses 800 PE-Ci as an upper inventory estimate for any single TRU waste container. For events that involve the entire WCRRF, the HA assumes a maximum inventory of 1,800 PE-Ci (inside and outside inventory). The evaluation in the HA also conservatively assumes that all TRU waste to be processed is in a combustible and readily dispersible form. These inventory values and their applicability in the HA are summarized in Table 3A-5.

Table 3A-5. Inventory Values Used in the HA.

Inventory (PE-Ci)	Inventory Applicability
≤ 800	Maximum inventory allowed in Bldg. TA-50-69. Maximum inventory in any single TRU waste container.
≤ 1800	Maximum WCRRF inventory (inside and outside)

The WCRRF handles three basic types of contaminated material. These are noncombustible solids, combustible solids, and filter media. Rather than establish and track inventory limits for each type of contaminated waste matrix that enters Building TA-50-69, a conversion factor was developed that equated the inventory of the different types of material to combustible material. The analyses within the HA assume that the waste containers involved in any event contain the upper limit of activity to be processed (800 PE-Ci), and that the TRU waste container contents are combustibleFor implementation, an inventory limit of 800 PE-Ci of combustible equivalent waste is used for inside Building TA-50-69.

The upper bound WCRRF inventory limit of 1,800 PE-Ci (inside and outside) allows the WCRRF to contribute to the Laboratory commitment to remove the TRU waste inventory from TA-54 Area G in a timely manner. The WCRRF site limit is strictly based on the actual PE-Ci content of the TRU waste container, regardless of waste matrix.

These inventory values and material form estimates provide a bounding estimate for the purposes of this HA. The goal of the HA is to identify all important hazard controls that serve to minimize risk to the worker and public from physical (non-SIH), radiological, and chemical exposures leading to consequences ranging from minor injury all the way to death or irreversible illness. It is important that the HA be internally consistent such that the relative risk of events can be determined. The estimated inventories and consequences are bounding and generally defaulted to the most conservative value. Use of bounding unmitigated consequences allows the determination of which accidents are reliant upon controls and ensures that all significant events (i.e., consequence category High to the Public and Collocated Worker) are captured in the Chapter 3 Accident Analysis. Conversely, if the worst possible or unmitigated consequences and risk are low, then formal controls and Accident Analysis are not required (e.g., reliance on SMPs).

Although the hazard analysis is mostly a qualitative process, the radiological consequences (doses) to the public were estimated using a simplified quantitative determination. The dose to the maximally exposed off-site individual (MEOI) and to the collocated worker for each postulated accident scenario was estimated as the product of the source term and the dose-to-source-term ratio. To determine the consequence category, these parameters are conservatively estimated using simplifying assumptions based on expected releases.

The doses from inhalation for loss of confinement (spill) and for fire release were calculated using the following equation:

$$\text{Dose (rem)} = \text{ST (Ci)} \times \text{DCF (rem/Ci)} \times \text{BR (m}^3\text{/s)} \times \text{X/Q (s/m}^3\text{)} \qquad \text{[Eq. A-1]}$$

where:

ST = source term
DCF = dose conversion factor
BR = breathing rate
X/Q = atmospheric dispersion factor

Calculations were performed using the curies of ^{239}Pu (or PE-Ci) rather than the mass, and the following values for each of the above-defined parameters:

DCF (for ^{239}Pu) = 1.85 E+8 rem/Ci
BR = 3.33E-4 m^3/s
X/Q for a spill release = 5.74E-5 s/m^3 (public) or 8.19E-3 (collocated worker)

The same X/Q value was used for the bounding fire release (assuming no lofting due to plume heat and no plume meander) for the public because of the uncertainty in dispersion due to the effect of canyons and mesas. Because there are no canyons between the WCRRF release point and the collocated worker at 100m, a X/Q of 5.41E-04 s/m^3 (for a low-buoyancy 0.1MW smoldering fire) was used for collocated worker dose calculations for material released in a fire plume.

The following X/Q values (which credit lofting and plume meander, but still assume a point source instead of a less conservative distributed source) were used for comparison dose calculations for releases due to fuel pool fires outside the building, recognizing that actual doses would likely fall somewhere between these and the very conservative doses calculated with X/Q assumptions for spills or 0.1MW fires.

X/Q for a (10MW) fire release = 7.62E-6 s/m^3 (public) or 4.7E-5 (collocated worker)

The X/Q values were determined [Appendix 3B, and LANL 2010] from meteorological data from 2003 through 2007 and based on the distance from the WCRRF site boundary to the LANL site boundary (for the public) and 100 m for the collocated worker. The DCF for public and collocated worker receptors is taken from ICRP Publication 72 (ICRP 1996).

These values can be combined to establish dose to source term factors (DSF) for ease of calculating public and collocated worker doses due to a spill or fire release for a given ST:

$$DSF = DCF\ (rem/Ci) \times BR\ (m^3/s) \times X/Q\ (s/m^3)$$

Receptor – event type	**DCF (rem/Ci)**	**BR (m^3/s)**	**X/Q (s/m^3)**	**DSF (rem/PE-Ci)**
Public - spill (or non-buoyant fire, without meander)	1.85 E+8	3.33E-4	5.73E-5	3.54
Public - 10 MW fire, for comparison	*1.85 E+8*	*3.33E-4*	*7.62E-06*	*0.47*
Collocated worker - spill	1.85 E+8	3.33E-4	8.19E-03	504.5
Collocated worker – (0.1 MW smoldering fire)	1.85 E+8	3.33E-4	5.41E-04	33.3
Collocated worker - 10 MW fire, for comparison	*1.85 E+8*	*3.33E-4*	*5.41E-05*	*2.90*

*Note: The rows with italicized text are provided for comparison for fuel pool fire release scenarios; these comparison values are <u>not</u> used for calculating consequences for selection of controls.

The ST calculations were based on maximum material quantities for the affected area or item, depending on the inventory limits presented in Table 3A-5. These inventories form the basis for the consequence assessments in the hazards evaluation. The inventory limits, as modified in the *Accident Analysis*, are protected in the Technical Safety Requirements (TSRs) to ensure that the facility remains within its safety analysis.

The source terms for the postulated accident scenarios were determined using the Five-Factor Formula described in DOE-HDBK-3010 (DOE 2000). The Five-Factor Formula is expressed as follows:

$$\text{Source Term (ST)} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF} \qquad \text{[Eq. A-2]}$$

Public and collocated worker consequences for postulated accidents were estimated using the following conservative values for these factors:

- *MAR*: Selected from Table 3A-5 depending on the particular accident scenario.

  DR: Assumed to be 1.0 for most accidents. When DR = 1.0, all MAR is assumed to be affected by the accident. When it is clear that the accident can impact only a fraction of waste containers, *DR* < 1.0 was assumed.
- *ARF/RF*: ARF/RF values of 1E-3/0.1 were used for spill scenarios. These values are the recommended values in DOE-HDBK-3010, Section 5.0, *Surface Contamination* (DOE 2000). The values are for packaged waste. DOE-STD-5506 (DOE 2007), Section 4.5.3.1, also recommends 1E-3/0.1.
- For the postulated fire accidents, the ARF and RF were conservatively assumed to be 1E-2 and 1.0, respectively. These are the bounding values specified in Section 5.0 of DOE 2000 for uncontained cellulosics or largely cellulosic mixed waste (e.g., paper, cardboard, rags, and wood shavings). Although values of 5E-2 and 1.0 are provided for uncontained plastics, the supporting data indicate that these values are based on tests of powder piles on burning plastic material. A test configuration more representative of the TRU waste material packaged in drums is air-dried liquid on a plastic substrate. The maximum ARF x RF value for this configuration is on the order of 1E-2. This value is also recommended by DOE-STD-5506 (DOE 2007) for combustible cellulosic or plastic materials that are either ejected from containers or otherwise unconfined or packaged. Thus, an ARF x RF product of 1E-2 was used to estimate the consequences of a fire involving uncontained plastic, resulting in the same value for cellulosic and plastic waste material.
- *LPF:* Conservatively assumed to be 1.0. There is no holdup for accidents that occur outside Building TA-50-69. For accidents that occur inside the building, some holdup and an LPF of less than 1.0 are expected. However, for conservatism in hazard analysis, no building confinement was credited.

Based on the above, the dose consequence to the *public* is expressed as follows for most loss of confinement and fire accident scenarios involving TRU waste material:

Fire scenarios (conservatively assume that all waste is uncontained, and the fire does not cause any lofting of the plume):

$$\begin{aligned}\text{Dose (rem)} &= \text{DSF rem/PE-Ci)} \times \text{ST (PE-Ci)} \\ &= 3.54 \text{ rem/PE-Ci)} \times \text{ST (PE-Ci) (public)} \\ &= 3.54 \times \text{MAR} \times \text{DR} \times 1\text{E-2} \times 1.0 \times 1.0 \\ &= 3.54\text{E-2} \times \text{MAR} \times \text{DR}\end{aligned}$$

Loss of confinement scenarios:

Dose = 3.54 x MAR x DR x 1E-3 x 0.1 x 1.0

= 3.54 E-4 x MAR x DR

The dose consequence to the *collocated worker* is expressed as follows for most loss of confinement and fire accident scenarios involving TRU waste material:

Fire scenarios (conservatively assume that all waste is uncontained, and the heat from a 0.1 MW smoldering fire causes minimal lofting of the plume):

Dose (rem) = DSF rem/PE-Ci) x ST (PE-Ci)
= 33.3(rem/PE-Ci) x ST (PE-CI) (collocated worker)
= 33.3 x MAR x DR x 1E-2 x 1.0 x 1.0

= 0.33x MAR x DR

Loss of confinement scenarios:

Dose = 504.5 x MAR x DR x 1E-3 x 0.1 x 1.0

= 5.05E-2 x MAR x DR

Table 3A-6 provides estimated consequences to the MEOI and collocated worker for uncontained fires and spills using the bounding inventory limits and material forms. The balance of events types are qualitatively derived from these values.

Table 3A-6. Radiological Consequence Estimates for Hazard Analysis Tables

Inventory Limit (PE-Ci)	Consequence to MEOI (rem)			Consequence to CW (rem)		
	Loss of confinement	**Fire**	***10MW*** *comparison fire*	**Loss of confinement**	**Fire**	***10MW*** *comparison fire*
1,800	0. 64	63.7	*8.5*	90.8	594	*52.2*
800	0. 28	28.3	*3.8*	40.4	264	*23.2*

* Note: These estimates are based on simplified bounding assumptions for ARF, RF, and DR. The columns with italicized text are provided for comparison, for fuel pool fire release scenarios; these comparison values are not used for control selection. A more detailed analysis of scenarios considered to be design basis accidents is developed in Section 3.4 of Chapter 3.

The public consequence categories were determined using these values. For example, for a large fire accident scenario that impacts the site inventory limit of radioactive material outside Building TA-50-69, the unmitigated, upper bound estimate for dose to the MEOI is 63.7 rem based on an inventory of 1,800 PE-Ci of combustible waste. The estimated dose consequences were then used to estimate the public consequence category provided in Table 3A-2. In the example of the previous paragraph, a 63.7rem dose to the public is High consequence.

Collocated Worker

The unmitigated, upper bound consequences to the collocated worker given maximum inventory from a fire exceed 100 rem and are therefore classified as High.

Worker

Worker consequence estimates are based on a qualitative assessment using engineering judgment plus the calculated consequences for collocated workers. For scenarios that evolve quickly (e.g., explosion or criticality), facility worker doses are judged to equal or exceed those calculated for collocated workers. For scenarios that progress more slowly (such as a fire), so that trained facility workers have time to become aware of the event and remove themselves from the area before they can be exposed to the full extent of the hazard, facility worker doses are judged to be equal to or less than those calculated for collocated workers.

Mitigated public, collocated worker, and worker consequences were estimated crediting the engineered features and administrative controls applicable to the scenario. The mitigated consequences for some accident scenarios were the same as the unmitigated consequences. Mitigated consequences were based on a semi-quantitative estimate of how effective the controls would be in reducing the unmitigated release.

For the limiting and representative accident scenarios carried forward to the accident analysis, the dose consequences to the public and collocated worker were calculated more precisely through developing more detailed scenarios and quantitative models of physical phenomena. In some cases, the consequence analyses resulted in calculated doses that were less than the lower bounds of the consequence categories assigned in the hazard analysis. Such apparent anomalies are the result of the conservative, simplifying assumptions used in the hazard analysis. These situations were expected, and do not invalidate the hazard analysis results.

The control selection process provides the engineered and administrative controls that are specifically credited with reducing the risk of the analyzed accident scenarios determined to be Anticipated events, or of high consequence to the public.

Preventive controls are selected to reduce frequency. Mitigative controls are selected to reduce consequences. The control features that are most significant in reducing the scenario risk are noted in the HA tables (√) to identify those controls that are major contributors to defense in depth.
As a general philosophy, controls which were credited to reduce frequency or consequence when required to do so to meet risk ranking goals were considered Safety-Class (SC) or Safety-Significant (SS) and covered by a TSR control (e.g., an SSC or directive action SAC). However, the risk ranking was not used as a limit to preclude further control selection if an available control could significantly reduce risk further. These additional controls are identified in the HA Tables as significant risk reducers, but may not be explicitly credited with a reduction in frequency or consequence. This approach is consistent with the defense-in-depth philosophy and results in a robust set of controls.

3A.3.3 HI, What-If, and HE Tables for Outside Operations

Hazard Identification Checklist

Table 3A-7 identifies the hazards present outside the WCRRF. The hazards were identified from walkdowns of the WCRRF, review of facility and glovebox system design documentation, discussions with facility, operations, and design personnel, and observations and document reviews of similar operations.

Table 3A-7. Hazard Identification Checklist for Outside Operations

Hazards	Hazards Applicability	Process or Area
Acceleration		
Inadvertent motion	Vehicle sudden starts, brake failure (forklift, delivery trucks, project vehicles)	Throughout outdoor yard areas, nearby roadway.
Sloshing of liquids	N/A	N/A
Translation of loose objects	Stacked TRU waste containers	Throughout outdoor yard areas, including within transportainers.
Deceleration		
Impacts (sudden stops)	Forklift, delivery vehicles, project vehicles, external vehicles on nearby roadway hitting structures or braking	Throughout outdoor yard areas, nearby roadways.
Failure of brakes, wheels, tires, etc. (e.g., vehicle accidents)	Forklift brake failure	Throughout outdoor yard areas, nearby roadway.
	Drum dolly and material handling devices	Throughout outdoor yard areas, nearby roadway.
	Brake failure on transportation trucks, external vehicles	Nearby roadways
Falling objects (1)	Stacked waste containers. Waste containers fall from material handling devices such as forklifts and drum grabs. Elevated transportainer.	Throughout outdoor yard areas
	Waste container falls	From delivery trucks
Fragments or missiles	Compressed gas cylinder storage. Deflagrating drum.	Stored outside Building TA-50-69
Chemical Reaction (non-fire, can be subtle over time)		
Disassociation—product reverts to separate components	Waste Containers (overpressurization due to reaction products)	Waste Characterization Glovebox, throughout Building TA-50-69
Combination—new product formed from mixture	N/A	N/A
Corrosion, rust, etc.	TRU waste containers (corrosion weakens metal).	Waste containers, equipment, transportainers
Improper mixing, reagents, water	N/A	N/A
Electrical		
Shock	General facility electrical	Throughout outdoor yard areas
Electrocution	General facility electrical	Throughout outdoor yard areas
Burns	Vehicles and electrical equipment (e.g., power tools, motors, etc.)	Throughout outdoor yard areas
Overheating	Vehicles and electrical equipment (e.g., power tools, motors, etc.)	Throughout outdoor yard areas. Electrical equipment and space heaters in transportainers.
Ignition of combustibles	Vehicles and electrical equipment (e.g., power tools, motors, etc.)	Throughout outdoor yard areas. Electrical equipment and space heaters in transportainers.

Table 3A-7. Hazard Identification Checklist for Outside Operations

Hazards	Hazards Applicability	Process or Area
Inadvertent activation	Material handling equipment	Forklift operating in outdoor yard area
Explosion, electrical	N/A	N/A
Explosion		
Commercial explosives present	N/A	N/A
Explosive gas	Hydrogen may be present in TRU waste containers	TRU waste containers staged in outdoor yard areas
Explosive liquid	N/A	N/A
Explosive dust	N/A	N/A
Flammable gas cylinders	Flammable gas cylinders (Approx. 5 ea. 20L LPG cylinders for forklift)	Storing and replacement of forklift fuel cylinders
Flammability, Fires, Explosion		
Presence of fuel—solid, liquid, gas	Vegetation	Around outside site perimeter
	General combustibles (waste paper and plastic). Miscellaneous combustibles associated with work activities and equipment (cable sleeves, plastic handles on tools, tires on forklifts, grease, etc.). Limited number of wood pallets for equipment delivery.	Located throughout outdoor yard area.
	Vehicle fuel supplies (diesel, gasoline, propane)	Vehicle location
	Auxiliary generator static fuel tank (diesel ~ 125 gal)	Diesel generator located on NW corner of yard area.
	Flammable solvents	Small quantities used throughout yard for maintenance
	Hydraulic fluids, lubricants, epoxies, paints, decontamination solvents, grease, hydraulic fluid, etc.	Forklifts, vehicles, small quantities used throughout yard for maintenance
	Off-gassing of electrical battery during recharging	Screened, not a credible ignition hazard, throughout yard
Presence of strong oxidizer—exothermic	Unknowns in waste (PID)	Outside transportainer staging area
Presence of flammable liquids (also covers combustible liquids)	Unknowns in waste (PID)	Outside transportainer staging area
Presence of pyrophoric, oxidizer—self-igniting	Unknowns in waste (PID)	Outside transportainer staging area
Spontaneous combustion	Unknowns in waste (PID)	Outside transportainer staging area
Static electrical discharge	Ignition source (in particular for hydrogen)	Throughout outdoor yard areas
Presence of strong ignition source—welding torch	Maintenance hotwork	Throughout outdoor yard areas. Electrical equipment and space heaters in transportainers.
Heat and Temperature		

Table 3A-7. Hazard Identification Checklist for Outside Operations

Hazards	Hazards Applicability	Process or Area
Source of heat, non-electrical	Engine exhaust	Throughout outdoor yard areas
Hot surface burns	Engine exhaust, electrical equipment	Throughout outdoor yard areas. Electrical equipment and space heaters in transportainers.
Very cold surface burns	N/A	N/A
Increased gas pressure caused by heat	N/A	N/A
Increased volatility caused by heat	N/A	N/A
Mechanical		
Sharp edges or points	Waste container edges	Screened, SIH, throughout outdoor yard areas
Rotating equipment	Drum handler, engines, forklifts	Throughout outdoor yard areas
Reciprocating equipment	Saw	Used for maintenance activities in outdoor yard areas
Pinch points	Container handling	Screened, SIH, throughout outdoor yard areas
	Doors (transportainer doors, vehicle airlock, and enclosure door)	Screened, SIH, transportainers
	Containers against base plate	Screened, SIH, outdoor transportainer area.
Heavy equipment operation e.g., forklift, Bobcat, loader	Forklift, lift tail gates on trucks.	Moving transportainers, waste container receiving and shipment, construction-related maintenance.
Weights to be lifted	Waste containers, transportainers, vehicle barriers	Container staging and process areas
Stability/toppling tendency	Waste containers	Outside transportainer staging area
	Transportainers and waste containers. Affected by seismic events or vehicle impacts	Outside transportainer staging area
Ejected parts or fragments	Compressed gas cylinder storage. Deflagrating drum.	Stored outside Building TA-50-69
Pressure		
Compressed gas	Compressed gas (O_2, N_2, LPG, breathing air trailer)	Gas cylinder delivery, cylinder storage areas adjacent to Building TA-50-69.
Compressed air tool	Hand tools	Used throughout outdoor yard areas during maintenance
Pressurized hydraulic fluid	Material handling equipment (e.g., forklift)	Receiving, staging and container transfers plus drum lifts
Pressure system exhaust	N/A	N/A
Accidental release—gas, fluid	Gas cylinder failure	Gas cylinder delivery
Objects propelled by pressure	Gas cylinder leak	Gas cylinder delivery and surrounding outdoor yard areas.
Water hammer	N/A	N/A
Flex hose whipping	N/A	N/A
Overflow (RTDs, tanks)	N/A	N/A

Table 3A-7. Hazard Identification Checklist for Outside Operations

Hazards	Hazards Applicability	Process or Area
Overpressurization	N/A	N/A
Static		
Container rupture	Unvented TRU waste containers (rupture due to reaction products, etc.)	Container staging and process areas
Overpressurization	Unvented TRU waste containers (rupture due to reaction products, etc.)	Outside transportainer staging area
Negative pressure effects	N/A	N/A
Hose rupture, piping, valve flange, glovebox gaskets	N/A	N/A
Leak of Material		
Flammable	Flammable gas cylinders (Approx. 5 ea. 20L LPG cylinders for forklift)	Storing and replacement of forklift fuel cylinders
	Vehicle fuel leaks (gas, diesel, propane)	Routine use of site equipment, maintenance vehicles, and delivery vehicles
	Auxiliary generator static fuel tank. During refueling, diesel generator fuel leaks or spills	Diesel generator pad is located outside to the NW of Building TA-50-69
Explosion, Deflagration	TRU waste containers (hydrogen generation)	Container staging and process areas
Toxic	Unknowns in TRU waste containers (PID)	Container staging and process areas
Corrosive	Unknowns in TRU waste containers (PID)	Container staging and process areas
Pyrophoric or oxidizer	Unknowns in TRU waste containers (PID)	Container staging and process areas
Flammable liquids (includes combustible liquids)	Unknowns in TRU waste containers (PID)	Container staging and process areas
Radioactive	Waste containers and surface contamination	Container staging and process areas
	Other radiation sources (see Radiation below)	(see Radiation below)
Slippery	Oil and lubricant spills or leaks (small volume)	Screened, SIH, maintenance and transportation activities
	Ice	Screened, SIH, throughout outdoor yard areas
Radiation		
Ionizing radiation	TRU waste- majority is alpha radiation with small beta/gamma component.	Container staging and process areas
Ionizing radiation	PID in shielded waste container	Container staging and process areas
Ultraviolet light	N/A	N/A
High-intensity visible light	N/A	N/A
Infrared radiation	N/A	N/A
Microwave, Radio	N/A	N/A

Table 3A-7. Hazard Identification Checklist for Outside Operations

Hazards	Hazards Applicability	Process or Area
Laser radiation	N/A	N/A
Toxicity		
Gas or liquid	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Asphyxiate	Nitrogen cylinders	Screened, SIH, gas cylinder delivery, cylinder storage areas adjacent to Building.
Irritant	Unknowns in waste containers (PID)	Screened, SIH, Container staging and process areas. Waste containers received and handled closed.
Systemic poison	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Carcinogen	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Mutagen	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Combination product	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Combustion product	Unknowns in waste containers (PID)	Container staging and process areas. Waste containers received and handled closed.
Vibration		
Vibrating tools	Power tools, saws, drills, etc.	Screened, SIH, throughout outdoor yard areas
High noise source level	N/A	N/A
Metal fatigue	N/A	N/A
Flow or jet vibration	N/A	N/A
Supersonics	N/A	N/A
Miscellaneous		
Lubricity	Lubricating fluids for equipment	Screened, SIH, throughout outdoor yard areas

What-If Analysis Tables for Outside Operations

Outside operations include those performed in the yard, and transportainers and waste staging areas (i.e., outside Building TA-50-69). Accidents for these types of operations are presented in the following What-If Tables, Table 3A-8 and Table 3A-9. The outside operations examined consist of the following two types of activities:

- SO, Staging Outside: Activities include staging containers for future processing or for shipment from the site. Temperature equilibration is also included.

- HO, Handling Outside: Activities include moving waste containers between processes outside the building; loading/unloading waste containers onto vehicles, transportainers, or larger containers; and moving waste containers within the staging areas

The two-character designations are used to identify accident scenarios in the What-If Analysis tables. Staging and handling, activities common to both inside and outside Building TA-50-69, are addressed in the What-If Analysis tables for outside staging and handling and in the tables for inside the building. The codes for these activities are *S* (for staging) and *H* (for handling), followed by either *O* (for outside operations) or *I* (for inside operations).

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Location: Outside staging areas
Facility: Waste Characterization, Reduction, and Repackaging
Site: TA-50, Los Alamos National Laboratory

Process/Activity: Waste container receipt and staging excluding staging inside Building TA-50-69. Temperature equilibration is evaluated as staging in transportainers.

Hazards of Concern: TRU waste container contents (up to about 200 containers). Flammables and combustibles associated with vehicles, transportation, and staging. NPH.

Table 3A-8. What-If Table for Waste Container Staging Outside TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SO-1	Nuclear Criticality	Waste containers with significant fissionable material are stacked in a configuration that causes a criticality.	Improper stacking of high FGE drums causes inadvertent criticality.		HSO-1, HSI-1
SO-2	Explosion	Vehicle accident or leak causes fuel to ignite and causes fuel tank to explode.	Explosion breaches waste containers outside Building TA-50-69 and contents burn.		HSO-2
SO-3	Explosion	Vehicle accident involving fully loaded propane cylinder delivery truck causes cylinders to explode.	Explosion breaches waste containers outside Building TA-50-69 and contents burn.		HSO-3
SO-4	Fire	Electrical failure or heater in transportainer causes fire, spontaneous combustion, or human error during hot work, maintenance, smoking, or unauthorized activities causes fire.	Burning combustible / flammable material in transportainer breaches container.		HSO-4
SO-5	Fire	Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire.	Fire in the outdoor transportainer area involves the TRU waste containers.		HSO-5
SO-6	Fire	Accident or mechanical failure causes vehicle fuel leak, or vehicle impacts waste containers with flammable liquids (including combustible liquids) or pyrophorics, resulting in ignition of waste container contents.	Fire breaches and ignites waste containers staged outside.		HSO-6
SO-7	Fire	Vehicle or forklift accident breaches and ignites stored propane cylinders.	Fire spreads to outside staging area, breaching and igniting waste containers.		HSO-7

Table 3A-8. What-If Table for Waste Container Staging Outside TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SO-8	Fire	Vehicle breaches LPG cylinders and propane ignites (forklift, maintenance or delivery vehicle).	Fire spreads to exterior of Building TA-50-69 but causes no release.		HSO-7
SO-9	Explosion	Hydrogen gas builds up in TRU waste container ignited due to impacts with vehicles operating in outside staging areas.	Flammable gas deflagrates, ruptures container, and burns.		HSO-25
SO-10	Deleted				
SO-11	Loss of Containment / Confinement	Corrosion or container defect causes container failure.	Container integrity fails, causing radioactive material release from one container.		HSO-9
SO-12	Loss of Containment / Confinement	Accident while positioning mobile units or transportainers causes a spill or containers dropped while transferring to transportainer.	Impact to mobile units or transportainers breaches staged containers or containers dropped by forklift during transfer to transportainer.		HSO-10, HSO-11
SO-13	Loss of Containment / Confinement	Vehicle impacts staged waste containers.	Forklift, maintenance or delivery vehicle impact breaches waste containers.		HSO-11
SO-14	Loss of Containment / Confinement	Waste container vent failure causes gas build-up.	Reaction products, flammable gas build-up, expansion of container contents due to weather.		HSO-26
SO-15	External Event	Vehicle (not facility-related) or refueling truck accident adjacent to site causes fuel leak that ignites and spreads throughout WCRRF.	Fire spreads to transportainers and waste containers. Containers release radioactive material.		HSO-13
SO-16	External Event	Wildfire adjacent to site.	Grass/brush fire in fields ignites transportainers, causing radioactive material release from containers.		HSO-14
SO-17	External Event	Vehicle impacts staged containers (not facility-related).	Impact breaches containers.		HSO-15
SO-18	External Event	While refueling a diesel generator tank, the fuel truck ignites	Major fuel spill from tank ignites, causing large fire that breaches and burns waste containers.		HSO-16

Table 3A-8. What-If Table for Waste Container Staging Outside TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SO-19	Natural Phenomena	Lightning causes fire in yard and or ignites transportainer.	Fire in transportainers with combustible loading causes drums to rupture and release radioactive contaminants.		HSO-17
SO-20	Natural Phenomena	Wind overturns transportainer.	Transportainer impact breaches nearby containers.		HSO-18
SO-21	Deleted				
SO-22	Natural Phenomena	Wind-driven missile.	Missile impacts and breaches outside staged waste containers.		HSO-20
SO-23	Natural Phenomena	High winds overturn drums.	Winds overturn and breach staged waste containers.		HSO-21
SO-24	Natural Phenomena	Seismic event.	Seismic event topples transportainers and/or staged waste containers and breaches containers.		HSO-22
SO-25	Natural Phenomena	Seismic event.	Seismic event causes fire.		HSO-23
SO-26	Loss of Containment / Confinement	Gas cylinder ruptures and impacts staged waste containers.	Gas cylinder impact breaches waste containers.		HSO-11
SO-27	External Event	Aircraft crash.	Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.		HSO-24

Location: Staging areas and yard outside Building TA-50-69
Facility: Waste Characterization, Reduction, and Repackaging
Site: TA-50, Los Alamos National Laboratory

Process/Activity: Waste container handling, loading, and unloading activities outside Building TA-50-69.

Hazards of Concern: TRU waste containers handled singly or on pallets of up to four drums. Flammable vehicle fuels.

Table 3A-9. What-If Analysis Table for Waste Container Handling Outside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
HO-1	Fire	Vehicle fire is caused by short, human error, or other causes while carrying load	Fire breaches containers on pallets		HSO-6
HO-2	Explosion	Forklift impacts containers. Spark or other ignition sources cause deflagration and fire	Deflagration of flammable gases in waste containers breaches containers and burns contents		HHO-1
HO-3	Loss of Containment / Confinement	Container dropped from elevation causes a spill	Drop during loading or unloading operations breaches container		HHO-2
HO-4	Loss of Containment / Confinement	Forklift impacts handled container	Forklift impact by tine or vehicle breaches waste container		HHO-3
HO-5	Loss of Containment / Confinement	Vehicle impacts handled containers	Maintenance vehicle impacts and breaches waste containers		HHO-3
HO-6	Loss of Containment / Confinement	Operator mishandles container	Damage from overturning, falling off dolly, unsecured lids, or missing bung plugs breaches waste containers		HHO-4
HO-7	Loss of Containment / Confinement	Degraded, corroded, or damaged container fails during handling	Handling with hand truck or forklift beaches container		HHO-5
HO-8	Loss of Containment / Confinement	Containers dropped from elevation, pallet of four drums.	Container drops from pallet and loses confinement		HHO-2
HO-09	Loss of Containment / Confinement	Impact, overturning, container integrity failure, or other events breach container, causing a spill	Inclement weather creates conditions leading to loss of vehicle control, slips, overturning, or other events, causing loss of container control		HHO-4, HHO-8

Table 3A-9. What-If Analysis Table for Waste Container Handling Outside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
HO-10	Loss of Containment / Confinement	Lifting device failure causes container drop	Drop breaches container		HHO-7
HO-11	Loss of Containment / Confinement	Damage to lid or loose lid on container causes loss of confinement while handling	Containers release radioactive material		HHO-6
HO-12	Loss of Containment / Confinement	Gas cylinder ruptures and impacts staged waste containers	Gas cylinder impact breaches waste containers		HHO-3
HO-13	Loss of Containment / Confinement	Waste container vent failure causes gas build-up	Reaction products, flammable gas build-up, expansion of container contents due to weather		HSO-26

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Hazards Analysis Tables for Outside Operations

The Hazard Analysis tables for outside operations (Table 3A-10 and Table 3A-11) present the unmitigated (or uncontrolled) frequency and consequence categories for the public, collocated worker , and workers, as well as the associated risk rankings. Immediately following the uncontrolled data, controlled or mitigated estimates are provided applying the listed controls to the accident scenario. Primary controls (i.e., the more effective controls) are marked with a check mark (√) in the applicable column. Checked controls are the credited controls that reduce risk. The residual risk reflects frequency reduction and consequence mitigation achieved by the application of these controls.

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Location: Outside Building TA-50-69
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: Waste container receipt and staging in yard and transportainers. Temperature Equilibrium is evaluated as staging in transportainers.

Hazard of Concern: Radioactive material in TRU waste containers.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSO-1	Nuclear Criticality	Improper stacking of high FGE drums causes inadvertent criticality	Waste containers with significant fissionable material are stacked in a configuration that causes a criticality	**UNCONTROLLED**			EU	L	L	H	IV	IV	II	
		(SO-1, SI-1)		**CONTROLLED/RESIDUAL RISK**			BEU	L	L	H	IV	IV	III	
				Emergency preparedness	EP-FAC	MPA								
				Nuclear Criticality Safety Program	NC-CSP	PPA	√							FGE limits and drums stored in accordance with NCSE requirements
				Spotter required	HR-SPT	PPA								Spotter required during container handling helps assure proper handling
				Training and Qualification Program	TR-TQ-TRN	PPA								
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	PFA								Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-2	Explosion	Explosion breaches waste containers Building TA-50-69 and contents burn	Vehicle accident or fuel leak causes fuel to ignite and causes fuel tank to explode	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR Site limit (1,800 PE-Ci)
		(SO-2)		**CONTROLLED/RESIDUAL RISK**			BEU	M	M	M	IV	IV	IV	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA								Evacuate (may not be effective for fast-developing events)
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Site perimeter fence	FD-SPF	PFF								
				Spotter required	HR-SPT	PFA								

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transportainer	ED-TDI	MFF								Robust container may reduce frequency that TRU waste will be impacted. May provide limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	CD-WCD	MFF		√	√	√				Applies to outdoor staging areas only.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Vehicle access system	FP-VAC	PFA	√							Controls vehicle access to the site. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSO-3	Explosion	Explosion and fire impacts TRU waste containers.	Vehicle accident involving fully loaded propane cylinder delivery truck causes propane cylinders to breach and explode	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR- Site limit (1,800 PE-Ci)
		(SO-3)		**CONTROLLED/RESIDUAL RISK**			BEU	M	M	M	IV	IV	IV	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA								Evacuate (may not be effective for fast developing events)
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility. Includes propane delivery truck.
				Site perimeter fence	FD-SPF	PFF								
				Spotter required	HR-SPT	PFA								
				Transportainer	ED-TDI	MFF								Robust container may reduce frequency that TRU waste will be impacted. May provide limited secondary containment if compromised.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure. Applies to outdoor staging only.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Vehicle access system	FP-VAC	PFA	√							Propane cylinder delivery truck prohibited from access to the WCRRF.. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-4	Fire	Burning combustible/flammable material in transportainer.	Electrical failure of wiring or instruments in transportainer ignites fire or spontaneous combustion, human error, hot work, maintenance, smoking, or unauthorized activities causes fire	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR — Several containers (1,800 PE-Ci)

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(SO-4)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	Risk significantly mitigated by excluding wooden floors in the transportainers.
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate (slowly developing event)
				Fire protection program	FP-FPP	PPA MPA								
				Hotwork prohibition	FP-HOT	PPA	√							Hot work control when TRU waste is present.
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	PFF								Wooden floor is prohibited by Combustible loading control.
				TRU waste containers staged in transportainers	HM-TRU	MFA								Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				ConOps Program	CO-COP	PPA								
HSO-5	Fire	Fire in the outdoor transportainer involves TRU waste containers.	Hot vehicle exhaust, human error, hot work, maintenance, or electrical fault causes yard fire	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR- Several containers (1,800 PE-Ci)
		(SO-5)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	Risk significantly mitigated by excluding wooden floors in the transportainers.
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate (slowly developing event)
				Fire protection program	FP-FPP	PPA MPA								
				Hotwork prohibition	FP-HOT	PPA	√							Hot work prohibition when TRU waste is present.
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	PFF								Wooden floor is prohibited by Combustible loading control.
				TRU waste containers staged in transportainers	HM-TRU	MFA								Requires the use of transportainers for all outside TRU waste storage.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Vehicle access system	FP-VAC	PFA	√							Controlled access to the facility. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				ConOps Program	CO-COP	PPA								
HSO-6	Fire	Vehicle impact and fire in the outdoor transportainer area	Vehicle impacts containers, vehicle fuel tank leaks and ignites, or flammable (incl. combustible) liquids or pyrophorics in waste containers are ignited during accident.	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — Site limit (1,800 PE-Ci)
		(SO-6, HO-1)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Site perimeter fence	FD-SPF	PFF								
				Spotter required	HR-SPT	PFA								
				Training and qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure. Applies to outdoor staging only.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Vehicle access system	FP-VAC	PFA	√							Controlled access to the facility. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							Includes separation distance for pool fires.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
HSO-7	Fire	Fire spreads to staging area impacting TRU waste containers	Vehicle or forklift accident breaches stored propane cylinders and ignites (forklift, maintenance, or delivery vehicle)	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR- Site limit (1,800 PE-Ci)
		(SO-7, SO-8)		**CONTROLLED/RESIDUAL RISK**			BEU	M	M	M	IV	IV	IV	
				Combustible loading controls	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Site perimeter fence	FD-SPF	PFF								

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Spotter required	HR-SPT	PFA								Only required for movement of TRU waste containers containing TRU waste.
				Waste container inspection (incl. Vent / headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; vent verified functional before receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container. (Note: 3 different admin controls rolled into this one inspection: container inspection; vent verification; independent headspace gas analysis)
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure. Applies to outdoor staging only.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Vehicle access system	FP-VAC	PFA	√							Controlled access to the facility. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							Includes separation distance for pool fires.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	MFA								Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-8	Deleted													
HSO-9	Loss of Containment / Confinement	Loss of waste container confinement	Corrosion or container defect	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(SO-11)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF PFF	√	√	√	√				Robust container design.
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							Inspect container integrity..
HSO-10	Loss of Containment / Confinement	Staged TRU waste containers impacted by moving mobile units or transportainers	Accident while positioning mobile units or transportainers	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-12)		**CONTROLLED/RESIDUAL RISK**			EU	L	L	L	IV	IV	IV	Conducted infrequently (about once per year)
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline-, diesel-, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Spotter required	HR-SPT	PPA								Required for TRU waste container movements only
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Vehicle access system	FP-VAC	PFA	√							Controlled access to the facility. Inventory not allowed when vehicles are present within the WCRRF.
				Vehicle barrier	ED-BRR	PFF	√							Controlled access to the facility. Inventory not allowed when vehicles are present within the WCRRF.
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSO-11	Loss of Containment / Confinement	Forklift, maintenance or delivery vehicle impacts TRU waste containers	Operational vehicle/forklift impacts staged waste containers	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-12, SO-13, HO-5, SO-26)		**CONTROLLED/RESIDUAL RISK**			EU	L	L	L	IV	IV	IV	
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Spotter required	HR-SPT	PFA								Required for TRU waste container movements only
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Vehicle access system	FP-VAC	PFA	√							Controlled access to the facility. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-12 Deleted														
HSO-13	External Event	Fire spreads to the WCRRF impacting TRU waste containers.	Vehicle (not facility related) or refueling truck accident adjacent to site causes fuel leak and spreads throughout WCRRF	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — Site limit (1,800 PE-Ci)
		(SO-15)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Site perimeter fence	FD-SPF	PFF								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				TRU waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Vehicle access system	FP-VAC	PFA	√							Protects against inadvertent access to the site. Provides for the placement of vehicle barriers
				Vehicle barrier	ED-BRR	PFF	√							Protects against runaway vehicles.
HSO-14	NPH	Grass/brush fire in fields impacts TRU waste containers	Wildfire adjacent to site	**UNCONTROLLED**			A	H	H	M	I	I	II	MAR — Site limit (1,800 PE-Ci)
		(SO-16)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA								Gasoline-, diesel-, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
HSO-15	External Event	TRU waste containers impacted.	Vehicle impacts staged containers (not facility-related)	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-17)		**CONTROLLED/RESIDUAL RISK**			EU	L	L	L	IV	IV	IV	
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Site perimeter fence	FD-SPF	PFF								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Vehicle access system	FP-VAC	PFA	√							Protects against inadvertent access to the site. Provides for the placement of vehicle barriers
				Vehicle barrier	ED-BRR	PFF	√							Protects against runaway vehicles.
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-16	External Event	Large fuel spill ignites causing large fire that impacts TRU waste containers.	During refueling of auxiliary generator tank, mishap or accident spills fuel and fuel ignites	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — Site limit (1,800 PE-Ci)
		(SO-18)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline-, diesel-, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure. Applies to outdoor staging only.
				Vegetation exclusion area	FP-VEG	PPA MPA								
				Diesel generator fuel tank double wall	FP-GFT									
				Diesel generator refueling exclusion	FP-RFX	PFA	√							Prevents fuel leaks during refueling from impacting the building when TRU waste containers are in building.
				ConOps Program	CO-COO	PPA								
HSO-17	Natural Phenomena	Ignition of combustibles impacts TRU waste containers staged outside. Potential for fire to spread to the Building.	Lightning causes fire in yard and/or transportainer	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR — Site limit (1,800 PE-Ci)
		(SO-19)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Fire protection program	FP-FPP	PPA MPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Lightning Protection System	FD-LPS	PFF	√							Provides limited reduction in probability for lightning induced fires.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
HSO-18	Natural Phenomena	Overturning transportainer impacts staged TRU waste containers next to and inside transportainer	Wind overturns transportainer	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-20)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	Workers are unlikely to be in staging area during high winds
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transportainer placement	HM-TSP	PFA	√							Restriction on height that they are leveled above ground (<4 ft). Low center of gravity prevents from tipping.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Robust container reduces frequency that TRU waste will be impacted. May provide limited secondary containment if compromised.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSO-19	deleted													
HSO-20	Natural Phenomena	Missile impacts staged TRU waste containers	Wind-driven missile	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR- Several containers (1,800 PE-Ci)
		(SO-22)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				Workers are unlikely to be outdoors during high winds
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Yard maintenance	PR-HKP	PPA								Remove potential missiles
HSO-21	Natural Phenomena	TRU waste containers impacted.	High winds topple stacked TRU waste containers.	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-23)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				Workers are unlikely to be outdoors during high winds

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-22	Natural Phenomena	TRU waste containers toppled by seismic event.	Seismic event	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(SO-24)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transportainer placement	HM-TSP	PFA	√							Transportainer not sited > 4 ft above grade. Prevents toppling of containers. Located 35 ft from building.
				TRU waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-23	Natural Phenomena	TRU waste containers toppled by seismic event and impacted by fire.	Seismic event initiates a facility-wide fire.	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR — Site limit (1,800 PE-Ci)
		(SO-25)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transportainer placement	HM-TSP	PFA	√							Transportainer not sited > 4 ft above grade. Prevents toppling of containers. Located 35 ft from building.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure. Applies when outside TA-50-69.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-24	External Event	Aircraft crash	Aircraft crashes into staging area or building causing a full facility (inside and outside) fire.	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR — Site limit (1,800 PE-Ci)
		(SO-27)		**CONTROLLED/RESIDUAL RISK**			EU	H	H	H	II	II	II	
				Combustible loading controls	FP-CLP	PPA MPA								Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA		√	√	√				Evacuate. For this highly visible event, EPP is credited with decreasing the exposure time (and radiological consequences) for all receptors.
				Fire Protection Program	FP-FPP	PPA MPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage. Protects containers.

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transportainer placement	HM-TSP	PFA								Transportainer not sited > 4 ft above grade.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vegetation exclusion area	FP-VEG	PPA MPA								Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Waste container staging practices	HM-WCS	MFA								Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSO-25	Explosion	Flammable gas deflagrates, ruptures container, and burns	Hydrogen gas builds up in TRU waste container ignited due to impacts with vehicles operating in outside staging areas	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — 1 container (800 PE-Ci) Deflagrations involving TRU waste containers have the potential for energetic lid loss and *high* physical consequences to nearby workers. Radiological consequences to the worker are moderate.
		(SO-9)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA								Rapidly developing event where evacuation may not mitigate dose.
				Fire protection program	FP-FPP	PPA MPA								
				Spotter required	HR-SPT	PFA								Ensures proper container handling and minimizes impacts with nearby objects.
				Training and qualification program	TQ-TRN	PPA								

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF PFF	√	√	√	√				
				Waste container inspection (incl. Vent / headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; Vent verified functional prior to receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container. (Note: 3 different admin controls rolled into this one inspection: container inspection; vent verification;independent headspace gas analysis)
HSO-26	Loss of Containment / Confinement	Reaction products, flammable gas build-up, expansion of container contents due to weather	Waste container vent failure causes gas build-up	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR- 1 container (800 PE-Ci)
		(SO-14, HO-13)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	Frequencies based on condition that drums arrive at the WCRRF after having been vented.
				Emergency Preparedness Program	EP-FAC	MPA								Rapidly developing event where evacuation may not mitigate dose.
				Fire Protection Program	FP-FPP	PPA MPA								
				Spotter required	HR-SPT	PFA								Ensures proper container handling and minimizes impacts with nearby objects.
				Training and Qualification Program	TQ-TRN	PPA								

Table 3A-10. Hazard Analysis Table for Receipt and Staging

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Waste container inspection (:incl. Vent/headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; Vent verified functional prior to receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container.

Location: Outside Building TA-50-69
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: Waste container handling, loading, and unloading activities with the containers outside Building TA-50-69.

Hazard of Concern: Radioactive materials in TRU waste containers, hazards of using material handling equipment.

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
HHO-1	Explosion	Deflagration of flammable gases in TRU waste container during handling in the outside staging areas.	Forklift impact with TRU waste container initiates deflagration or fire	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — 1 container (800 PE-Ci); Deflagrations involving TRU waste containers have the potential for energetic lid loss and *high* physical consequences to nearby workers. Radiological consequences to the worker are *moderate*.
		(HO-2)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA								Rapidly developing event where evacuation may not mitigate dose.
				Fire protection program	FP-FPP	PPA MPA								
				Spotter required	HR-SPT	PFA								Assures proper container handling and minimizes impacts with nearby objects.
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF PFF		√	√	√				Forklift impact with robust, vented, waste container may cause spill, but not fire or deflagration.

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				Waste container inspection (incl. Vent / headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; vent verified functional before receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container. (Note: 3 different admin controls rolled into this one inspection: container inspection; vent verification;independent headspace gas analysis)
HHO-2	Loss of Containment / Confinement	TRU waste container strikes ground	TRU waste container is dropped from elevation during handling.	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-3, HO-8)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Hoisting and Rigging Program	HR-LFT	PPA								Applicable to forklift movements of TRU waste.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Training and Qualification Program	tQ-TRN	PPA								
				Transportainer placement	HM-TSP	PFA		√	√	√				Transportainer not sited > 4 ft above grade.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage. Mitigates release

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF PFF	√	√	√	√				
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HHO-3	Loss of Containment / Confinement	Forklift tine punctures or cylinder or vehicle impacts TRU waste container	Forklift, damaged cylinder, or vehicle impacts TRU waste container during handling	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-4, HO-5, HO-12)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Hoisting and Rigging Program	HR-LFT	PPA								Applicable to forklift movements of TRU waste.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if open.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage. Mitigates release
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides limited hold up of material.

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				Vehicle access system	FP-VAC	PFA	√							Controls vehicle access to the site. Provides for the placement of vehicle barriers.
				Vehicle barrier	ED-BRR	PFF	√							Does not help for forklift moving container
				Spotter required	HR-SPT	PPA								Spotter required during container handling helps assure proper handling
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HHO-4	Loss of Containment / Confinement	Damage to TRU waste container from overturning or falling off dolly or material spilled due to unsecured lids	Operator mishandles TRU waste container	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-6, HO-9)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is undamaged upon receipt. Inspect before handling
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
HHO-5	Loss of Containment / Confinement	Loss of TRU waste container confinement	Degraded, corroded, or damaged TRU waste container fails during handling	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR- 1 container (800 PE-Ci)
		(HO-7)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF PFF	√	√	√	√				Provides limited hold up of material.
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is undamaged upon receipt. Inspect before handling
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HHO-6	Loss of Containment / Confinement	Loss of TRU waste container confinement	Damaged or loose TRU waste container lid fails during handling	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-11)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Hoisting and Rigging Program	HR-LFT	PPA								Applicable to forklift movements of TRU waste.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides limited hold up of material.
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is undamaged upon receipt. Inspect before handling
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HHO-7	Loss of Containment / Confinement	TRU waste container impacted	Lifting device failure causes drop of container	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-10)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Hoisting and Rigging Program	HR-LFT	PPA								Applicable to forklift movements of TRU waste.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				Transportainer placement	HM-TSP	PFA								Transportainer not sited > 4 ft above grade.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage. Mitigates impacts to TRU waste
				Waste container staging practices	HM-WCS	MFA								Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HHO-8	Loss of Containment / Confinement	TRU waste container is impacted	Inclement weather creates conditions leading to loss of vehicle control, slips, overturning, or other loss of control during container handling operations	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HO-9)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Hoisting and Rigging Program	HR-LFT	PPA								Applicable to forklift movements of TRU waste.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Training and Qualification Program	TQ-TRN	PPA								
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if compromised.

Table 3A-11. Hazard Analysis Table for Loading and Unloading Waste Containers

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	CW	P	W	
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Requires the use of transportainers for all outside TRU waste storage.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.

3A.3.4 Hazard Identification, What-If, and Hazard Evaluation Tables for Inside Operations

Hazard Identification Checklist

Table 3A-12 identifies the hazards present inside the WCRRF. The hazards were identified from walkdowns of the WCRRF, review of facility and glovebox system design documentation, discussions with facility, operations, and design personnel, and observations and document reviews of similar operations.

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Acceleration		
Inadvertent motion	Forklift, Vehicle Airlock doors.	Forklift within vehicle airlock, Building TA-50-69
Sloshing of liquids	N/A	N/A
Translation of loose objects	Mechanical hoist (on rails). **NOTE**: Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Within vehicle airlock, Building TA-50-69
Deceleration		
Impacts (sudden stops)	Forklift impacts with structure	Vehicle airlock
Failure of brakes, wheels, tires, etc. (e.g., vehicle accidents)	Forklift brake failure	Driving surfaces in TA-50-69
	Failure of drum dolly and material handling devices such as pallet jacks drop waste containers	Airlock and walking surfaces in Building TA-50-69
	Mechanical hoist. **NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Vehicle Airlock
Falling objects	Mechanical hoist. **NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Vehicle Airlock
	Failure of mechanical hoist device. **NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Raising drums to Waste Characterization Glovebox
	Falls from material handling device	Building TA-50-69
	Suspended mezzanine, space heaters, fixtures	Building TA-50-69
Fragments or missiles	Gas cylinder leak. Quench gases (e.g., P-10 gas cylinders). Deflagrating drum.	Cylinders associated with RCT equipment. Building TA-50-69.

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Chemical Reaction (non-fire, can be subtle over time)		
Disassociation—product reverts to separate components	Waste Containers (over-pressurization due to reaction products)	Waste Characterization Glovebox, throughout Building TA-50-69
Combination—new product formed from mixture	N/A	N/A
Corrosion, rust, etc.	TRU waste containers (corrosion weakens metal)	Limited volume on hand for Waste characterization Glovebox processing
	Mild acids (similar to vinegar, Scrubbing Bubbles)	Glovebox Enclosure S&M, Building and equipment decontamination processes, and RCT spot decontamination
Improper mixing, reagents, water	N/A	N/A
Electrical		
Shock	General building electrical systems	Building TA-50-69
Electrocution	Water from the GBE or Building TA-50-69 suppression systems contacts electrically charged positioning table or exposed circuits.	Glovebox Enclosure, Building TA-50-69 Note: Only GBE S&M activities allowed.
Burns	Electrical space heaters (no propane heaters inside building), motors on forklifts	Present within Building TA-50-69
Overheating	Electrical space heaters (no propane heaters inside building), motors on forklifts	Present within Building TA-50-69
Ignition of combustibles	Power tools, electrical outlets, electrical space heaters, filter cutting tools, motors, etc.	Waste Characterization Glovebox and throughout Building TA-50-69.
Inadvertent activation	Mechanical hoist and material handling equipment. **NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Travel from Vehicle Airlock to Glovebox Enclosure
	Roll-up doors are personnel hazards	Vehicle Airlock
Explosion, electrical	N/A	N/A
Explosion		
Commercial explosives present	N/A	N/A

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Explosive gas	Hydrogen or volatile organic compounds (VOCs) may be present in TRU waste containers	TRU waste containers staged within Building TA-50-69, Waste Characterization Glovebox
Explosive liquid	N/A	N/A
Explosive dust	N/A	N/A
Flammability, Fires		
Presence of fuel—solid, liquid, gas	Natural gas line	Screened, the historic natural gas line has been removed from the WCRRF and capped.
	General combustibles (waste paper and plastic). Miscellaneous combustibles associated with work activities and equipment (cable sleeves, plastic handles on tools, tires on forklifts, grease, etc.)	TRU waste within containers, Waste Characterization Glovebox, and Glovebox Enclosure S&M activities, transient combustibles present in Building TA-50-69.
	Combustible packing material	Waste Characterization Glovebox
	Fixed combustibles associated with Building, WCG and other equipment (e.g., windows, gloves)	Waste Characterization Glovebox, and Glovebox Enclosure, fixed combustibles present in Building TA-50-69.
	Flammable solvents	Waste Characterization Glovebox, Small quantities used throughout Building TA-50-69 for maintenance
	Class IIIB Liquids such as hydraulic fluids, lubricants, epoxies, paints, decontamination solvents, grease, liquid soap and cleaning products (with an NFPA Flammability Rating of 0 or 1).	Forklifts, Waste Characterization Glovebox, drum lifting apparatus, HVAC equipment, and in change rooms/restrooms.
	Off gassing of electrical battery during recharging	Screened, not a credible ignition hazard, Vehicle Airlock
Presence of strong oxidizer—exothermic	Unknowns in waste (PID)	Waste Characterization Glovebox (not expected)
Presence of pyrophoric or oxidizer—self-igniting	Unknowns in waste (PID)	Waste Characterization Glovebox (not expected)
Presence of flammable (incl. combustible) liquid	Unknowns in waste (PID)	Waste Characterization Glovebox (not expected)
Static electrical discharge	Ignition source for hydrogen in glovebox	Waste Characterization Glovebox
Presence of strong ignition source—welding torch	Maintenance hotwork	Building TA-50-69

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Heat and Temperature		
Source of heat	Electrical space heaters (no propane heaters inside building), welding activities, motors, forklift exhaust, etc.	Present within Building TA-50-69
Hot surface burns	Electrical space heaters (no propane heaters inside building), welding activities, motors, forklift exhaust, etc.	Screened, SIH, present within Building TA-50-69
Very cold surface burns	N/A	N/A
Increased gas pressure caused by heat	N/A	N/A
Increased volatility caused by heat	N/A	N/A
Mechanical		
Sharp edges or points	Waste containers (locking ring, head and bottom edges)	Screened, SIH, Building TA-50-69
	Hand tools, power tools (e.g., drill)	Screened, SIH, Waste Characterization Glovebox, Glovebox Enclosure S&M activities, throughout Building TA-50-69
	Filter cutting tools	Screened, SIH, vent filter removal and protective cover removal
	Drum vent edges	Screened, SIH, on drums
	Waste items with sharp edges	Screened, SIH, in drums and other waste containers
Rotating equipment	Air compressor, HVAC fans	Building TA-50-69
	Drum lift, power tools (e.g., drill)	Waste Characterization Glovebox, power tools used in Building TA-50-69 maintenance
Reciprocating equipment	Saws	Used in Building TA-50-69 maintenance
Pinch points	Container handling (e.g., mechanical hoist, pallet jacks, etc.). Note: Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Screened, SIH, Building TA-50-69
	Enclosure doors	Screened, SIH, Glovebox Enclosure
	Roll-up doors	Screened, SIH, Vehicle Airlock

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Heavy equipment operation—e.g., forklift, Bobcat, loader	Forklift, mechanical hoist in vehicle airlock. **NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	Vehicle Airlock, Glovebox Enclosure
Weights to be lifted	Waste containers	Screened, SIH, throughout Building TA-50-69
Stability/toppling tendency	Waste containers	Building TA-50-69
Ejected parts or fragments	Gas cylinder leak. Quench gases (e.g., P-10 gas cylinders). Deflagrating drum.	RCT equipment. Building TA-50-69
Pressure		
Compressed gas	Compressed breathing air. Quench gases (e.g., P-10 gas cylinders).	RCT equipment. Airlines have been disconnected to Waste Characterization Glovebox
Compressed air tool	Hand tools	Used in Building TA-50-69 during maintenance
Pressurized hydraulic fluid	Material Handling Equipment (e.g., forklift)	Vehicle Airlock
	Hydraulic container lifts	Supports Waste Characterization Glovebox operations
	Drum lid installer	Closing drums, Waste Characterization Glovebox operations
	Drum crusher	Screened, drum crusher in Glovebox Enclosure no longer used.
Pressure system exhaust	N/A	N/A
Accidental release—gas, fluid	Compressed breathing air piping, gas cylinder failure (breathing air)	Breathing air cylinders associated with GBE.
Objects propelled by pressure	Gas cylinder leak (breathing air or P-10 gas)	RCT equipment. Breathing air cylinders associated with GBE.
Water Pressure	Activation of WCG sprinkler head.	Inside WCG
Water hammer	N/A	N/A
Flex hose whipping	N/A	N/A
Overflow (RTDs, tanks)	N/A	N/A

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Over-pressurization	Failure of operator interface terminal (OIT), air lines to gloveboxes, etc. Drum failure due to reaction products.	Waste Characterization Glovebox, Glovebox Enclosure, Building TA-50-69. **NOTE:** Air lines have been disconnected to Waste characterization Glovebox.
Static		
Container rupture	TRU waste containers (rupture due to reaction products, etc.)	Waste Characterization Glovebox, throughout Building TA-50-69
Over-pressurization	TRU waste containers (rupture due to reaction products, etc.)	Waste Characterization Glovebox, throughout Building TA-50-69
Negative pressure effects	Building TA-50-69, Waste Characterization Glovebox, and Glovebox Enclosure HVAC systems.	Waste Characterization Glovebox, Glovebox Enclosure, throughout Building TA-50-69
Hose rupture, piping, valve flange, glovebox gaskets	Seal failure	Waste Characterization Glovebox, bag-in/out
Leak of Material		
Flammable	Flammable gas cylinders associated with hotwork	Building TA-50-69
	Flammable organic solvents in waste containers	Waste Characterization Glovebox
	Small volumes of solvents used for decontamination. Small volumes of spray paints, etc.	Used throughout Building TA-50-69 for S&M activities.
	Natural gas leak	Natural gas line has been removed from the WCRRF and capped.
Explosion, Deflagration	Hydrogen or VOCs present in waste containers, natural gas line, propane cylinders associated with forklifts, flammable gas cylinders associated with hotwork.	Waste Characterization Glovebox, Building TA-50-69 Vehicle airlock (note that propane cylinders are prohibited as a result of this evaluation). Natural gas line has been removed from the WCRRF and capped.
Toxic	Unknowns in TRU waste containers (PID)	Waste Characterization Glovebox
Corrosive	Unknowns in TRU waste containers (PID)	Waste Characterization Glovebox
Pyrophoric or oxidizer	Unknowns in TRU waste containers (PID)	Waste Characterization Glovebox

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Radioactive	TRU waste containers and surface contamination	Waste Characterization Glovebox, Glovebox Enclosure, Building TA-50-69
Slippery	Solvent spills (small volume)	Screened, SIH, used in maintenance activities throughout Building TA-50-69
	Oil and lubricant leaks from hydraulics, vehicles, and equipment	Screened, SIH, present throughout Building TA-50-69
Radiation		
Ionizing radiation	TRU waste- majority is alpha radiation with small beta/gamma component. TRU waste containers can be staged in the building waiting processing. Residual contamination on various building and equipment surfaces.	Waste Characterization Glovebox, Glovebox Enclosure, Building TA-50-69
	TRU waste container	Waste Characterization Glovebox, up to 800 PE-Ci staged within Building TA-50-69
	Up to 4 55-gal. TRU drums or one SWB	Screened, Glovebox Enclosure operations no longer conducted. Residual contamination considered.
Ionizing radiation	Unknown in waste (PID)	WCG
Ultraviolet light	N/A	N/A
High-intensity visible light	N/A	N/A
Infrared radiation	N/A	N/A
Microwave, Radio	N/A	N/A
Laser radiation	N/A	N/A
Toxicity		
Gas or liquid	Unknowns in waste containers (PID)	Waste Characterization Glovebox
Asphyxiate	Nitrogen cylinders, P-10 gas cylinders	Screened, SIH
Irritant	Unknowns in waste containers (PID)	Screened, SIH, Waste Characterization Glovebox
Systemic poison	Unknowns in waste containers (PID)	Waste Characterization Glovebox
Carcinogen	Unknowns in waste containers (PID)	Waste Characterization Glovebox
Mutagen	Unknowns in waste containers (PID)	Waste Characterization Glovebox
Combination product	Unknowns in waste containers (PID)	Waste Characterization Glovebox

Table 3A-12. Hazard Identification Checklist for Inside Operations

Hazards	Hazards Applicability	Process or Area
Combustion product	Unknowns in waste containers (PID)	Waste Characterization Glovebox
Vibration		
Vibrating tools	Power tools, saws, drills, etc.	Limited use in Waste Characterization Glovebox, used throughout Building for maintenance.
High noise source level	N/A	N/A
Metal fatigue	N/A	N/A
Flow or jet vibration	N/A	N/A
Supersonics	N/A	N/A
Miscellaneous		
Lubricity	Lubricating fluids for equipment	Screened, SIH, throughout outdoor yard areas

What If Analysis Tables for Inside Operations

Inside operations include all activities performed within Building TA-50-69, including waste container handling and staging operations, as well as process activities performed inside the building. Accidents for these types of operations are presented in the following What-If Tables, Table 3-A-13 through Table 3A-16. The inside operations examined consist of the following types of activities:

SI Staging Inside: staging containers for inside processes

HI Handling Inside: moving and handling containers inside the building

GB WCG operations: TRU waste visual examination, repackaging, prohibited item disposition (PID), and other process activities conducted in the WCG

GE GBE operations: S&M activities conducted in the GBE

NOTE: Significant information is presented in Appendix 3A regarding the glovebox enclosure (GBE). At this time, the GBE will not be used (or required) to stage or process TRU waste containers. The information regarding GBE operations is retained in Appendix 3A due to the contamination present in the GBE and the communication between the GBE and WCG operations ventilation systems. The GBE will also be a part of routine S&M activities associated with Building TA-50-69.

Two-character designations are used to identify accident scenarios in the What-If Analysis tables. Staging and handling, activities common to both inside and outside Building TA-50-69, are addressed in the What-If Analysis tables for outside staging and handling and for inside operations. The codes for these activities are *S* (for staging) and *H* (for handling), followed by either *O* (for outside operations) or *I* (for inside activities). The What-If Analysis for operations performed inside the WCG and GBE was organized by using the above-described activity categories rather than by describing and examining each individual process.

Location: Staging areas inside Building TA-50-69
Facility: Waste Characterization, Reduction, and Repackaging
Site: TA-50, Los Alamos National Laboratory

Process/Activity: Containers awaiting processes are staged inside Building TA-50-69.

Hazards of Concern: TRU waste containers; flammables and combustibles; vehicles.

Table 3A-13. What-If Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SI-1	Nuclear Criticality	Waste containers with significant fissionable material are stacked in a configuration that causes a criticality	Improper stacking of high FGE drums causes inadvertent criticality		HSI-1
SI-2	Loss of Containment / Confinement	Snow loading on roof of Building TA-50-69	Snow loading on roof of Building TA-50-69 causes structural failure and release of material.	Screened, Building is designed to survive live load from snow (up to 30 psf).	None Required
SI-3 Deleted					
SI-4 Deleted					
SI-5 Deleted					
SI-6	Fire	Leaking fuel tank ignites	Fire spreads to the waste containers inside the vehicle airlock. Containers breached and burn	MAR is building limit	HSI-3
SI-7	Fire	Propane cylinder on forklift ignites	Fire breaches staged waste containers	MAR is building limit	HSI-4
SI-8	Fire	Electrical short or other operations cause fire	Building fire breaches glove boxes or containers	MAR is building limit	HSI-5

Table 3A-13. What-If Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SI-9	Fire	Any initiator causes building fire	Large building fire involving combustible loading causes structural damage that impacts radioactive containers, causing release	MAR is building limit	HSI-5
SI-10	Loss of Containment / Confinement	Loss of negative pressurization due to electrical failure that interrupts HVAC	Radioactive material is released from building	MAR is contained inside waste containers and glovebox enclosure	HSI-13
SI-11	Loss of Containment / Confinement	Damage to, or mechanical failure of, airlock door system	Airlock doors operation or their interlocks fail to ensure at least one door is fully closed. Continuous path to outside resulting in loss of building relative negative pressure allows release of contamination	Contamination level expected to be <10% HC-3 level. Proper door operation is a significant part of structural integrity considered with other scenarios	None Required
SI-12	Loss of Containment / Confinement	Container leaks during handling due to damage from overturning, falling off dolly, unsecured lids, missing bung plugs, or corrosion	Container breached	Negligible consequence to the public	HSI-6
SI-13 Deleted					
SI-14	Natural Phenomena	Seismic event	Structural damage debris impacts waste containers, WCG, GE, or staged TRU containers, releasing radioactive material.		HSI-8
SI-15	Natural Phenomena	High winds	Structural damage to building and debris breach containers	Consequences less than seismic event damage. Roll into Acceleration HA (seismic/wind)	HSI-9
SI-16	Natural Phenomena	Lightning initiates fire	Damage causes loss of ventilation and fire. Radioactive material is released from gloveboxes and staged containers		HSI-10
SI-17	Natural Phenomena	Seismic event initiates electrical fire inside building	Fire and structural debris impact TRU waste containers, WCG, or GBE		HSI-12

Table 3A-13. What-If Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
SI-18	Loss of Containment / Confinement	Failure of the operator interface terminal (OIT)	Building overpressurization results in release of radioactive material	MAR is contained inside waste containers and glovebox enclosure	HSI-13
SI-19	Loss of Containment / Confinement	Internal water sources found in some of the waste storage facilities include domestic water and fire suppression piping. Contributors can include; construction/other activities impact runoff, clogged/plugged drain (debris or trash), drain covered by container, insufficient drain capacity. In the case of the GBE fire suppression system, a potential initiator to a criticality (see GE-7, GE-8)	Activation or failure of the fire suppression systems, failure of domestic water lines.	Negligible release is expected	None Required

Location: Inside Building TA-50-69
Facility: Waste Characterization, Reduction, and Repackaging
Site: TA-50, Los Alamos National Laboratory

Process/Activity: Handling waste containers and loading them onto or into processes located within the building such as visual examination, size reduction, and repackaging.

Hazards of Concern: Radioactive contents of one to four TRU waste containers.

Table 3A-14. What-If Analysis Table for Handling Waste Containers Inside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
HI-1	Explosion	Forklift impacts or tines breach container. Actions create ignition source	Fire or deflagration of flammable gases breach waste container		HHI-1
HI-2	Fire	Vehicle fire caused by short, human error or other causes while carrying load	Fire breaches containers carried on pallet		HHI-2
HI-3 Deleted					
HI-4	Loss of Containment / Confinement	Drum falls from mechanical hoist	Drum strikes floor, is breached, and releases radioactive material	**NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	HHI-4
HI-5	Loss of Containment / Confinement	Drum falls from mechanical hoist	Drum strikes glovebox, penetrating or causing loss of confinement Radioactive material released	**NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility. MAR minor contamination	HHI-4
HI-6	Loss of Containment / Confinement	Forklift failure or operator error drops containers	Pallet of drums overturned with impact breaching drums	MAR is building limit	HHI-5
HI-7	Loss of Containment / Confinement	Forklift punctures standard waste box	Container is breached, releasing radioactive material	MAR 1 drum in SWB or contents of SWB	HHI-6
HI-8	Loss of Containment / Confinement	Forklift impacts glovebox	Glovebox containment is breached, and radioactive material is released.	MAR 1 drum	HHI-6
HI-9	Loss of Containment / Confinement	Forklift impacts or punctures drums	Containers are breached, releasing radioactive material	MAR 2 drums	HHI-6

Table 3A-14. What-If Analysis Table for Handling Waste Containers Inside Building TA-50-69

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
HI-10	Loss of Containment / Confinement	Forklift impacts handled container	Forklift impact by tine or vehicle breaches waste container		HHI-6
HI-11	Loss of Containment / Confinement	Drum falls from mechanical hoist and separates from bag-on seals	Drum strikes floor, is breached, and releases radioactive material	**NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility.	HHI-7
HI-12	Loss of Containment / Confinement	Container mishandling	Damage from overturning, falling off dolly, unsecured lids or missing bung plugs, or tearing out of bag-on/off seals breaches waste containers		HHI-7
HI-13	Loss of Containment / Confinement	Gas cylinder ruptures and impacts staged waste containers	Gas cylinder impact breaches waste containers		HHI-6
HI-14	Fire	Human error during hotwork, maintenance, smoking, or unauthorized activities causes fire	Fire breaches waste containers.		HSI-5

Location: Waste characterization glovebox, Building TA-50- 69
Facility: Waste Characterization, Reduction, and Repackaging
Site: TA-50, Los Alamos National Laboratory

Process/Activity: Waste Characterization Glovebox processes including visual examination, PID, repackaging, segregation, and sorting.

Hazards of Concern: TRU waste contents in one drum.

Table 3A-15. What-If Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
GB-1	Direct Exposure	Radioactive source falls from shielding	Worker exposed to radioactive source that was in a shielded waste drum. Source remains in glovebox.	Radiation exposure to worker. No consequence to the public	HGB-1
GB-2	Explosion	Flammable gas build-up in container results in deflagration	Built-up gas released during container opening ignites, breaching the glovebox		HGB-2
GB-3	Fire	Pyrophoric, flammable (incl. combustible Class II or IIIA) liquid, gas, or oxidizer material results in deflagration and fire	Drum contents ignite and fire spreads to combustibles. Glovebox confinement is breached, releasing radioactive material	Class IIIB liquids will not *initiate* a fire, but could be consumed along with ordinary combustibles if heated enough during a fire.	HGB-3
GB-4	Loss of Containment / Confinement	Process actions puncture containment	Unpacking actions break WCG or sharp edges puncture glove, causing leakage of spilled radioactive material or contamination	Contamination level expected at levels controlled by Radiation Protection Program	None Required
GB-5	Loss of Containment / Confinement	Confinement system failure by non-process action	Aging, degradation, maintenance activities, or other non-process activity causes glove, seals, or structural damage, resulting in loss of confinement	Contamination level expected at levels controlled by Radiation Protection Program	None Required
GB-6	Loss of Containment / Confinement	Loss of relative negative pressurization in glovebox due to loss of balanced exhaust system	Glovebox overpressurizes, breaching confinement and releasing radioactive material		HGB-4
GB-7	Loss of Containment / Confinement	Corrosive liquid spill	Chemical reaction breaches glovebox confinement and causes radioactive contamination	Contamination level expected <10% HC-3 level	None Required

Table 3A-15. What-If Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
GB-8	Loss of Containment / Confinement	Drum hits glovebox during handling	Drum impact damages glovebox seals or gloves, or breaks glasses, causing radioactive material release		HGB-6
GB-9	Natural Phenomena	Seismic event	Structural damage debris breaches glovebox confinement, releasing radioactive contents		HGB-5
GB-10	Natural Phenomena	Lightning strike causes power loss	HVAC shuts down, causing loss of negative pressure/overpressurization in exhausted glove boxes. Confinement is breached and radioactive material released	Contamination level expected <10% HC-3 level	None Required
GB-11	Loss of Containment / Confinement	Operator error during bag-out	Drum displaced from WCG during removal, breaking containment and releasing radioactive material		HGB-6
GB-12	Loss of Containment / Confinement	Operator error	During HEPA filter change, operator error causes loss of confinement and radioactive material release	Contamination level expected <10% HC-3 level	None Required
GB-13	Loss of Containment / Confinement	Structural failure of lift	Drum lift device fails, dropping drums, breaching confinement, and releasing material.	WCG Drum Lift maintained at ML-2 (PC-2 rated)	HGB-7
GB-14	Natural Phenomena	Seismic event	Drum separates from confinement sleeve, releasing radioactive material (drum remains on drum lift)		HGB-5
GB-15	Natural Phenomena	Seismic event	WCG drum lift collapses, dropping drums and breaching confinement	WCG Drum Lift maintained at ML-2 and rated at PC-2	HGB-5
GB-16	Loss of Containment / Confinement	Worker error activates WCG drum lift	Drum lift actuates, pulling drum from confinement sleeve, and releasing material		HGB-6
GB-17	Loss of Containment / Confinement	Mechanical failure	WCG drum lifting device winch motor or cable fails		HGB-6
GB-18	Loss of Containment / Confinement	Pressurization of a glovebox due to tool air supply failure or mishap.	Glovebox pressurizes, breaching confinement and releasing radioactive material		HGB-4

Table 3A-15. What-If Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
GB-19	Fire	Power tools or electrical equipment located within the WCG ignite combustibles in the WCG.	Fire in WCG ignites exposed combustible TRU waste.	Power tools are battery operated (e.g., 16 V). Plug in scales, recharger, etc.	HGB-9
GB-20	Fire	Flammable liquid in waste containers spill and catch on fire due to ignition source	Fire in gloveboxes breaches the glovebox		HGB-3
GB-21	Loss of confinement/containment	Water from the activation (e.g. actual fire response or inadvertent activation) of the WCG sprinkler head fills the WCG and leaks onto the floor.	Water from sprinkler activation breaches the glovebox.	Radiological material is entrained in the fire suppression water.	HGB-10
GB-22	Loss of confinement/containment	Water from the activation (e.g. actual fire response or inadvertent activation) of the WCG sprinkler head either clogs the WCG outlet HEPA filter or pressurizes the WCG causing a loss or decrease in the WCG vacuum.	Radiological material is released into the building.		HGB-11

Location: Glovebox enclosure, Building TA-50-69
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process/Activity: Surveillance and Maintenance (S&M) of glovebox enclosure.

Hazards of Concern: Residual contamination within glovebox enclosure. Common ventilation system with the WCG.

Table 3A-16. What-If Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
GE-1	Loss of Containment / Confinement	Residual contamination in GBE.	Worker exposed to residual contamination in GBE during routine S&M activities.	Contamination level expected <10% HC-3 level in GBE.	HGE-1
GE-2	Fire	Any ignition source (e.g., power tools, shorts in electric hoist) ignites combustibles in the GBE or GBE airlock.	Fire consumes rubber gloves or breaches HEPA filters or ductwork, causing loss of confinement or over-pressurizes GBE forcing through air supply ducts and penetrations. Overpressurization or the GBE may impact the WCG, as well.	**NOTE:** Mechanical hoist is out of service, will not be used, and will be removed from the facility. Contamination level expected <10% HC-3 level in GBE. May spread to involve remainder of facility	HGE-2, HGE-3
GE-3	Loss of Containment / Confinement	Mechanical handling device or forklift impacts glovebox enclosure walls or doors	Mechanical impact breaches confinement.	Contamination level expected <10% HC-3 level in GBE. May impact confinement in the WCG, as well.	HGE-4, HGB-8
GE-4	Loss of Containment / Confinement	Electrical power fails	Electrical power failure causes loss of HVAC negative pressure or overpressurization in exhausted glovebox	Contamination level expected <10% HC-3 level in GBE. Common exhaust with WCG.	HGB-4
GE-5	Loss of Containment / Confinement	Human error or mechanical failure causes airlock failure	Both inner and outer airlock doors open at the same time, releasing radioactive material	Contamination level expected <10% HC-3 level in GBE. May impact confinement in the WCG, as well.	HGE-5, HGB-8
GE-6	Natural Phenomena	Seismic event	Glovebox Enclosure fails releasing contamination\	Contamination level expected <10% HC-3 level in GBE.	HSI-8, HGB-5

Table 3A-16. What-If Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Initiating Event or Cause	Scenario	Comment or Action	HA ID #
GE-7	Nuclear Criticality	Fire sprinkler system actuates inside GBE and floods GBE liquid collection sump (water reflection and moderation)	GBE fire sprinkler system water reflection and moderation inside GBE sump causes inadvertent criticality	Likelihood beyond extremely unlikely due to GBE configuration and contamination levels.	HGE-6
GE-8	Nuclear Criticality	Use of water or other moderator during routine operations (e.g., decontamination) causes criticality	Collection of water or other moderator inside GBE creates criticality	Likelihood beyond extremely unlikely due to GBE configuration and contamination levels.	HGE-6
GE-9	Loss of Containment / Confinement	Loss of relative negative pressurization in glovebox due to loss of balanced exhaust system causes loss of confinement	Glovebox overpressurizes, forcing radioactive material out from confinement.	Contamination level expected <10% HC-3 level in GBE. May impact confinement in the WCG as well.	HGB-8
GE-10	Electrocution	Water from the GBE suppression system contacts an electrically charged positioning table	Water-based suppression system actuates, contacting positioning table in glovebox and resulting in potential worker electrocution	Standard Industrial Hazard	None required

Hazards Analysis Tables for Inside Operations

The Hazard Analysis tables for inside operations (Table 3A-17 through Table 3A-20) present the unmitigated (or uncontrolled) frequency and consequence categories for the public and workers, and the associated risk rankings. Immediately following them are controlled or mitigated estimates incorporating the benefits of applying the listed controls to the accident scenarios. Primary controls (i.e., more effective controls) are marked with a check mark (√) in the applicable column. Checked controls are the credited controls that reduce risk. The residual risk reflects frequency reduction and consequence mitigation achieved through these controls.

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Location: Inside Building TA-50-69 common areas
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: Staging waste containers in preparation for WCRR processes inside Building TA-50-69.

Hazard of Concern: Radioactive material in staged TRU waste containers.

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSI-1	Nuclear Criticality	Improper stacking of high FGE drums causes inadvertent criticality	TRU waste containers with significant fissionable material are stacked in a configuration that causes criticality	**UNCONTROLLED**			EU	L	L	H	IV	IV	II	
		(SO-1, SI-1)		**CONTROLLED/RESIDUAL RISK**			BEU	L	L	H	IV	IV	III	
				Emergency Preparedness Program	EP-FAC	MPA								
				Nuclear Criticality Safety Program	NC-CSP	PPA	√							Within FGE limits and drums stored in accordance with NCSE requirements
				Spotter required	HR-SPT	PPA								Spotter required during container handling helps assure proper handling
				Training and Qualification Program	TQ-TRN	PPA								

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	PFA								Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSI-2 deleted														
HSI-3	Fire	Fire spreads to TRU waste containers staged inside the vehicle airlock	Leaking fuel from a truck parked near the building ignites and burns	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR — Building limit (800 PE-Ci)
		(SI-6)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								Assumed airlock door is open
				Building TA-50-69 structural integrity	FD-BSD	MFF								Assumed airlock door is open
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Vehicle access system	FP-VAC	PFA	√							Ensures only project-related vehicles access site.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
HSI-4	Fire	Fire impacts staged TRU waste containers	Forklift accident inside building, fuel system damage, fuel leaks cause a fire	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — Building limit (800 PE-Ci)

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(SI-7)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					FP-FSS supports building confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					FP-FSS supports building integrity
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				Maintenance program	MP-INS	PPA								Inspects forklifts for leaks and ensures they are in good service.
HSI-5	Fire	Building fire impacts gloveboxes or TRU waste containers	Electrical short or operations cause fire	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR — Several containers (1,800 PE-Ci)
		(SI-8, SI-9, HI-14)		**CONTROLLED/RESIDUAL RISK**			U	L	L	M	III	III	II	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					FP-FSS supports building confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					FP-FSS supports building integrity
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√					

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Hot work prohibition	FP-HOT	PPA	√							Hot work prohibition when TRU waste is present.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				.If drum is opened. No protection provided. Filtered vent paths allow containers to relieve pressure
HSI-6	Loss of Containment / Confinement	Loss of confinement from TRU waste container	TRU waste container overturns or falls off dolly or unsecured lid leaks	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(SI-12)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Provides secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Provides secondary confinement
				Emergency preparedness programs	EP-FAC	MPA				√				Evacuate

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Assumed to be open
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							
HSI-7 Deleted														
HSI-8	Natural Phenomena	Structural damage to building, debris impacts TRU waste containers	Seismic event	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Building limit (800 PE-Ci)
		(SI-14)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					PC-2 qualified
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if open.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Located 35 ft from building. Prevents outside containers from being involved.
				Transportainer placement	HM-TSP	PFA	√	√	√	√				Located 35 ft from building to maintain MAR limit of 800 PE-Ci. Prevents outside containers from being involved.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides limited barrier to release
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				Seismically qualified to PC-2

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HSI-9	Natural Phenomena	Structural damage to building and debris breach TRU waste containers	High wind	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Building limit (800 PE-Ci)
		(SI-15)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 structural integrity	FD-BSD	PFF	√							Building is qualified for high wind events.
				Emergency preparedness	EP-FAC	MPA				√				Evacuate
				Transportainer	ED-TDI	MFF								Provides limited secondary containment if open.
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				Located 35 ft from building. Prevents outside containers from being involved.
				Transportainer placement	HM-TSP	PFA	√							Located 35 ft from building. Prevents outside containers from being involved.
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				
HSI-10	Natural Phenomena	Fire spreads through building and impacts gloveboxes or TRU waste containers	Lightning initiates fire inside the building	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR — Building limit (800 PE-Ci)

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(SI-16)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Building may be compromised by fire. Although marked only limited credit can be taken for this control.
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Building may be compromised by fire. Although marked only limited credit can be taken for this control.
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate (slowly developing event)
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				The FSS may be disabled by the lightning damage to the building. Although marked only limited credit can be taken for this control.
				Lightning Protection System	FD-LPS	PFF	√							Provides limited reduction in probability for lightning induced fires.

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				
HSI-11 Deleted														
HSI-12	Natural Phenomena	Fire and structural debris impact TRU waste containers, WCG, or GBE	Seismic event initiates electrical fire inside building	**UNCONTROLLED**			EU	H	H	H	II	II	II	MAR — Building limit (800 PE-Ci)
		(SI-17)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√	√				
				Building TA-50-69 structural integrity	FD-BSD	PFF MFF	√	√	√	√				PC-2 qualified
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				
				Maintenance program	MP-INS	PPA								
				Transportainer Placement	HM-TSP	PFA	√							Transportainer not staged > 4 ft above grade. Prevents toppling of containers. Located 35 ft from building to maintain MAR limit of 800 PE-Ci.
				Transportainer	ED-TDI	MFF								
				TRU waste containers staged in transportainers	HM-TRU	MFA		√	√	√				
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides limited protection of material from seismic impact.
				WCG design integrity and confinement	ED-WCD	MFF	√	√	√	√				Provides limited holdup of material.
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				Seismically qualified to PC-2

Table 3A-17. Hazard Analysis Table for Waste Container Staging Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container staging practices	HM-WCS	MFA		√	√	√				Stacking restrictions limit number of containers that fail due to toppling. Stacking of drums and SWBs disallowed.
HSI-13	Loss of Containment / Confinement	Building overpressurization leads to loss of confinement	Failure of operator interface terminal (OIT) or loss of power.	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — Building limit (800 PE-Ci)
		(SI-10, SI-18)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Provides passive contamination holdup.
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Provides passive contamination holdup.
				Diesel generator	ED-GEN	MFF								Provides backup power to ventilation system.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Drum may be open (will be located in glovebox)

Location: Inside Building TA-50-69
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: TRU container handling to move containers to WCRR processes.

Hazard of Concern: Radioactive material in drums and SWBs.

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
high	Explosion	Deflagration of flammable gases in TRU waste containers during handling in the vehicle airlock	Forklift impact with TRU waste container initiates deflagration and/or fire	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — 1 container (800 PE-Ci) Deflagrations involving TRU waste containers have the potential for energetic lid loss and *high* physical consequences to nearby workers. Radiological consequences to the worker are *moderate*.
		(HI-1)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	Event assumes unrecognized failure of the TRU container venting system.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√	√				Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA								Rapidly developing event where evacuation may not mitigate dose.
				Fire protection program	FP-FPP	PPA MPA								

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				Prevents event from cascading.
				Spotter required	HR-SPT	PFA								Assures proper container handling and minimizes impacts with nearby objects.
				Training and Qualification Program.	TQ-TRN	PPA		.						
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF								
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; vent verified functional before receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container. (Note: 3 different admin controls rolled into this one inspection: container inspection; vent verification; independent headspace gas analysis)
HHI-2	Fire	Fire impacts TRU waste containers carried on pallet during offloading in the vehicle airlock.	Forklift fire caused by electrical short, human error, or other causes while carrying TRU waste containers	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — Building limit (800 PE-Ci)
		(HI-2)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Combustible loading controls	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√					
				Vehicle fuel restrictions	FP-PRO	PFA	√							Gasoline, diesel, or propane-fueled vehicles shall not be used at WCRRF while TRU waste is present in the facility.
				Spotter required	HR-SPT	PFA								

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container inspection (incl. Vent / headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; vent verified functional before receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container. (Note: 3 different admin controls rolled into this one inspection: container inspection; vent verification; independent headspace gas analysis)
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Filtered vent paths allow containers to relieve pressure.
HHI-3 Deleted														
HHI-4	Loss of Containment / Confinement	TRU waste container strikes floor	Drum falls from lifting device	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HI-4, HI-5)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Hoisting and Rigging Program	HR-HRP	PPA								

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Critical lift plan	HR-LFT	PPA	√							Applicable to forklift movements of degraded TRU drums when not in a TRU waste container.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides some holdup of material
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								
HHI-5	Loss of Containment / Confinement	Pallet of TRU waste containers overturned in the vehicle airlock	Forklift failure or operator error drops TRU waste containers	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — Several containers (1,800 PE-Ci)
		(HI-6)		**CONTROLLED/RESIDUAL RISK**			EU	L	L	L	IV	IV	IV	
				Hoisting and Rigging Program	HR-HRP	PPA								
				Critical lift plan	HR-LFT	PPA	√							Applicable to forklift movements of degraded TRU drums when not in a TRU waste container.

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Emergency preparedness plan	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Spotter required	HR-SPT	PFA								Spotter required during container handling helps assure proper handling
				Training and Qualification Program	TQ-TRN	PPA								(Spotter cannot prevent failure)
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides some holdup of material
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								
HHI-6	Loss of Containment / Confinement	TRU waste container impacted	Forklift or damaged cylinder punctures or forcefully impacts gloveboxes or TRU waste containers during staging or handling	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — Building limit (800 PE-Ci)

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(HI-7, HI-8, HI-9, HI-10, HI-13)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Hoisting and Rigging Program	HR-HRP	PPA								
				Critical lift plan	HR-LFT	PPA	√							Applicable to forklift movements of degraded TRU drums when not in a TRU waste container.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Spotter required	HR-SPT	PFA								Spotter required during container handling helps ensure proper handling
				Training and Qualification Program	TQ-TRN	PPA								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides some holdup of material

Table 3A-18 Hazard Analysis Table for Waste Container Handling Inside Building TA-50-69

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HHI-7	Loss of Containment / Confinement	Drum strikes floor	TRU waste container is mishandled	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci)
		(HI-11, HI-12)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Hoisting and Rigging Program	HR-HRP	PPA								
				Critical lift plan	HR-LFT	PPA	√							Applicable to forklift movements of degraded TRU drums when not in a TRU waste container.
				Emergency Preparedness Program	EP-FAC	MPA				√				Confine or evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	MFF		√	√	√				Provides some holdup of material

Location: Inside Building TA-50-69 at WCG
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: Waste Characterization Glovebox processes including visual examination and repackaging.

Hazard of Concern: Radioactive material in TRU waste containers.

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGB-1	Direct Exposure	Worker exposed to penetrating radiation from items in WCG	Unexpected radioactive source is removed from waste containers attached to WCG	**UNCONTROLLED**			U	L	L	M	III	III	II	
		(GB-1)		**CONTROLLED/RESIDUAL RISK**			U	L	L	M	III	III	II	
				Emergency Preparedness Program	EP-FAC	MPA				√				Timely evacuation if RCT identifies abnormal dose rates
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PPA								
				Radiation protection program	RP-RPP	MPA								RCT/PPE>56 PE-Ci monitoring CAMs

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGB-2	Explosion	Built-up gas released while opening TRU waste container results in deflagration impacting the waste and glovebox.	Flammable gas build-up in TRU waste container resulting in deflagration in WCG	**UNCONTROLLED**			A	H	H	H	I	I	I	MAR- 1 container (800 PE-Ci) Deflagrations involving TRU waste containers have the potential for energetic lid loss and physical and radiological consequences to nearby workers.
		(GB-2)		**CONTROLLED/RESIDUAL RISK**			U	L	L	M	III	III	II	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA				√				Rapidly developing event where evacuation may not mitigate dose.
				Fire Protection Program	FP-FPP	PPA MPA								
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				Maintains some containment

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				WCG sprinkler activates.
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Transuranic waste containers (design integrity and filtered vent)	ED-TRU	PFF	√							May be open at the time of the event. TRU waste container fitted with filtered vent. May be open at the time of the event.

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container inspection (incl. vent/headspace gas analysis verification)	HM-WCI	PPA	√							Ensure container is sound; Vent verified functional prior to receipt at WCRRF. Minimizes potential for flammable gases to be present in the waste container.
				Grounded Unvented Drum	GU-FPP	PPA	√							Applicable to 30-gallon drums
				Drum lid restraint	LR-FPP	MPA		√	√	√				Applicable to 30-gallon drums
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				Seismically qualified to PC-2. Strap will hold drum in place in case of deflagration inside of WCG.
				Use of Nonsparking tools/ de-energization of WCG electric receptacles when breaching unvented, sealed waste packages in the WCG.	FP-NST	PPA	√							

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGB-3	Fire	Drum contents ignite, spreading fire to combustibles, impacting the glovebox confinement	Pyrophoric, flammable (including combustible Class II or IIIA) liquid, gas, or oxidizer material ignites, or spontaneous combustion causes fire	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — 1 container (800 PE-Ci)
		(GB-3, GB-20)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement. WCG exhaust filters are sufficiently downstream and protected to not be impacted by this event.
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Fire Protection Program	FP-FPP	PPA MPA								

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				
				Operator interface terminal (OIT)	ED-VCC	MFF								

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Waste container inspection (incl. Vent and headspace gas analysis verification)	HM-WCI	PFA	√							Verified container is within inventory limits.
HGB-4	Loss of Containment / Confinement	Radioactive material leaks from WCG confinement	Loss of exhaust system or pressurization of the WCG or loss of power during container processing	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci). Event with lower MARs (e.g., ~ 56 PE-Ci) may occur more frequently (e.g., II); however; consequence categories would also be reduced one bin each.
		(GE-4, GB-6, GB-18)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	Frequency estimates reflect conditional probability that loss of power occurs during high MAR container processing.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Diesel generator	ED-GEN	MFF								Provides backup power to ventilation system.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Minimize sharp objects	CO-SHP	PPA								Minimizes potential to compromise boundary
				Restrictions on pressurized system usage	CO-PSU	PPA								All air lines to glovebox have been disconnected as a result of lessons learned. Significant overpressurization is not expected.
				TRU waste containers (design integrity and filtered vents)	ED-TRU	MFF		√	√	√				Maintains some containment without exhaust
HGB-5	Natural Phenomena	Structural damage and debris breach WCG confinement	Seismic event causes building structural failure when TRU waste material is in WCG	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR- Building limit (800 PE-Ci)

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(GE-6, GB-9, GB-14, GB-15)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√	√				Meets PC-2 criteria
				Emergency Preparedness Program	EP-FAC	MPA				√				
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				Seismically qualified to PC-2
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				Seismically qualified to PC-2
HGB-6	Loss of Containment / Confinement	Drum displaced from WCG, causing loss of confinement	Worker error during bag-in or bag-out process or inadvertent activation of WCG drum lift	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR — Building limit (800 PE-Ci)

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(GB-8, GB-11, GB-16, GB-17)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Inspection of drum lift occurs as part of the inspection of the WCG system.
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				
HGB-7	Loss of Containment / Confinement	Loss of confinement	Drum lift device fails, dropping drums, breaching confinement, and releasing material.	**UNCONTROLLED**			A	L	M	M	III	II	II	MAR- 1 container (800 PE-Ci)
		(GB-13,)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Assumed to fail

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Assumed to fail
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Inspection of drum lift occurs as part of the inspection of the WCG system.
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				Debris may provide some holdup.
				WCG drum lift design	ED-GBL	PFF MFF	√	√	√	√				Seismically qualified to PC-2, maintained at ML-2
HGB-8	Loss of Containment / Confinement	Radioactive material leaks from WCG confinement. Container is in process in the WCG.	Upsets in the GBE result in overpressurization or loss of confinement in the WCG. Initiators can include fires in the GBE, impacts with the GBE structure or ductwork, airlock failures, or loss of power.	**UNCONTROLLED**			U	L	M	M	III	II	II	MAR — 1 container (800 PE-Ci). Event with lower MARs (e.g., ~ 56 PE-Ci) may occur more frequently (e.g., II); however; consequence categories would also be reduced one bin each.
		(GE-3, GE-5, GE-9)		**CONTROLLED/RESIDUAL RISK**			U	L	L	L	III	III	II	Frequency estimates reflect conditional probability that overpressurization occurs during high MAR container processing.

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					Secondary containment
				Diesel generator	ED-GEN	MFF								Provides backup power to ventilation system.
				Emergency Preparedness Program	EP-FAC	MPA				√				Evacuate
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Minimize sharp objects	CO-SHP	PPA								Minimizes potential to compromise boundary

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Restrictions on pressurized system usage	CO-PSU	PPA								All air lines to glovebox have been disconnected as a result of lessons learned. Significant overpressurization is not expected.
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				Maintains some containment without exhaust
HGB-9	Fire	Any ignition source (e.g., power tools, hotwork) ignites combustibles in the WCG.	Fire consumes rubber gloves or breaches HEPA filters or ductwork, causing loss of confinement. Potential for direct release path to exterior of Building.	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR — 1 container (800 PE-Ci). Event with lower MARs (e.g., ~ 56 PE-Ci) may occur more frequently (e.g., II); however, consequence categories would also be reduced one bin each.
		(GB-19)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	Frequency estimates reflect conditional probability that fire occurs during high MAR container processing.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					FSS protects this control. Secondary confinement

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					FSS protects this control. Secondary containment
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading from glovebox to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				WCG sprinkler activates.
				Hot work prohibition	FP-HOT	PPA	√							Hot work prohibition when TRU waste is present.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				WCG design integrity and confinement	ED-WCD	MFF		√	√	√				Maintains some containment without exhaust

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGB-10	Loss of containment/ confinement	Radioactive material is entrained in water from the activation of the WCG sprinkler head which fills the WCG and leaks onto the floor.	Actual fire response or inadvertent activation	**UNCONTROLLED**			U	M	L	L	II	III	III	MAR – 1 container (800 PE-Ci) Radioactive material remains entrained within the water.
				CONTROLLED/RESIDUAL RISK			EU	L	L	L	IV	IV	IV	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Hot work prohibition	FP-HOT	PPA	√							Hot work prohibition when TRU waste is present.
				Fire protection program	FP-FPP	PPA MPA								
HGB-11	Loss of confinement/co ntainment	Water from the activation of the WCG sprinkler head either clogs the WCG outlet HEPA filter or pressurizes the WCG causing a loss or decrease in the WCG vacuum and release of radioactive material.	Actual fire response or inadvertent activation of the WCG sprinkler head.	**UNCONTROLLED**			U	M	M	M	II	II	II	MAR – 1 container (800 PE-Ci)

Table 3A-19. Hazard Analysis Table for Waste Characterization Glovebox Processes

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				CONTROLLED/RESIDUAL RISK			EU	M	M	M	III	III	III	
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Hot work prohibition	FP-HOT	PPA	√							Hot work prohibition when TRU waste is present.
				Fire protection program	FP-FPP	PPA MPA								

Location: Glovebox Enclosure, Building TA-50-69
Facility: TA-50, Waste Characterization, Reduction, and Repackaging
Site: Los Alamos National Laboratory

Process or Activity: Surveillance and Maintenance (S&M) of glovebox enclosure.

Hazard of Concern: Residual contamination within glovebox enclosure. Common ventilation system with the WCG.

Note: Information is presented in Table 3A-20 regarding the glovebox enclosure (GBE). At this time, the GBE will not be used (or required) to stage or process TRU waste containers. The information regarding GBE operations is retained due to the contamination present in the GBE and the cross-communication between the GBE and WCG ventilation systems. To ensure that GBE operations are not initiated without further evaluation and approval, the prohibition on staging or processing waste in the GBE is an Initial Condition that will be carried forward as a SAC.

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGE-1	Loss of Containment / Confinement	Worker exposed to airborne / loose contamination in GBE during routine S&M	Residual contamination remaining in GBE.	**UNCONTROLLED**			A	L	L	L	III	III	III	MAR — Residual contamination in GBE.
		(GE-1)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	Contamination level expected <10% HC-3 level in GBE.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF								Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA								Evacuate
				GBE design integrity	ED-GBD	PFF								
				GBE exhaust system	ED-GBE	MFF								
				Two-man rule	CO-TMR	PPA								
HGE-2	Fire	Any ignition source (e.g., power tools, hotwork) ignites combustibles in the GBE airlock.	Fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement. Fire spreads to remainder of building.	**UNCONTROLLED**			U	H	H	H	I	I	I	MAR- Building limit (800 PE-Ci)

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
		(GE-2)		**CONTROLLED/RESIDUAL RISK**			EU	M	M	M	III	III	III	
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF		√	√					FSS protects this control. Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF		√	√					FSS protects this control. Secondary containment
				Combustible loading control	FP-CLP	PPA MPA	√	√	√	√				Prevents fire from spreading from glovebox to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA				√				
				Fire protection program	FP-FPP	PPA MPA								
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF		√	√	√				GBE water suppression
				GBE design integrity	ED-GBD	PFF								
				GBE exhaust system	ED-GBE	MFF								
				GBE inlet HEPA filters	ED-GBF	MFF								

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Hotwork prohibition	FP-HOT	PPA	√							Hotwork prohibition when TRU waste is present.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGE-3	Fire	Any ignition source (e.g., power tools, hotwork) ignites combustibles in the GBE or GBE airlock.	Fire breaches HEPA filters, ductwork, or enclosure, causing loss of confinement. Fire restricted to GBE.	**UNCONTROLLED**			A	L	L	L	III	III	III	MAR- Residual contamination in GBE.
		(GE-2)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	Contamination level expected <10% HC-3 level in GBE.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								FSS protects this control. Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF								FSS protects this control. Secondary containment
				Combustible loading control	FP-CLP	PPA MPA								Prevents fire from spreading from glovebox to other containers. Minimizes magnitude of fire and potential releases.
				Emergency Preparedness Program	EP-FAC	MPA								
				Fire protection program	FP-FPP	PPA MPA								

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Building TA-50-69 and WCG Fire Suppression System	FP-FSS	MFF								GBE water suppression
				GBE design integrity	ED-GBD	PFF								
				GBE exhaust system	ED-GBE	MFF								
				GBE inlet HEPA filters	ED-GBF	MFF								
				Hot work prohibition	FP-HOT	PPA								Hot work prohibition when TRU waste is present.
				Maintenance program	MP-INS	PPA								Forklifts that will be lifting TRU waste containers are maintained.
				Operator interface terminal (OIT)	ED-VCC	MFF								

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
HGE-4	Loss of Containment / Confinement	Mechanical impact breaches GBE confinement	Container or mechanical handling device (manipulator arm) impacts GBE walls or doors	**UNCONTROLLED**			A	L	L	L	III	III	III	MAR — Residual contamination in GBE.
		(GE-3)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	Contamination level expected <10% HC-3 level in GBE.
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF								Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA								
				GBE exhaust system	ED-GBE	MFF								Reduces amount leaving GBE through penetration
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Radiation protection program	RP-RPP	MPA								RCT/PPE >56 PE-Ci monitoring CAMs

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				Training and Qualification Program	TQ-TRN	PPA								Manipulator arm
				Two-man rule	CO-TMR	PPA								
				ConOps PRogram	CO-COP	PPA								
HGE-5	Loss of Containment / Confinement	Both inner and outer GBE airlock doors open at the same time, allowing release	Mechanical failure, door switch failure, or human error	**UNCONTROLLED**			A	L	L	L	III	III	III	MAR — Residual contamination in GBE.
		(GE-5)		**CONTROLLED/RESIDUAL RISK**			A	L	L	L	III	III	III	Contamination level expected <10% HC-3 level in GBE. No motive force to drive material from GBE
				Airlock door usage administratively controlled (GBE)	PR-GBA	PFF								
				Building TA-50-69 confinement ventilation system	FD-BCN	MFF								Secondary confinement
				Building TA-50-69 structural integrity	FD-BSD	MFF								Secondary containment
				Emergency Preparedness Program	EP-FAC	MPA								Manually close doors

Table 3A-20. Hazard Analysis Table for Glovebox Enclosure S&M Activities

ID No.	Accident Type	Scenario	Cause or Initiating Event	Control Description	Control ID	Control Type	Freq	Conseq			Risk			Notes
								P	CW	W	P	CW	W	
				GBE exhaust system	ED-GBE	MFF								
				Maintenance program	MP-INS	PPA								
				Operator interface terminal (OIT)	ED-VCC	MFF								
				Two-man rule	CO-TMR	PPA								
HGE-6	Nuclear Criticality	GBE fire sprinkler system water reflection and moderation inside GBE sump causes inadvertent criticality	Fire sprinkler system actuates inside GBE and floods GBE liquid collection sump (water reflection and moderation)	**UNCONTROLLED**			BEU	L	L	H	IV	IV	III	Criticality safety evaluation has determined that a criticality is not possible.
		(GE-7, GE-8)		**CONTROLLED/RESIDUAL RISK**			BEU	L	L	H	IV	IV	III	

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APPENDIX 3B

Radioactive Material Dispersion Calculations Using MACCS2 and POSTMAX

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APPENDIX 3B: RADIOACTIVE MATERIAL DISPERSION CALCULATIONS USING MACCS2 AND POSTMAX

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3B.1 INTRODUCTION

Radiological offsite dispersion calculations were performed using a pair of computer codes, the MELCOR Accident Consequence Code System, Version 2 (MACCS2) code (Ref. 1), and the POSTMAX dispersion analysis postprocessor code (Ref. 2). MACCS2 is a Department of Energy/Nuclear Regulatory Commission (DOE/NRC) sponsored code that has been used widely in support of probabilistic risk assessments (PRAs) for the nuclear power industry and for consequence analyses for safety documentation throughout the DOE complex. POSTMAX was developed at Los Alamos National Laboratory (LANL) to enable the calculation of site-specific 95th percentile consequence metrics from MACCS2 output files.

Evaluation guides historically have been defined in terms of the radiation dose that might be received by an offsite individual from a single acute exposure to airborne materials. This measure of consequence focuses on the potential health hazard to a single person at any offsite location that might be affected by an atmospheric dispersion plume. When this hypothetical person is exposed to the highest ground-level air concentration that occurs at or beyond the site boundary, the term “maximally-exposed offsite individual (MEOI)” is used to define this person. Appendix A of DOE-STD-3009 (Ref. 3) cites a quantitative Evaluation Guideline (EG) of 25 rem total effective dose equivalent (TEDE) to the MEOI for comparison with the doses estimated from various bounding and unique accident scenarios analyzed in Chapter 3 of this document.

To base safety decisions on realistic accident conditions that are reasonably conservative but not extreme as a result of rare combinations of atmospheric stability and wind direction, Appendix A to DOE-STD-3009 specifies the 95th percentile of the distribution of doses to the MEOI, accounting for variations in both the distance to the site boundary and in meteorological conditions as a function of direction, as the comparison point for assessment against the EG. Furthermore, the method used to derive the 95th percentile should be consistent with the statistical treatment of calculated χ/Q values described in Regulatory Position 3 of NRC Regulatory Guide 1.145 (Ref. 4). The LANL Safety Basis Office (SBO) (formerly the Office of Authorization Basis [OAB]) has issued Operational Support Tool 300-00-06.0, *LANL Guidelines for Performing Atmospheric Dispersion Analysis* (Ref. 5), to provide detailed guidance for performing dispersion analyses for LANL facilities using the MACCS2 and POSTMAX computer codes. The guidelines established to meet the requirements outlined in Appendix A to DOE-STD-3009. This approach was followed for the atmospheric dispersion calculations supporting the Waste Characterization, Reduction, and Repackaging Facility (WCRRF) Basis for Interim Operation (BIO).

The MACCS2 code can use three separate input modules to perform transport and dose calculations: ATMOS, EARLY, and CHRONC. Other input files might be needed to support the calculations. These include meteorological data files (data taken from the LANL meteorological tower located at Technical Area [TA]-6 were used for these analyses), a site data file containing the population distribution around the postulated release location (not used for these analyses), and a nuclide dose-conversion factor file (not used because only a χ/Q value is being calculated using MACCS2).

The ATMOS module performs all the calculations pertaining to atmospheric transport, dispersion, and deposition, as well as the radioactive decay that occurs prior to release and while the material is in the atmosphere. The results of the calculations are stored for use by the EARLY and CHRONC modules when those modules are included as part of the calculation. The downwind transport of up to four plumes can be modeled. In addition to the air and ground concentrations, ATMOS stores information on wind direction, plume arrival and departure times, and plume dimensions.

The EARLY module performs all the dose calculations pertaining to the emergency phase of an accident. The emergency phase begins, at each successive downwind distance point, when the first plume of the release arrives. The exposure pathways considered during this period are cloudshine, groundshine, and resuspension inhalation. The CHRONC module calculates doses incurred after the plume has passed and the only exposure source is from ground-deposited material. Such doses are attributable to groundshine, resuspension inhalation, and from ingesting contaminated food and water. The LANL guidelines describe how to use the ATMOS module to calculate the χ/Q values for each weather trial. That information is provided as input to POSTMAX. Because no dose calculations are carried out using MACCS2, the EARLY and CHRONC modules are not exercised. Doses to the MEOI are calculated in Section 3.4 using a hand calculation based on the 95th percentile χ/Q values calculated from POSTMAX results.

To support consequence calculations for the various postulated evaluation basis accidents, several sets of MACCS2 and POSTMAX runs simulating buoyant and non-buoyant plume releases from ground level were carried out to provide 95th percentile χ/Q values for use in the accident analysis. The runs were made based on the release of 1 Ci of ^{239}Pu, although the nuclide specified does not affect the χ/Q calculation. All other MACCS2 input parameters were identical from one run to the next except for input parameters used to specify plume buoyancy.

3B.2 MACCS2 DISPERSION-MODEL ASSUMPTIONS

The following discussion itemizes modeling assumptions used to define input parameters to the MACCS2 dispersion code.

MACCS2 requires a radial grid be defined to specify receptor distances under consideration. Within this grid, the source location is assumed to be the center of the coordinate system (i.e., r = 0). For the WCRRF analyses, 35 spatial intervals with gradually increasing widths are defined out to a radius of 7 km to include the farthest distance to the site boundary and to allow smooth interpolation of ground level air concentration values between the radial grid centerpoints during subsequent POSTMAX calculations.

Hourly averaged values for wind speed, wind direction, atmospheric stability, and precipitation rate were provided in year-long weather files compiled specifically for use in MACCS2. Data recorded at the LANL TA-6 meteorological tower were used in compiling the files. Precipitation had no effect on plume dispersion because wet deposition was not allowed in the MACCS2 calculations.

A five-year meteorological data set from 1995 to 1999 was used for the accident analyses. MACCS2 dispersion calculation results for six separate years were combined using the POSTMAX utility code so that yearly variability would be incorporated into the selection of representative site boundary dilution factors.

Tadmor and Gur analytic correlations to Pasquill-Gifford dispersion-coefficient data were applied. These correlations are based on actual plume dispersion measurements over grassy terrain (roughness length equal to 3 cm) within the range of 0.5 to 5 km.

A surface roughness scale factor of $(z/z_0)^{0.2} = (38/3)^{0.2} = 1.66$ was used to correct the smooth-terrain vertical dispersion coefficients that are based on a 3-cm roughness to a local surface roughness of 38 cm. The selection of 38 cm as a representative roughness length for the general area in the vicinity of WCRRF at TA-50 is discussed later in this appendix. The American Meteorological Society (Ref. 6) has endorsed this formula as a reasonable modification of available experimental data to site-specific conditions.

One plume was released for each accident scenario modeled.

No credit was taken for additional dilution during plume meander under very low wind speed and very stable conditions for the 60-second spill release duration. This approach can introduce a factor-of-two conservatism to the very conditions that typically give the highest concentration estimates for many source configurations. The release duration and the plume-meander time reference were set equal to 1200 seconds for fire event calculations for the collocated worker.

The MACCS2 results of interest to this study are time-integrated air concentrations (i.e., cumulative exposure) as a function of direction and radial distance. For this reason, the exact value specified for release duration is irrelevant. This statement is true for all scenarios, including fire, because plume rise is determined by the heating rate and not by the total energy released. For the WCRRF accident consequence calculations, spill release durations were set equal to 60 seconds, and release durations were set equal to 1200 seconds for simulation of a release due to fire.

MACCS2 meteorological sampling option 5 (stratified random sampling) with 24 samples per day was invoked for all dispersion calculations. This choice forces MACCS2 to evaluate every hour of data in a meteorology data file.

No building wake effects were considered. The initial vertical and horizontal dispersion coefficients were set to the minimum allowed values of $\sigma_y(x=0) = \sigma_z(x=0) = 0.1\,\text{m}$ to approximate a point source. The building height MACCS2 input parameter was set to 1.0 m.

Both spill and fire accident scenarios were modeled as ground-level releases. The spill release was non-buoyant. One non-buoyant (0.0 MW) plume release and 12 buoyant plume releases, ranging from 0.10 MW to 25 MW, were modeled for comparison for the fire scenarios.

Wet deposition was suppressed by specifying MACCS2 input parameters in such a way that conservatively high air concentrations could be maintained. Dry deposition was allowed with a

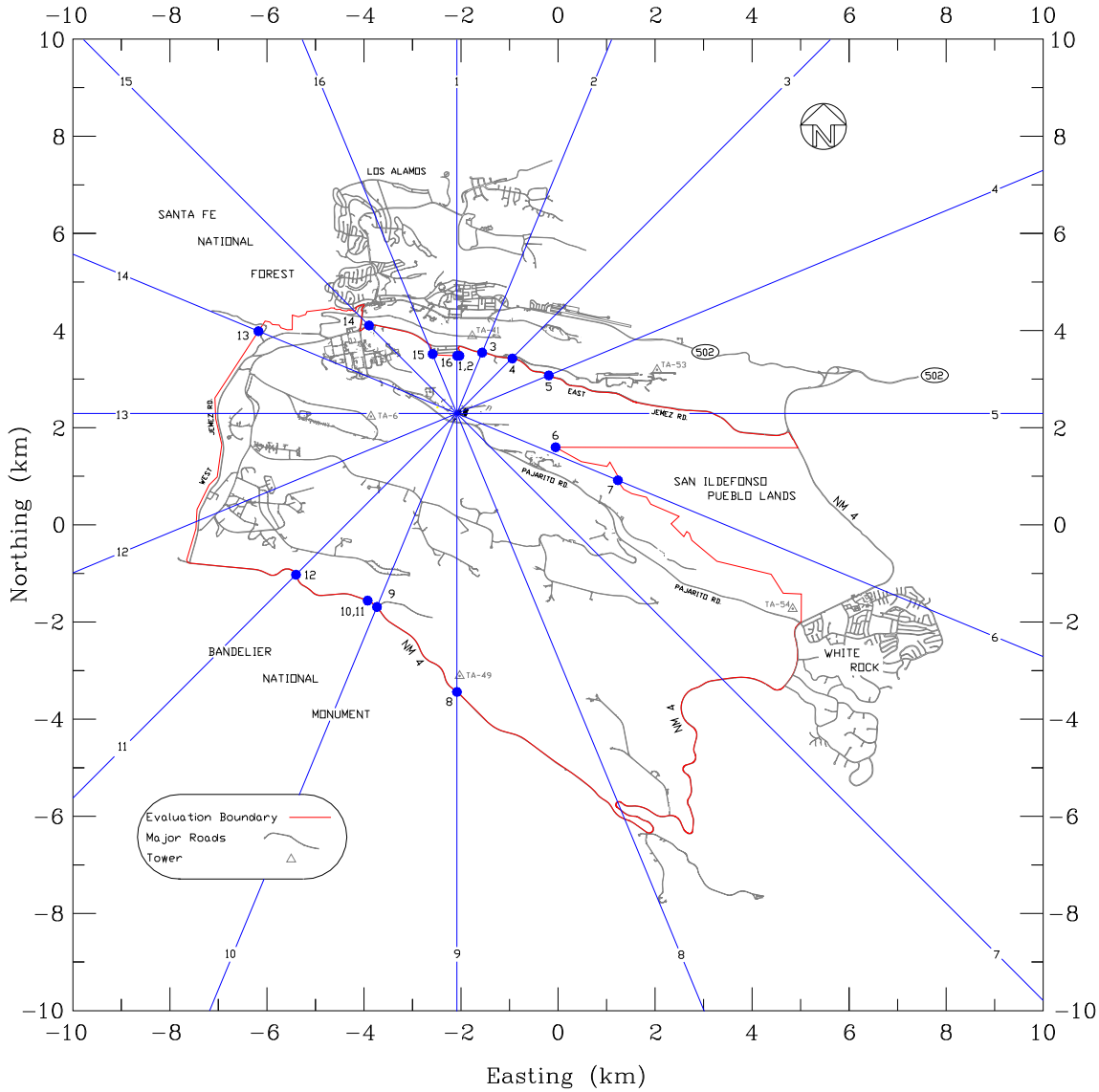
deposition rate of 1 cm/s. The NRC sponsored work by Sandia National Laboratories to recommend parametric dry deposition values for use in MACCS dispersion analyses for risk assessments associated with the operation of nuclear reactors (Ref. 7). This study recommends a range of values for particulate dry deposition velocity. The values range from 0.03 to 3.0 cm/s. A value of 1 cm/s for dry deposition falls within the range suggested by NRC.

3B.3 DEFINITION OF THE SITE BOUNDARY DISTANCES FOR RELEASES FROM WCRRF

The Regulatory Guide 1.145 methodology referenced in Appendix A to DOE-STD-3009 collapses the geometry of a site into 16 points. One point is identified for each nearest distance between the source and the site boundary that can be found within a 45° sector (arc) that is centered successively on each of the 16 compass directions (compass points are numbered clockwise from north). These distances were determined by Ray Sartor of SB-PG (Ref. 8). These distances are given in Table 3B-1 and are illustrated for WCRRF by the solid dots in Figure 3B-1. This figure was rendered in AUTOCAD of maps and drafting data supplied by the KSL UMAP organization. The data were derived from the LANL Geographic Information System (GIS) (New Mexico State Plane Coordinate System NAD 83, as amended). The wide sectors surrounding each compass direction are imposed to account for the possibility that the wind direction might shift during plume transport away from the straight line assumed by Gaussian dispersion models. Forty-five degree sectors are also intended to accommodate additional variability in site meteorology that might not be adequately represented in the available data. The nearest public access points on the site boundary within each sector are rarely found exactly along the wind rose directions and, because the 45° sectors overlap, some sectors share the same point of closest approach. In effect, this method assumes that plume centerlines *always* pass over the nearest distance corresponding to the wind direction sector at the time of release. Thus, this method allows some credit for distance to the site boundary in every direction of the wind rose.

Table 3B-1. Nearest Site Boundary Distances in Each Wind Direction for WCRRF

Boundary Point Number and Location Description	Direction from WCRRF	Distance from WCRRF (m)
1 Royal Crest Trailer Court	N	1187.03
2 Royal Crest Trailer Court	NNE	1187.03
3 East Jemez Road	NE	1356.23
4 East Jemez Road	ENE	1598.63
5 East Jemez Road	E	2045.85
6 San Ildefonso Pueblo Land	ESE	2147.05
7 San Ildefonso Pueblo Land	SE	3588.55
8 Bandelier National Monument along State Road 4	SSE	5728.07
9 Bandelier National Monument along State Road 4	S	4307.43
10 Bandelier National Monument along State Road 4	SSW	4266.66
11 Bandelier National Monument along State Road 4	SW	4266.66
12 Bandelier National Monument along State Road 4	WSW	4676.71
13 West Jemez Road	W	4426.61
14 East Jemez Road	WNW	2562.10
15 Royal Crest Trailer Court	NW	1318.71
16 Royal Crest Trailer Court	NNW	1187.94



(Sectors are centered on the 16 wind directions.)

Figure 3B-1. Nearest Site Boundary Distances in Each 45° Sector for WCRRF

Note that nearest boundary points at LANL are often found at the edge of a sector. Since the sectors overlap, it is possible for two sectors to share the same nearest point.

Once the site boundary locations have been selected, plume-centerline, ground-level air concentrations are computed at the site boundary distances corresponding to the wind directions for all hourly observations of weather data. As stated previously, five full years of hourly meteorological data were evaluated using MACCS2 and POSTMAX. The complete set of concentration values represents conservatively the distribution of possible exposures that a person standing anywhere on the boundary might receive from an accident that occurred at a random time during the year. The 95th percentile of possible site-boundary ground-level air

concentrations is then reported as a representative consequence to be used in all calculations of public dose. Results are then compared to the EG.

3B.4 DISCUSSION OF SURFACE ROUGHNESS

Typical facility safety analyses conducted at LANL incorporate meteorology data compiled, processed, and archived by its Air Quality Monitoring Group (Environmental Stewardship Division, Meteorological & Air Quality [ENV-MAQ] formerly Environment, Safety, and Health [ESH]-17). An annual weather file used in MACCS2 applications contains data that consist of 8760 hourly-averaged values of wind speed, wind direction, atmospheric stability category, and precipitation. ENV-MAQ determines the stability category of a measurement by computing the standard deviation of vertical wind fluctuations over an hour and comparing this value to a table provided by the U.S. Environmental Protection Agency (EPA) that defines the ranges of each category. According to the EPA-450 protocol (Ref. 9), ENV-MAQ also adjusts the ranges of the table to account for differences between the local surface roughness within 1 to 3 km of the TA-6 meteorology tower (estimated at 40 cm) and the 15-cm roughness length on which the standard table is developed. This adjustment is made by scaling all *ranges* in the standard table by a factor of $(40\,\text{cm}/15\,\text{cm})^{0.2} = 1.217$ *before* classifying the local measurements.

Figure 3B-2 illustrates the process of classifying a measurement's stability category. When interpreting this process, it is important to recognize that the measurements already incorporate, or reflect, the turbulence induced by local surface roughness in the vicinity of the tower. As shown in the figure, a measurement that might be categorized as Stability B in an area with a 15-cm roughness length (no adjustment to standard table) is now categorized as Stability C in a region with a 40-cm roughness length. Given the common understanding that increased roughness contributes to instabilities in the surface-level wind field, the EPA method appears to conservatively shift the categorization back towards more stable conditions than are actually supported by local measurements. Over a full year of data, the LANL frequency distribution of atmospheric stability is skewed towards more stable, less dispersive, conditions, and this frequency distribution affects the determination of the 95th-percentile site-boundary dilution factors.

The standard table provided in the reference is plotted in black (lower curve). The table corrected by local roughness around the meteorology tower is plotted in red (upper curve). This process shifts observations towards more stable (conservative) categories than measurements of vertical wind-direction standard deviations would indicate.

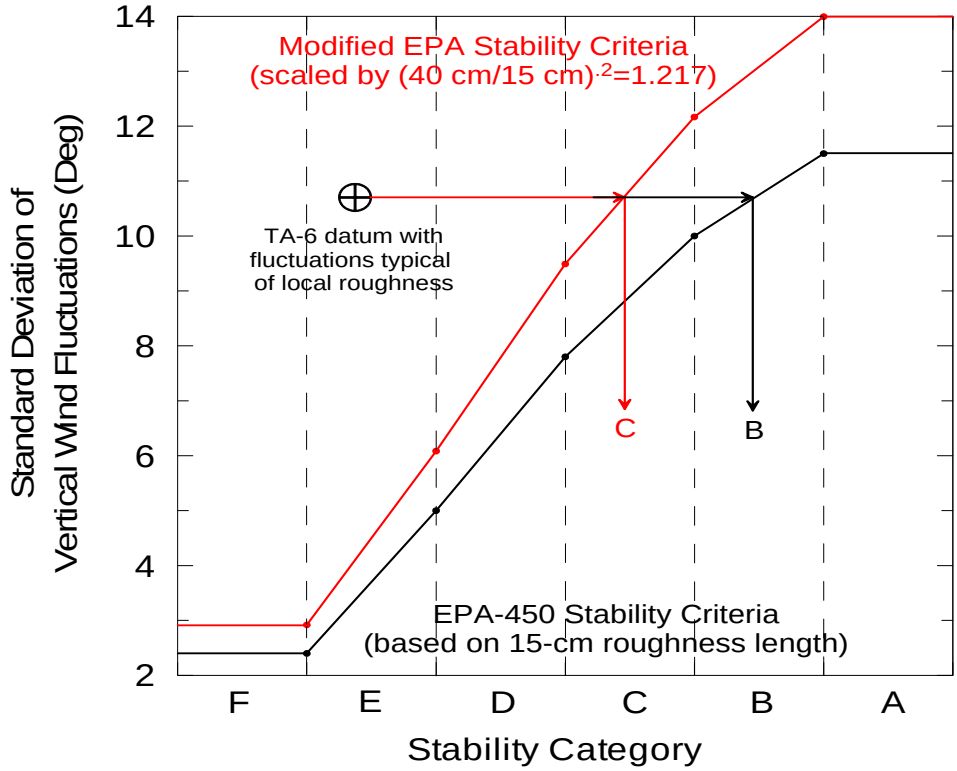


Figure 3B-2. Stability Categorization by the Method of EPA-450

The effect of the EPA correction is to remove the enhanced turbulence component that is added due to roughness beyond the 15 cm, and to report stability in terms of the convective (solar heating) and shear stress (wind speed) components of turbulence alone. These are the only two factors used by the original Pasquill-Gifford categorization schemes that provide a common definition of stability for most Gaussian dispersion models. To understand this more fully, consider two measurements of vertical fluctuation taken under identical wind speeds and solar incidence. One measurement is taken in an area of 15-cm roughness and the other in an area of 40-cm roughness. By the Pasquill-Gifford definitions, the atmospheric stability is the same. If the EPA method is to reflect this fact, enhanced turbulence caused by the 40-cm roughness must be scaled out of the measurement.

Regardless of the procedure by which stability categories are defined from the raw data, the role of site meteorologists is to describe the distribution of local conditions, i.e., the fraction of observations falling into each category. The role of the safety analyst, on the other hand, is to model plume dispersion for each category in a technically defensible manner while retaining some predictive value for estimating downwind concentrations. As long as a common definition of atmospheric stability is being applied, any considerations of surface roughness made during these two processes are entirely independent.

The single most influential choice of parameters that a safety analyst makes is the set of dispersion coefficients, i.e., the correlations that define lateral and vertical plume growth as functions of downwind distance. Many such correlations available in the literature are based on

experiments conducted in a variety of terrain conditions. A given set of correlations based on a roughness z_0 can be adjusted for a local surface roughness z by the scaling factor $(z/z_0)^{0.2}$ as suggested by the American Meteorological Society. Because the Tadmor and Gur correlations selected for this study are based on data collected over a smooth terrain of 3-cm roughness, a roughness correction is appropriate for a facility that is surrounded by an open, rolling terrain. A surface roughness of 38 cm at TA-50 was cited in *Los Alamos Climatology* (Ref. 10) based on wind measurements during neutral stability conditions. This corresponds to an average surface roughness scaling factor of 1.66 and is the value selected for use in MACCS2 as appropriate for the vicinity surrounding WCRRF.

3B.5 RESULTS OF MACCS2 AND POSTMAX CALCULATIONS

Table 3B-2 provides the 95th percentile MEOI χ/Q values at the site boundary, and Table 3B-3 provides the 95th percentile χ/Q values at 100 m for the collocated worker, in units of s/m^3, calculated using MACCS2 and POSTMAX for non-buoyant and buoyant accident scenarios (Ref. 11). All accident scenarios are modeled as ground level releases. Buoyant accidents range between 0.10 MW and 10 MW plume buoyancies. The χ/Q values were obtained by using MACCS2 and POSTMAX according to the LANL methodology for performing atmospheric dispersion analysis. Results are based on five years of meteorological data, from 2003 through 2007. Figure 3B-3 presents a plot of 95th percentile χ/Q values versus plume buoyancy based on the information in Table 3B-2.

In a special high-wind case providing a 95th percentileχ/Q value, a wind of 34 m/s (77 mph) [Ref. 10] was artificially defined into a straight-line Gaussian Plume equation. The distance of 1,187.03 meters was used as the distance to the MEOI, and a release height of 3 meters was used for the point release. The A-stability class (the classification of an extremely unstable meteorological condition) Tadmor and Gur analytic correlations to Pasquill-Gifford dispersion-coefficient data was applied for the standard deviation of concentration in lateral and vertical directions. The result χ/Q value for this special case is 2.51 E-8 s/m^3

Table 3B-2. 95th Percentile Site Boundary MEOI χ/Q Values for WCRRF Accident Scenarios

Accident Scenario	WCRRF Site Boundary X/Q (s/m^3) For 1cm/s deposition and 38-cm surface roughness
Spill Accident – Nonbuoyant release	5.74E-05
Fire Accident – 0.00 MW release	3.93 E-05
Fire Accident – 0.10 MW smoldering release	4.95E-05
Fire Accident – 0.25 MW plume	4.56E-05
Fire Accident – 0.50 MW plume	4.11E-05
Fire Accident – 1.0 MW plume	3.30E-05
Fire Accident – 1.50 MW plume	2.72E-05

Table 3B-2. 95th Percentile Site Boundary MEOI χ/Q Values for WCRRF Accident Scenarios

Accident Scenario	WCRRF Site Boundary X/Q (s/m^3) For 1cm/s deposition and 38-cm surface roughness
Fire Accident – 2.0 MW plume	2.31E-05
Fire Accident – 2.5 MW plume	1.97E-05
Fire Accident – 3.0 MW plume	1.75E-05
Fire Accident – 4.0 MW plume	1.43E-05
Fire Accident – 5.0 MW plume	1.23E-05
Fire Accident – 10.0 MW plume	7.62E-06
Fire Accident – 25.0 MW plume	3.95E-06

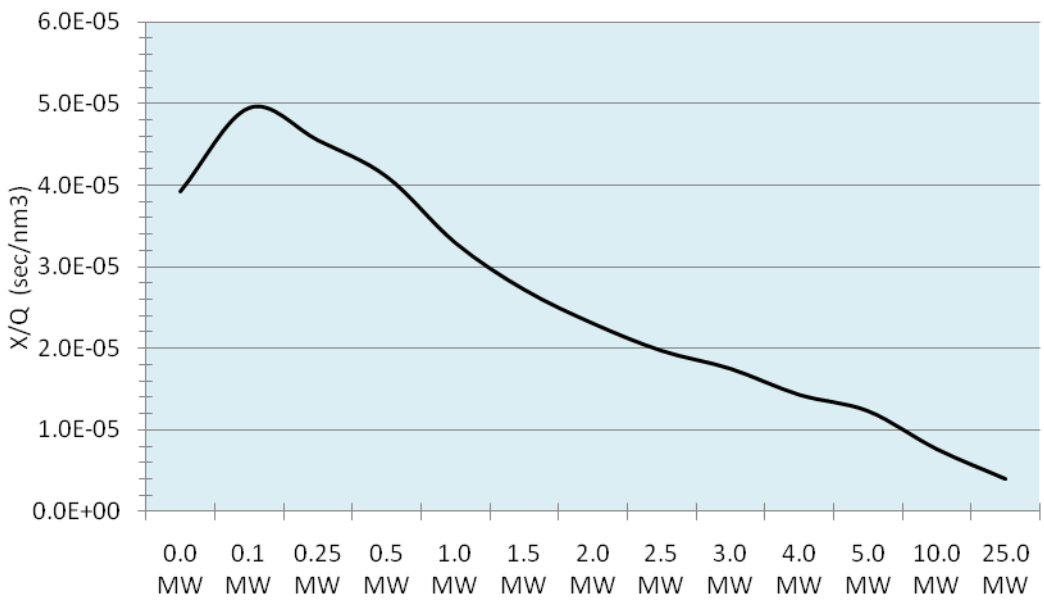


Figure 3B-3. 95th Percentile Site Boundary MEOI χ/Q Values for WCRRF Accident Scenarios

Table 3B-3. 95th Percentile Collocated Worker χ/Q Values for WCRRF Accident Scenarios

Accident Scenario	WCRRF X/Q (s/m^3) at 100 m For 1cm/s deposition and 38-cm surface roughness
Spill Accident – Nonbuoyant release	8.19E-03
Fire Accident – 0.00 MW release	5.63E-03
Fire Accident – 0.10 MW smoldering release	5.41E-04
Fire Accident – 0.25 MW plume	4.02E-04
Fire Accident – 0.50 MW plume	3.18E-04
Fire Accident – 1.0 MW plume	2.37E-04
Fire Accident – 1.50 MW plume	1.79E-04
Fire Accident – 2.0 MW plume	1.51E-04
Fire Accident – 2.5 MW plume	1.35E-04
Fire Accident – 3.0 MW plume	1.22E-04
Fire Accident – 4.0 MW plume	1.02E-04
Fire Accident – 5.0 MW plume	8.67E-05
Fire Accident – 10.0 MW plume	4.70E-05
Fire Accident – 25.0 MW plume	1.10E-05

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APPENDIX 3C

Lightning-Initiated Fire Frequency

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APPENDIX 3C: LIGHTNING-INITIATED FIRE FREQUENCY

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3C.1 INTRODUCTION

This appendix presents estimates of the probable frequency of a lightning-initiated fire at Building TA-50-69. It uses the following process to develop these estimates.

1. Establish the number of lightning strikes to the facility per yr for the Los Alamos area.

The National Oceanic and Atmospheric Administration (NOAA) provides a lightning flash density map for the U.S. on its web site (Ref. 0). This map is included as Figure 3C-1. The large scale of the map makes it difficult to read the density in specific areas, but it appears that a small area with a density of four to eight strikes per yr per km^2 falls on the Los Alamos area. This area is within a larger area with a density of two to four strikes per yr per km^2. The mid-point of the higher range is six strikes per yr per km^2. This value is corroborated by lightning flash frequency presented in *Lightning Activity in Los Alamos Area 1998-2000* (Ref. 0).

2. Calculate the "total attractive strike area" and lightning strike frequency for the entire Waste Characterization, Reduction, and Repackaging Facility.

A National Lightning Safety Institute (NLSI) paper (Ref. 0) states that the probability of lightning striking a particular object situated on the ground is found by multiplying the object's lightning-attractive area by the local ground-flash density (lightning strikes to ground per km^2 per yr). The paper notes that the attractive area is a function of the object's ground surface area, its height, and the characteristics of the particular lightning strike.

3C.2 LIGHTNING STRIKE FREQUENCIES

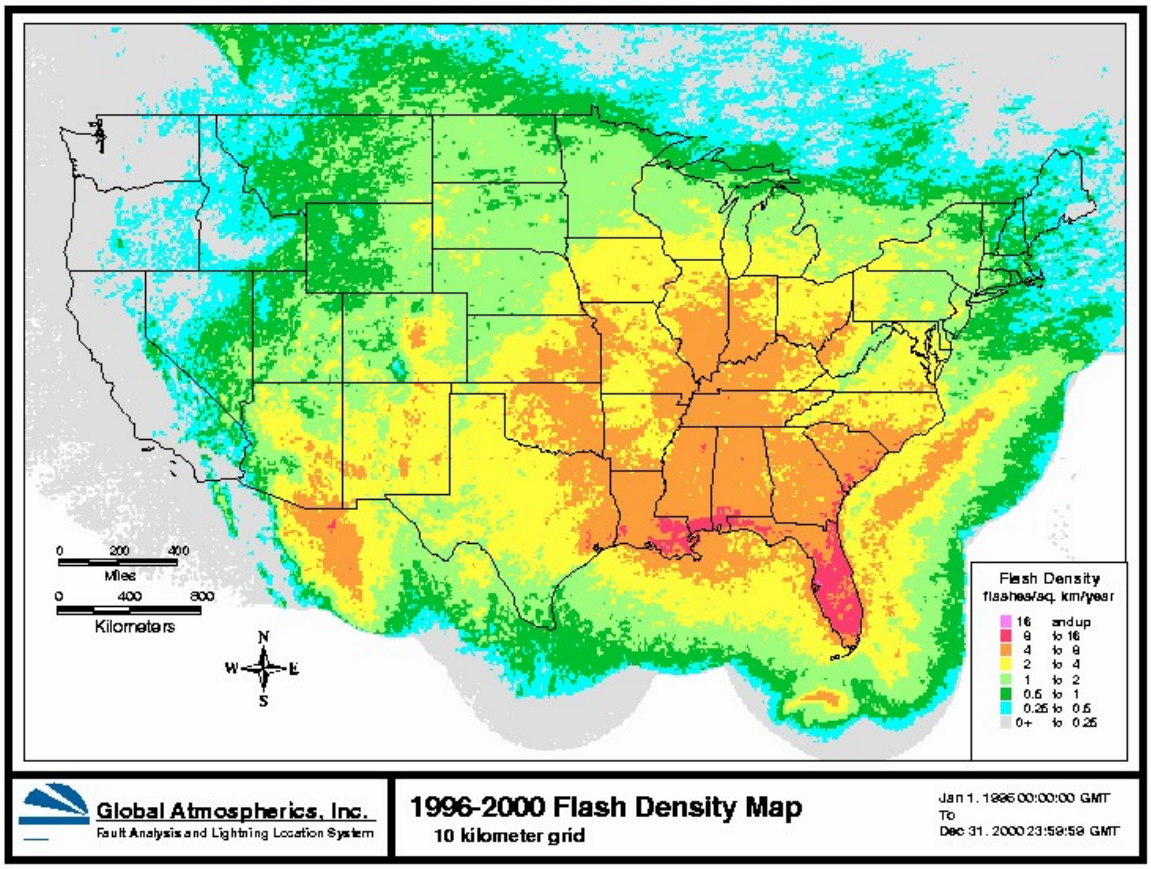

Figure 3C-1. Lightning Flash Density Map for the United States

According to the NLSI paper, the lightning strike frequency for any facility (P) is the product of the lightning ground flash density (N_g) and the total building effective lightning attractive area (total attractive area, A_A), or

$$P = N_g \times A_a \tag{1}$$

where N_g is taken to be six strikes per yr per km^2.

The total attractive area is given by Ref. 0:

$$A_a = L \cdot W + 2 \cdot r_a (L + W) + \pi \cdot r_a^{\,2} \tag{2}$$

where L and W are the building length and width, respectively, and r_a is the capture radius).

Because of the effect of height, the total attractive area of a structure is greater than its physical footprint. The most conservative expression for the attractive area for heights above about 10 m, and the method currently used at Los Alamos National Laboratory (LANL), is the capture radius originally developed by Cianos and Pierce (Ref. 0),

$$r_a = 80\sqrt{h}\left(e^{-0.02\cdot h} - e^{-0.05\cdot h}\right) + 400\left(1 - e^{-0.0001\cdot h^2}\right) \tag{3}$$

where r_a and h are both in meters.

The following physical dimensions are assigned to Building TA-50-69:

L (length) = 76 ft (23.16 m);
W (width) = 43.5 ft (round up to 44 ft) (13.41 m); and
h (effective height based on tallest stack) = 41 ft (12.50 m).

Substituting into Equation 3 yields a capture radius of 75 m.

Substituting into Equation 2 gives a total attractive area of 23,500 m^2, or 2.35E-02 km^2.

From Equation 1, the lightning strike frequency for the WCRR Facility is:

$$P = N_g \times A_a = \text{1.4E-1 strikes per yr.} \tag{4}$$

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APPENDIX 3D

Fire Accident Calculations

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APPENDIX 3D: FIRE ACCIDENT CALCULATIONS

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3D.1 INTRODUCTION

This appendix summarizes fire analysis calculations that were performed in support of the Waste Characterization, Reduction, and Repackaging Facility (WCRRF) Documented Safety Analysis (DSA). This appendix contains three main parts, including *ordinary* combustible evaluation, pool fire evaluation, and CFAST calculations. For the *ordinary* combustible evaluation and the pool fire evaluation, separation distances were calculated to prevent fire propagation or failure of items of interest (Ref. 1). Results from pool fire analysis were also used to estimate amount of energy that will contribute to plume buoyancy. CFAST calculations were used to estimate maximum temperatures in the WCRRF building and sprinkler actuation times (Ref. 2). The CFAST calculations provide justification of the importance of the fire suppression system and were used to aid in a *safe* combustible loading recommendation. The *safe* combustible loading used in conjunction with the *safe* separation distances will provide both preventive and mitigative benefits in the event of a fire.

The method used in to calculate radiant energy at distances away from an object was taken from the *Society of Fire Protection Engineers (SFPE) Handbook, 3rd Edition* (Ref. 7). This method is also the recommended method for *ordinary* type combustible fuel packages as described in the National Fire Protection Association 555, *Guide on Methods for Evaluating Potential for Room Flashover* (Ref. 3).

3D.1.1 Approach/Methodology

This section summarizes results taken from Ref. 1 for calculating *safe* separation distance between a fire and an object receiving the radiant energy. This calculation can be broken down into three main steps:

- Estimating maximum permissible heat flux
- Calculating the heat characteristics of fire
- Using Mudan method to calculate radiant energy at a distance away from object:
    - Calculating flame height
    - Calculating the geometric view factor
    - Calculating average emissive flame power
    - Calculating *safe* separation distance

3D.1.2 Estimating Maximum Permissible Heat Flux

The maximum permissible heat flux that an item can see before failure or ignition occurs depends on the item of interest. The two concerns in this appendix is fire propagation caused by radiant heat flux on nearby items and failure of a 55-gal drum as the result of incident radiant heat flux.

Fire Propagation

Ignition of combustibles caused by an un-piloted radiant ignition source (absence of a pilot source such as a small flame or an electric spark) varies depending on what types of combustibles they are. For radiant ignition purposes, combustibles can be classified by how much radiant energy they take to cause auto ignition. The following list identifies three general types of combustibles and their associated un-piloted ignition heat fluxes:

- Easily ignitable (10 kW/m^2)
- Normal ignition range (12-15 kW/m^2)
- Difficult to ignite (40 kW/m^2)

Failure of 55-gal Drum

The failure criteria for a 55-gal drum are based on Ref. 4, *Fire Protection Guide for Waste Drum Storage Arrays*. Based on this reference, the criteria for lid loss are the following:

$\dot{q}''$ < 45 kW/m^2 –- No lid loss
45 < $\dot{q}''$ < 75 kW/m^2 –- Some lid loss, some lid seal failures
$\dot{q}''$ > 75 kW/m^2 –- Lid loss expected

To be conservative, an incidental heat flux of 45 kW/m^2 was chosen for the analysis, which represents the lowest heat flux that could cause drum lid failure. The *Fire Protection Guide for Waste Drum Storage Arrays* has determined that "the use of 45 kW/m^2 as a critical limit for lid loss represents the most conservative analysis." In addition, based on Ref. 4, *Fire Protection Guide for Waste Drum Storage Array*, the shortest amount of time that a drum must be engulfed by a pool fire to result in lid failure and expulsion of material from the drum is 70 sec. It is, therefore, assumed that for drum failure to occur as the result of radiant heat, it also must be subjected to 45 kW/m^2 for a minimum of 70 sec. Also, it should be mentioned that failure caused by radiative heat only results in drum lid failure and no significant expulsion of waste that may be contained in the drum. Results presented in Ref. 4 show that a fully engulfing fire is necessary to result in ejection of drum contents. Failure caused by radiant heat flux results in contained burning of waste within the container.

The above criteria will be used to establish *safe* separation distances to prevent fire propagation and failure of nearby drums.

3D.2 *SAFE* SEPARATION DISTANCE, *ORDINARY* COMBUSTIBLES

3D.2.1 Representative Fuel Package

A combustible fuel package includes transient and fixed combustibles. *Safe* separation distances are based on limiting incident radiative heat fluxes to items of interest. It is necessary to stipulate separation distances in addition to limiting combustible loading in order to limit fire propagation and or ignition or failure of an item of interest. The *safe* separation distances calculated in this analysis are based on many variables, which include fire size, fire geometry, and type of combustible. In determining conservative *safe* separation distances, it is necessary to account for changes in fuel package geometry. Such changes typically correspond to changes in fuel package mass. This analysis illustrates the importance of accounting for changes in both fuel package mass and geometry in estimating safe separation distances.

This analysis considers conservative fuel packages whose heat release rates (HRRs) are comparable to trash fire data for varying sizes. This analysis develops a representative fuel package (RFP) to establish the basis for this analysis and to facilitate the identification of fire characteristics of a variety of fuel packages. To account for different size combustible fuel packages that might be found in the facility, increasing RFPs are examined to estimate *safe* separation distances for a variety of combustible fuel packages. In general, the larger the fuel package, the greater the *safe* separation distance required.

First, we estimate an RFP within the WCRRF to be used as a typical standardized unit of combustible loading for the purposes of this analysis. A cardboard box filled with *ordinary* combustibles (wood, paper, and similar material), with a heat of combustion of ~18,600 kJ/kg, (Ref. 5) is chosen as the type of combustibles for the RFP. The dimensions of the cardboard box are 2 ft × 1 ft × 3 ft (L × W × H). The burning area of this RFP is assumed to be the outside surface area of the box, which is equal to 2.0 m^2 (22 ft^2). The mass of the RFP is assumed to be 11.3 kg (25 lb). The RFP and its associated fire characteristics presented in this analysis are similar to experimental values obtained from a similar type of fuel package (Ref. 6).

The objective of this analysis is to estimate *safe* separation distances for a range of increasing mass and volume fuel packages. Using the RFP and changing the number of RFPs in increments of one, separation distances are calculated for different amounts of combustibles. Results reflect not only increases in mass but also changes in configuration of the fuel. The amount of fuel (e.g., burning surface area) contributing to the fire is assumed to increase in proportion to the number of RFPs and not in proportion to just the outside of the fuel package. For example, the outside surface area of 4 RFPs arranged side-by-side is ~4.8 m^2, not 8.2 m^2, as used in this analysis. Table 3D-1 provides key characteristics of fuel packages analyzed.

Table 3D-1. Characteristics of Fuel Packages Analyzed

Number of RFP	Mass of *Ordinary* Combustibles (lb)	Burning Area(m^2)
1	25	2.0
2	50	4.1
3	75	6.1
4	100	8.2
5	125	10.2
6	150	12.3

3D.2.2 Heat Characteristics

A typical fire has three distinct fire regions: (1) a growth phase, (2) a steady-state phase, and (3) a decay phase. The relevant phase in this calculation is the steady-state heat release rate.

3D.2.2.1 Steady-State Heat Release Rate

Equation 1 defines the steady-state HRR, while Eq. 2 defines the mass burnup rate.

$$q' = \Delta h_c \cdot B' \tag{1}$$

$$B' = \frac{(q''_e + q''_{fc} + q''_{fr} - q''_{rr})A}{L} \tag{2}$$

where:

q' = steady-state heat release rate (kJ/sec)
Δh_c = heat of combustion (kJ/kg)
B' = mass burnup rate (kg/sec)
q''_e = external heat flux (kW/m^2)
q''_{fc} = flame convective heat flux (kW/m^2)
q''_{fr} = flame radiative heat flux (kW/m^2)

q''_{rr} = flame re-radiative heat loss (kW/m^2)
A = burning surface area (m^2)
L = heat of gasification of combustible (kJ/kg)

Using Eq. 2, fuel properties of paper cellulose ($q''_e = 0$, $q''_{fc} = 18$, $q''_{fr} = 40$, $q''_{rr} = 12$, L = 3,200), and a burning area A = 2.0 m^2, the mass burnup rate for one RFP is calculated to be 0.029 kg/sec. This mass burnup rate corresponds to a mass loss rate per unit area of 0.0144 kg/sec-m^2, as would be expected for cellulose material. Using a heat of combustion for *ordinary* combustibles of 18,600 kJ/kg, the steady-state HRR for the one RFP is estimated to be ~546 kW. This method is repeated for up to 6 RFPs using the burn areas provided in Table 3D-1. Table 3D-2 provides mass burnup rates and steady-state HRR values for all RFPs.

Table 3D-2. Steady-State Heat Release Rate for Fuel Packages

Number of RFP	Steady-State HRR (kW)
1.0	546
2.0	1,093
3.0	1,639
4.0	2,186
5.0	2,732
6.0	3,279

3D.2.3 Calculation Procedure for Flame Radiation to External Targets

3D.2.3.1 Plume Fire Model (Mudan Method)

The model used in this analysis was developed by Mudan as taken from Ref. 7. The thermal radiation intensity to an element outside the flame envelope is given by the following equation:

$$q''_r = \tau \; E_f \; F \tag{3}$$

where:

q''_r = radiant intensity at distance from source (kW/m^2)
τ = atmospheric transmissivity (unit less)
E_f = average emissive power (kW/m^2)
F = view factor at distance from source (unit less)

Equation 3 can be used with the assumption that the flame is a vertical or tilted cylinder. For this analysis, it was assumed that the flame is vertical. This corresponds to a wind-free condition. For this analysis, the atmospheric transmissivity was assumed 1.0. In reality it would be less than 1.0, and the incident heat flux would decrease accordingly. In determining the average emissive power E_f, and the view factor F, it requires the flame diameter and flame height to be determined. The flame diameter is taken to be the equivalent diameter of the area equal to the floor area covered by the fuel given by the following equation.

$$\frac{\pi D_{eq}^2}{4} = A = L \times W \times \# \, units \tag{4}$$

where:

D_{eq} = equivalent diameter (m)
A = area of fire source (m^2)
L = length of fuel package arrangement (m)
W = width of fuel package arrangement (m)
$\# units$ = number of RFPs

3D.2.3.2 Calculation of Flame Height

The flame height correlation used in the Mudan Method, was developed by P. H. Thomas (Ref. 8). This model was developed based on a correlation for the mean visible height of turbulent diffusion flames (in the absent of wind), based on experimental data of laboratory-scale wooden crib fires and dimensional analysis considerations. The correlation for the flame height of a circular fire is given by Eq. 5 (Ref. 9, p. 2-51). For this methodology an equivalent diameter may be used for rectangular fires of small aspect ratios (length to width ratio) of less than 5 given by Eq. 4.

$$H/D = 42\left[\frac{m''}{\rho_a\sqrt{gD}}\right]^{0.61} \tag{5}$$

where:

H = flame height (m)
D = diameter of fire source or equivalent diameter for noncircular fire sources (m)
m'' = mass loss rate per unit area (kg/sec-m^2)
ρ_a = ambient air density (1.2 kg/m^3)
g = acceleration of gravity (9.81 m/sec2)

An equivalent diameter for one RFP was then calculated using Eq. 4 to be 0.49 m (1.6 ft). Using Eq. 5, the equivalent diameter, and the previously calculated mass loss rate per unit area of 0.0144 kg/m^2-sec, the flame height for the RFP is calculated to be ~0.85 m (2.8 ft). Table 3D-3 provides equivalent diameters and flame heights for all RFPs.

Table 3D-3. Number of RFPs, Equivalent Diameters, and Corresponding Flame Heights

Number of RFP	Equivalent Diameter (m)	Flame Height (m)
1	0.49	0.85
2	0.69	1.09
3	0.84	1.25
4	0.97	1.38
5	1.09	1.49
6	1.19	1.59

3D.2.3.3 Calculation of Geometric View Factor

The radiation exchange factor between a fire and an element outside the fire depends on the flame's shape, the relative distance between the fire and the receiving element, and the relative orientation of the element. In general, the view factor is represented by Eq. 6 (Ref. 9).

$$F_{A_1 \longrightarrow dA_2} = \oint_{A_1} \frac{\cos\theta_1 \cos\theta_2}{\pi \quad r^2} dA_1 \tag{6}$$

θ_1 and θ_2 are the angles between the line of sight r and the surface normal; r is the distance between the fire and the receiving element. The integration is carried out over the entire surface of the flame. For the purpose of this analysis, Eq. 6 is simplified. The solid flame model assumes that a cylinder approximates a turbulent flame. Under wind-free conditions, the cylinder is vertical. The view factor for a vertical cylinder with a receiving element perpendicular to the cylinder is given in Eq. 7 (Ref. 9, p. 1-95). References 3 and 7 show this equation in a slightly different form, but the results are the same.

$$F_{d1-2} = \frac{1}{\pi H}\tan^{-1}\left[\frac{L}{\sqrt{H^2-1}}\right] + \frac{L}{\pi}\left\{\frac{X-2H}{H\sqrt{XY}}\tan^{-1}\sqrt{\frac{X(H-1)}{Y(H+1)}} - \frac{1}{H}\tan^{-1}\sqrt{\frac{H-1}{H+1}}\right\}$$

$$L = h/r, \quad H = R/r, \quad X = (1+H)^2 + L^2, \quad Y = (1-H)^2 + L^2 \tag{7}$$

where:

F = geometric view factor (unit less)
h = height of cylinder (m)
r = radius of cylinder (m)
R = distance from centerline of cylinder to element receiving energy (m)

In Eq. 7, the heat is being transferred from the element dA_1 to the cylinder, but it is true that the view factor the element sees from the cylinder is the same as the one that is seen from the cylinder to the element. As it is commonly assumed, when the radiant fluxes from both surfaces are regarded as being distributed uniformly and diffusely, a reciprocal relation for the view factors for any given pair in a group of exchanging surfaces can be readily expressed as follows (Ref. 9, p. 1-94):

$$A_i F_{i-j} = A_j F_{j-i} \tag{8}$$

In this correlation, it is assumed that the element receiving the radiation is at the base of the cylinder and vertical to the cylinder. The calculation of heat received by the element can therefore be modeled as if it were located at the mid-elevation of the cylindrical fire. This is equivalent to calculating half of the total radiative energy. By simply doubling this value, we can obtain the total radiative energy received by the element. This is accounted for by simply multiplying the calculated view factor by two, to be used in Eq. 3.

It should be noted that the height of the cylinder used for each RFP case was obtained by adding the flame height and the initial height of the RFP. For example, for the 1 RFP case, the initial box height was 0.91 m (3 ft) plus the flame height of 0.85 m (2.8 ft), which is ~1.8 m (5.8 ft). This is done because the fuel package is considered part of the fire cylinder.

3D.2.3.4 Average Emissive Power

The average emissive power of the flame is calculated using Eq. 9.

$$E_{avg} = E_m e^{-SD} + E_s\left(1 - e^{-SD}\right) \tag{9}$$

where:

E_{avg} = average emissive power (kW/m^2)
E_m = maximum emissive power of luminous spots (140 kW/m^2)
E_s = emissive power of smoke (20 kW/m^2)
S = extinction coefficient (0.12 m^{-1})
D_{eq} = equivalent diameter of fire (m)

Using Eq. 9, E_m = 140 kW/m^2, E_s equal to 20 kW/m^2, S equal to 0.12 m^{-1} and each respective equivalent diameter for the RFP cases, the average emissive powers were calculated. Table 3D-4 provides these values.

Table 3D-4. Average Emissive Power for *Ordinary* Combustibles

Number of RFP	Emissive Power of Flame (kW/m^2)
1	133.2
2	130.5
3	128.5
4	126.8
5	125.3
6	124.0

3D.2.4 Results for *Safe* Separation Distance for *Ordinary* Combustibles

The calculation of separation distance is accomplished through an iterative process. As the distance from the source changes, the view factor changes. Equation 7 is solved simultaneously with Eq. 3 until the radiant energy at the distance becomes equal to the ignition heat flux. This distance is from the centerline of the flame. The *safe* separation distance is then calculated by subtracting the equivalent radius for the RFP from this value. Table 3D-5 provides results for *safe* separation distances from *ordinary* combustibles with varying masses to different types of combustibles using ignitability categories. The values provided are to be taken from edge of fuel packages.

Table 3D-5. *Safe* Separation Distances - *Ordinary* Combustibles to Other Combustibles

Number of RFP	Mass *Ordinary* Combustibles (lb)	*Safe* Separation Distance (m)			
		Fuel Ignitability Category			
		10 kW/m^2	12 kW/m^2	15 KW/m^2	40 kW/m^2
1	25	1.6	1.4	1.2	0.5
2	50	2.0	1.8	1.6	0.7
3	75	2.3	2.1	1.8	0.8
4	100	2.6	2.3	2.0	0.9
5	125	2.8	2.5	2.1	0.9
6	150	2.9	2.6	2.2	1.0

3D.3 *SAFE* SEPARATION DISTANCE POOL FIRE

This section discusses the methodology used to calculate pool fire heat characteristics, including calculation of the pool fire area and its steady-state heat release rate. The pool fire area will be used in calculation of maximum heat flux at a distance away from pool fire and the steady-state HRR will be used to estimate the plume heat addition rate to be used in consequence analysis. The results presented in this section are taken from Ref. 1.

The methodology used here is the same as that presented above using Mudan Method, Calculation Procedure for Flame Radiation to External Targets. The purpose of this section is to calculate separation distances from pool fires that will prevent failure of containers containing MAR. Separation distances are calculated for both diesel fuel and gasoline using results from unconfined pool fires. To be conservative, an incidental heat flux of 45 kW/m^2 was chosen as the limiting value, which represents the lowest heat flux that could cause drum lid failure. Also as mentioned above, for drum failure to occur as the result of radiant heat, it also must be subjected to 45 kW/m^2 for a minimum of 70 sec.

3D.3.1 Pool Fire Analysis

3D.3.2 Determining Pool Fire Area

The pool fire areas were calculated using two methods. The first method is based on an unconfined instantaneous spill taken from the SFPE Handbook (Ref. 9); the second was based on failure criteria of 55-gal drums, taken from *Fire Protection Guide for Waste Drum Storage Arrays* (Ref. 4). For the second method, the failure criteria use the minimum time the drums must be engulfed in a fire for lid failure to occur. Each of these pool fire areas were used to calculate their associated HRRs and the amount of energy that is contribute to plume buoyancy. The appropriate results will be used in the consequence analysis contained within Chapter 3 of the DSA.

First Methodology

For the first pool fire methodology, it was assumed that the pool size would be the result of an unconfined instantaneous spill of flammable liquid. Diesel fuel and gasoline were analyzed to determine which fuel provides bounding consequences. A parametric study was performed varying the type and volume of fuel.

The methodology used to calculate average diameter for an unconfined instantaneous spill is based on SFPE Handbook, 1st Edition (Ref. 9, Section 2, Chapter 4). Table 3D-6 provides the fuel properties for gasoline and diesel fuel used in this analysis.

Table 3D-6. Fuel Properties

Fuel	Heat of Combustion (kJ/kg)	Mass Loss Rate (kg/m^2-sec)	Density (kg/m^3)	Liquid Burning Rate (Surface Regression Rate) (m/sec)	$k\beta$ (m^{-1})
Gasoline[1]	43,700	0.055	740	7.4E-5	2.1
Diesel Fuel[2]	40,000	0.039	825	4.7E-5	3.5

[1] Source: Table 2-1.2, p. 2-2 (Ref. 9)
[2] Source: Source: Fire Protection Guide for Waste Drum Storage Arrays (Ref. 4)

Using the methodology provided in the SFPE Handbook, the maximum diameter for an instantaneous spill can be calculated using Eq. 10.

$$D_m = 2\left[V_L^{\,3} g' \big/ y^2 \right]^{1/8} \tag{10}$$

where:

$$y = m''' \big/ \rho_L \tag{11}$$

$$m''' = m'''_{\infty}\left(1 - e^{-k\beta D}\right) \tag{12}$$

$$g' = g\left(1 - \rho_L / \rho_w\right) \tag{13}$$

The time needed to reach this maximum diameter is given by Eq. 14.

$$t_m = 0.6743\left[V_L \big/ g' y^2 \right]^{1/4} \tag{14}$$

where:

D_m = Maximum diameter of spilled liquid (m)

V_L = Total volume of spilled liquid (m^3)

g' = Effective acceleration caused by gravity (m/s^2)

g = Acceleration caused by gravity ($9.81 m/s^2$)

y = Liquid burning rate (m/s)

m''' = Mass loss rate (kg/m^2s)

m'''_{∞} = Mass loss rate for an infinite diameter (kg/m^2s)

D = Average diameter of spilled liquid (m)

K = Extinction absorption coefficient of the flame

β = Mean-beam-length corrector

ρ_L = Density of liquid (kg/m^3)

ρ_w = Density of water (kg/m^3)

t_m = Time to reach maximum diameter (sec)

Using Eq. 10 and properties provided in Table 3D-6, the maximum diameter was calculated for both diesel fuel and gasoline for various spill volumes. The corresponding amount of time needed to reach the maximum diameter was calculated using Eq. 14. Because this maximum diameter exists for a very short time, the SFPE Handbook recommends using an average diameter to obtain a more accurate estimate of the fire characteristics. Using an average pool diameter provides more realistic results in calculating the steady-state heat release rate of the pool fire. Moreover, it is also conservative to assume the fire's steady-state heat release rate to be as small as possible. This is because, in general, the larger the heat release rate, the larger the plume buoyancy heat addition rate, and the smaller the dose to the MEOI for this site. Therefore, an average diameter was used.

Equation 15 provides the relationship between time and diameter.

$$D(t) = D_m \left\{ \frac{\sqrt{3}}{2} \left(\frac{t}{t_m} \right) \left[1 + \left(\frac{2}{\sqrt{3}} - 1 \right) \left(\frac{t}{t_m} \right)^2 \right] \right\}^{1/2} \tag{15}$$

The average of any function is defined by the following relationship.

$$Average = \frac{\int_{x_1}^{x_2} f(x)dx}{(x_2 - x_1)} \tag{16}$$

Using MathCAD, time-averaged pool diameters were obtained for each case by using the relationship provided in Eq. 16. For example, for a 10-gal spill of diesel fuel, the maximum diameter is calculated to be 7.56 m and the time to reach this diameter is 37.8 sec. Inserting this maximum diameter and time to reach this maximum diameter into Eq. 15, integrating from 0 to 37.8 and dividing by 37.8 gives an average diameter of 4.8 m.

The areas of the pool fires were then calculated using the average pool diameters. Spill depths for uncontained liquid spill fires can range from 0.7 mm to 4 mm, depending primarily on the initial quantity of fuel released (Ref. 7). Table 3D-7 provides the results for pool fire area based on fuel type and volume of fuel spill. The pool depth is calculated by dividing volume by area.

Table 3D-7. Pool Fire Characteristics

Type Fuel	Volume of Spill (gal)	Average Diameter (m)	Area (m^2)	Pool Depth (mm)
Diesel Fuel	10	4.8	18.4	2.1
	20	6.3	30.9	2.4
	40	8.1	52.0	2.9
	50	8.9	61.6	3.1
	80	10.6	87.6	3.5
	100	11.5	103.5	3.7
	250	16.2	205.8	4.6
Gasoline	10	4.5	16.2	2.3
	20	5.9	27.3	2.8
	40	7.6	45.9	3.3
	50	8.3	54.2	3.5
	80	9.9	77.1	3.9
	100	10.8	91.1	4.2
	250	14.8	173.1	5.5

Second Methodology

Based on Ref. 4, *Fire Protection Guide for Waste Drum Storage Array*, the shortest amount of time that a drum must be engulfed by a pool fire to result in lid failure and expulsion of material from the drum is 70 sec. In this methodology, the pool fire area is based on this minimum burn time.
If it is assumed that the fuel spill burns at the maximum rate for the duration of the fire, the burn time for the fire can be represented by the following equation (Ref. 7).

$$t_b = \frac{V \cdot \rho}{m'' A} \tag{17}$$

where:

t_b = total burn time (sec)
m'' = mass loss rate (kg/s-m^2)
A = area of pool fire (m^2)
V = volume of fuel (m^3)
ρ = density of fuel (kg/m^3)

Using Eq. 17 and solving for pool fire area, A, gives the following relationship.

$$A = \frac{V \cdot \rho}{m'' t_b} \tag{18}$$

Using Eq. 18 and the fuel properties provided in Table 3D-6, the pool fire area can be calculated for a given fuel volume. Knowing the pool fire area, the diameter and pool depth can be calculated. Table 3D-8, provides the results for the second methodology.

Table 3D-8. Methodology 2 Pool Fire Characteristics

Fuel Type	Volume of Spill (gal)	Diameter (m)	Area (m^2)	Pool Depth (mm)
Diesel Fuel	10	3.8	11.4	3.3
	20	5.4	22.9	3.3
	40	7.6	45.8	3.3
	50	8.5	57.2	3.3
	80	10.8	91.5	3.3
	100	12.1	114.4	3.3
	250	19.1	286.0	3.3
Gasoline	10	3.0	7.3	5.2
	20	4.3	14.6	5.2
	40	6.1	29.1	5.2
	50	6.8	36.4	5.2
	80	8.6	58.2	5.2
	100	9.6	72.8	5.2
	250	15.2	181.9	5.2

3D.3.3 Heat Characteristics

3D.3.3.1 Steady-State Heat Release Rate for Pool Fire

As mentioned above, a typical fire has three distinct fire regions: (1) a growth phase, (2) a steady-state phase, and (3) a decay phase. The relevant phase in this calculation is the steady-state heat release rate. The HRR during steady-state can be calculated using Eq. 1, repeated here for convenience.

$$q' = \Delta h_c \cdot B' \tag{1}$$

$$B' = m''' \cdot A \tag{19}$$

where:

q' = heat release rate (kJ/sec)
B′ = mass burnup rate (kg/sec)
Δh_c = heat of combustion (kJ/kg)
m''' = mass loss rate (kg/m^2-sec)
A = burning surface area of fire (m^2)

The steady-state heat release rates for all fuel volumes were calculated using Eq. 1, the burning surface area of the pool, and fuel properties provided in Table 3D-6. Plume buoyancy energy was assumed to be 25% of the steady-state heat release rate because the ground and containers involved in the accident absorb 75% of the pool fire energy. Table 3D-9 provides the steady-state HRR and plume buoyancy energies for different fuel types and volume of spill considered in this analysis. Plume buoyancy energies were not provided for the bermed pool fires. As mentioned above, it is conservative to assume the amount of energy that contributes to the plume buoyancy is as small as possible. This is because, in general, the greater amount of energy available for the plume buoyancy the smaller the dose to the MEOI for this site.

Table 3D-9. Energy Contributing to Fire Plume for Fuel Volumes

Fuel Type	Volume of Spill (gal)	Steady-State Heat Release Rate(MW)		Amount Energy Contributing to Fire Plume (MW)	
		Method 1	Method 2	Method 1	Method 2
Diesel Fuel	10	28.7	17.8	7.2	4.5
	20	48.3	35.7	12.1	8.9
	40	81.2	71.4	20.3	17.8
	50	96.0	89.2	24.0	22.3
	80	136.6	142.8	34.2	35.7
	100	161.5	178.5	40.4	44.6
	250	321.1	446.1	80.3	111.5
Gasoline	10	38.96	17.5	9.7	4.4
	20	65.5	35.0	16.4	8.7
	40	110.2	70.0	27.6	17.5
	50	130.3	87.4	32.6	21.9
	80	185.4	139.9	46.3	35.0
	100	219.0	174.9	54.7	43.7
	250	416.1	437.2	104.0	109.3

3D.3.3.2 Calculation of Flame Height

Using Eq. 5 above, and the pool fire diameters previously calculated, the flame heights for each of the spill volumes were calculated for both diesel fuel and gasoline. Table 3D-10 provides these results.

Table 3D-10. Flame Heights for Pool Fires

Fuel Type	Volume of Spill (gal)	Diameter (m)	Flame Height (m)
Diesel Fuel	10	3.8	6.6
	20	5.4	8.4
	40	7.6	10.6
	50	8.5	11.5
	80	10.8	13.5
	100	12.1	14.6
	250	19.1	20.1
Gasoline	10	3.0	6.9
	20	4.3	8.8
	40	6.1	11.2
	50	6.8	12.1
	80	8.6	14.3
	100	9.6	15.4
	250	15.2	21.2

3D.3.3.3 Calculation of Geometric View Factor

The geometric view factor was calculated using Eq. 7 above.

3D.3.3.4 Average Emissive Power

The average emissive power of the flame was calculated using Eq. 9 above. Using Eq. 9, E_m = 140 kW/m^2, E_s equal to 20 kW/m^2, S equal to 0.12 m^{-1} and each respective pool fire diameter, the average emissive power for each fuel spill was calculated. Table 3D provides these values.

Table 3D-11. Average Emissive Power for Pool Fires

Fuel Type	Volume of Spill (gal)	Emissive Power of Flame (kW/m^2)
Diesel Fuel	10	95.9
	20	82.8
	40	68.0
	50	63.1
	80	52.9
	100	48.2
	250	32.2
Gasoline	10	103.3
	20	91.6
	40	77.8
	50	73.0
	80	62.7
	100	57.8
	250	39.3

3D.3.4 Results for *Safe* Separation Distance for Pool Fires

The calculation of separation distance was accomplished through an iterative process. As the distance from the source changes, the view factor changes. Equation 3 is solved simultaneously with Eq. 7 until the radiant energy at the distance becomes equal to the failure criteria of 45 kW/m^2. Table 3D-12 presents the *safe* separation distances for all pool fires analyzed. The results are presented from centerline of flame and from either edge of berm or edge of pool fire.

Table 3D-12. *Safe* Separation Distances – Pool Fires to Prevent 45 kW/m^2

Fuel Type	Volume of Spill (gal)	*Safe* Separation Distance from Flame Centerline (m (ft))	*Safe* Separation Distance from Berm Edge or from Edge of Pool Fire (m (ft))
Diesel Fuel	10	3.8 (12.4)	1.9 (6.1)
	20	4.7 (15.4)	2.0 (6.6)
	40	5.6 (18.4)	1.8 (5.9)
	50	5.9 (19.3)	1.6 (5.3)
	80	6.3 (20.7)	0.92 (3.0)
	100	6.5 (21.2)	0.43 (1.4)
	250	9.5 (31.3)	0.0 (0.0)
Gasoline	10	3.3 (10.8)	1.8 (5.8)
	20	4.2 (13.7)	2.0 (6.6)
	40	5.1 (16.8)	2.1 (6.8)
	50	5.4 (17.7)	2.0 (6.6)
	80	5.9 (19.5)	1.6 (5.4)
	100	6.21 (20.2)	1.3 (4.4)
	250	7.6 (25.0)	0.0 (0.0)

3D.3.5 Summary/Recommendation

The results of this analysis are conservative estimates of separations distances between combustibles and items of interest. Table 3D-5 provides conservative *safe* separation distances for a range of fuel packages of different masses and arrangements to other combustibles using ignitability categories.

Table 3D-12, shown above, provides *safe* separation distances from pool fires for different type of fuel and volume. As can be seen in this table, using the results from gasoline, which bound diesel fuel, the *safe* distance as taken from the edge of the pool fire reaches a maximum when the spill is ~40 gal. This corresponds to a pool fire area ~29.1 m^2. In order to determine a more precise pool fire area that maximize the separation distance, the results for pool fire areas from 0 to 128 m^2 were calculated.

shows this relationship. As can be seen in figure, when the pool fire area is ~2.1 m^2, the *safe* separation distance is maximized. Therefore, one can infer from these results that when a berm is used to confine the liquid, the *safe* separation distance from the edge of the berm that will result in the target seeing 45 kW/m^2 no matter how large the spill volume, is ~2.09 m (6.9 ft). The difference for larger spill sizes that may be confined to smaller areas is that the fire will burn longer. These results effectively provide a distance that bounds all fuel volumes.

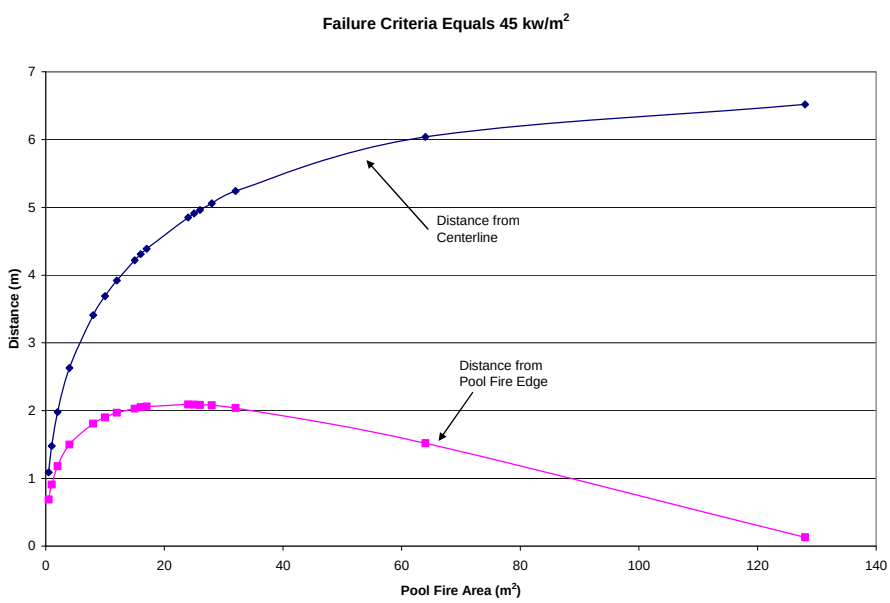

Figure 3D-1. *Safe* Separation Distance vs. Pool Fire Area

3D.4 CFAST

This section summarizes the results of computer fire modeling that was performed for the WCRRF (Ref. 2).

The Consolidated Model of Fire Growth and Smoke Transport (CFAST) (Ref. 10) computer model developed by the National Institute of Standards and Technology (NIST) was used to determine upper layer gas temperatures (ULGTs) within the WCRRF Building (See Ref. 2). This analysis also estimates sprinkler actuation times for this locations. The CFAST computer model is a zone fire model that divides each inputted compartment into two volumes, an upper layer volume and a lower

layer volume. "CFAST is based on solving a set of equations that predict the change in enthalpy and mass over time. The equations are derived from the conservation equations for energy, mass and momentum, and an equation of state, in this case the ideal gas law" (Ref. 10). CFAST is a recognized tool in the fire protection community for estimating fire growth and smoke transport.

Within CFAST, sprinkler actuation times can be estimated. The parameters needed include the location of the sprinkler relative to the fire source, the activation temperature of the sprinkler, the RTI value of the sprinkler, and the spray density of the sprinkler head. For this analysis the spray density was kept as the default value for commercial sprinklers. This value is not a key variable in this analysis because it is the activation time that is being sought (and therefore the maximum HRR for a growing fire), not the effectiveness of a sprinkler in suppressing the fire.

The analysis presented in this appendix, generally conforms to the guidance philosophy of the CFAST Computer Code Application Guidance for Documented Safety Analysis (Ref. 11). The following presents this guidance taken from Section 4.4, *Solution Methods*, of Ref. 11.

1. Establish the most likely ventilation condition and geometry.
2. Establish a reasonably bounding input HRR curve as the base condition. The total energy released should not exceed the total energy content of the combustibles that are permitted to be present.
3. Iterate the ventilation conditions (e.g., open or close doors, adjust fan operations) and geometry to maximize the upper level temperature. (See discussion on flashover below.)
4. Iterate the HRR curve to produce a Peak HRR that is 50 percent higher than the base condition. The fire duration should be adjusted to avoid releasing more energy than can credibly be present. Repeat ventilation iteration. [For this analysis, four fires sizes were analyzed.]
5. Iterate the HRR curve to produce a HRR that is 80% of the base condition. The fire duration should be adjusted to avoid releasing more energy than can credibly be present. Repeat ventilation iteration. [For this analysis, four fires sizes were analyzed.]
6. Report the most demanding time-temperature profiles developed above as sufficiently bounding temperature profiles.

The purpose of this analysis was to estimate ULGT of postulated fires within the areas of interest, and verify that the temperatures obtained were acceptable and to estimate sprinkler actuation times. The condition of concern was flashover. Flashover conditions occur when (1) the ULGT is about 600°C and (2) the radiant heat flux on un-ignited material in the room is about 20 kW/m^2 (Ref. 5, p. 1-89).

The following presents the development of the CFAST model, including its required input HRR and building dimensions and construction.

3D.4.1 Fire Models

This model consisted of a fire located in the center of Room 102 of the WCRRF. The walls and ceiling of the WCRRF were modeled as 5/8 gypsum board and the floor concrete. The dimensions of Room 102 are approximately 44 ft (13.41 m) by 50.5 ft (15.39 m) by 18.5 ft (5.64 m) high. Four HRRs were developed for this model using 4%, 8%, 20% and 50% of Room 102 floor area as a basis for the burning surface area of the fires (see Table 3D-13 below for values). This model consisted of a three-compartment model (see CFAST section below). Pendant type sprinkler exist within the Room 102 of the facility.

Table 3D-13. Comparative Fire Areas in Relation to Room Floor

	WCRRF Room 102 (m^2)
4%	8.23
8%	16.51
20%	41.28
50%	103.21

3D.4.2 Determination of Heat Release Rate

As mentioned above, a typical fire has three distinct fire stages: a growth stage, a steady-state stage, and a decay stage. This analysis assumes that all the fuel burns to completion during the growth and steady-state stages. The decay stage is therefore assumed instantaneous. This assumption adds conservatism to the analysis because the fire would actually taper off and the fuel would not burn at the same intensity in the later stage. This analysis is based on *ordinary* combustibles (wood, paper, and similar materials) with a heat of combustion of ~18,610 kJ/kg (Ref. 5). The results of this analysis are valid for other similar types of fuels, and an equivalent amount can be calculated by taking the ratio of their heats of combustions. However, flammable liquids are not considered to be similar and would therefore be analyzed using fuel properties for flammable liquids. The following describes calculation of the steady-state and growth stage of the fire.

3D.4.3 Steady-State Heat Release Rate

This analysis examined a fire located in Room 102 of WCRRF. This fire was centered within the compartment. In an effort to follow DOE guidance for the development of the HRR curves, four HRR curves were developed.

For convenience, Eqs. 1 and 2 presented above are repeated here. Equation 1 defines the steady-state HRR, while Eq. 2 defines the mass burnup rate.

$$q' = \Delta h_c \cdot B' \tag{1}$$

$$B' = \frac{(q''_e + q''_{fc} + q''_{fr} - q''_{rr})A}{L} \tag{2}$$

where:

q' = steady-state heat release rate (kJ/sec)
Δh_c = heat of combustion (kJ/kg)
B' = mass burnup rate (kg/sec)
q''_e = external heat flux (kW/m^2)
q''_{fc} = flame convective heat flux (kW/m^2)
q''_{fr} = flame radiative heat flux (kW/m^2)
q''_{rr} = flame re-radiative heat loss (kW/m^2)
A = burning surface area of fire (m^2)
L = heat of gasification of combustible (kJ/kg)

For this analysis, several HRRs were developed. For all HRRs, the fuel properties of paper cellulose ($q''_e = 0$, $q''_{fc} = 18$, $q''_{fr} = 40$, $q''_{rr} = 12$, L = 3200) were assumed. The burning surface areas used in

this analysis were provided above in Table 3D-13. Using equation 10 above, the mass burnup rates were calculated. The mass loss rate per unit area for all HRRs was 0.0144 kg/sec-m^2 (mass burn rate divided by area), as would be expected for cellulose material. Using a heat of combustion of 18,610 kJ/kg, the steady-state HRR for all cases was calculated as presented in Table 3D-14.

Table 3D-14. Steady-State Heat Release Rates

	WCRRF Room 102 (kW)
4%	2,208
8%	4,417
20%	11,044
50%	27,609

3D.4.4 Heat Release Rate During Growth Phase

During the growth stage, a power law (as shown in Eq. 20) can approximate the HRR of a fire.

$$Q \cong \alpha_f t^2 \tag{20}$$

where:

Q = heat release rate (kW)
α_f = fire growth coefficient (kW/s^2)
t = time (sec)

For this fire scenario, the growth of the fire is assumed follow that of a medium fire growth curve. Eq. 21 below shows this relationship.

$$Q \cong 0.01172t^2 \tag{21}$$

Setting Q in Eq. 21 equal to each steady-state HRR as provided in Table 3D-14 above, and solving for time, t, provides the amount of time it takes to reach steady-state. These times are commonly known as the level-off time and are provided in Table 3D-15. Knowing the level-off time and the steady-state HRR, the fire curve is known.

Table 3D-15. Time to Reach Steady-State

	WCRRF Room 102 (sec)
4%	434
8%	613
20%	971
50%	148

3D.4.5 CFAST Simulations

This section describes the CFAST model as taken from Ref. 2. See Ref. 2 for CFAST input files.

Building a fire model consists of both the physical properties of the room and the characteristics of the fire being modeled. The inputs used in CFAST are a combination of physical geometry of the compartments, connection to each of the compartments through vents, and fire specifications. Room dimension were taken from Ref. 12. The fires (input HRR) used in CFAST described above were centered within the room of interest. All simulations within CFAST were run constrained (i.e., available oxygen limits HRRs) with the fire extinction limit set at 10% oxygen by volume.

3D.4.6 Construction and Geometry

This model (Model 1) consisted of a fire located in Room 102 of the WCRRF. This model was a three-compartment model consisting of Room 102, including the small rooms and the area below and above the mezzanine, modeled as one compartment, and Rooms 103 and 104 as the other two compartments. The dimensions and material properties as used in CFAST are summarized in Table 3D-16. For this model, four different ventilation configurations were modeled with the two extreme cases (no passive openings versus very large passive openings) with and without sprinklers. For all cases simulated for this model, the opening between the fire room (Room 102) and Room 104 was always open, as this is a permanent opening between the two rooms. The four ventilation configurations modeled were (1) no openings to any of the rooms including outside (except the permanent openings); (2) two passive openings between the fire room and outside simulating exhaust and intake vents; (3) same as (2) with the addition of a personnel door open; and (4) same as (2) with the vehicle doors open, both from compartment 2 to 3 and from 3 to the outside. See Table 3D-16, for dimensions of these openings. Sprinkler runs were performed for ventilation configurations 1 and 4 with the sprinkler located at a distance away from the fire equal to a grid of sprinklers surrounding the fire with a spacing of 15 ft. This will provide actuation times to the two extreme cases of no passive openings versus very large passive openings. For all cases performed for model 1, the fire was located in the center of the fire room. The input HRR curves used in model 1 were the four HRR curves calculated above. A total of 24 CFAST simulations were performed for Model 1.

The sprinkler parameters used for Model 1 were based on Grinnell F950 model which are currently installed. The activation temperature for these sprinklers is 100°C (212°F) and a response time index (RTI) value of 109.5 $m^{0.5}sec^{0.5}$ (198.4 $ft^{0.5}sec^{0.5}$). The activation temperature is based on most recent FHA (Ref. 13.), and the RTI is based on Plunge testing for this model (Ref. 14). The sprinkler spacing was assumed to be 4.6 m x 4.6 m (15 ft x 15 ft). For this analysis, it was assumed that the fire was centered as if it were located between four sprinklers. Note that within CFAST, only one sprinkler was modeled, spaced 2.29 m (7.5 ft) away from the fire in the x-direction and 2.29 m (7.5 ft) away from the fire in the y-direction. This results in a radial distance from the fire to the sprinkler head of ~2.79 m (9.2 ft). The sprinkler was modeled to be approximately 6 in. below the ceiling. See Ref. 2 for details for the CFAST input files.

Table 3D-16. Room Dimensions and Construction Materials Room 102

Parameter	Compartment #1 (Room 102) FIRE Room	Compartment #2 (Room 104)	Compartment #3 (Room 103)
Elevation (m)	0	0	0
Length (m)	15.39	5.25	5.25
Width (m)	13.41	5.71	5.71
Height (m)	5.64	5.64	5.64
Vent (from room to room, size (m))	1⇒2 13.66 × 4.88 2⇒3 13.66 × 4.88 (vehicle door) 3⇒4 13.66 × 4.88 (vehicle door) 3⇒4 0.914 × 2.13 (personnel door) 1⇒Outside 0.61 × 0.61 (Exhaust vent) 1⇒Outside 0.61 × 0.61 (intake vent)		
Ceiling Construction	Gypsum Board (5/8″)	Gypsum Board (⅝″)	Gypsum Board (⅝″)
Wall Construction	Gypsum Board (5/8″)	Gypsum Board (⅝″)	Gypsum Board (⅝″)
Floor Construction	Concrete	Concrete	Concrete

3D.4.7 Results WCRRF Fire without Sprinklers

Table 3D-17 below presents the results of Room 102 WCRRF fire without sprinklers. For the cases where the fire became oxygen limited, the table provides the HRR obtained, the time to reach this HRR, the amount of combustibles consumed up to this point and the maximum ULGT. For the cases where the fire never becomes oxygen limited, the table provides the peak HRR when flashover (600°C) occurs, the time it took to reach flashover, and the amount of combustibles consumed up to this point. The values presented in this table are approximate values on the higher end of the data output. That is, values were recorded every 10 sec and further interpolation was not performed to calculate the exact CFAST output values. A graphical representation of ULGTs, and HRRs, can be found for each case in Ref. 2.

Table 3D-17. Summary WCRRF Facility Fire without Sprinklers

Scenario	CFAST INPUT File	Input SS-HRR (kW)	Ventilation Condition 1 = No Openings 2 = Exhaust and Intake Ventilation 3= 2 + Personnel Door 4= 2 + Vehicle Doors	Time at max ULGT (sec)	HRR (KW)	Mass Consumed at Time Indicated (kg)	Maximum ULGT (C°)
Case 1	WCRRB1	2208	1	1400	2210	132	267
Case 2	WCRRB2	4417	1	960	4418	131	352
Case 3	WCRRB3	11044	1	840	8368	126	429
Case 4	WCRRB4	27609	1	840	8368	127	429
Case 5	WCRRB1v	2208	2	1040	2198	89	244
Case 6	WCRRB2v	4417	2	730	4389	76	319
Case 7	WCRRB3v	11044	2	700	5743	73	344
Case 8	WCRRB4v	27609	2	700	5473	74	344
Case 9	WCRRB1P	2208	3	5000	2187	555	293
Case 10	WCRRB2p	4417	3	3240	4088	630	431
Case 11	WCRRB3p	11044	3	3240	5203	766	495
Case 12	WCRRB4p	27609	3	2340	5343	525	460
Case 13	WCRRB1D	2208	4	5000	2197	557	251
Case 14	WCRRB2D	4417	4	5000	4384	1084	362
Case 15	WCRRB3D	11044	4	2460	10866.3	1065	600
Case 16	WCRRB4D	27609	4	1160	15663	330	600

3D.4.8 Results WCRRF Fire with Sprinklers

Table 3D-18, presents the results of Room 102 WCRRF fire with sprinklers. It provides the HRR required for actuation, the time it takes for the sprinklers to actuate, the amount of combustibles consumed at time of actuation, and the maximum ULGT at time of actuation. The values presented in this table are approximate values on the higher end of the data output. That is, values were recorded every 10 sec and further interpolation was not performed to calculate the exact CFAST HRR. A graphical representation of upper layer gas temperatures, HRRs, and sensor temperature (simulated sprinkler) can be found for each case in Ref. 2.

Table 3D-18. Summary WCRRF Fire with Sprinklers

Scenario	CFAST INPUT File	Input SS-HRR (kW)	Ventilation Condition 1 = No Openings 2 = Exhaust and Intake Ventilation 3= 2 + Personnel Door 4= 2 + Vehicle Doors	Time of Sprinkler Actuation (sec)	Peak HRR at time of Sprinkler Actuation (KW)	Mass Consumed at time of actuation (kg)	Maximum ULGT (C°)
Case 17	WCRRB1s	2208	1	280	937	4.8	80.7
Case 18	WCRRB2s	4417	1	280	937	4.8	80.7
Case 19	WCRRB3s	11044	1	280	937	4.8	80.7
Case 20	WCRRB4s	27609	1	280	937	4.8	80.7
Case 21	WCRRB1Ds	2208	4	280	937	4.8	81.3
Case 22	WCRRB2Ds	4417	4	280	937	4.8	81.3
Case 23	WCRRB3Ds	11044	4	280	937	4.8	81.3
Case 24	WCRRB4Ds	27609	4	280	937	4.8	81.3

3D.5 CONCLUSIONS

3D.5.1 Results – Model 1 WCRRF Fire

The results of Model 1 show that the ULGT remain below 600° C for a variety of CFAST simulations. For the cases where there are no passive openings, the ULGT remain relatively low because the fires become oxygen limited. See Figures in Ref. 2. For the cases where the openings are large, the heat is allowed to escape and this keeps the ULGTs relatively low. The cases that produce the largest ULGTs were the cases where the personnel door was modeled open. These cases ended prematurely, and only a limited amount of data was collected. However, as can be seen by the graphical images, even though the ULGTs reached high values, the curve was starting to level off. In addition, as the figure for Case 11 in Ref. 2 shows, the fire size for the cases where the personnel door is open is limited size. It peaks at around 6.2 MW and then levels off. CFAST predicts the sprinklers to actuate at ~280 sec for all cases. This is a direct result of the algorithms used in CFAST to calculate sprinkler actuation times. It can be expected that, depending on the type of growth of the fire in the facility (i.e., slow, medium, fast, and ultra-fast), faster or slower actuation times can occur. The results of this analysis used a medium growth curve, and these results provide a center point of what can be expected. At 280 sec into a fire within Room 102, the ULGT are relatively low, and flashover conditions do not exist. The sprinklers are very important in minimizing the fire size for Room 102.

It should be noted that the effect of door openings on actuation times is negligible. This is because it is the ceiling jet of the fire that produces the heat transfer to actuate the sprinklers and not the accumulation of hot gases in the upper layer. "Detection is modeled using temperatures obtained from ceiling jet" (Ref. 15). Other sprinkler activation codes such as DETACT-QS version 1.2 (Refs. 16 and 17) use similar methods in estimation of activation times. If the dwelling time in the hot gas were accounted for, the actuation times would be expected to be shorter.

3D.5.2 Combustible Loading Recommendation

In an effort to establish a combustible loading that will prevent both flashover and the ignition of other combustibles, one additional CFAST model was developed (Model 2). As mentioned above, the definition for flashover conditions, per Ref. 5, is when (1) the ULGT is approximately 600°C and (2) the radiant heat flux on un-ignited material in the room is about 20 kW/m^2. For conservatism, the ULGT that will be used is 500°C. At this temperature, the ignition of *ordinary* combustibles may occur. Therefore, the ULGT that the combustible loading will be evaluated against is 500°C.

In reviewing Model 1, WCRRF fires, for the simulations performed without sprinklers, the cases of concern are with personnel door open and large fires with vehicle doors open. The simulations with the vehicle doors open will be controlled through TSR level controls that require that these doors remain closed during operation. Therefore, the limiting case is that obtained with the personnel door open. The cases performed with the personnel door open were cases 9, 10, 11, and 12. The results for these cases are similar once the fire becomes limited in size as the result of oxygen limitations, and as shown in the figures for these cases, the ventilation condition with the personnel door open limits the fire size that can be sustained. The maximum sustainable fire was ~6.3 MW for these ventilation conditions. Model 1 will build on Case 11 to develop a recommended combustible loading to prevent the ULGT from reaching 500°C. Case 11 represents these cases adequately and provides a HRR that is the maximum that can be obtained for this ventilation condition.

Model 2

It was necessary to develop an additional CFAST model because in the previous models the dimensions of the fire compartment were modeled slightly larger than Building 69 to maximize the fire size that the compartment could support. In determining a *safe* combustible loading, it is important to maximize the fire size while at the same time minimize the overall volume of the compartment in order to obtain the largest temperatures possible. This model is therefore slightly smaller than the building dimensions. As mentioned above, the ULGT that the combustible loading will be evaluated against is 500°C.

Using the CFAST input file for Case 11, the dimensions of compartment 1 (fire compartment) were decreased from 15.39 by 13.41 by 5.64 m to 15.39 by 11.66 by 5.64 m. See Ref. 12 for building dimensions. These dimensions will provide a more realistic representation of the facility and provide a conservative combustible loading per square foot for the building as a whole. This was the only change made to the input file. The CFAST input file for Model 2 is WCRRCL.dat, which is contained in Ref. 2. The table below summarizes the results.

Table 3D-19. Summary Model 2 Combustible Loading Summary

CFAST INPUT File	Input SS-HRR (kW)	Peak HRR (MW)	Time to reach 500°C (sec)	Mass Consumed at 500°C (kg)
WCRRCL	11044	~5.7	2380	527.8

As mentioned above, the amount of combustibles consumed during a given period is calculated by integrating the HRR curve to obtain the total amount of energy produced and dividing by the heat of combustion to obtain a mass. For this analysis, the heat of combustion used was 18,610 kJ/kg, which is that of ordinary combustibles (Ref. 5). As summarized in the table above, 500°C is reached when ~527.8 kg (1,163.6 lb) of combustibles are consumed. Therefore, based on this analysis, the maximum safe combustible loading that, if burned, will maintain the ULGT below the criteria of 500°C, is 527.8 kg (1,163.6 lb). Using Compartment 1's dimensions of 38.3 ft by 50.5 ft results in a floor area of 1,932 ft^2, and the resulting combustible loading per square foot is therefore 0.60 lb/ft^2. This limit is applicable to the entire building and is the recommended *safe* combustible loading based on this analysis.

3D.6 SUMMARY OF RECOMMENDATIONS

In summary, the following limits for combustibles are recommended.

1. The recommended combustible loading for Building 69 on average is ≤0.60 lb/ft^2 This combustible loading excludes the MAR that is being repackaged.

2. Fuel packages within the WCRRF are recommended to be limited to 50 lb of common combustibles with ignitability category of 12 kW/m^2 (or equivalent), and these fuel packages are recommended to be separated a minimum of 1.8 m (6~ft) away from each other.

3. No combustible (packages) shall be placed within the WCG Exclusion Zone. The WCG exclusion zone is a minimum of 1.8 m (~6ft) around the glovebox or up to the walls of Room 102, whichever is less.

4. If berms are used to prevent pool fires from challenging metal waste containers, (e.g., Type A Drums or similar), the separation distances should not be less than 2.1 m (~7ft).

The results of this analysis are valid for similar types of fuels, and an equivalent amount can be calculated by taking the ratio of their heats of combustion, as is customarily done in combustible loading surveys.

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APPENDIX 3E

Aircraft Crash Frequency Analysis

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APPENDIX 3E: AIRCRAFT CRASH FREQUENCY ANALYSIS

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3E.1 INTRODUCTION

The aircraft crash impact frequency for the Waste Characterization, Reduction, and Repackaging Facility (WCRRF) is determined using the four-factor formula described in U.S. Department of Energy (DOE) Standard (STD) 3014-96 (Ref. 1). This formula considers (1) the number of aircraft operations; (2) the probability that an aircraft will crash; (3) the probability that, given a crash, the aircraft crashes into a one-square-mile area where the facility of interest is located; and (4) the size of the facility. The formula from DOE-STD-3014-96 is:

$$F = \sum_{i,j,k} N_{ijk} \cdot P_{ijk} \cdot f_{ijk}(x, y) \cdot A_{ij} \qquad (1)$$

where:

F = estimated annual aircraft crash impact frequency for the facility of interest (number/year)

N_{ijk} = annual number of site-specific airport operations (i.e., takeoffs, landings, in-flights) for each applicable summation parameter (number/year)

P_{ijk} = aircraft crash rate per takeoff or landing for near-airport phases and per flight for the in-flight (nonairport) phase of operation for each applicable summation parameter

f_{ijk} (x,y) = aircraft crash location conditional probability (per square mile) given a crash evaluated at the facility location for each applicable summation parameter

A_{ij} = site-specific effective area for the facility of interest that includes skid and fly-in effective areas (square miles) for each applicable summation parameter, aircraft category or subcategory, and flight phase for military aviation

i = (index for flight phases): i = 1, 2, and 3 (takeoff, in-flight, and landing)

j = (index for aircraft category or subcategory): j = 1, 2,…, 11

k = (index for flight source): k = 1, 2,…, k (there could be multiple runways, and non-airport operations)

$\Sigma = \Sigma_i \Sigma_j \Sigma_k$

Ijk = site-specific summation over flight phase, i; aircraft category or subcategory, j; and flight source, k

The facility is modeled as a single structure, although the facility consists of an irregular shaped building. The overall rectangular area in which the building's footprint resides determined the facility dimensions used in this evaluation. The dimensions used are 88 ft by 45 ft by 23.5 ft high. The uppermost point of the facility determined the height of the facility. The results of the aircraft crash frequency analysis and a discussion of how the four-factor formula was applied to the WCRRF follow.

3E.2 POTENTIAL AIRCRAFT CRASH FREQUENCIES

Table 3E-1 presents the total annual aircraft impact frequency for both airport and non-airport operations, along with the overall total aircraft crash probability for the WCRFF. These frequencies are calculated in Table 3E-3 on page 3E-6 for airport operations using the four-factor formula discussed above, and in Table 3E-4 on page 3E-7 for non-airport operations.

Table 3E-1. Annual Aircraft Impact Frequency for WCRRF

Type of Crash	Aircraft Operation	Aircraft Crash Frequency (per year)
Airport (takeoffs and landings)	Commercial aviation (air taxi), general aviation, and helicopter	2.48E-06
Non-airport (Overflights)	Commercial aviation (air carrier and taxi), general aviation, and military aviation (large and small aircraft)	3.79E-07
	Total Aircraft Crash Frequency	**2.85E-06**

3E.3 IMPACT FREQUENCY FROM AIRPORT OPERATIONS

This section describes how the annual aircraft impact frequency, during takeoff and landing operations at the Los Alamos Airport, is calculated for the WCRRF due to airport operations (i.e., takeoffs and landings) at the Los Alamos Airport. There are no other airports in the general area of the WCRRF that may impact the frequency of occurrence of such events. The results of the calculation are shown in Table 3E-3.

The aircraft crash frequency analysis also includes helicopter flights in its scope. According to DOE-STD-3014-96, helicopters flying over a facility pose a hazard to the facility that must be considered when applicable. Helicopter operations occur at the Los Alamos Airport and are therefore considered in this analysis.

Impact Frequency

The aircraft impact frequency per year for airport operations is determined by multiplying the number of operations, the conditional crash probability, the crash probability, and the effective area of the facility, as described in the four-factor formula presented previously. How the four input parameters are determined is discussed below.

Annual Number of Site-Specific Airport Operations

Data for numbers of aircraft operations at the Los Alamos Airport were obtained from the U.S. Department of Transportation Federal Aviation Administration's Airport Master Record for the Los Alamos Airport.[1] The latest traffic information for commercial air taxis cites 1,500 total takeoffs and landings per year (i.e., 750 takeoffs and 750 landings). General aviation traffic consists of a total of

[1] Airport information provided by GCR & Associates, Inc. is accessible via http://gcr1.com/5010web/. The effective date for the data used was November 25, 2004.

18,500 takeoffs and landings per year (i.e., 9,250 takeoffs and 9,250 landings). Finally, helicopter traffic involves 95 operations per year.

Aircraft Crash Rate Per Takeoff or Landing

The takeoff and landing crash rates for each type of aircraft listed in Table 3E-2 are taken from Table B-1 of DOE-STD-3014-96. This table lists the probability that a given type of aircraft will crash upon takeoff or landing.

Table 3E-5 provides a summary of the aircraft crash frequency for the facility for each type of aircraft operation. The table is further broken down into airport type crashes (i.e., crashes during takeoff or landing operations) and non-airport type crashes (i.e., aircraft crashes associated with overflights). The bottom of the summary table sums the aircraft crash frequency for each type of aircraft to give an overall aircraft impact frequency for the WCRRF.

Aircraft Crash Location Conditional Probability

Table 3E-3 lists the orthonormal distance (Cartesian distance in miles, both x and y coordinates) from the Los Alamos Airport runway to the WCRRF. The origin of the coordinate system is the center of the runway. The x-axis coincides with the extended runway centerline; the positive direction is the direction of flight. The y-axis is perpendicular to the x-axis, with the positive direction created by a 90-degree counterclockwise rotation of the positive x-axis. The orthonormal distances are measured from a map of LANL. These maps were renderings in AUTOCAD of maps and drafting data supplied by the KSL UMAP organization. The data were derived from the LANL Geographic Information System (GIS) (New Mexico State Plane Coordinate System NAD 83, as amended).

Airplanes

From the orthonormal distance, the generic aircraft crash location probability was determined using Tables B-2 through B-13 in DOE-STD-3014-96. These tables list the probability that, given a crash upon takeoff or landing of a specific type of aircraft, the crash will occur in the one-square-mile area where the facility of interest is located.

Helicopters

For helicopters, DOE-STD-3014-96 defines the impact frequency as:

$$F_H = N_H \cdot P_H \cdot \frac{2}{L_H} \cdot A_H \qquad (2)$$

Equation 2 is very similar to Equation 1. In Equation 2, F_H is the helicopter impact frequency, N_H the expected number of local helicopter overflights per year, P_H the probability of a helicopter crash per flight, and A_H the effective area. Note that f(x,y) in Equation 1 is replaced with $2/L_H$, where L_H is the average length, in miles, of a helicopter flight. For this calculation, the lateral variations in crash locations for a helicopter are assumed to be one quarter of a mile from the centerline of its flight path. Since the crash frequency increases or decreases dramatically with a change in flight length, to be conservative, the length of flight is set at one quarter of a mile less than the distance from the airport to the WCRRF. This is the most conservative length of flight that is still considered to have the ability to impact the facility.

Site-Specific Effective Area

Table 3E-2 lists the effective area for the facility of interest used in the four-factor formula to determine the impact frequency of aircraft. In calculating the effective area, the following assumptions were made: (1) an aircraft can crash into the facility either by skidding or by flying directly into it; and (2) an aircraft skids or flies into the facility in the direction that produces the largest area, i.e., the crash occurs in a direction perpendicular to the largest diagonal of the facility. The effective area of the facility, therefore, depends on the type of aircraft and the actual dimensions of the facility.

Aircraft Characteristics: The facility's effective area depends on multiple factors. Among these factors, aircraft characteristics play a very important role. The wingspan dictates how close the aircraft can come to the facility and still impact it. The angle of an impact is also specific to the type of aircraft is involved in the accident. In this analysis, the cotangent of the impact angle is used in the calculation. The skid-distance is also specific to the type of aircraft involved, as well as the airspeed of the aircraft. Values that characterize the types of aircraft examined are given in Appendix B to DOE-STD-3014-96 (Tables B-16, B-17, and B-18). These values are used in Table 3E-2 to determine the effective area for the WCRRF.

Facility Dimensions: Another important factor that affects the size of an effective area of the facility is the facility's actual external dimensions. The facility's dimensions, i.e., the height, width, and length, are input into Table 3E-2. The length and width are used to calculate the length of the diagonal of the facility:

$$R = \sqrt{L^2 + W^2} \tag{3}$$

where:

R = diagonal length of facility

L = length of facility, facility-specific

W = width of facility, facility-specific

Each of these parameters is then used to calculate the effective fly-in area (A_f) and the effective skid area (A_s) for the facility according to the following formulas from Appendix B to DOE-STD-3014-96:

$$A_f = (WS + R) \cdot H \cot\phi + \frac{2 \cdot L \cdot W \cdot WS}{R} + L \cdot W \tag{4}$$

and

$$A_s = (WS + R) \cdot S \tag{5}$$

where:

WS = aircraft wingspan (provided in Table B-16, of DOE-STD-3014-96)

H = facility height, facility-specific

$\cot\phi$ = mean of the cotangent of the aircraft impact angle (Table B-17)

S = aircraft skid distance (mean value) (Table B-18)

These two areas are then summed to determine the effective area of the facility (A_{eff}):

$$A_{eff} = A_f + A_s \tag{6}$$

3E.4 IMPACT FREQUENCY FROM NON-AIRPORT OPERATIONS

Although typically small, the impact frequency contribution from non-airport operations cannot be overlooked when following the DOE-STD-3014-96 methodology. Impact frequency calculations for non-airport operations are performed based on the same four-factor formula used for airport operations except that the first three terms are lumped together, i.e., NPf(x,y), the expected number of crashes per square mile per year. NPf(x,y) values are given in Tables B-14 and B-15 in Appendix B to DOE-STD-3014-96. Table B-14 provides values of NPf(x,y) for general aviation applicable to selected DOE sites. Table B-15 presents selected DOE site values of NPf(x,y) for commercial and military aviation.

NPf(x,y) values for the WCRRF are listed in Table 3E-4. The non-airport impact frequencies per year are determined by multiplying these values by the facility effective area (discussed above). These frequencies are listed in the last column of Table 3E-4 and used along with the airport impact frequencies to determine the overall aircraft impact frequency per year for the facility of interest.

Table 3E-5 summarizes the total aircraft crash probabilities for the WCRRF as a function of aircraft type and type of operation.

Table 3E-2. Effective Area Data and Calculations for WCRRF

Variable	Commercial Air Carrier	Commercial Air Taxi	General Aviation	Military Large (Takeoff)	Military Small (Takeoff)	Helicopter
WS (ft)*	98	59	50	223	110	55
L (ft)	88	88	88	88	88	88
W (ft)	45	45	45	45	45	45
H (ft)	23.5	23.5	23.5	23.5	23.5	23.5
R (ft)	98.8	98.8	98.8	98.8	98.8	98.8
cot (Φ)*	10.2	10.2	8.2	7.4	8.4	0.58
S (ft)*	1440	1440	60	780	246	0
A_f (mi^2)	2.12E-03	1.67E-03	1.31E-03	2.79E-03	1.94E-03	3.75E-04
A_s (mi^2)	1.02E-02	8.15E-03	3.20E-04	9.00E-03	1.84E-03	0
A_{eff} (mi^2)	**1.23E-02**	**9.82E-03**	**1.63E-03**	**1.18E-02**	**3.78E-03**	**3.75E-04**

* WS, cotΦ, and S values are taken from Tables B-16, B-17, and B-18 in Appendix B to DOE-STD-3014-96, respectively.

Table 3E-3. Aircraft Crash Frequency Calculation for Airport Operations

Aircraft Operation	ΣN_{ijk} Number of Operations (per year) [1]	P Crash Rate[2]	X Distance	Y Distance	f(x,y) Aircraft Crash Location Probability[3]	A_{eff} Effective Area (square mile)[4]	F Impact Frequency (per year)
Commercial Aviation - Air Taxi (Takeoff)	750	1.00E-06	-1.4	-2.13	0	9.82E-03	0
Commercial Aviation - Air Taxi (Landing)	750	2.30E-06	1.4	2.13	0	9.82E-03	0
General Aviation (Takeoff)	9250	1.10E-05	-1.4	-2.13	1.10E-03	1.63E-03	1.83E-07
General Aviation (Landing)	9250	2.00E-05	1.4	2.13	4.40E-03	1.63E-03	1.33E-06
Helicopter	95	2.50E-05	1.85 (from WCRRF to origin on runway)		N/A[5]	3.75E-04	9.62E-07
Total Aircraft Crash Frequency (per year)							**2.48E-06**

1 U.S. Department of Transportation Federal Aviation Administration, Airport Master Record for the Los Alamos Airport, September 28, 2006. See footnote 1 on page 3E-2.
2 Table B-1 in Appendix B to DOE-STD-3014-96.
3 Tables B-2 through B-13 in Appendix B to DOE-STD-3014-96.
4 Taken from Table 3E-2.
5 See Equation 2. In place of f(x,y), $2/L_H$ is used. L_H is the distance from the center of the airport runway to the WCRRF less 1/4 mile.

Table 3E-4. Aircraft Crash Frequency Calculation for Non-Airport Operations

Type of Aircraft	NPf(x,y) Number of Crashes (per square mile per year)[1]	A_{eff} Effective Area (square mile)[2]	Non-Airport Crash Frequency (per year)
Commercial Aviation - Air Carrier	2.00E-07	1.23E-02	2.46E-09
Commercial Aviation - Air Taxi	3.00E-06	9.82E-03	2.95E-08
General Aviation	2.00E-04	1.63E-03	3.27E-07
Military Aviation - Large Aircraft	1.00E-07	1.18E-02	1.18E-09
Military Aviation - Small Aircraft	5.00E-06	3.78E-03	1.89E-08
		Total Aircraft Crash Frequency (per year)	**3.79E-07**

1 Tables B-14 and B-15 in Appendix B to DOE-STD-3014-96.
2 Results from Table 3E-2.

Table 3E-5. Summary: Aircraft Crash Frequencies Calculated for WCRRF

Type of Crash	Aircraft Operations	Aircraft Crash Frequency (per year)
Airport	Commercial Aviation - Air Taxi (takeoff)	0
	Commercial Aviation - Air Taxi (landing)	0
	General Aviation (takeoff)	1.83E-07
	General Aviation (landing)	1.33E-06
	Helicopter	9.62E-07
	Total of Airport Operations Aircraft Crash Frequency	2.48E-06
Non-Airport	Commercial Aviation - Air Carrier	2.46E-09
	Commercial Aviation - Air Taxi	2.95-08
	General Aviation	3.27E-07
	Military Aviation - Large Aircraft	1.18E-09
	Military Aviation - Small Aircraft	1.89E-08
	Total of Non-airport Operations Aircraft Crash Frequency	3.79E-07
	Total Aircraft Crash Frequency	**2.85E-06**

3E.5 REFERENCE

1. *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96, U.S. Department of Energy, Washington D.C., October 1996.

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

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Acronyms and Abbreviations

ARF	airborne release fraction
BIO	Basis for Interim Operation
CFR	Code of Federal Regulations
DBA	design-basis accident
DF	design feature
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EDS	Electrical Distribution System
FSS	Fire Suppression System
GBE	glovebox enclosure
HEPA	high-efficiency particulate air
HVAC	heating, ventilating, and air conditioning
ISI	in-service inspection
LFL	lower flammability limit
LCO	limiting condition for operation
LPS	Lightning Protection System
MAR	material-at-risk
NFPA	National Fire Protection Association
NPH	Natural Phenomena Hazard
PLC	programmable logic controller
OIT	operator interface terminal
PC	Performance Category
RF	respirable fraction
SAC	specific administrative control
SR	surveillance requirement
SSC	structure, system, and component
TA	Technical Area
TE/TI	Temperature Element/Temperature Indicator

TRU	transuranic
TSR	Technical Safety Requirement
UPS	uninterruptible power supply
VOC	volatile organic compound
wc	water column
WCG	waste characterization glovebox
WCRRF	Waste Characterization, Reduction, and Repackaging Facility
WIPP	Waste Isolation Pilot Plant

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

The analyses in Section 3.3, *Hazard Analysis*, and Section 3.4, *Accident Analysis*, identified a set of safety-class and safety-significant structures, systems, and components (SSCs) and a set of specific administrative controls (SACs) for the Waste Characterization, Reduction, and Repackaging Facility (WCRRF) at Technical Area (TA) 50, Building 69 (Building TA-50-69). As part of the accident analysis, functional and performance requirements were established for these SSCs and SACs with respect to the derivative design-basis accidents (DBAs) evaluated in Chapter 3, *Hazard and Accident Analysis*.

Chapter 4 presents and evaluates the adequacy of the selected safety-class and safety-significant SSCs and SACs by providing for each a brief description of the control, its safety functions, its functional requirements to support the safety functions, an evaluation of the functional requirements based on performance criteria, and the development of the related technical safety requirements (TSRs). The evaluation of the SSCs establishes the reasonable assurance that the safety functions and functional requirements for each SSC can be met. A result of the SSC evaluation may be the identification of SSC performance criteria vulnerabilities.

The following SSCs were identified in Chapter 3, *Hazard and Accident Analysis*, as being the most important to safety for the WCRRF at TA-50:

- Vehicle barriers
- Transuranic (TRU) waste container in Building TA-50-69 (design integrity and filtered vent) (safety-class outside; safety-significant inside Building TA-50-69)
- Building TA-50-69 and waste characterization glovebox (WCG) fire suppression system (FSS)
- Building TA-50-69 structural integrity
- Building TA-50-69 confinement ventilation system
- Waste characterization glovebox (design integrity-confinement)
- Transuranic Waste Containers (inside)
- Uninterruptible power supply (UPS)

Table 4-1 lists each of the safety-related SSCs, along with its safety designation, associated accident scenarios, safety functions, and TSR coverage.

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Table 4-1. WCRRF Safety Structures, Systems, and Components

SSC	SSC Designation	Accidents Designed to Mitigate or Prevent	SSC Safety Functions	Related TSRs*
Vehicle Barriers	Safety Class	3.4.2.2 Operational Fires Outside Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire) 3.4.2.1 Operational Fires Outside Building TA-50-69 Involving Ordinary Combustibles (Fire) 3.4.2.5 Loss of Confinement/Containment (Spill)	Prevent impacts between moving vehicles and TRU waste containers staged inside Building TA-50-69 or in outdoor transportainers Prevent subsequent vehicle fuel pool fires involving TRU waste as a result of the separation distance between pooled fuel and the TRU waste containers.	DF/ISI
TRU-Waste Container	Safety Class (Outside) Safety Significant (Inside)	3.4.2.2 Operational Fires Outside Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire) 3.4.2.6 Seismic Event with Fire (Natural Phenomena Hazard or NPH) 3.4.2.1 Operational Fires Outside Building TA-50-69 Involving Ordinary Combustibles (Fire) 3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.5 Loss of Confinement/Containment (Spill) 3.4.2.7 Wildfire (NPH) 3.4.2.8 Lightning Strike (External Event) 3.4.2.9 Aircraft-Crash-Induced Fire (External Event)	Provide primary confinement for TRU waste Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents Prevent accumulation of flammable gases inside the TRU waste containers	DF/ISI
Building TA-50-69 and WCG Fire Suppression System	Safety Significant	3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.4 Drum Deflagration (Explosions) 3.4.2.6 Seismic Event with Fire (NPH) 3.4.2.8 Lightning Strike-Induced Fire (NPH)	Limit the size and duration of fires in the WCG and in Building TA-50-69, thereby protecting the staged TRU waste and the building ventilation system high-efficiency particulate air (HEPA) filters from over temperature threats and minimizing the release of radioactive material from Building TA-50-69 to the environment.	LCO/SR

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Table 4-1. WCRRF Safety Structures, Systems, and Components (cont.)

SSC	SSC Designation	Accidents Designed to Mitigate or Prevent	SSC Safety Functions	Related TSRs*
Building TA-50-69 Structural Integrity	Safety Significant	3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.4 Drum Deflagration (Explosions) 3.4.2.5 Loss of Confinement/Containment (Spill) 3.4.2.6 Seismic Event with Fire (NPH) 3.4.2.8 Lightning Strike	Provides structural integrity to support safety SSCs Prevent insult to the material-at-risk (MAR) inside Building TA-50-69 Mitigates releases of MAR in conjunction with the confinement ventilation system	LCO/SR DF/ISI
Building TA-50-69 Confinement Ventilation System	Safety Significant	3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.4 Drum Deflagration (Explosions) 3.4.2.5 Loss of Confinement/Containment (Spill) 3.4.2.6 Seismic Event with Fire (NPH) 3.4.2.8 Lightning Strike-Induced Fire (NPH)	Mitigates releases of MAR in conjunction with the WCG and Building TA-50-69 structural integrity	LCO/SR DF/ISI
Uninterruptible Power Supply	Safety-Significant (support system to confinement ventilation system)	3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.4 Drum Deflagration (Explosions) 3.4.2.5 Loss of Confinement/Containment (Spill) 3.4.2.6 Seismic Event with Fire (NPH) 3.4.2.8 Lightning Strike-Induced Fire (NPH)	Provides continuous, conditioned power to the control system for the confinement ventilation system	LCO/SR

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Table 4-1. WCRRF Safety Structures, Systems, and Components (cont.)

SSC	SSC Designation	Accidents Designed to Mitigate or Prevent	SSC Safety Functions	Related TSRs*
Waste Characterization Glovebox (and Drum Lift Fixture)	Safety Significant	3.4.2.3 Operational Fires Inside Building TA-50-69 (Fire) 3.4.2.4 Drum Deflagration (Explosions) 3.4.2.6 Seismic Event with Fire (NPH)	The WCG must provide primary confinement for visual inspection, waste characterization, and repackaging operations. The Drum Lift Fixture must prevent drum drops and mitigate the consequences from malfunction and/or seismic events.	LCO/SR DF/ISI

* LCO/SR = limiting condition for operation/surveillance requirement
DF/ISI = design feature/in-service inspection

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4.2 REQUIREMENTS

This section lists the general requirements associated with development of this chapter.

- U.S. Department of Energy (DOE) Guide 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements* (DOE 2001a)
- DOE Order 420.1B, *Facility Safety* (DOE 2005)
- DOE Guide 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B 10 Code of Federal Regulations* (CFR) 830 (CFR 2001b)
- DOE-STD-1020-2002, *Natural Phenomena Hazard Design and Evaluation Criteria for Department of Energy Facilities* (DOE 2002a)
- DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* (DOE 2006)
- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002b)
- 49 CFR 173, *Shippers—General Requirements for Shipments and Packagings*, Subpart I – Class 7, "(Radioactive) Materials" (CFR 2003)
- DOE Office of Nuclear Safety Policy and Standards, *Interim Advisory on Straight Winds and Tornados,* 1998 (DOE 1998)

4.3 SAFETY-CLASS STRUCTURES, SYSTEMS, AND COMPONENTS

The preventive or mitigative function of safety-class SSCs is critical in limiting exposure of radioactive hazardous material to the public. This section describes each of the safety-class SSCs identified in Chapter 3, *Hazard and Accident Analysis*, and their safety functions and functional requirements. In addition, this section evaluates the identified safety functions and functional requirements, and develops the associated TSR controls.

4.3.1 Vehicle Barriers

4.3.1.1 Safety Function

Vehicle barriers are designated as safety-class SSCs based on their ability to prevent impacts between moving vehicles and the TRU waste containers staged inside Building TA-50-69 or in outdoor transportainers. The vehicle barriers also prevent subsequent vehicle fuel pool fires from involving TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.

4.3.1.2 System Description

Properly positioned and connected vehicle barriers provide protection against motor vehicles inadvertently impacting waste containers staged at the WCRRF. Vehicle barriers are standard traffic control obstacles that absorb or redirect the momentum of errant vehicles to prevent impact with TRU waste containers. The movable concrete barriers are interconnected and positioned in strategic locations at WCRRF to prevent accidental vehicle impacts to TRU waste containers staged in Building TA-50-69 or in outdoor transportainers that could result in material releases. The vehicle barriers are also placed to provide a sufficient separation distance between any subsequent fuel pool fire and the TRU waste containers. The interconnection of the barriers as part of the WCRRF vehicle access

system includes gated areas with removable connections. Barrier design and integrity are ensured by this TSR design feature (DF). Proper placement of vehicle barriers is ensured through the SAC for vehicle access system. Annual in-service inspections (ISIs) ensure the integrity of the barrier system, including interconnecting wire rope and hardware.

The gates are used for shipment of TRU waste containers to and from the WCRRF. During these shipments the transportation vehicle backs up to the gate entrance and forklifts are used to load and unload the vehicle. During this time the gate is disconnected from its supports to facilitate TRU waste handling; the delivery truck provides protection against other vehicles impacting the waste. Before the delivery truck departs, the gate is put back in place.

4.3.1.3 Functional Requirements

Vehicle barriers protect TRU waste containers by reducing the frequency of vehicular accidents that impact or rupture these containers and the subsequent pool fires that may impinge on the containers. Table 4-2 identifies the minimum functional requirements needed to fulfill the safety function identified in Section 4.3.1.1, *Safety Function*.

Table 4-2. Functional Requirements for Vehicle Barriers

Safety Function	Functional Requirements
Prevent impacts between moving vehicles and TRU waste containers staged in Building TA-50-69 or in outdoor transportainers.	Capable of preventing vehicular impacts between a tractor trailer and the TRU waste containers that are staged inside Building TA-50-69 or in outdoor transportainers.
Prevent subsequent vehicle fuel pool fires from involving TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.	Provide a sufficient separation distance to prevent a subsequent vehicle fuel pool fire of 100 gal. of diesel fuel from involving the TRU waste.

4.3.1.4 System Evaluation

This section provides the performance criteria for the vehicle barriers that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-2. This section also evaluates the capability of the vehicle barriers to meet these performance criteria. The performance criteria and associated evaluations are provided in Table 4-3.

Table 4-3. Vehicle Barrier Performance Requirements

Functional Requirements	Performance Criteria	Evaluation
Capable of preventing impacts between a tractor trailer and the TRU waste containers that are staged in Building TA-50-69 or in outdoor transportainers. Provide a sufficient separation distance to prevent subsequent vehicle fuel pool fire of 100 gal. diesel fuel from involving the TRU waste.	The interconnected vehicle barriers (concrete Jersey barriers or equivalent) or alternate design must be capable of stopping a vehicle gross weight of up to 72,000 lbs (based on a tractor/trailer carrying transportainers and waste containers) within 25 ft of the impact point moving at a velocity of up to 28 mph at a 25˚ impact angle or up to 9 mph at a 90˚ impact angle. The gate configuration of vehicle barriers must be capable of stopping a vehicle gross weight of up to 72,000 lbs within 25 ft of the impact point moving at a velocity of up to 9 mph at a 90˚ impact angle. Gates may be removed for emergency vehicle access in an emergency and the gates may be removed during TRU waste shipment activities when the delivery truck is positioned in front of the gate entrance.	The approximate dimensions of each barrier are 2 ft by 3 ft by 10 ft, with a mass in excess of 3,700 lb. Barriers are connected by wire rope in accordance with engineering specifications. Movable cable barriers consisting of two ⅝-inch-diameter wire ropes connected to cable support stands anchored to four Jersey barriers are also used. LANL Calculation SB-DO: CALC 07-007 (Mertz 2007a) verifies that the above configurations meet the performance criteria with a stopping distance after impact of 25 ft. All barriers will be placed at least 50 ft from TRU waste containers to ensure adequate vehicle stopping distance (25 ft) and separation distance (25 ft on level pavement) between TRU waste containers and potential pooled fuel from the impact vehicle. The speed limit on Pecos Drive, which is adjacent and roughly parallel to the vehicle barriers, is 25 mph, which is adequate to limit potential impacts to glancing impacts of less than 28 mph. The speed limit in the parking lot leading to the gates on the north side of the WCRRF is 5 mph, which limits potential impacts on this gate to less than 9 mph. The configuration of buildings around this gate also limits the speed of potential impacts.

4.3.1.5 Technical Safety Requirement Controls

The vehicle barriers are provided with the following TSR controls:

- The interconnected vehicle barriers (concrete Jersey barriers or equivalent or alternate design must be capable of stopping a vehicle gross weight of up to 72,000 lbs (based on a tractor/trailer carrying transportainers and waste containers) within 25 ft of the impact point moving at a velocity of up to 28 mph at a 25˚ impact angle or up to 9 mph at a 90˚ impact angle.

- The gate configuration of vehicle barriers must be capable of stopping a vehicle gross weight of up to 72,000 lbs within 25 ft of the impact point moving at a velocity of up to 9 mph at a 90˚ impact angle.
- Gates may be removed for emergency vehicle access in an emergency and the gates may be removed during TRU waste shipment activities when the delivery truck is positioned in front of the gate entrance.

The physical integrity of the vehicle barriers shall be inspected annually to identify any abnormalities that may develop, such as deterioration of concrete and degradation of wire rope and connectors, including corrosion and loose connections. Another annual inspection ensures that the physical placement of the vehicle barriers fulfills the distances described in the vehicle access system SAC.

4.3.2 Transuranic Waste Containers (outside Building TA-50-69)

4.3.2.1 Safety Function

The TRU waste containers are designated as safety-class SSCs based on their ability to reduce risks (frequency and consequence) to the public and workers by limiting the amount of radioactive material that would be released during an accident involving a fire or an impact and preventing the accumulation of flammable gases inside the containers when the TRU waste containers are staged outside TA-50-69. When the TRU waste containers are in TA-50-69, they are opened for processing. Once the TRU waste containers are opened, they continue to serve a safety-significant function by limiting the amount of radioactive material that would be released during a postulated fire event.

The safety functions of TRU waste containers are as follows:

- Provide primary confinement for TRU waste.
- Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents.
- Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents.
- Prevent accumulation of flammable gases inside the TRU waste containers.

4.3.2.2 System Description

The TRU waste containers received at the WCRRF may or may not serve as an outer package. The TRU waste container must meet the following criteria for acceptance into the WCRRF:

- Noncombustible construction (top, bottom, and sides).
- Design from a prototype that met the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests.*
- Vent opening large enough to prevent buildup of flammable gases inside the container.

This BIO identifies TRU waste containers with vents as authorized waste containers at the WCRRF. Waste Isolation Pilot Plant (WIPP) compliant HEPA-grade filters are installed in the containers to release gases and to prevent pressure buildup within the containers. The opening in the container boundary is the safety feature. The filter media perform a contamination control function. Thus, the vent is a feature of the TRU waste container and not a separate component.

4.3.2.3 Functional Requirements

The TRU waste containers protect TRU waste and support the bases of the hazard and accident analyses. Table 4-4 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.3.2.1, *Safety Function*.

Table 4-4. Functional Requirements for Transuranic Waste Containers

Safety Function	Functional Requirements
Provide primary confinement for TRU waste.	When outside Building TA-50-69, TRU waste containers must be capable of withstanding operational loads associated with handling, lifting, transporting, stacking, and external environmental stresses (temperature, pressure, precipitation, etc.) that might be experienced during normal operations.
Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents.	When outside Building TA-50-69, TRU waste containers must be capable of resisting mechanical stresses that might occur as the result of operational accidents and external event accidents.
Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents.	When outside Building TA-50-69, TRU waste containers must be capable of resisting thermal stresses that might occur as the result of operational accidents and external event accidents.
Prevent accumulation of flammable gases in the TRU waste containers.	TRU waste containers must be capable of venting flammable gases to prevent buildup in the drum.

4.3.2.4 System Evaluation

This section provides the performance criteria for the TRU waste containers that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-4. This section also evaluates the capabilities of the container to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-5.

Table 4-5. Transuranic Waste Container Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
When outside Building TA-50-69 , the TRU waste containers have the following functional requirements: TRU waste containers must be capable of withstanding operational loads associated with handling, lifting, transporting, and stacking, and external environmental stresses (temperature, pressure, precipitation, etc.) that might be experienced during normal operations. TRU waste containers must be capable of resisting mechanical and thermal stresses that might occur as the result of operational accidents and external event accidents.	The TRU waste container shall be of noncombustible construction (top, bottom, and sides). The TRU waste container shall be of a design whose prototype met the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests*.	All new TRU waste containers are procured as U.S. Department of Transportation (DOT) 7A, Type A containers, which requires the containers to be of steel construction and meet the performance criteria delineated in 49 CFR 173.465(c)(1), *Type A Packaging Tests.* All existing TRU waste containers are to have met DOT 7A Type A requirements at the time they were packaged. These requirements addressed the TRU waste container having (1) steel construction and (2) a design prototype that was free-drop-tested to survive a 4-ft drop as specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests*. The noncombustible nature of the steel TRU waste containers is sufficient to provide a passive barrier and reduce the amount of material released during any fire event. The exterior of TRU waste containers are inspected before acceptance in the WCRRF. Containers that have dents, corrosion, or other signs of deterioration or that may have been overpacked before being accepted into WCRRF could be rejected.
TRU waste containers must be capable of venting flammable gases to prevent buildup in the drum.	TRU waste containers shall have a WIPP-approved filtered vent to prevent buildup of flammable gases inside the container.	All metal TRU waste containers have WIPP-approved vent filters installed and, thus, meet the performance criteria. The filtered drum vents are inspected before being sent to the WCRRF. Waste acceptance criteria require that vents be installed in all unvented waste containers before being accepted into WCRRF for processing.

4.3.2.5 Technical Safety Requirement Controls

The TRU waste containers are provided with the following TSR controls:

- TRU waste containers shall be of noncombustible construction (top, bottom, and sides) (DF/ISI).
- TRU waste containers shall be of a design that has had a prototype meet the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests* (DF/ISI).
- TRU waste containers shall have a WIPP-approved, filtered vent to prevent buildup of flammable gases in the container (DF/ISI).

The TRU waste containers are passive design features and are included in the Design Features portion of the TSR document. Metal containers can degrade over time especially when exposed to the elements for long periods. Before receipt into WCRRF, the TRU waste containers are visually inspected for degradation, and headspace gas samples are taken. Although the period between receipt inspections at the WCRRF and waste processing is relatively short, TRU waste containers are kept in a transportainer when staged outside Building TA-50-69 to reduce the effects of the elements and to protect TRU waste containers during wildland fire. (See SACs in Section 4.5.4 and 4.5.8.)

4.4 SAFETY-SIGNIFICANT STRUCTURES, SYSTEMS, AND COMPONENTS

Safety-significant SSCs protect workers against potentially life-threatening or disabling conditions. This designation can also apply to SSCs that provide significant defense-in-depth to protect the public and workers. This section describes each of the safety-significant SSCs identified in Chapter 3, *Hazard and Accident Analysis*, and its safety functions and functional requirements. The analysis also evaluates the identified SSCs and develops the associated TSRs.

4.4.1 Building TA-50-69 and WCG Fire Suppression System (FSS)

The Hazard and Accident Analysis of Chapter 3, Hazard and Accident Analysis, identifies the Building TA-50-69 and WCG FSS as a safety-significant SSC because of its capacity to reduce public consequences by limiting the size and duration of fires inside the building. The Building TA-50-69 and WCG FSS consists of a wet-pipe sprinkler system that protects the building, the WCG, and the glovebox enclosure (GBE).

Activation of the WCG portion of the FSS may compromise the containment/confinement of the glovebox as a result of the anticipated release of fire water from the WCG to the building, and possible loss of vacuum by over-pressurization of the WCG or clogging of the WCG HEPA filters. However, rapid fire suppression should help to minimize consequences from airborne releases because the radioactive material released into the building is entrained with fire water. Loss of confinement due to required or inadvertent FSS discharge into the WCG is recognized in the hazard analysis as a possible *cause* of loss of glovebox containment/confinement, but the intrinsic benefit of entrainment of the airborne material in fire water is not credited with reducing the consequences of a release.

4.4.1.1 Safety Function

The safety function of the Building TA-50-69 and WCG FSS is to limit the size and duration of fires in the WCG and in Building TA-50-69, thereby protecting the staged TRU waste and the building ventilation system HEPA filters from over temperature threats and minimizing the release of radioactive material from Building TA-50-69 to the environment.

4.4.1.2 System Description

The Building TA-50-69 FSS is a wet-pipe system in which pressurized water is always available at the sprinklers. The sprinkler system is hydraulically designed for National Fire Protection Association (NFPA) 13 (NFPA 1976) Ordinary Hazard Group 2 coverage (0.19 gpm/ft^2 and minimum 250-gpm hose stream allowance), which exceeds the requirements for combustible loading in Building TA-50-69 (LANL 2007a). Local heat activates sprinkler heads individually. The heads activate at a temperature of 68 °C (155 °F). As required by NFPA 13, individual sprinkler coverage does not exceed 130 ft^2.

Water is supplied to the FSS from a gravity-fed system connected to a 500,000-gal. supply tank. This tank supplies water to all TA-50 facilities. A 12-inch site water main supplies water to a 6-inch branch water line, which is connected to a hydrant and provides firefighting water to Building TA-50-69. (Additional information on the FSS is provided in Chapter 2, Section 2.7.1.)

Upon activation, fire suppression water is collected in Building TA-50-69. Floor drains in the building are connected to the TA-50 Radioactive Liquid Waste Treatment Facility by a 2-inch drain. These drain lines and the Radioactive Liquid Waste Treatment Facility have the capability to collect fire water from actuation of a few sprinkler heads, but they are not capable of collecting the full 68,000 gal. of water from a design-basis fire. If a design-basis fire were to occur, some water would be expected to flow out of the facility unless emergency actions were taken. A construction project is near completion to create a tank farm at TA-50 to collect fire water. When complete, this tank farm will have the capacity to hold all the WCRRF fire water, although the 2-inch drain line for WCRRF may be insufficient to flow all the water to the tank farm fast enough to preclude overflow outside Building TA-50-69 unless emergency actions are taken.

Activation of the WCG portion of the FSS may compromise the containment/confinement of the glovebox as a result of the anticipated release of fire water from the WCG to the building, and possible loss of vacuum by over-pressurization of the WCG or clogging of the WCG HEPA filters. However, rapid fire suppression should help to minimize consequences from airborne releases because the radioactive material released into the building is entrained with fire water. This intrinsic benefit of fire water entrainment is not credited in the accident analysis.

4.4.1.3 Functional Requirements

Table 4-6 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.4.1.1, *Safety Function*.

Table 4-6. Functional Requirements for the Building TA-50-69 Fire Suppression System

Safety Function	Functional Requirements
Limit the size and duration of fires in the building, thereby protecting the TRU waste and the ventilation system HEPA filters from overtemperature threats and minimizing the release of radioactive material from Building TA-50-69 to the environment.	The FSS must be capable of limiting the growth of fires occurring in Building TA-50-69 through activation of the sprinklers and, thereby protecting TRU waste and curtailing over-temperature threats to the confinement ventilation system HEPA filter elements, and the walls of Building TA-50-69.

4.4.1.4 System Evaluation

This section provides the performance criteria for the FSS that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-6. This section also evaluates the capabilities of the FSS to meet these performance criteria. The performance criteria and associated evaluations are provided in Table 4-7.

Table 4-7. Building TA-50-69 and WCG Fire Suppression System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The FSS must be capable of limiting the growth of fires occurring in the WCG and in Building TA-50-69 through individual activation of the sprinklers and thereby protecting TRU waste and curtailing over-temperature threats to the building confinement ventilation system HEPA filter elements and the walls of Building TA-50-69.	With a riser gauge static pressure of ≥ 48 psig, the FSS shall meet NFPA 13 Ordinary Hazard Group 2 requirements (sprinkler coverage of 0.19 gpm/ft^2 and minimum 250-gpm outside hose stream allowance) (NFPA 1976). An open and unobstructed flow path from the water supply tank to the TA-50-69 sprinkler heads.	The FSS is designed and built to limit the size and spread of fire. It is an automatic system hydraulically designed for NFPA 13 Ordinary Hazard Group 2 coverage (0.19 gpm/ft^2 over 1,500 ft^2,and minimum outside hose stream allowance [250 gpm]) with a riser gauge static pressure of ≥ 48 psig. The sprinkler heads open at a temperature of 68 °C (155 °F) (NFPA 1976).
	Water supply tank contains ≥ 100,000 gal. (2-hr duration at 306 gpm sprinkler requirement + 250-gpm required hose stream allowance + additional 250-gpm hose stream allowance = 96,720 gal). The temperature of Building TA-50-69 including the attic space is greater than 40ºF.	Periodic surveillance is accomplished to verify valve alignment from the water supply tank to the sprinkler system supply valve. The 500,000-gal water supply tank serving TA-50 facilities has a capacity sufficient to meet the 2-hr minimum fire protection water demand of WCRRF. Periodic surveillance is accomplished to verify water supply tank level and riser pressure. **Vulnerability:** The hydraulically designed sprinkler system has a 5% margin in the supply pressure instead of the 10% margin recommended by DOE-STD-1066. The 10% margin is not a requirement (i.e, the Standard says the system "should be "designed with this margin). A 5% margin in the specified minimum static pressure allows for any small discrepancies in the design assumptions for the hydraulic calculations, and has been determined to be adequate for the existing sprinkler system.

Table 4-7. Building TA-50-69 and WCG Fire Suppression System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		Vulnerability: The configuration of the fire suppression system does not allow for the identification of a blockage in the fire suppression piping due to ice build-up. **Discussion:** The Building TA-50-69 ventilation system has a set-point of 40ºF which automatically secures building supply air to minimize the introduction of cold air in the building. The ventilation interlock itself is not credited with providing or supporting a safety function, but its 40ºF setpoint was selected as a reasonable minimum temperature for the fire suppression system to allow for equipment uncertainty and to minimize the potential of falling below 32 ºF in the building. This interlock function requires operator response before the ventilation system can be returned to normal operation.
		Daily TSR surveillance requirements when the Building TA-50-69 will receive or contains MAR require that operators confirm that the temperature of the facility has been above 40ºF for at least 48 hours. Calculation CALC-10-TA5000069-003, *Evaluate Frozen Fire Water Piping*, determined that it would take 42 hours to completely thaw a frozen cross section of ice in a three (3)-in. pipe once the building temperature reached 40 ºF. The calculation assumes that the initial temperature in the building was at 5 ºF. For additional conservatism, the thaw period is increased to 48 hours. The building fire riser contains both six (6)-in. and four (4)-in. piping. However, the complete freezing of these larger pipes is not a concern due to the amount of time required to completely freeze the larger pipes and their location having multiple heat sources (e.g. underground water supply and concrete slab).

Table 4-7. Building TA-50-69 and WCG Fire Suppression System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		The combination of the 40 ºF set-point along with the surveillance requirement to ensure the temperature of the facility has been at 40 ºF for at least 48 hours, will ensure that the WCRRF facility will not be returned to an 'operable' status with frozen pipes on the FSS.
	The FSS must be capable of controlling a fire during and after a Performance Category (PC) 2 seismic event.	**Vulnerability:** While Building TA-50-69 has been evaluated to meet PC-2 performance criteria, the FSS is not known to be able to withstand a PC-2 seismic event. **Discussion:** Combustible-loading controls and other Fire Protection Program controls reduce the risk from fires should a seismic event of any magnitude degrade the FSS.

4.4.1.5 Technical Safety Requirement Controls

The FSS is provided with the following TSR controls:

Limiting Condition for Operation/Surveillance Requirement

- An open, unobstructed flow path from the water supply tank to the Building TA-50-69 and WCG sprinkler heads.
- Riser gauge static pressure is 48 psig or greater at the base of the riser.
- Water supply tank contains 100,000 gal. or greater.
- The temperature of Building TA-50-69 including the attic space is greater than 40 ºF.

The WCRRF FSS is an automatic system hydraulically designed for NFPA 13 Ordinary Hazard Group 2 coverage. The FSS is an active engineered design control. The FSS is subject to routine surveillance and maintenance to maintain compliance with NFPA 13 (NFPA 1976). Additionally, to ensure effectiveness of the FSS within its design criteria, combustible loading in the facility is controlled by an SAC.

4.4.2 WCRRF Building TA-50-69 Structural Integrity

4.4.2.1 Safety Function

The WCRRF building is designated a safety-significant SSC based on its ability to provide structural integrity to support safety SSCs; prevent insult to MAR in the building; and in conjunction with the confinement ventilation system, provide confinement for release of MAR.

4.4.2.2 System Description

The Building TA-50-69 structure is a one-story, high-bay building with approximately 2,712 ft^2. A floor plan is provided in Chapter 2. The roofing is fire-retardant 4-ply membrane roofing with bitumen and gravel. The roofing rests on 2 inches of rigid insulation supported by a metal roof deck. The metal roof deck is supported by a bar joist that spans between load bearing stud walls. A 5/8-inch gypsum ceiling is suspended from the bar joist. The floor is a reinforced concrete slab on compacted fill. The exterior walls are constructed of structural steel-stud framing with a gypsum board sheathing and 2-inch rigid insulation covered with a plaster finish. Interior walls are ⅝-inch gypsum board on steel studs. Interior ceilings are constructed of suspended gypsum board.

Penetrations through the exterior walls include ductwork, electrical conduit, breathing air lines, and personnel and vehicle doors.

The Building TA-50-69 building has a vehicle airlock that is used for moving waste containers to and from the building. The airlock floor space is approximately 360 ft^2. The airlock is separated from the outside environment and the main process area inside the building by a pair of vehicle airlock doors. One door opens to the outside and the other door separates the main process area from the airlock. In addition to the vehicle airlock doors, there are personnel doorways into the vehicle airlock from the outside and into the main process area from the airlock. These doors are controlled manually to keep at least one door closed.

Two sets of personnel access doors are on the west side of the building. One set provides access to the change room (normal personnel access), and the second set provides access directly to the main process area. Each entrance is protected by two doors in series to act as an airlock during personnel access to maintain building confinement. These doors are controlled manually to keep at least one door closed.

The Building TA-50-69 structure meets PC-2 seismic, wind, and snow criteria as required by DOE-STD-1020 for its safety-significant designation.

4.4.2.3 Functional Requirements

Table 4-8 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.4.2.1, *Safety Function*.

Table 4-8. Functional Requirements for Building TA-50-69 Structural Integrity

Safety Function	Functional Requirements
Provide structural integrity to support safety SSCs, prevent insult to MAR in the building, and in conjunction with the confinement ventilation system, to provide confinement for releases of MAR.	Building TA-50-69 must be capable of providing (1) a functional structure that supports SSCs and prevents insult to MAR in the building during DBAs, and (2) in conjunction with the confinement ventilation system, provides secondary confinement to mitigate releases of MAR.

4.4.2.4 System Evaluation

This section provides the performance criteria for the structure that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-8. This section also evaluates the capabilities to meet these performance criteria. The performance criteria and associated evaluations are provided in Table 4-9.

Table 4-9. Building TA-50-69 Structural Integrity Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Building TA-50-69 must be capable of providing (1) a functional structure that supports SSCs and prevents insult to MAR in the building during DBAs, and (2) in conjunction with the confinement ventilation system, provides secondary confinement to mitigate releases of MAR.	Building TA-50-69 must remain a functional support structure during and following a PC-2 seismic design-basis earthquake.	Building TA-50-69 meets PC-2 seismic design criteria (NFPA 1976).
	Building TA-50-69 must remain a functional support structure during PC-2 wind loading. Building TA-50-69 must remain a functional support structure during PC-2 snow loading.	A DOE-STD-1020 PC-2 wind event is characterized by a three-second-gust wind speed of 90 mph and with an importance factor of 1.15. Building TA-50-69 has been evaluated to meet the PC-2 wind event requirement described in Mertz 2007b. Building TA-50-69 meets PC-2 snow-loading criteria.

Table 4-9. Building TA-50-69 Structural Integrity Performance Criteria (continued)

Functional Requirements	Performance Criteria	Evaluation
	Building TA-50-69 must remain a functional support structure during the following postulated accidents (1) combined seismic and fire accident; (2) drum deflagration; (3) loss of confinement; (4) lightning strike; and (5) fire in the building.	Interior surfaces of Building TA-50-69 are constructed of noncombustible materials. Roofing fire resistance is untested but equivalent to Underwriters Laboratories Class C (LANL 2007a). Class C roof coverings are not readily flammable, are effective against light fire exposures, and do not readily carry or communicate fire. Wall system fire resistance is untested. Construction is steel stud with gypsum board sheathing. An NFPA Ordinary Hazard Group 2 sprinkler system is installed throughout Building TA-50-69. Building TA-50-69 construction and seismic and wind resistance of the design attests to its ability to resist significant damage from low-energy accidents such as loss of confinement, drum deflagration, small fires, low winds, etc.
	Building TA-50-69 must provide protection of the TRU waste from external fires in adjacent structures and wildfires.	While the external walls have not been evaluated as a fire-rated configuration, separation distances to adjacent structures prevent external fires from challenging the structure (LANL 2007a).
	Building TA-50-69 in conjunction with the confinement ventilation system must provide a confinement barrier to mitigate TRU waste releases during spills in the building.	The building provides a functional barrier to mitigate the release of hazardous material in conjunction with the ventilation system and controls on the airlock. Personnel portals are equipped with multiple doors to provide confinement through manual control. Given their small size and redundant doors, no specific TSR controls are required.
	Building TA-50-69 in conjunction with the confinement ventilation system must provide a confinement barrier to mitigate TRU waste releases during spills in the building.	The interior building walls are constructed of noncombustible ⅝-inch gypsum board that provides a functional confinement barrier during fires in conjunction with the ventilation system and combustible loading controls.

4.4.2.5 Technical Safety Requirement Controls

The Building TA-50-69 building has the following TSR controls:

Design Features

- The Building TA-50-69 structure meets PC-2 seismic criteria.
- The Building TA-50-69 structure is designed to meet PC-2 wind and snow loading requirements.
- The interior walls of Building TA-50-69 must be constructed of non-combustible materials that provide a confinement barrier in conjunction with the confinement ventilation system.

The Building TA-50-69 structure meets PC-2 seismic, wind, and snow criteria. As in-service inspections or supplemental controls, the TSRs require inspecting the Building TA-50-69 structure confinement boundary annually.

4.4.3 Building TA-50-69 Confinement Ventilation System

4.4.3.1 Safety Function

The Building TA-50-69 confinement ventilation system is the final barrier between the environment and the facility. The safety function of the confinement ventilation system is to mitigate releases of MAR in conjunction with the confinement provided by the integrity of the building structure. This means that the structure, the WCG, and installed filters must remain functional barriers to radioactive material and withstand damage during DBAs.

The confinement ventilation system also maintains the differential pressure between the WCG and the process area, and between the process area and the environment, to minimize the spread of contamination during normal operation. Maintaining the differential pressure is not a confinement ventilation system function that is credited with any accident prevention or mitigation (i.e., reduction in any source term parameter) in the WCRRF hazard and accident analyses. The ventilation fans that produce the differential pressure gradients are not designed to operate upon loss of normal power from the Electrical Distribution System (EDS). For events (e.g., power failure, failure of OIT, loss of balanced exhaust) in the hazard analysis that are postulated to involve loss of negative pressure or overpressurization, the confinement ventilation system is only credited with providing passive secondary confinement.

4.4.3.2 System Description

The TA-50-69 filtered ventilation systems include one common supply air/heating, ventilating, and air conditioning (HVAC) system and three autonomous exhaust systems. Intake air entering the building passes through prefilters, a refrigerant cooling coil, electric heating coil, a hot water heating coil, and a backdraft damper before being drawn into the building. Ductwork distributes supply air throughout the building, including one outlet in the vehicle airlock.

Makeup air is drawn into the WCG and the GBE. Makeup air enters the WCG through two HEPA filters mounted over the top of the glovebox. Makeup air is drawn into the GBE through three separate ports. One port is located in the GBE airlock, one above the false ceiling of the GBE airlock to the main process area, and one in the bag-out area. These ports are provided with 2-ft by 2-ft HEPA filters. A duct with HEPA filtration also connects the GBE airlock with the GBE process area.

Three independent exhaust systems serve Building TA-50-69: (1) the GBE and WCG exhaust (FE-003) (air is exhausted from the two through a single exhaust path); (2) the welding fume hood exhaust (FE-001 is used only for welding and point source ventilation operations); and (3) the building exhaust (FE-002). The welding fume hood exhaust damper can be locked closed and is used only occasionally. Each exhaust system is equipped with a dedicated exhaust plenum and a HEPA filter bank. Air cleaning equipment for the three exhaust systems consists of prefilters and nuclear-grade HEPA filters that have a minimum efficiency of 99.95%. All credited exhaust HEPA filters meet DOE-STD-1066-99 (DOE 1999) and DOE-HDBK-1169-2003 (DOE 2003) criteria.

The Electrical Distribution System (EDS) powers the ventilation fans which maintain the differential pressure between the WCG and the process area, and between the process area and the environment, to minimize the spread of contamination during normal operation. Upon loss of EDS power, the ventilation fans will become inoperable. Availability of electrical power and operation of the ventilation fans is not credited with accident mitigation or required for the achievement of the confinement function of the system (in conjunction with the building's structural integrity). Fan inoperability is covered by the LCO on differential pressure and no specific LCO coverage of the EDS is required

The system includes a programmable logic controller (PLC) that controls the startup/shutdown sequencing and overall function of the ventilation components of the system to maintain negative pressure in the facility and the glovebox, which minimizes the spread of contamination during normal or abnormal operation. Under normal conditions, MAR is not present in the building until the ventilation parameters satisfy the confinement ventilation LCO. If MAR were present during an upset condition (e.g. loss of power), the MAR would be placed in a safe configuration as required by the ventilation LCO until the ventilation parameters could be satisfied. The PLC does not control the credited confinement function of the confinement ventilation system. Connected to the PLC is the interlock for the glovebox and room ventilation systems, as well as the supply and exhaust interlocks. The PLC monitors the differential pressure between the building and the outside atmosphere and the differential pressure between the WCG and the main processing area. The PLC activates a time-delayed alarm when the differential pressures are greater than credited setpoints of -0.05 inches wc for the building and -0.1 inches wc for the WCG. Maintenance of a negative pressure differential within the glove box is necessary to control the release of dispersible radioactive material to the workplace atmosphere in the event the glovebox confinement is compromised. The credited differential pressure set points are the minimum operable differential pressures carried forward to the TSR, but operating practices and procedures implement more conservative differential pressure limits. The conservative limits that are implemented for normal operation also assure the face velocity would be sufficient to meet radiation protection program requirements for worker safety in the event of a failed glove.

The Building TA-50-69 supply ventilation system will automatically shut down when the temperature of Building TA-50-69 reaches a temperature of 4°C (40°F) as indicated by the temperature reading of TE/TI-001 or TE/TI-002 on the ventilation control system (i.e., PLC). This shutdown stops the flow of cold air (< 40 °F) entering from the outside of Building TA-50-69 to the inside to minimize the freezing potential of the FSS. This temperature interlock and the associated use of thermostatically controlled attic heaters represents good engineering practice, but is not credited with preventing the FSS piping from exposure to freezing temperatures. Vacuum pumps are located outside Building TA-50-69 to support CAMs and fixed-head air sampling. The vacuum pumps' maximum airflow is approximately 75 cfm. Discharge from the vacuum pumps is directly to the outside with no filtration. This is a small amount of airflow in comparison to the Building TA-50-69 exhaust. In the event of a release of radioactive contamination inside Building TA-50-69 in conjunction with a loss of Building TA-50-69 exhaust (FE-002), personnel will evacuate

Building TA-50-69 and the vacuum pumps will be de-energized through power cut-offs located outside Building TA-50-69 to prevent unfiltered releases through the vacuum pumps.

4.4.3.3 Functional Requirements

Table 4-10 identifies minimum functional requirements for fulfilling the safety functions listed in Section 4.4.3.1, *Safety Function*.

Table 4-10. Functional Requirements for the Building TA-50-69 Confinement Ventilation System

Safety Function	Functional Requirements
Provides confinement of MAR in conjunction with the Building TA-50-69 structural integrity.	The confinement ventilation system (in conjunction with the building structure and the WCG) must provide primary confinement in the WCG and secondary confinement in the building to mitigate releases of the TRU waste inventory during normal operations and postulated accidents that affect the TRU waste inventory in the building.

4.4.3.4 System Evaluation

This section provides the performance criteria for the Building TA-50-69 confinement system that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-10. This section also evaluates the capabilities to meet these performance criteria. The performance criteria and associated evaluations are provided in Table 4-11.

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The confinement ventilation system (in conjunction with the building structure and the WCG) must provide primary confinement in the WCG and secondary confinement in the building to mitigate releases of the TRU waste inventory during normal operations and postulated accidents that affect the TRU waste inventory in the building.	Building TA-50-69 shall maintain a negative pressure differential with respect to the atmosphere. The WCG must be capable of maintaining confinement and a negative pressure differential with respect to the main process area during normal conditions. Exhaust pressure drop across the HEPA filter stage does not exceed 3.5 inches water column (wc). The ventilation control system activates an alarm when the differential pressure between the building and the outside atmosphere is greater than -0.05 inches wc. The ventilation control system	The confinement ventilation system consists of several subsystems. Based on historical experience, the operation of the subsystems is sufficient to maintain negative pressure in the building and to exhaust the air through HEPA filters that meet LANL requirements. HEPA filter-pressure drop surveillance is performed daily and verifies that the pressure drop does not exceed 3.5 inches wc. The ventilation control system is tested to ensure it will activate an alarm when the differential pressure between the building and the outside atmosphere is greater than the credited setpoint of –0.05 inches wc. The ventilation control system is tested to ensure it will activate an alarm when the differential pressure between the WCG and the main

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
	activates an alarm when the differential pressure between the WCG and the main process area is greater than -0.1 inches wc.	process area is greater than the credited setpoint of –0.1 inches wc. The credited differential pressure set points are the minimum operable differential pressures carried forward to the TSR, but operating practices and procedures implement more conservative differential pressure limits to provide additional (non-credited, defense-in-depth) protection of the facility worker, along with institutional programs including radiation protection, conduct of operations, training, and emergency planning and response. There are appropriate time delays between the detection of increasing differential pressure and the activation of alarms, to accommodate ventilation system start-up and shutdown sequencing. The differential pressure alarms and responses are not credited with mitigation of any accident consequences, and thus the 5 to 30 second time delays have no effect on the predicted consequences of material release accidents. With the building integrity and the exhaust HEPA filters helping to mitigate public and collocated worker consequences of a material release concurrent with a loss of negative pressure differential in the glovebox or building confinement ventilation system, the main concern regarding a time delay between detection and alarm/response for a differential pressure upset is the potential for contamination or uptake by the facility worker in the immediate vicinity of the glovebox if the WCG confinement vacuum is lost. If increasing pressure was accompanied by an actual loss of WCG confinement, the continuous air monitors (CAMs) would alarm to alert facility workers of airborne radiological material. The CAMs and operator training on CAM alarm response are elements of the Radiation Protection Program.
	All exhaust Building TA-50-69 HEPA filter banks must have an in-place minimum efficiency of 99.95%. The combined in-place efficiency of the WCG (FE-003) exhaust train HEPA filters	In-place testing of HEPA filters is performed when they are installed and annually or after maintenance thereafter. HEPA filters exceed this requirement in that they are rated for exposure to 402°C (756°F) hot air for 5 min and are rated for more than 12 hrs of continuous service at 121°C (250°F)

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
	shall be at least 99.95%. The HEPA filters must be rated for 12-hr continuous service at 121 °C (250 °F) (NFPA 2002). The Building TA-50-69 and WCG confinement barrier is supported by keeping at least one vehicle airlock door, the roof access port above the mezzanine, and at least one GBE airlock door fully closed.	(DOE 1999). The vehicle airlock and roof access doors are covered by the Building TA-50-69 confinement ventilation LCO. The GBE airlock door is covered by the WCG confinement ventilation LCO. In-place testing of the HEPA filters efficiency is covered by the Building TA-50-69 confinement ventilation and WCG confinement ventilation LCOs.
	As a safety-significant SSC, the ventilation system must maintain confinement during and following a PC-2 seismic event (DOE 1999).	**Vulnerability:** The ventilation system has not been evaluated or determined to meet PC-2 seismic criteria. **Discussion:** Building TA-50-69 has been evaluated as meeting PC-2 performance criteria to support the ventilation system in a seismic event. **Vulnerability:** The intake filters are not HEPA filters and cannot be relied upon to provide effective filtration during loss of building negative pressure. **Discussion:** Negative pressure differentials maintained between gloveboxes, building, and atmosphere during glovebox operations. This ensures that airflow across these HEPA filters is directed from areas of potentially lower contamination to areas of potentially higher contamination. Combustible loading and ignition source controls are implemented in the building. The fire suppression system helps prevent fire growth. **Vulnerability:** The vacuum pumps for the radiological monitoring systems (CAMs and fixed-head monitors) are located outside Building TA-50-69 and discharge up to 75 cfm of air through an unfiltered leak patch. **Discussion:** During normal operations, the vacuum pumps are required to support radiological monitoring equipment used to detect airborne releases of radioactive material. This is acceptable because the 75 cfm discharge from the vacuum pumps is trivial compared to the Building TA-50-69 ventilation exhaust (FE-002) which filters thousands of cfm. However, if an airborne

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		release of radioactive material were to occur while the building exhaust is inoperable, the vacuum pumps would provide an unfiltered leak path out of Building TA-50-69. For this reason, a compensatory measure is being included as an element of the Emergency Preparedness program that requires the vacuum pumps to be de-energized via a power shut-off located outside the building if a release of airborne radioactive material occurs in conjunction with a loss of Building TA-50-69 exhaust (FE-002). **Vulnerability:** The ducting downstream of the exhaust HEPA filters is not routinely inspected. Potential leaks in the ducting downstream of the FE-001 and FE-003 HEPAs could, if undetected, allow ingress of unfiltered air from the building into the ducts. FE-001 and FE-003 fans are located within Building TA50-69 on the mezzanine. Both ventilation fans are driven by an open motor to shaft assembly which allows unfiltered air to exhaust out of the stacks. **Discussion:** The unmitigated consequence analysis of accidental releases from inside the building does not take any credit for confinement, filtration, or hold-up of released material (i.e., leak path factor was 1.0), and the mitigated consequence estimations do not include a quantified reduction in dose due to HEPA filtration. While the HEPA filters are designed, installed, and tested to provide a minimum 99.95% efficiency, they are not credited with accident source term reduction. Minor inleakage of building air through fan motor shaft assembly or degraded ductwork downstream of the HEPA filters will not increase the conservatively calculated consequences of a fire or spill that causes material to become airborne. During normal operation, building air is not contaminated and inleakage past the filters would not release radiological material to the environment. **Vulnerability:** The GBE is not considered a safety-significant supporting SSC for the confinement ventilation system and does not have in-service inspections requirements.

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		Discussion: The physical enclosure of the GBE is not identified as a confinement ventilation system *support* system, because it is a part of the confinement ventilation system. The GBE is necessary for maintaining the validity of confinement ventilation system operating assumptions in the safety basis (e.g., flow ratio for HEPA temperatures in a fire, and WCG differential pressure relative to the building main process area) for the ventilation exhaust train from the WCG to the FE-003 filter bank. As part of the WCG confinement ventilation exhaust system, the physical enclosure of the GBE (including dampers and airlock doors that are relied upon to control confinement and exhaust flow) is considered and treated as a safety-significant SSC. Limiting conditions of operation for the confinement ventilation system ensure that the airflow within the building is drawn from the building into the GBE and WCG and through the filtered ventilation. If conditions arise that would prevent the facility from maintaining its vacuum hierarchy (e.g. ducting, plenum degradation), the facility must enter LCO action statements. Major physical impairments of the GBE could disrupt the differential pressure gradient and invoke LCO actions statements to prevent release of radioactive material. Minor physical impairment of the GBE could allow inleakage into the system, but, because such air would be released as filtered exhaust, the GBE would not create a leak path for unfiltered air. Any proposed modifications to the GBE confinement structure would be evaluated through the Unreviewed Safety Question process. Therefore, routine inspections beyond the expectations of the Radiation Protection Program for the GBE and its exhaust ducting are not necessary to ensure the ability of the confinement ventilation system to perform its safety function of mitigating the consequences of the release of radioactive material from inside the building. **Vulnerability**: Building TA-50-69 heating has the potential of becoming inoperable in the winter months allowing freezing

Table 4-11. Building TA-50-69 Confinement Ventilation System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		temperatures in the building. This potentially impacts the FSS because the configuration of the fire suppression system does not allow for the identification of a blockage in the fire suppression piping due to ice build-up. **Discussion:** Ice build-up in the FSS is avoided by a combination of the following: 1) Building TA-50-69 ventilation system set-point of 40ºF automatically secures building supply air to minimize the introduction of cold air in the building. Supplemental attic heating is provided by thermostatically controlled electric space heaters. Operator response is required to return the ventilation system to normal operation. 2) TSR surveillance requirements for the FSS require that operators confirm that the temperature of the facility has been above 40ºF for at least 48 hours when the Building TA-50-69 will receive or contains MAR.

4.4.3.5 Technical Safety Requirement Controls

The Building TA-50-69 Confinement Ventilation System is provided with the following TSR controls and/or performance requirements.

Design Feature

- The FE-001, FE-002, and FE-003 exhaust train HEPA filters are rated at 121°C (250 F) for 12 hrs of continuous service.
- HEPA filter plenum and ductwork must provide a functional confinement barrier in conjunction with the exhaust ventilation systems.

The FE-001, FE-002, and FE-003 exhaust train HEPA filters and plenum and ductwork are passive engineered design controls and are included in the Design Feature section of the TSR document. The Building TA-50-69 and WCG/GBE air exhaust ductwork are inspected annually for degradation or unauthorized modification.

Limiting Condition for Operation/Surveillance Requirement

- The Building TA-50-69 shall maintain negative air pressure differential with respect to the atmosphere.
- The Building TA-50-69 exhaust (FE-001, FE-002, and FE-003) HEPA filters shall be operable. They must be 99.95 % efficient in place, and the pressure drop across the HEPA filter shall not exceed 3.5 inches wc. The combined in-place efficiency of the two stages of the WCG (FE-003) HEPA filter shall be at least 99.95%
- The ventilation control system activates an alarm when the differential pressure between the building and the outside atmosphere is greater than –0.05 inches wc.

- The ventilation control system activates an alarm when the differential pressure between the WCG and the main process area is greater than –0.1 inches wc.
- The WCG shall be maintained at a negative pressure differential with respect to the main process area of Building TA-50-69.
- Only one vehicle airlock door may be open at any one time.
- At least one GBE airlock door shall remain closed.
- The roof access port above the mezzanine is closed.

TSR Administrative Control—Element of the Emergency Preparedness Program

- Upon detection of an airborne release of radioactive contamination in Building TA-50-69, workers will evacuate per facility procedures, and, if the Building TA-50-69 exhaust fans are inoperable, the vacuum pumps for the radiological monitoring equipment (CAMs and fixed-head air samplers) will be de-energized by the power cut-offs located outside Building TA-50-69.

4.4.4 Deleted

Table 4-12. Deleted

Table 4-13. Deleted

4.4.5 Waste Characterization Glovebox and Drum Lift Fixture

4.4.5.1 Safety Function

The safety-significant SSC safety function of the WCG is to provide primary confinement during visual inspection, waste characterization, and repackaging (sort-segregation) operations. The safety-significant SSC safety function of the drum lift fixture is to prevent or mitigate the consequences of drum drops.

4.4.5.2 System Description

The WCG is a 13-ft by 3-ft by 7-ft stainless steel and glass glovebox for operations involving radioactive material. This glovebox has three drum ports. It is equipped with glove ports that contain Hypalon®, butyl, or similar gloves. One 55-gal. drum port is located on the side of the glovebox. A drum lift is installed adjacent to this port to lift and turn a drum to a horizontal position to allow the drum to mate with the port. This orientation facilitates removing the drum contents into the glovebox. The WCG can accommodate only one drum in the entry port and two drums in the packaging ports. The WCG also has an introductory box to pass tools and other supplies into the glovebox. The WCG is maintained at a negative pressure relative to the main process area.

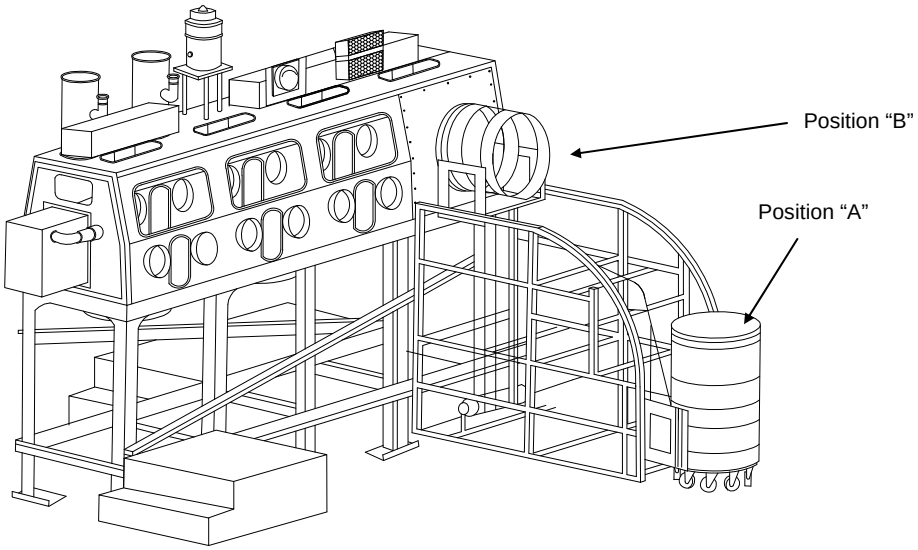

Figure 4-1. Waste Characterization Glovebox (typical)

Air is exhausted from the WCG through two HEPA canisters mounted to the top of the WCG, which are then combined to a single flow and passed to a point where it is merged with the exhaust flow from the GBE. The WCG has been shown capable of maintaining a minimum face velocity of 100 ft/min (required by DOE 6430.1A [DOE 1989]) across an open glove port given a glove rupture during the lowest flow condition (LANL 2006). The combined flow then passes through a HEPA filter unit and is exhausted to a stack through the building roof by FE-003. The ventilation configuration keeps the WCG (and GBE) at a negative air pressure with respect to the main process area of Building TA-50-69. Makeup air from the main process area is drawn into the WCG through two HEPA filters mounted atop the glovebox.

The WCG instrumentation includes differential pressure gauges and transmitters. The differential pressure transmitters are connected to the automated ventilation system operator interface terminal (OIT). Loss of negative pressure in the WCG caused by changes in the exhaust flow rate or glovebox confinement activates warning alarms on the OIT. Operators may also check the pressure differential visually using the Magnehelic® gauges mounted on the WCG and the pressure indicators on the OIT.

The WCG drum lift fixture is used to lift a vertical drum sitting on the floor and position the drum horizontally against the side of the WCG. The height of the lift is approximately 61 inches. The drum lift fixture is shown in Figure 4-1 with the drum on the floor.

The trolley is placed in position A to load a drum on the fixture. The drum is positioned against the trolley and attached to the trolley with two steel drum restraining straps. The trolley is then pulled along the trolley support rail by a cable attached to an electric hoist. The trolley rails are supported by a tubular steel frame anchored to the concrete floor. The electric hoist and the cable are enclosed by the tubular steel frame. The hoist is operated manually by an operator. The drum lift fixture B is designed to lift a drum weighing up to 630 lbs. All drums are weighed before being placed on the

drum lift fixture. The electric hoist is equipped with a holding brake to limit the speed of drum fall in the event of loss of power or hold the drum when the controls are released.

4.4.5.3 Functional Requirements

Table 4-14 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.4.5.1, *Safety Function*.

Table 4-14. Functional Requirements for the Waste Characterization Glovebox

Safety Function	Functional Requirements
The WCG and its support systems must provide primary confinement for visual inspection, waste characterization, and repackaging operations.	The WCG must provide primary confinement for the waste material operations and prevent releases to the main process area during normal operations and accident conditions.
The Drum Lift Fixture must prevent drum drops and mitigate the consequences from malfunction and/or seismic events.	The Drum Lift Fixture must prevent and mitigate the consequences of drum drops during normal operation and seismic events.

4.4.5.4 System Evaluation

This section provides the performance criteria for the WCG that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-14. This section also evaluates the WCG capabilities to meet these performance criteria. The performance criteria and associated evaluations are provided in Table 4-15.

Table 4-15. Waste Characterization Glovebox Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The WCG must provide primary confinement for waste material operations and prevent releases to the main process area during normal operations and accident conditions. The Drum Lift Fixture must prevent and mitigate the consequences of drum drops during normal operation and seismic events.	The WCG must remain a confinement barrier during normal operations. The WCG must remain a passive confinement barrier during loss of ventilation. The WCG and Drum Lift Fixture meet PC-2 seismic design criteria. The drum-lift fixture will hold the drum securely to ensure the GB confinement barrier will not be compromised. The drum lift fixture shall be capable of safely supporting its rated load capacity of 630 lbs. The drum lift fixture hoist handling brake shall be capable of stopping and holding a drum weighing at least 630 lbs. when the lifting controls are released (LANL 2007b). The Drum Lift Fixture hoist shall be capable of limiting lowering speed of a drum weighing at least 630 lbs. to 26 ft/min following loss of power (LANL 2007b).	Periodic inspections are performed to evaluate the structural integrity of the WCG. The WCG, including the drum-lifting fixture, meets DOE-STD-1020 PC-2 seismic design criteria (DOE 2002a). Historical operations have shown the WCG and the WCG confinement ventilation system provides adequate primary confinement during normal operations and loss of ventilation. A daily visual inspection of the drum lift fixture trolley is performed to verify it can safely lift drums. An annual visual inspection and load test is performed on the drum lift fixture to demonstrate that it is capable of safely supporting 125% of its rated load capacity of 630 lbs. (630 lbs. × 1.25=788 lbs.). (DOE-STD-1090.) An annual load test is performed which includes a test of the hoist holding brake controls to demonstrate that it is capable of safely supporting 125% of its rated load capacity of 630 lbs. (630 lbs. × 1.25=788 lbs.). An annual load test is performed which includes a test of the hoist holding brake under loss of power conditions to demonstrate that it is capable of safely supporting 125% of its rated load capacity of 630 lbs. (630 lbs. × 1.25=788 lbs.). Drums are weighed prior to being connected to the drum lift fixture to ensure they weigh less than 630 lbs.

4.4.5.5 Technical Safety Requirement Controls

The WCG is provided with the following TSR controls and/or performance requirements.

Design Feature

- The WCG shall provide primary confinement for waste material operations and minimize releases to the main process area during normal operation, loss of ventilation, and following a PC-2 seismic event.

The WCG confinement is a passive engineered design control and is included in the Design Features section of the TSR document. The WCG is subject to annual visual inspections for structural and confinement deterioration.

Limiting Condition for Operation/Surveillance Requirements

- The drum lift fixture shall be capable of supporting a drum weighing 630 lbs. during normal operations and PC-2 seismic events.
- The drum lift fixture hoist holding brake shall be capable of stopping and holding a drum weighing at least 630 lbs. when the lifting controls are released.
- The drum lift fixture hoist shall be capable of limiting the lowering speed of a drum loaded to 630 lbs. to 26 ft/min following loss of power.

4.4.6 Deleted

Table 4-16. Deleted

4.4.7 Transuranic Waste Containers (Inside Building TA-50-69)

4.4.7.1 Safety Function

The TRU waste containers in Building TA-50-69 are designated as safety-significant SSCs based on their ability to provide primary confinement.

The safety functions of TRU waste containers are as follows:

- Provide primary confinement for TRU waste.
- Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents.
- Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents.
- Prevent accumulation of flammable gases inside the TRU waste containers.

4.4.7.2 System Description

The TRU waste containers received at the WCRRF may or may not serve as an outer package. The TRU waste container must meet the following criteria for acceptance into the WCRRF:

- Noncombustible construction (top, bottom, and sides), excluding any protective covering applied to the drum.
- Design from a prototype that met the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests*.

- Degraded and loss of integrity drums shall be wrapped with a protective covering as a conservative measure.
- Vent opening large enough to prevent buildup of flammable gases inside the container.

This BIO identifies TRU waste containers with vents as authorized waste containers at the WCRRF. Waste Isolation Pilot Plant (WIPP) compliant HEPA-grade filters are installed in the containers to release gases and to prevent pressure buildup within the containers. The opening in the container boundary is the safety feature. The filter media perform a contamination control function. Thus, the vent is a feature of the TRU waste container and not a separate component.

The TRU waste containers that are identified as degraded or exhibiting signs of loss of integrity are wrapped in a protective plastic covering and inserted into an overpack prior to shipment to the WCRRF. Inside Building TA-50-69, these drums are removed from their overpacking. Degraded or loss of integrity drums are only handled inside Building TA-50-69 when their overpacking is removed.

4.4.7.3 Functional Requirements

The TRU waste containers protect TRU waste and support the bases of the hazard and accident analyses. Table 4-18 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.4.7.1, *Safety Function*.

Table 4-18. Functional Requirements for Transuranic Waste Containers

Safety Function	Functional Requirements
Provide primary confinement for TRU waste.	When inside Building TA-50-69, TRU waste containers must be capable of withstanding operational loads associated with handling, lifting, transporting, stacking, and external environmental stresses (temperature, pressure, precipitation, etc.) that might be experienced during normal operations.
Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents.	When inside Building TA-50-69, TRU waste containers must be capable of resisting mechanical stresses that might occur as the result of operational accidents and external event accidents.
Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents.	When inside Building TA-50-69, TRU waste containers must be capable of containing the TRU waste in the drum during thermal stresses.
Prevent accumulation of flammable gases in the TRU waste containers.	TRU waste containers must be capable of venting flammable gases to prevent buildup in the drum.

4.4.7.4 System Evaluation

This section provides the performance criteria for the TRU waste containers that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-18. This section also evaluates the capabilities of the container to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-19.

Table 4-19. Transuranic Waste Container Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
When inside Building TA-50-69, TRU waste containers must be capable of withstanding operational loads associated with handling, lifting, transporting, stacking, and external environmental stresses (temperature, pressure, precipitation, etc.) that might be experienced during normal operations. When inside Building TA-50-69, TRU waste containers must be capable of resisting mechanical stresses that might occur as the result of operational accidents and external event accidents. When inside Building TA-50-69, TRU waste containers must be capable of containing the TRU waste in the drum during thermal stresses.	The TRU waste container shall be of noncombustible construction (top, bottom, and sides), excluding any protective covering applied to the drum. Degraded and loss of integrity drums shall be wrapped with a protective covering as a conservative measure. The TRU waste container shall be of a design whose prototype met the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests*.	All TRU waste containers are either made of steel or specified during procurement to be made of steel. Degraded and loss-of-integrity drums are wrapped in plastic before being shipped to WCRRF. All drums are of a design that had a prototype to meet the free drop requirements, but some may be degraded. The containerization safety function provides the basis for using a lower ARF and RF for confined material in a fire. DOE-HDBK-3010-94 (DOE 1994) provides these values in Section 5.2.1.1, page 5-12, which states, "For this purpose, even waste in taped plastic bags or pails is considered packaged." The TRU waste container or even a degraded drum inside the TRU waste container is more robust than the packaging (cardboard box) described in DOE-HDBK-3010-94 and is assessed to provide sufficient containerization to meet the safety function.
TRU waste containers must be capable of venting flammable gases to prevent buildup inside the drum.	TRU waste containers shall have a WIPP-approved filtered vent opening large enough to prevent buildup of flammable gases inside the container.	All metal TRU waste containers have WIPP-approved vent filters installed and, thus, meet the performance criteria. The filtered drum vents are inspected before being sent to the WCRRF. Waste acceptance criteria require that vents be installed in all unvented waste containers before being accepted into WCRRF for processing.

4.4.7.5 Technical Safety Requirement Controls

The TRU waste containers are provided with the following TSR controls:

Design Features

- The TRU waste container shall be of noncombustible construction (top, bottom, and sides), excluding any protective covering applied to the drum.

- Degraded and loss of integrity drums shall be wrapped with a protective covering as a conservative measure.
- The TRU waste container shall be of a design whose prototype met the free-drop tests specified in 49 CFR 173.465(c)(1), *Type A Packaging Tests.*
- TRU waste containers shall have a WIPP-approved filtered vent opening to prevent buildup of flammable gases in the container.

As part of the in-service inspection for this design feature, the TRU waste containers known to be degraded or loss-of-integrity drums will be verified to have a protective plastic covering. If the protective plastic is damaged, the degraded or loss-of-integrity drum shall be rewrapped before WCG processing.

Degraded or loss-of-integrity drums may still have some level of surface contamination. In this case, decontamination controls as provided by the Radiological Protection Program shall be carried out.

4.4.8 Deleted

Table 4-20. Deleted

4.4.9 Uninterruptible Power Supply (UPS)

The UPS provides safety-significant support to the confinement ventilation system by providing continuous power to the control system.

4.4.9.1 Safety Function

The safety function of the UPS is to provide continuous, conditioned power to the control system for the confinement ventilation system for at least one hour upon loss of offsite power.

4.4.9.2 System Description

The UPS at Building TA-50-69 consists of a microprocessor controlled uninterruptible power supply made up of a rectifier, inverter, battery bank, and internal bypass. The rectifier converts incoming AC power to DC that is used to charge the batteries and to supply power to the inverter. Under a normal mode of operation, with utility power available, the inverter takes DC power from the rectifier and converts it to AC for use by the output load. When the system is in the On-Battery mode, with no utility power available, the inverter takes DC power from the battery bank and converts it to AC for use by the output load. An internal bypass allows the incoming utility power to bypass the UPS rectifier and inverter circuits to feed the output load directly in the event of a failure of the internal circuits of the UPS. A failure of the UPS coupled with a failure of the internal bypass switch would lead to a shut-down of the ventilation system through the ventilation control system. The internal microprocessor controller monitors and controls all UPS functions, logs alarms (failures, changes in operations mode, etc.), and annunciates faults though the front panel display and buzzer.

The UPS provides 120V power to the Operator Interface Terminal (OIT) and PLC which then provides power to the differential pressure sensors. The UPS has sufficient standby battery capacity to provide power to these components for a minimum of 1 hour.

4.4.9.3 Functional Requirements

The UPS is a support system for the confinement ventilation system. Table 4-23 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.4.9.1, *Safety Function*.

Table 4-23. Functional Requirements for the Uninterruptible Power Supply

Safety Function	Functional Requirements
The safety function of the UPS is to provide continuous, conditioned power to the control system for the confinement ventilation system for at least one hour upon loss of offsite power.	Provide continuous, conditioned power to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system during normal operation, and for at least one hour upon loss of offsite power.

4.4.9.4 System Evaluation

This section provides the performance criteria for the UPS to meet the functional requirements listed in Table 4-23. This section also evaluates the capabilities of the UPS to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-24.

Table 4-24. Uninterruptible Power Supply Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Provide continuous, conditioned power to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system during normal operation, and for at least one hour upon loss of offsite power.	During normal operations, the UPS shall provide continuous 120 V conditioned power to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system. Upon loss of offsite power, the UPS shall provide continuous 120 V conditioned power to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system for at least one hour.	During normal operations the UPS panel provides 120 V conditioned power from circuit CKT-1 to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system. Upon loss of offsite power, the UPS panel provides 120 V conditioned battery power from circuit CKT-1 to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system for at least one hour. One hour is considered a sufficient amount of time to detect the loss of ventilation fans due to the loss of off-site power, activate an alarm, and allow operator action.

4.4.9.5 Technical Safety Requirement Controls

The UPS is provided with the following TSR control:

Limiting Condition for Operation/Surveillance Requirement

- The UPS shall provide power to required loads for at least 1 hour.

The UPS provides continuous, conditioned power to the programmable logic controllers, the differential pressure sensors, the OIT, and the alarms of the confinement ventilation control system during normal operation, and for at least one hour upon loss of offsite power. Loss of power to these systems will result in a shutdown of the confinement ventilation system, which is covered by the above LCOs for the confinement ventilation system.

This surveillance requirement will be included in the confinement ventilation LCO/SR.

4.5 SPECIFIC ADMINISTRATIVE CONTROLS

Relevant information is provided in the following SAC-specific subsections to provide an understanding of the safety function of each SAC. The following SACs were identified in Chapter 3, *Hazard and Accident Analysis*, as being the most important to safety:

- Combustible-loading control
- Hot work controls
- Vehicle fuel restrictions
- TRU waste container inspection
- TRU waste container staging practices
- Inventory limits
- Transportainer placement
- TRU waste containers staged in transportainers
- Vehicle access system
- Diesel Generator Refueling Exclusion
- Critical Lift Plan
- Drum lid restraints when breaching unvented 30- to 5-gallon waste package in the WCG.
- Use of nonsparking tools or processes / de-energization of WCG electrical receptacles when processing unvented, sealed 30- to 5-gallon waste packages within the WCG.
- Grounding waste packages before breaching unvented, sealed waste packages.
- Extra Fire Controls for High-MAR Processing in WCG

The safety functions of these SACs contribute substantially to preventing or mitigating the accidents or accident consequences evaluated in Chapter 3, *Hazard and Accident Analysis*. They provide critical defense-in-depth or contribute significantly to worker safety in potentially life-threatening or disabling situations.

Table 4-25 lists each of the safety-related SACs, along with its safety designation, associated accident scenarios, safety functions, and TSR coverage.

Table 4-25. WCRRF Specific Administrative Controls

SAC Title	Accidents Designed to Mitigate or Prevent	SAC Safety Functions	Related TSRs*
Combustible-loading control	Fire	Minimization of combustible loading prevents a fire from propagating and impinging on TRU waste and mitigates release of TRU waste by limiting fire size.	LCO/SR
Hot work prohibition	Fire	The control of hot work reduces the probability of a fire igniting that could threaten TRU waste.	SAC
Vehicle fuel restrictions	Fire Explosion	The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF prevents explosions and minimizes the potential for fires that will impact TRU waste.	SAC
TRU waste container inspection	All	TRU waste container inspections accomplish three functions: confirms that the container is of sound integrity; verifies that the container is equipped with a WIPP-approved vent and the vent is free of obvious obstruction; and verifies that independent headspace gas analysis has been performed. These inspections prevent flammable gas fires and deflagrations and ensure that containers can mitigate other accidents involving containerized waste.	SAC
TRU waste container staging practices	Spill	The restrictions on TRU waste container stacking and lift height prevent the release of material by reducing the likelihood of a container failure caused by a drop from an elevated position.	SAC
Inventory limits	All	The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated.	LCO/SR
Transportainer placement	Spill	Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.	SAC
TRU waste containers staged in transportainers	All	The requirement to stage TRU waste containers inside secondary containment (transportainers) while in outdoor staging minimizes the release of TRU waste from external fires involving the TRU waste containers.	SAC

Table 4-25. WCRRF Specific Administrative Controls

SAC Title	Accidents Designed to Mitigate or Prevent	SAC Safety Functions	Related TSRs*
Vehicle access system	Fire	The implementation of a vehicle access system prevents vehicle impacts and subsequent fuel pool fires that could impinge upon TRU waste in Building TA-50-69 and TRU waste containers staged in transportainers.	SAC
Diesel generator refueling exclusion	Fire	Prevents fuel pool fires associated with diesel generator refueling from affecting TRU waste in Building TA-50-69.	SAC
Critical lift plan	Spill	The use of a critical lift plan minimizes the probability of impacts and drops involving degraded drums or loss-of-integrity drums.	SAC
Drum lid restraints when breaching unvented 30- to 5-gallon waste packages in WCG	Explosion	Provides physical protection in the WCG in case of a lid ejection and to minimize material release (e.g., prevents unconfined burning of material) when breaching an unvented, sealed 30- to 5-gallon waste package.	SAC
Use of nonsparking tools or processes / de-energization of WCG electric receptacles when processing unvented, sealed waste packages in the WCG.	Fire	When breaching unvented, sealed waste packages within the WCG, the use of nonsparking tools or processes and the de-energization of WCG electric receptacles prevent the occurrence of sparks, thereby preventing the ignition of a potentially flammable atmosphere with the WCG.	SAC
Grounding waste packages before breaching unvented, sealed waste packages.	Fire	The safety function of the ground is to reduce the probability for a spark during the opening of unvented 30- to 5-gallon waste packages within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere within the WCG.	SAC
Extra Fire Controls for High-MAR Processing in WCG	Fire	A stationary fire watch and the use of fire control agents by trained operators mitigates the effects of a fire in the WCG during the processing of a parent drum containing greater than 300 PE-Ci of combustible equivalent waste. This control ensures appropriate fire suppression tools are available in the WCG and workers are trained to detect fires in order to safely extinguish small, early developing fires.	SAC

* LCO/SR = limiting condition for operation/surveillance requirement
SAC = specific administrative control

4.5.1 Combustible-Loading Control

4.5.1.1 Safety Function

Minimization of combustible loading prevents a fire from propagating and impinging on TRU waste and mitigates release of TRU waste by limiting fire size.

4.5.1.2 SAC Description

Inside the building, transient combustible and flammable loading in Building TA-50-69 shall be strictly controlled. This control prevents accumulation of sufficient fuel to lead to flashover conditions in Building TA-50-69 and provides an exclusion area around the WCG to prevent facility fires from propagating to the WCG. Outside the building, control of combustibles limits the propagation of fire and the MAR involved.

4.5.1.3 Functional Requirements

Table 4-26 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.1.1, *Safety Function*.

Table 4-26. Functional Requirements for Combustible Loading Control

Safety Function	Functional Requirements
Minimization of combustible loading prevents a fire from propagating and impinging upon TRU waste, and it mitigates release of TRU waste by limiting fire size in Building TA-50-69 and outside the building.	Combustible loading inside must be low enough to prevent flashover in the building and prevent fires from propagating to the WCG. Combustible loading outside must be low enough to prevent incipient fires from spreading beyond the immediate vicinity.

4.5.1.4 SAC Evaluation

This section provides the performance criteria for the transient combustible loading control that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-26.This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-27.

Table 4-27. Combustible-Loading Control Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Combustible loading inside Building TA-50-69 must be low enough to prevent flashover in the building and prevent fires from propagating to the WCG. Combustible loading	The combustible loading shall be: ≤ 0.60 lb/ft^2 on average in building TA-50-69.* No flammable liquids or gases and combustible liquids with NFPA Flammability Rating greater than 1 shall be stored or used within Building TA-50-69 when TRU waste is in Building TA-50-69, except three	Execution of this control will be accomplished, as needed, throughout the duration of each operational task (between operational steps), and it has a low level of difficulty associated with it. Fire loading is composed of two elements: fixed combustibles (permanently installed in the WCRR facility) and transient combustibles (not permanently installed in the WCRR facility). A Combustible Loading Program with appropriately derived limits is established to

Table 4-27. Combustible-Loading Control Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
outside Building TA-50-69 must be low enough to prevent incipient fires from spreading beyond the immediate facility.	size 1 cylinders of P-10 gas. No combustibles shall be stored within the WCG exclusion zone.* The WCG exclusion zone is 10 ft around the WCG, up to the GBE, or up to the walls of Room 102, whichever is less. Inside TA-50-69, no combustible fuel package may be greater than 50 lbs and must be separated from other combustibles ≥ 6 ft,* excluding the change rooms/rest rooms. Combustible materials inside and within 10 ft of the exterior of the transportainers shall be limited to materials and equipment necessary to complete operational tasks.	minimize the amount and the continuity of fixed and transient combustibles in the facility that could fuel and sustain a fire. By minimizing the combustibles in the facility, the program reduces the fuel component of the fire and improves suppression effectiveness. As a result, significant reductions in offsite dose consequences can be achieved. Neither combustible (Class II or IIIA) liquids or flammable liquids or gases may be stored or used for maintenance purposes when there are TRU waste containers present within Building TA-50-69. Class IIIB liquids (such as hydraulic fluids within a closed system, or liquid soap used in restrooms) are excluded from this control because they have a flashpoint greater than 200 °F, an NFPA Flammability Rating of 1 or 0, and cannot spontaneously ignite to initiate a fire. Forklifts, which contain hydraulic fluids and have combustible parts such as rubber and plastic, are necessary for movement of TRU waste containers, are only present within the building on a transient basis, and are excluded from consideration in the determination of average combustible loading for the building and from the 50-lb fuel package limit and 6-ft separation distance. Also excluded from these limits (i.e., building average, and 50-lb, 6-ft fuel package) is the operationally necessary material and equipment within the WCG exclusion zone. Material and equipment necessary for operation is not counted as material stored within the WCG exclusion zone. These necessary allowances do not significantly increase the continuity of combustibles that would allow propagation of a fire from one work area to another.

Table 4-27. Combustible-Loading Control Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
	* The following are excluded from the above limitations: • INVENTORY that is in the WCG or staged in BUILDING TA-50-69. • Combustible components of support equipment (e.g., wiring insulation, operator platforms and rubber mats) within the WCG Exclusion Zone and associated with WCG processing. • Drum liners or wrapping around DEGRADED/LOSS OF INTEGRITY drums that are inside BUILDING TA-50-69 being loaded, and working amounts of materials necessary to complete bag-on/off operations such as tape, cheesecloth, and extra operator gloves. • Hydraulic fluid within the engineered, closed-loop, containment systems. • Combustible components associated with a forklift.	Limiting combustible material loading inside and around the outside of transportainers which contain TRU waste containers limits the continuity of combustibles that would allow fire spread. The transportainers are constructed of non-combustible material and are not provided with electrical power. Combustible loading inside and within 10 ft of the exterior of the transportainers is limited to those materials and equipment that are necessary to perform operational tasks. The allowable combustibles include items such as combustible waste inside a closed TRU waste container, container labeling, lid restraints, plastic wrapping around empty parent drums, gaskets that prevent rainwater intrusion into the transportainers, and plastic or rubber-wheeled container dollies that may be stored in or near the transportainers. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel at the WCRRF are specifically trained to implement this control. Operations personnel must be trained to all applicable LANL and WCRRF procedures that apply to the implementation of this control.

4.5.1.5 Technical Safety Requirement Controls

The combustible loading control for WCRRF is included in the TSRs as a limiting condition for operation in the TSRs. The combustible loading shall be:

1. $\leq$ 0.60 lb/ft^2 on average in Building TA-50-69.*
2. No flammable liquids or gases, and no combustible liquids with NFPA Flammability Rating greater than 1, shall be stored or used within Building TA-50-69 when TRU waste is in Building TA-50-69, except three size-1 cylinders of P-10 gas and flammable or combustible liquids found in the TRU WASTE CONTAINER.
3. No combustibles shall be stored within the WCG exclusion zone.* The WCG exclusion zone is 10 ft around the WCG, up to the GBE, or up to the walls of Room 102, whichever is less.
4. No combustible fuel package inside the building may be greater than 50 lbs and must be separated from other combustibles $\geq$ 6 ft*, excluding the change rooms/rest rooms.

5. Combustible material inside and within 10 ft of the exterior of the transportainers shall be limited to those materials and equipment necessary to accomplish required tasks.

* The following are excluded from the above limitations:

- INVENTORY that is in the WCG or staged in BUILDING TA-50-69.
- Combustible components of support equipment (e.g., wiring insulation, operator platforms and rubber mats) within the WCG Exclusion Zone and associated with WCG processing.
- Drum liners or wrapping around DEGRADED/LOSS OF INTEGRITY drums that are inside BUILDING TA-50-69 being loaded and working amounts of materials necessary to complete bag on/off operations such as tape, cheese cloth, and extra operator gloves.
- Hydraulic fluid within the engineered, closed-loop, containment systems.
- Combustible components associated with a forklift.

4.5.2 Hot Work Prohibition

4.5.2.1 Safety Function

The control of hot work reduces the probability of a fire igniting that could threaten TRU waste.

4.5.2.2 SAC Description

Hot work is not allowed in Building TA-50-69 when TRU waste is present. Hot work involves the use of heat, spark, or flame-generating equipment. Some examples include welding activities, the use of grinders, the use of torches, etc. Should hot work be needed to complete maintenance or repair work, all TRU waste must be removed from Building TA-50-69 (other than residual contamination from earlier operations). Hot work outside Building TA-50-69 is performed in accordance with the Fire Protection Program hot work controls. All TRU waste staged outdoors is in TRU waste containers with sealed lids and inside metal transportainers and does not need to be covered by this SAC.

4.5.2.3 Functional Requirements

Table 4-28 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.2.1, *Safety Function*.

Table 4-28. Functional Requirements for Hot Work Prohibition

Safety Function	Functional Requirements
The control of hot work reduces the probability of a fire igniting that could threaten exposed TRU waste.	TRU waste must be protected from fire hazards during hot work activities.

4.5.2.4 SAC Evaluation

This section provides the performance criteria for the hot work control that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-28. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-29.

Table 4-29. Hot Work Prohibition Performance Criteria

Functional Requirements	Performance Criteria	`Evaluation
TRU waste must be protected from fire hazards during hot work activities.	No hot work may be performed in Building TA-50-69 when TRU waste is present.	Execution of this control is accomplished before performing hot work activities. All work at the WCRRF is planned and then coordinated with facility management to ensure coincident activities are compatible with regard to safety and authorization bases. This control has a low level of difficulty associated with it. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations and maintenance personnel at the WCRRF are specifically trained on the implementation of this control. The Fire Protection Program ensures adequate hot work controls to prevent fire initiation and propagation.

4.5.2.5 Technical Safety Requirement Controls

The prohibition of hot work is included in the TSRs as a Specific Administrative Control (SAC) in the Administrative Controls section of the TSRs.

- No hot work may be performed in Building TA-50-69 when TRU waste is present.

4.5.3 Vehicle Fuel Restrictions

4.5.3.1 Safety Function

The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF prevents explosions and minimizes the potential for fires that will impact TRU waste.

4.5.3.2 SAC Description

A vehicle access system shall be established within the WCRRF. This system shall be defined by vehicle barriers and administrative procedures. Gasoline, diesel, propane, or other combustible-fueled vehicles or forklifts shall not be used within the vehicle access system when TRU waste is present.

Section 3.4.2.2, *Operational Fires Outside Building TA-50-69*, identified that fuel pool fires and their impingement upon TRU waste containers would result in dose consequences to the public that exceeded the Evaluation Guideline. No engineered SSC could be identified to completely disallow the fuel from being on-site, because an engineered control of this type would impede TRU waste container movement and WCRRF maintenance activities, and as a result, introduce additional hazards. Instead, to protect TRU waste from fuel pool fires, the safety-class-level SAC that prohibits fuel or fuel-powered vehicles from being at WCRRF when TRU waste containers are there serves the dual role of (1) preventing fuel interaction with TRU waste containers, while still allowing (2) maintenance vehicle access when TRU waste containers are not at WCRRF.

Exceptions to this prohibition are as follows:

- Emergency vehicles must have access to WCRRF at all times;
- Equipment (ATVs, hand-operated snow blowers, weed cutters, etc.) with a maximum of 5 gal. of fuel are allowed to perform grounds maintenance and snow and ice removal actives.

Five gallons of gasoline or equivalent is determined to be an acceptable amount to be used outside the WCRRF for short periods of time to allow efficient facility operations. This amount of fuel will be in a fuel system that is an integral part of the vehicle or equipment. This fuel source is primarily a hazard during snow removal; therefore, the likelihood of a fuel tank rupture igniting a pool fire is minimized by virtue of the snow. During snow removal, waste drums are not being moved or in a vulnerable condition because forklift operations are suspended until the work area is clear. Normally, hand tools are adequate to clear the snow and are the tools of choice. Grounds maintenance activities are also short in duration, and typical weed cutters have far less than 5 gal. of fuel. Therefore, 5 gal. of gasoline or equivalent is the limit to be used for these activities.

4.5.3.3 Functional Requirements

Table 4-30 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.3.1, *Safety Function*.

Table 4-30. Functional Requirements for Vehicle Fuel Restrictions

Safety Function	Functional Requirements
The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF prevents explosions and minimizes the potential for fires that will impact TRU waste.	TRU waste must be protected from fires or explosions caused by propane, gasoline, or diesel-fueled vehicles.

4.5.3.4 SAC Evaluation

This section provides the performance criteria for the prohibition of propane, gasoline, or diesel-fueled vehicles within the vehicle access system when TRU waste containers are present that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-30. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-31.

Table 4-31. Vehicle Fuel Restrictions Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
TRU waste must be protected from fires or explosions caused by propane, gasoline, or diesel-fueled vehicles.	• Propane, gasoline or diesel-fueled vehicles shall not be used anywhere at the WCRRF when TRU waste is present at the WCRRF. • **Exceptions**: (1) Emergency vehicles in the case of any emergency, and (2) equipment with less than 5 gal. of fuel may be used for grounds maintenance or snow and ice removal.	All work at the WCRRF is planned and then coordinated with facility management to ensure propane, gasoline, and diesel-powered vehicles are not brought into the facility when TRU waste is present. This control has a low level of difficulty associated with it. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations and maintenance personnel at the WCRRF are specifically trained on the implementation of this control. The vehicle access system defines the WCRRF vehicle access boundaries and prohibits the use of gasoline, diesel, propane or other combustible-fueled vehicles at WCRRF with the exception for emergency vehicles and grounds maintenance or snow removal.

4.5.3.5 Technical Safety Requirement Controls

The prohibition of propane, gasoline, or diesel-fueled vehicles in the WCRRF is included in the TSRs as a SAC in the Administrative Controls section of the TSRs.

- Propane, gasoline, or diesel-fueled vehicles shall not be used anywhere at the WCRRF when TRU waste is present at the WCRRF. **Exceptions**: (1) Emergency vehicles in the case of any emergency, and (2) equipment with less than 5 gal. of fuel may be used for grounds maintenance or snow and ice removal.

4.5.4 TRU-Waste Container Inspection

4.5.4.1 Safety Function

The TRU waste container inspections prevent flammable gas deflagrations and ensure that containers can mitigate other accidents involving containerized waste.

4.5.4.2 SAC Description

The receipt and staging inspection and acceptance criteria for TRU waste containers includes the following:

- Verification that the TRU waste container is of noncombustible construction (top, bottom, and sides) and is of a design that has had a prototype meet the free-drop tests in 49 CFR 173.465 (c)(1).
- Verification that the TRU waste container is integral and shows no signs of degradation.
- Verification that the TRU waste container is equipped with WIPP-approved filtered vents, and that the vents are free of obvious obstructions.
- Verification of documentation indicating the headspace gas concentration of the received TRU waste containers and any interior drums has been tested and is $\leq$ 4% hydrogen concentration and $\leq$ 8,000 ppm for volatile organic compounds (VOCs).

Containers that do not meet the above requirements shall not be accepted at the site. Degraded drums or drums with loss of integrity that have been overpacked into a protective container to ensure protection and containment of contents may be accepted if the outer container meets all of the inspection acceptance criteria, and the inner drum has fulfilled the inspection criteria for headspace gas analyses for H_2 LFL and VOCs.

The Section 3.4 accident analysis identifies several accidents that are mitigated or prevented by the condition that TRU waste containers fulfill the above inspection criteria.

Across the DOE complex, this inspection verification is carried out visually, and no engineered control has been identified to accomplish this inspection. The first inspection criteria is performed as part of this SAC to verify the containers meet the (SC-) Design Feature requirements to allow one comprehensive receipt inspection in lieu of an ISI. For the third inspection criteria, it is not plausible that this type of analysis be performed at the WCRRF because it is not within the mission work scope for the WCRRF. However, all TRU waste containers received at WCRRF are sent from TA-54, Area G, which does have the capability to perform the headspace gas analysis for hydrogen and VOCs. The fact that operations at TA-54, Area G and WCRRF are managed by the same organization ensures that TA-54, Area G procedures cite the requirement that TRU waste containers at WCRRF must undergo this analysis before shipment to WCRRF, and that WCRRF TRU waste container (receipt) inspection procedures ensure that this analysis has occurred at TA-54, Area G. It is not practical that the equipment needed to perform the same hydrogen gas and VOC analysis be required at two sites within the same organization.

4.5.4.3 Functional Requirements

Table 4-32 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.4.1, *Safety Function*.

Table 4-32. Functional Requirements for TRU-Waste Container Inspection

Safety Function	Functional Requirements
TRU waste container inspections prevent flammable gas deflagrations and ensure that containers can mitigate other accidents involving containerized waste.	TRU waste containers must meet the minimum performance requirements assumed in the accident analysis. WCRRF operator training and procedures on the specific criteria to determine whether a TRU waste container can be received at the WCRRF site ensure that the SAC is accomplished.

4.5.4.4 SAC Evaluation

This section provides the performance criteria for the controls that are needed to meet the functional requirements listed in Table 4-32. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-33.

Table 4-33. TRU-Waste Container Inspection Performance Criteria

Functional Requirements	Performance Criteria	Evaluations
TRU waste containers must meet the minimum performance requirements assumed in the accident analysis. WCRRF operator training and procedures on the specific criteria to determine whether a TRU waste container can be received at the WCRRF site ensure that the SAC is accomplished.	Incoming TRU waste at WCRRF shall be visually inspected upon arrival (before the containers are placed in storage) to ensure that the containers meet the following minimum performance requirements: • Verify that the TRU waste container is of noncombustible construction (top, bottom, and sides) and is of a design that has had a prototype meet the free-drop tests specified in 49 CFR 173.465(c)(1). • Verify that the TRU waste container is integral and shows no signs of degradation. (see details in Section 4.5.4.5, *Technical Safety Requirement Controls*) • Verify that the TRU waste container is equipped with WIPP-approved vents, and the vents are free of obvious obstructions; and, • Verify receipt documentation indicating that the headspace gas concentration of the received TRU waste containers and any interior drums has been tested and is < 4% hydrogen concentration and < 8,000 ppm for VOCs.	All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel at the WCRRF are specifically trained on the implementation of this control. This control has a low level of difficulty associated with it. Containers not meeting the above requirements shall not be unloaded at the site, and WCRRF personnel shall not accept the waste manifest. Degraded drums or drums with loss of integrity that have been overpacked into a protective container to ensure protection and containment of contents may be accepted if the outer container meets all the inspection acceptance criteria and the inner drum has fulfilled inspection criteria (4th bullet) on headspace gas analysis for hydrogen LFL and VOCs. Appendix B of the Department of Energy Standard 5506 *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* (DOE-STD-5506) cites the results of several empirical studies across the DOE complex, involving the pressurization of 55-gallon drums with high concentrations of hydrogen. A common theme of all of these studies is that hydrogen concentrations much greater than the LFL for hydrogen (4% by volume) are required to cause a drum to deflagrate and experience lid-loss. Results of Idaho drum deflagration tests cited in the DOE-STD-5506, involving drums filled with simulated combustible and metal waste matrices and filled with hydrogen concentrations between 6-30%, indicate that regular drum handling of an unvented drum will not cause a deflagration. A spark plug used as a ~5 Joule ignition source applied to a 55-gallon drum with hydrogen concentrations of 30% was required to cause 4 of 12 test drums to experience lid loss. In the same tests, a ~20 milli-Joule ignition applied to a drum with 30% hydrogen also caused lid loss. Tests involving drums, also with hydrogen concentrations of 30% and exposed to a 12-foot drop or drill bit puncture perturbations, did not result in a lid loss of any indication of inner burning.

Table 4-33. TRU-Waste Container Inspection Performance Criteria

Functional Requirements	Performance Criteria	Evaluations
		Other studies cited in DOE-STD-5506 include Savannah River Site (SRS) Drum Hydrogen Explosion Tests involving 18 test drums headspace hydrogen concentrations in the range of 13 to 36%. A hot wire was used as an ignition source. Five of the tests involving hydrogen concentrations ranging from 13.3 to 16.5 % experienced only bulging; four of the test drums with hydrogen concentrations in the range from approximately 17 to 35% experienced lid loss. A conclusion of these studies was that an explosive mixture up to 15-volume% of hydrogen can be contained in a 55-gallon TRU drum without lid loss. In particular, *the SRS experiments results show that "lid loss" occurred when exceeding ~ 17 vol%, and less than that caused the drum to bulge at the top and bottom, but with no loss of containment. This supports the 1983 Idaho conclusion that more than 14 vol% was needed for lid loss. The maximum pressures measured in the SRS experiment are also noteworthy regarding rapid depressurization that can cause ejection of some contents.* DOE-STD-5506 Table 6.4.1-1, Hazard Controls, cites that for characterization and container handling of unvented drums, *Until vented and hydrogen concentration is verified to be less than 8%, handle as suspect container.* *Drums with hydrogen less than 8% concentration may still present some worker hazards. In particular, known hydrogen concentrations in the LFL range may warrant explicit Safety Management Program attributes on drum handling. All drums should be handled in accordance with industrial safety/hygiene and radiation protection controls invoked through SMPs.* In comparison to the guidance in DOE-STD-5506, requiring verification of receipt documentation showing that the headspace gas concentration of hydrogen is less than 4% in a

Table 4-33. TRU-Waste Container Inspection Performance Criteria

Functional Requirements	Performance Criteria	Evaluations
		55-gal vented TRU waste container received at WCRRF, is conservative, since it is half of the hydrogen concentration cited in DOE-STD-5506 in the discussion on controls for deflagration accidents involving unvented drums, and less than one-third the value empirically determined to be required for a lid loss from an unvented drum to occur.

4.5.4.5 Technical Safety Requirement Controls

The following TRU waste container inspection criteria are included in the TSRs as an SAC in the Administrative Controls section of the TSRs.

Incoming TRU WASTE CONTAINERS at WCRRF shall be visually inspected upon arrival (before the TRU WASTE CONTAINERS are placed in storage) to ensure that the TRU WASTE CONTAINERS meet the following minimum performance criteria:

1. Verify that the TRU waste container is of noncombustible construction (top, bottom. and sides) and is of a design that has had a prototype meet the free-drop tests specified in 49 CFR 173.465(c)(1).
2. Verify that the TRU waste container is integral and shows no signs of degradation by verifying the following:
    - The TRU waste container is not obviously degraded

      Discussion: Obviously degraded means clearly visible and potentially significant defects in the TRU waste container or TRU waste container surface.
    - There is no evidence that the TRU waste container is, or has been, pressurized.

      Discussion: Pressurization can be indicated by a fairly uniform expansion of the sidewalls, bottom, or top. Past pressurization can be indicated by a notable outward deflection of the bottom or top. Verify that the drum is not warped.
    - There is no potentially significant rust or corrosion such that wall thinning, pinholes, or breaches are likely or the load bearing capacity is suspect.

      Discussion: Rust shall be assessed in terms of its type, extent, and location. Pitting, pocking, flaking, or dark coloration characterizes potentially significant rust or corrosion. This includes the extent of the TRU waste container surface area, covered, thickness, and, if it occurs in large flakes or built-up (caked) areas. Rusted TRU waste containers may not be accepted if:
      - Rust is present in caked layers or deposits
      - Rust is present in the form of deep metal flaking, or built-up areas of corrosion products. In addition, the location of rust should be noted; for example, on a drum: top lid; filter region; locking chine; top one-third, above the second rolling hoop; middle one-third, between the first and second rolling hoops; bottom one-third, below the second rolling hoop; and on the bottom. TRU waste containers may still be considered acceptable if the signs of rust show up as:
        a. Some discoloration on the TRU waste container.

b. If rubbed, rust would produce fine grit or dust or minor flaking (such that wall thinning does not occur).

- There are no split seams, tears, obvious holes, punctures (of any size), creases, broken welds, or cracks.

  Discussion: TRU waste containers with obvious leaks, holes or openings, cracks, deep crevices, creases, tears, broken welds, sharp edges or pits, are either breached or on the verge of being breached.

- The TRU waste container is properly closed.

  Discussion: Inspect the fastener and fastener ring (chine), if applicable, for damage or excessive corrosion. Check the alignment of the fastener to ensure that it is in firm contact around the entire lid and the TRU waste container will not open during transportation.

- There are no dents, scrapes, or scratches that make the TRU waste container's structural integrity questionable or prevent the top and bottom surfaces from being parallel.

  Discussion: Deep gouges, scratches, or abrasions over wide areas are not acceptable. If top and bottom surfaces are not parallel, this would indicate that the container is warped. Dents should be examined to determine impact on structural integrity.

- There is no discoloration which would indicate leakage or other evidence of leakage of material from the TRU waste container.

  Discussion: Examine the TRU waste container regions near vents, top lid fittings, bottom fittings, welds, seams and intersections of one or more metal sheets or plates. TRU waste containers must be rejected if evidence of leakage is present.

- The TRU waste container is not bulged.

  Discussion: For the purposes of this examination, bulging is indicated by:

  - A fairly uniform expansion of the sidewalls, bottom, or top (e.g., in the case of a drum, either the top or bottom surface protrudes beyond the planar surface of the top or bottom ring,
  - A protrusion of the side wall (e.g., in the case of a drum, beyond a line connecting the peaks of the surrounding rolling hoops or a line between a surrounding rolling hoop and the bottom or top ring), or
  - Expansion of the sidewall (e.g., in the case of a drum, such that it deforms any portion of a rolling hoop).

3. Verify that the TRU waste container is equipped with WIPP-approved filtered vents, and the vents are free of obvious obstructions; and,
4. Verify receipt documentation indicating that
   a. the headspace gas concentration of a 55-gallon drum waste container has been analyzed/ measured and contains < 4% volume of hydrogen and < 8000 ppm for VOCs, and the 55-gallon drum waste container is equipped a WIPP-approved filtered vent, and the vent is free of obvious obstructions and
   b. each overpack above the 55-gallon drum must also have a WIPP-approved filter installed that is free of any obvious obstruction.

Containers that do not meet the above requirements shall not be accepted at the site with the following exception: Degraded drums or drums with loss of integrity that have been overpacked into a protective container to ensure protection and containment of contents may be accepted if the outer container meets all of the inspection acceptance criteria, and the inner drum has fulfilled inspection criteria 4.

4.5.5 TRU-Waste Container Staging Practices

4.5.5.1 Safety Function

The restrictions on TRU waste container stacking and lift height prevent the release of material by reducing the likelihood of a container failure caused by a drop from an elevated position.

4.5.5.2 SAC Description

The TRU waste containers shall not be stacked and shall not be lifted higher than 4 ft, excluding the WCG drum lift and lifts during loading or unloading from delivery trucks.

4.5.5.3 Functional Requirements

Table 4-34 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.5.1, *Safety Function*.

Table 4-34. Functional Requirements for Restrictions on TRU-Waste Container Staging Practices

Safety Function	Functional Requirements
The restriction on TRU waste container stacking and lift height prevents the release of material by reducing the likelihood of a container failure caused by a drop from an elevated position.	TRU waste containers may not be stacked or lifted higher than the container-certification drop-test criteria, unless specifically approved exceptions are in place.

4.5.5.4 SAC Evaluation

This section provides the performance criteria for the TRU waste container stacking restriction that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-34. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-35.

Table 4-35. Restrictions on TRU-Waste Container Performance Criteria Staging Practices

Functional Requirements	Performance Criteria	Evaluation
TRU waste containers may not be stacked or lifted higher than the container-certification drop-test criteria, unless specifically approved exceptions are in place.	The TRU waste containers shall not be stacked and shall not be lifted higher than 4 ft, excluding the WCG drum lift and lifts during loading or unloading from delivery trucks.	All WCRRF personnel receive site-specific training, supplemented with job-specific training as appropriate. Operations personnel at the WCRRF are specifically trained on the implementation of this control. This control has a low level of difficulty associated with it. The TRU waste containers are required to meet the DOT 7A, Type A free-fall drop performance criteria (survive a 4-ft drop). The prohibition on stacking helps prevent the

Table 4-35. Restrictions on TRU-Waste Container Performance Criteria Staging Practices

Functional Requirements	Performance Criteria	Evaluation
		probability of a drop that could breach the container. Delivery truck beds used at LANL are approximately 51 inches above ground. Lift heights when TRU waste containers are loaded or unloaded from delivery trucks are slightly greater than 51 inches. Energy causes damage to the drum as a result of a drum drop, and the TRU waste drums have been tested to 4000 ft.-lbs (1000 lb. drum dropped from a height of 4 ft.); for an equivalent amount of damage to a 630 lb. drum, the drums would have to be dropped from about 6.3 ft (75.6 inches). SWBs are more robust than drums, so can be expected to survive drops during unloading and loading operations. In addition, the requirement for trained and qualified forklift operators and spotters minimizes the probability of TRU waste container drops during delivery truck loading or unloading operations. Therefore, the TRU waste container lift height incurred during loading or unloading from delivery trucks is excluded from the prohibition on lifts greater than 4 ft, based on the safety margin provided by the containers and by trained operators/spotters. The WCG drum lift requires lifts of 61 inches and is a safety significant control to prevent and mitigate drum drop events. This control compensates for lifts involving degraded or loss of integrity drums that may not meet the 4 ft. drop tests.

4.5.5.5 Technical Safety Requirement Controls

The limiting of TRU waste container stacking and the lift-height restriction is included in the TSRs as a SAC in the Administrative Controls section of the TSRs.

- The TRU waste containers shall not be stacked and shall not be lifted higher than 4 ft, excluding the WCG drum lift and lifts during loading or unloading from delivery trucks.

4.5.6 Inventory Limits

4.5.6.1 Safety Function

The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated.

4.5.6.2 SAC Description

The total WCRRF inventory limits are an underlying assumption for the accidents that occur inside and outside at the WCRRF for the accident analysis in Chapter 3, *Hazard and Accident Analysis*. The TRU waste inventory limits are administratively controlled bounding limits on radiological material quantities used in operation at the WCRRF. Inventory limits are imposed at the facility to ensure that the quantities of MAR assumed in the accident analysis are not exceeded potentially increasing the offsite dose consequence estimates for each of the evaluation basis accidents. The inventory received at the WCRRF is in the form of TRU waste. The limiting form of TRU waste from the accident analysis is combustible waste. No more than 800 PE-Ci of combustible waste is allowed in Building TA-50-69. Other TRU waste forms must be converted to equivalent combustible waste and counted against the 800 PE-Ci limit. The WCRRF shall not contain > 1,800 PE-Ci of TRU waste at the entire facility.

The unit of equivalent combustible waste applicable to TRU waste containers in Building TA-50-69 is a ratio based on the inventory amount of noncombustible waste or filter media that results in the same dose consequences derived from 800 PE-Ci of combustible waste for the bounding accident.

4.5.6.3 Functional Requirements

Table 4-36 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.6.1, *Safety Function*.

Table 4-36. Functional Requirements for Inventory Limits

Safety Function	Functional Requirements
The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenarios are not invalidated	The operations personnel must not allow the TRU waste inventory in the WCRRF to accrue to levels above the MAR limits evaluated in the accident analysis.

4.5.6.4 SAC Evaluation

This section provides the performance criteria for the WCRRF TRU waste inventory limits that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-36. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-37.

Table 4-37. Inventory Limits Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The operations personnel must not allow the TRU waste inventory in the WCRRF to accrue to levels above the MAR limits evaluated in the accident analysis.	The WCRRF shall not contain > 1,800 PE-Ci of TRU waste in the entire facility with ≤800 PE-Ci of equivalent combustible TRU waste inside Building TA-50-69.	All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel at the WCRRF are specifically trained on the implementation of this control. These TRU waste inventory limits are maintained through receipt and inspection paperwork. Inventory tracking is also used to account for TRU waste container movement. All the TRU waste inventory limits must be implemented as part of facility procedures. Operations personnel must be trained to all WCRRF procedures that apply to the implementation of this control.

4.5.6.5 Technical Safety Requirement Controls

The TRU waste inventory limits are included in the TSRs as a limiting condition for operation AC in the Administrative Controls section of the TSRs.

- The WCRRF shall contain ≤ 1,800 PE-Ci of TRU waste in the entire facility, including Building TA-50-69. Building TA-50-69 shall contain ≤ 800 PE-Ci of equivalent combustible TRU waste.

4.5.7 Transportainer Placement

4.5.7.1 Safety Function

Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.

4.5.7.2 SAC Description

The transportainers must not be elevated such that the inside floor is more than 4 ft above the ground level because the TRU waste containers are rated to survive falls from a height of 4 ft. In the event of a drop, the height of the transportainer aboveground must not jeopardize the structural integrity of a TRU waste container. The TRU waste containers accepted into the WCRRF for processing are steel and of a type that are designed and tested to survive a 4-ft drop; therefore, limiting the height of the transportainer helps reduces the probability of a drop causing a significant release. Locating the transportainers > 35 ft from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse caused by a seismic event. Building TA-50-69 is approximately 23 ft tall, placing the transportainers > 35 ft from the structure gives a clearance of approximately 1.5 times the building height, which is sufficient to prevent impact on the transportainers from a seismic collapse.

4.5.7.3 Functional Requirements

Table 4-38 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.7.1, *Safety Function*.

Table 4-38. Functional Requirements for Transportainer Placement

Safety Function	Functional Requirements
Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.	Transportainers containing TRU waste must be placed at an elevation no higher than the container-certification drop-test criteria and a separation distance from Building TA-50-69 that is greater than the height of Building TA-50-69.

4.5.7.4 SAC Evaluation

This section provides the performance criteria for the transportainer height staging control that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-38. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-39.

Table 4-39. Transportainer Placement Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Transportainers containing TRU waste must be placed at an elevation no higher than container-certification drop-test criteria and a separation distance from Building TA-50-69 that is greater than the height of Building TA-50-69.	• Support structures shall not elevate transportainers more than 4 ft above ground level. • Transportainers containing TRU waste shall be located > 35 ft away from Building TA-50-69.	All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel at the WCRRF are specifically trained on the implementation of this control. This control has a low level of difficulty associated with it. Transportainers are ~1.5 ft above ground.

4.5.7.5 Technical Safety Requirement Controls

The restriction on transportainer placement is included in the TSRs as an SAC in the Administrative Controls section of the TSRs.

- Support structures shall not elevate transportainers containing TRU waste containers more than 4 ft above ground level.
- Transportainers containing TRU waste shall be located greater than 35 ft away from Building TA-50-69.

4.5.8 TRU-Waste Containers Staged in Transportainers

4.5.8.1 Safety Function

The requirement to stage TRU waste containers inside secondary containment (transportainers) while in outdoor staging minimizes the release of TRU waste from external fires involving the TRU waste containers.

4.5.8.2 SAC Description

Each TRU waste container shall be staged in closed transportainers while in outdoor staging and container lids shall remain closed when staged outside Building TA-50-69. This requirement provides weather protection for containers and protection from grass wildland fires at the adjacent MDA-C site.

4.5.8.3 Functional Requirements

Table 4-40 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.8.1, *Safety Function*.

Table 4-40. Functional Requirements for Staging TRU-Waste Containers in Transportainers

Safety Function	Functional Requirements
The requirement to stage TRU waste containers in secondary containment (transportainers) while in outdoor staging minimizes the release of TRU waste from external fires involving the TRU waste containers.	TRU waste containers shall be staged in closed transportainers while in outdoor staging.

4.5.8.4 SAC Evaluation

This section provides the performance criteria for the TRU waste container outdoor staging restrictions that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-40. This section also evaluates the capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-41.

Table 4-41. Staging TRU-Waste Containers in Transportainers Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
TRU waste containers shall be staged in closed transportainers while in outdoor staging.	TRU waste containers shall be placed in the transportainers, and container lids shall remain closed when staged outside the Building TA-50-69 structure.	This control requires the use of the transportainers for outdoor TRU waste container staging. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel are specifically trained on the implementation of this control.

4.5.8.5 Technical Safety Requirement Controls

This administrative control is included in the TSRs as an SAC in the Administrative Controls section of the TSRs.

- TRU waste containers shall be placed in the transportainers, and container lids shall remain closed when staged outside the Building TA-50-69 structure.

4.5.9 Vehicle Access System

4.5.9.1 Safety Function

The implementation of a vehicle access system prevents vehicle impacts and subsequent fuel pool fires that could impinge upon TRU waste in Building TA-50-69 and TRU waste containers staged in transportainers.

4.5.9.2 SAC Description

Properly positioned vehicle barriers provide protection against motor vehicles inadvertently impacting TRU waste containers staged in Building TA-50-69 and in transportainers, and protects against potential fuel pool fires resulting from vehicle crashes. Vehicle barriers are standard traffic control obstacles, typically reinforced concrete, that absorb or redirect the momentum of errant vehicles away from TRU waste containers. The movable barriers are positioned in strategic locations at the WCRRF to prevent accidental impacts to TRU waste containers that could result in pool fires and material releases. Removable gates are provided in 2 locations.

Vehicle barriers are designated as safety-class SSCs based on their ability to prevent impacts between vehicles and TRU waste containers staged in Building TA-50-69 or in outdoor transportainers. The vehicle barriers also provide a sufficient separation distance between any subsequent 100-gal. (and less) fuel pool fire resulting from the collision or vehicle fuel leak and any TRU waste containers in these areas. The barriers are placed to ensure an adequate vehicle stopping distance after impact and a resultant separation or standoff distance between a vehicle fuel pool fire and TRU waste containers staged in WCRRF. The standoff distance is based on fire analysis calculations, Appendix 3D, *Fire Accident Calculations.*

The gates of the vehicle access system may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance of the gate to inadvertent vehicle impact, and during these times, it is acceptable to temporarily remove the gate.

4.5.9.3 Functional Requirements

Table 4-42 identifies the minimum functional requirements needed to fulfill the safety function identified in Section 4.5.9.1, *Safety Function*.

Table 4-42. Functional Requirements for the Vehicle Access System

Safety Function	Functional Requirements
The implementation of a vehicle access system prevents vehicle impacts and subsequent fuel pool fires that could impinge on TRU waste in Building TA-50-69 and TRU waste containers staged in transportainers.	Vehicle barriers must ensure a safe separation distance from fuel pool fires resulting from vehicle accidents and TRU waste containers that are staged in Building TA-50-69 or in transportainers.

4.5.9.4 SAC System Evaluation

This section provides the performance criteria for the vehicle barriers around waste staging areas that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-42. The performance criteria and associated evaluations are provided in Table 4-43.

Table 4-43. Vehicle Access System Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Vehicle barriers must ensure a safe separation distance from fuel pool fires resulting from vehicle accidents and TRU waste containers that are staged in Building TA-50-69 or in transportainers.	• Vehicle access system barriers must be located such that the impact vehicle stops at least 25 ft from the TRU waste containers staged in Building TA-50-69 or in transportainers to prevent up to a 100-gal. diesel fuel pool fire from impinging on waste containers. • The gates of the vehicle access system may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance of the gate to inadvertent vehicle impact, and during these times it is acceptable to temporarily remove the gate.	The approximate dimensions of each barrier are 2 ft by 3 ft by 10 ft, with a mass of no less than 3,700 lb. Barriers are connected by wire rope in accordance with engineering specifications (Mertz 2007a). Movable cable barriers consisting of two ⅝-inch-diameter wire ropes (gates) connected to cable support stands anchored to four Jersey barriers are also used. LANL Calculation SB-DO: CALC 07-007 (Mertz 2007a) verifies that the above configurations meet the performance criteria with a stopping distance after impact of 25 ft. The gates of the vehicle access system may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance to inadvertent vehicle impact, and during these times it is acceptable to temporarily remove the gate. All barriers will be placed at least 50 ft from TRU waste containers to ensure adequate vehicle stopping distance (25 ft) and a resultant separation distance (25 ft on level pavement) between potential pooled fuel from the impact vehicle and TRU waste containers.

4.5.9.5 Technical Safety Requirement Controls

The placement of vehicle access system barriers is included in the TSRs as an SAC in the Administrative Controls section of the TSRs.

- Vehicle access system barriers must be located such that the impact vehicle stops at least 25 ft from TRU waste containers staged in Building TA-50-69 or in transportainers to prevent up to a 100-gal. diesel fuel pool fire from impinging on waste containers.
- The gates of the vehicle access system may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance of the gate to inadvertent vehicle impact, and during these times it is acceptable to temporarily remove the gate.

The vehicle access system is a specific administrative control to ensure that the barriers are properly positioned, and undergo a periodic in-service inspection (as a minimum, annually) in accordance with the design feature to identify any abnormalities that may develop. The vehicle barriers design feature ensures barrier design and integrity. The barrier integrity and positioning shall be inspected after any movement of the barriers through procedures that implement the vehicle access system SAC.

4.5.10 Diesel Generator Refueling Exclusion

4.5.10.1 Safety Function

This control prevents fuel pool fires associated with the diesel generator refueling from affecting TRU waste in Building TA-50-69.

4.5.10.2 SAC Description

If a leak occurs during refueling of the diesel generator, diesel fuel spill may pool near Building TA-50-69. If the diesel fuel spill ignites, Building TA-50-69 may be affected, eventually leading to TRU waste containers in Building TA-50-69 being involved in the fire. By prohibiting diesel generator refueling when TRU waste containers are in Building TA-50-69, any fuel spills that ignite and involve Building TA-50-69 cannot impact TRU waste containers.

The diesel generator is located much farther away from the transportainers on the southerly side of Building TA-50-69, so any diesel fuel spills will not affect TRU waste containers staged in the transportainers.

The selection of an engineered control to prevent a diesel generator refueling spill is not feasible because the large volume of the refueling truck would require a costly engineering solution. Given the infrequent refueling operations, it is more cost-effective to prohibit refueling operations when TRU waste is in the building.

4.5.10.3 Functional Requirements

Table 4-44 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.10.1, *Safety Function*.

Table 4-44. Functional Requirements for Diesel Generator Refueling Exclusion

Safety Function	Functional Requirements
This control prevents fuel pool fires associated with diesel generator refueling from affecting TRU waste in Building TA-50-69.	The TRU waste in Building TA-50-69 must be protected from a diesel fuel pool fire caused by diesel generator refueling operations.

4.5.10.4 SAC Evaluation

This section provides the performance criteria for the diesel generator refueling exclusion that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-44. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-45.

Table 4-45. Diesel Generator Refueling Exclusion

Functional Requirements	Performance Criteria	Evaluation
The TRU waste in Building TA-50-69 must be protected from a diesel fuel pool fire caused by diesel generator refueling operations.	Refueling of the diesel generator is prohibited when TRU waste containers are in Building TA-50-69.	All work at the WCRRF is planned and then coordinated with facility management to track the refueling of the diesel generator and to ensure that TRU waste containers are not in TA-50-59 during diesel generator refueling operations. This control has a low level of difficulty associated with it. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations and maintenance personnel at the WCRRF are specifically trained on the implementation of this control. The WCRRF operator training and procedures on when diesel refueling operations are allowed ensure that the SAC is accomplished.

4.5.10.5 Technical Safety Requirement Controls

Diesel generator refueling operations shall fulfill the following TSR control:

- Refueling of the diesel generator is prohibited when TRU waste containers are inside Building TA-50-69.

4.5.11 Critical Lift Plan

4.5.11.1 Safety Function

The use of a critical lift plan minimizes the probability of impacts and drops involving degraded drums or loss-of-integrity drums.

4.5.11.2 SAC Description

The critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container inside Building TA-50-69.

A drum is considered degraded when it has visible rust, physical deformation, or other deficiencies that have not resulted in breach of the drum containment or reduction in structural capability. A drum is considered to have loss of integrity when it presents a visible breach or other indications such as external contamination that demonstrates a loss of confinement or physical deformation that compromise structural capabilities.

Degraded drums or drums that exhibit loss of integrity are wrapped with plastic as a conservative measure before being overpacked into a fully qualified TRU waste container and then shipped to the WCRRF.

Once the overpacked, wrapped drum is inside TA-50-69, it is lifted out of the TRU waste container overpack using a forklift and a combination of slings and straps. Because the lift involves a container that is considered to exhibit degradation or loss of integrity, no credit can be given for the Type A 4-ft free-drop testing, so reliance is placed on the critical lift, reducing the probability for a drum drop.

Part of the WCRRF mission is to repackage degraded or loss-of-integrity drums. No other engineered controls to lift the degraded drum out of the overpack could be readily identified as being practical or

plausible. Lifting drums to the WCG for repackaging is accomplished by the safety significant drum lift fixture.

4.5.11.3 Functional Requirements

Table 4-46 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.11.1, *Safety Function.*

Table 4-46. Functional Requirements for Critical Lift Plan

Safety Function	Functional Requirements
The use of a critical lift plan minimizes the probability of impacts and drops involving degraded drums or loss-of-integrity drums.	The critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container.

4.5.11.4 System Evaluation

This section provides the performance criteria for the critical lift that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-46. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-47.

Table 4-47 Critical Lift Plan Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container.	A critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container.	All work at the WCRRF is planned and then coordinated with facility personnel on the receipt of TRU waste contents, including the knowledge that a TRU waste container, serving as an overpack, could contain a (wrapped) degraded or loss-of-integrity drum. This coordination allows WCRRF personnel to plan accordingly for the critical lift. This control has a low level of difficulty associated with it. All WCRRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations and maintenance personnel at the WCRRF are specifically trained on the implementation of this control. Lifting of waste containers with a forklift must meet critical lift requirements. Operations, forklift operation, and rigging personnel must be trained to all procedures that apply to the implementation of this control.

4.5.11.5 Technical Safety Requirement Controls

Critical lifts at the WCRRF in Building TA-50-69 shall fulfill the following:

- A critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container.

4.5.12 Drum Lid Restraints

4.5.12.1 Safety Function

Restraints provide physical protection in the WCG in case of a lid ejection and minimize material release (e.g., prevent unconfined burning of material) when breaching an unvented, sealed 30- to 5-gallon waste package.

4.5.12.2 SAC Description

The lid restraining device may be constructed of an all metal or cloth design and is clamped in place on top of the TRU waste container. The use of lid restraining devices mainly protects glovebox workers working within the WCG from any flying debris from a lid ejection if a waste package overpressurization or deflagration were to occur. In addition, the glovebox is protected from flying debris breaching its confinement integrity. The lid restraining device has been demonstrated through testing or analysis to restrain an ejected lid during a drum deflagration.

4.5.12.3 Functional Requirements

Table 4-48 identifies the minimal functional requirements for fulfilling the safety functions listed in section 4.5.12.1, *Safety Function*.

Table 4-48. Functional Requirements for Drum Lid Restraints

Safety Function	Functional Requirements
Restraints provide physical protection in the WCG in case of a lid ejection and minimize material release (e.g., prevents unconfined burning of material) when breaching an unvented, sealed 30- to 5-gallon waste package.	Lid restraining device shall mitigate the effects of an unvented 30-gallon drum lid loss during an overpressurization or deflagration involving an unvented waste package.

4.5.12.4 SAC Evaluation

This section provides the performance criteria for the drum lid restraints that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-48. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-49.

Table 4-49. Drum Lid Restraints Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Lid restraining device shall mitigate the effects of an unvented 30-gallon drum lid loss during an overpressurization or deflagration involving an unvented waste package.	1. A lid restraining device shall be installed onto unvented, sealed 30- to 5-gallon waste packages when the lid is removed. Before breaching the waste package, the lid restraining device shall be inspected for degradation and proper installation. 2. After the removal of the lid and lid restraining device, WCG operations shall cease for 30 minutes.	The use of lid restraining devices mainly protects glovebox workers working within the WCG from any flying debris from a lid ejection if a waste package overpressurization or deflagration were to occur. In addition, the glovebox is protected from flying debris breaching its confinement integrity. The lid restraining device has been demonstrated through testing or analysis to restrain an ejected lid during a drum deflagration. DOE Standard 5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* (DOE 2007). cites results of Idaho Drum Deflagration Tests. Several drums were filled with representative combustible/metal waste matrices; the drums were also pressurized with a flammable gas mixture comprising oxygen, hydrogen, and nitrogen. The test drums were then subjected to sparks, a drill bit puncture, or a 12-foot drop. The results showed that puncturing or dropping the test drum did not result in a deflagration. In the 12-foot drop test, when the drum impacted the ground, it rotated a complete 180 degrees, yet it did not deflagrate, nor did it show signs that a fire occurred within the drum. This indicates that movement of metal items within the test drums did not produce enough of a spark to ignite the flammable gas mixture. Extending this result to WCG operations, it is not expected that handling an unvented, sealed drum, such as removing the lid from the drum, will cause the drum to deflagrate if a flammable gas mixture is present within the drum. The drums that deflagrated in the Idaho tests were the ones that were impacted with a soft (20 milli-Joules) or hard (5 Joules) spark. Extending this particular result

Table 4-49. Drum Lid Restraints Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		to WCG operations indicates that by preventing the occurrence of sparks, a deflagration will not occur if a flammable gas mixture exists with the waste package when it is breached. When breaching unvented, sealed waste package within the WCG, the use of nonsparking tools and grounding the metal waste packages and parent 55-gallon drum will prevent the introduction of sparks when breaching the unvented, sealed waste packages. Again, as indicated by the drum deflagration tests, spark production within the waste matrix by metal waste items rubbing against each other by the movement of an unvented, sealed waste package is not sufficient to cause a deflagration of a flammable gas mixture within the container. However, unvented, sealed waste package should be handled with care. After the unvented, sealed waste package is breached, the lid and lid restraining device can be removed. LANL Calc. CALC-07-50-069-000-0005-M-R-0 demonstrates that the maximum hydrogen concentration of 7.4% is possible in the WCG if 90% of a pressurized (11 psig) 30-gallon waste package is instantaneously released. The calculation cites that the overall concentration at the exhaust fan will not exceed flammable hydrogen concentrations due to the larger ductwork volume and ventilation flow rate at the common WCG and GBE exhaust header. The calculation further demonstrates that this type of instantaneous release is not possible due to the glovebox ventilation and drum configuration. The WCG ventilation sweeps away the hydrogen as it diffuses from the waste package, and after 30 minutes and with minimal WCG air flow

Table 4-49. Drum Lid Restraints Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
		(35 cubic foot per minute), the hydrogen concentration in the WCG and at the waste package opening are below flammable hydrogen concentrations. This control is only applicable to unvented, sealed waste packages with a volume of 30- to 5-gallons. Using the same calculations in LANL Calc. CALC-07-50-069-000-0005-M-R-0, the WCRRF Safety Basis Addendum No. 2, shows that breaching unvented, sealed waste packages with volumes smaller than 5 gallons will not cause the overall WCG atmosphere to experience a flammable gas concentration near 25% of the hydrogen lower flammability limit. The application of a lid restraining device on these smaller containers is not practical; however, the control for the use of nonsparking tools and the de-energizing of WCG receptacles, via SAC 5.10.1.6, is considered sufficient to prevent any flammable gas mixture to deflagrate in waste packages smaller than 5 gallons, and thus lid ejection from deflagration will not occur. Lid ejection from breaching a pressurized waste package less than 5 gallons is expected to not cause physical damage.

4.5.12.5 Technical Safety Requirements Controls

Drum lid restraints shall fulfill the following TSR control:

- A lid restraining device shall be installed onto unvented, sealed 30- to 5-gallon waste packages when the lid is removed. Before breaching the waste packages, the lid restraining device shall be inspected for degradation and proper installation.
- After the removal of the lid and lid restraining device, WCG operations shall cease for 30 minutes.

4.5.13 Nonsparking Tools or Processes/De-energization of WCG Electrical Receptacles

4.5.13.1 Safety Function

When breaching unvented, sealed waste packages within the WCG, the use of nonsparking tools or processes and the de-energization of WCG receptacles prevent the occurrence of sparks, thereby preventing the ignition of a potentially flammable atmosphere within the WCG.

4.5.13.2 SAC Description

The use of nonsparking tools or processes and the de-energization of WCG receptacles prevent the introduction of sparks that could ignite a flammable gas mixture during the handling of unvented TRU waste containers. Nonsparking tools or processes, for the handling of unvented TRU waste containers, are readily available from several manufacturers.

The requirement to de-energize WCG receptacles provides an additional layer of protection from the occurrence of sparks coming into contact with a possible flammable gas mixture.

4.5.13.3 Functional Requirements

Table 4-50 identifies the minimal functional requirements for fulfilling the safety functions listed in section 4.5.13.1, *Safety Function*.

Table 4-50. Functional Requirements Nonsparking Tools or Processes/De-energization of the WCG Electrical Receptacles

Safety Function	Functional Requirements
When breaching unvented, sealed waste packages within the WCG, the use of nonsparking tools or processes and the de-energization of WCG electrical receptacles prevent the occurrence of sparks, thereby preventing the ignition of a potentially flammable atmosphere within the WCG.	The process used to penetrate the lid of an unvented drum during its venting or headspace gas analysis does not produce sparks. WCG receptacles are de-energized when breaching unvented, sealed waste packages.

4.5.13.4 SAC Evaluation

The section provides the performance criteria for the nonsparking tools or processes/de-energization of the WCG electrical receptacles that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-50. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4.51.

Table 4-51. Nonsparking Tools or Processes/De-energization of the WCG Electrical Receptacles Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
The process used to penetrate the lid of an unvented drum during its venting or headspace gas analysis does not produce sparks. WCG receptacles are de-energized when breaching unvented, sealed waste	1. Tools and processes used to breach an unvented waste package shall be nonsparking. 2. Before breaching the unvented waste package within the WCG,	This control was credited to reduce ignition sources during the opening of unvented 30- to 5-gallon waste packages, thereby reducing the probability of a deflagration or explosion.

Table 4-51. Nonsparking Tools or Processes/De-energization of the WCG Electrical Receptacles Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
packages.	receptacles in the WCG shall be de-energized. 3. The WCG receptacles shall not be re-energized until 30 minutes has elapsed after removing the lid and lid restraining device.	

4.5.13.5 Technical Safety Requirement Controls

Nonsparking tools or processes/de-energization of the WCG electrical receptacles shall fulfill the following TSR controls:

- Tools and processes used to breach an unvented waste package shall be nonsparking.
- Before breaching the unvented waste package within the WCG, receptacles in the WCG shall be de-energized.
- The WCG receptacles shall not be re-energized until 30 minutes has elapsed after removing the lid and lid restraining device.

4.5.14 Grounding Waste Packages before Breaching Unvented Sealed Waste Packages

4.5.14.1 Safety Function

Grounding waste packages before breaching unvented, sealed waste packages reduces the probability for a spark during the opening of unvented 30- to 5-gallon waste packages within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere within the WCG.

4.5.14.2 SAC Description

Bonding and grounding is a very effective technique for minimizing the likelihood of an ignition from static electricity. A bonding system connects various pieces of conductive equipment together to keep them at the same potential. Static sparking cannot take place between objects that are the same potential. *Grounding* is a special form of bonding in which conductive equipment is connected to an earthing electrode or to the building grounding system in order to prevent sparking between conductive equipment and grounded structures. During the handling of unvented TRU waste containers in the WCG, the requirement to ground the unvented TRU waste container prevents the occurrence of sparks, which could ignite a possible flammable gas mixture within the unvented waste container.

4.5.14.3 Functional Requirements

Table 4-52 identifies the minimal functional requirements for fulfilling the safety functions listed in section 4.5.14.1, *Safety Function*.

Table 4-52. Functional Requirements for Grounding Waste Packages before Breaching Unvented, Sealed Waste Packages

Safety Function	Functional Requirements
Grounding waste packages before breaching unvented, sealed waste packages reduces the probability for a spark during the opening of an unvented 30- to 5-gallon waste package within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere within the WCG.	Ground must be applied before breaching the unvented, sealed waste package to be opened in the WCG.

4.5.14.4 SAC Evaluation

This section provides the performance criteria for the grounding of waste packages before breaching unvented, sealed waste packages that characterize the specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-52. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-53.

Table 4-53. Grounding Waste Packages before Breaching Unvented, Sealed Waste Packages Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Ground must be applied before breaching unvented, sealed waste packages to be opened in the WCG.	The parent 55-gallon drum bagged on to the WCG and metal waste package shall be grounded when the metal waste package is breached and for 30 minutes after removal of the lid and lid restraining device.	Grounding the parent 55-gallon drum and any unvented, sealed metal waste package with a 30- to 5-gallon volume before breaching the unvented, sealed waste package prevents the introduction of sparks, which could ignite a flammable gas mixture within the waste package. This is a credited control in the hazards analysis to prevent the introduction of sparks while breaching an invented, sealed waste package that could contain a flammable gas mixture.

4.5.14.5 Technical Safety Requirement Controls

Grounding of waste packages before breaching unvented, sealed waste packages shall fulfill the following TSR control:

> The parent 55-gallon drum bagged on to the WCG and metal waste package shall be grounded when the metal waste package is breached and for 30 minutes after the removal of the lid and lid restraining device.

4.5.15 Prohibit Storage, Staging, and Processing of Inventory Within the Glove Box Enclosure

4.5.15.1 Safety Function

Prohibiting the storage, staging, and processing of inventory within the GBE preserves an initial condition assumption for the hazard analysis.

4.5.15.2 SAC Description

Inventory storage, staging, and processing activities are prohibited within the GBE because these activities are not analyzed or authorized. An initial condition of the hazard analysis is that these activities would not be performed within the GBE without further evaluation and approval.

The GBE contains residual surface radiological contamination from past activities and is part of the confinement ventilation system. Surveillance and maintenance associated with these conditions have been analyzed and may be conducted as necessary within the GBE.

4.5.15.3 Functional Requirements

Table 4-54 identifies the minimal functional requirements for fulfilling the safety functions listed in section 4.5.15.1, *Safety Function*.

Table 4-54. Functional Requirements for Prohibit Storage, Staging, and Processing of Inventory within the GBE

Safety Function	Functional Requirements
Prohibiting the storage, staging, and processing of inventory within the GBE preserves an initial condition assumption for the hazard analysis.	Inventory shall not be stored, staged, or processed within the confines of the GBE.

4.5.15.4 SAC Evaluation

This section provides the performance criteria for prohibition against storage, staging, or processing of inventory within the GBE specific operational responses and capabilities needed to meet the functional requirements listed in Table 4-54. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-55.

Table 4-55. Prohibit Storage, Staging, or Processing of Inventory within the GBE - Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Inventory shall not be stored, staged, or processed within the confines of the GBE.	No TRU waste inventory will be brought into the GBE for storage, staging, or processing. This prohibition limits the radiological material inventory present in the GBE to the residual contamination that remains from prior operations.	Prohibiting the storage, staging, and processing of inventory within the GBE preserves an initial condition assumption for the hazard analysis, and limits amount of radiological material that could be released in a GBE accident to the residual contamination that remains from past operations. The residual contamination within the GBE is assumed to be no greater than 10% of the Hazard Category 3 limit.

4.5.15.5 Technical Safety Requirement Controls

Prohibition of storage, staging, and processing of inventory shall fulfill the following TSR control:

Inventory shall not be stored, staged, or processed within the confines of the GBE.

4.5.16 Extra Fire Controls for High-MAR Processing in WCG

4.5.16.1 Safety Function

A stationary fire watch and the use of fire control agents by trained operators mitigates the effects of a fire in the WCG during the processing of a parent drum containing > 300 PE-Ci of combustible equivalent waste. This control ensures appropriate fire suppression tools are available in the WCG and workers are trained to detect fires in order to safely extinguish small, early developing fires.

4.5.16.2 SAC Description

The WCG is equipped with carbon spheroids or Met-L-X to enable operations personnel to control a fire that might occur in the WCG. The carbon spheroids or Met-L-X may be poured over metal fires to deprive the fuel of oxygen. A continuous fire watch is required when the waste material contains > 300 PE-Ci of combustible equivalent waste. Operations personnel are trained to use the fire suppression agents. The requirement for a fire watch is exempted when building conditions require evacuation.

4.5.16.3 Functional Requirements

Table 4-56 identifies the minimum functional requirements for fulfilling the safety functions listed in Section 4.5.16.1.

Table 4-56. Functional Requirements for Waste Characterization Glovebox Fire Controls

Safety Function	Functional Requirements
Fire watch and the use of fire control agents by trained operators mitigates the effects of a fire in the WCG. This control ensures that appropriate fire suppression tools are available in the WCG and workers are trained to detect fires in order to extinguish small, early developing fires.	Prompt identification of incipient fires in the WCG allows prompt mitigation response actions. The fire control agents must be present in the WCG during TRU waste operations, in sufficient quantities to be useful in fighting potential glovebox fires. Personnel performing WCG operations must be trained to use the fire control agents available for fighting glovebox fires, as well as to perform a fire watch.

4.5.16.4 SAC Evaluation

This section provides the performance criteria for the fire watch and fire control agents and the training of their use that are necessary to meet the functional requirements listed in Table 4-56. This section also evaluates their capabilities to meet the performance criteria. The performance criteria and associated evaluations are provided in Table 4-57.

Table 4-57. Waste Characterization Glovebox Fire Controls Performance Criteria

Functional Requirements	Performance Criteria	Evaluation
Prompt identification of incipient fires in the WCG allows prompt mitigation response actions. The fire control agents must be present in the WCG during TRU waste operations, in sufficient quantities to be useful in fighting potential glovebox fires. Personnel performing WCG operations must be trained to properly use the fire control agents available for fighting glovebox fires.	A continuous fire watch is required when the waste material contains > 300 PE-Ci of combustible equivalent waste, in order to extinguish small, early developing fires in coordination with WCG operators.. WCG operators shall be trained in glovebox fire suppression techniques in order to extinguish small, early developing fires in coordination with the fire watch. Three 1-liter containers of carbon spheroids or Met-L-X will be provided in the glovebox as fire suppression agents.	All WCCRF personnel receive site-specific training, which is supplemented with job-specific training as appropriate. Operations personnel at the WCCRF are specifically trained on the implementation of this control. Based on experience at other LANL facilities, workers have been effectively trained to extinguish glovebox fires through early detection and operator response when the proper tools are provided. When TRU waste containing > 300 PE-Ci of combustible equivalent waste is in the WCG, because of the higher potential consequences of a fire involving this material, a dedicated fire watch shall be in place while glovebox operations occur.

4.5.16.5 Technical Safety Requirement Controls

1. The WCG shall be equipped with three 1-liter containers of carbon spheroids or Met-L-X when the glovebox inventory is > 300 PE-Ci of equivalent combustible waste.
2. A stationary fire watch shall be in place when the WCG contains inventory > 300 PE-Ci of equivalent combustible waste, in order to extinguish small, early developing fires, in coordination with WCG operators.
3. WCG operators shall be trained in glovebox fire suppression techniques in order to extinguish small, early developing fires when processing INVENTORY > 300 PE-Ci of equivalent combustible waste, in coordination with the stationary fire watch.

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DOE 2002a: *Natural Phenomena Hazard Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-2002, U.S. Department of Energy, Washington, D.C., 2002.

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DOE 2003: *Nuclear Air Cleaning Handbook*, DOE-HDBK-1169-2003, U.S. Department of Energy, Washington, DC, December 2003.

DOE 2005: *Facility Safety*, DOE Order 420.1B, U.S. Department of Energy, Washington, D.C., December 2005.

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NFPA 13, National Fire Protection Association, Quincy, MA, 1976.

NFPA 2002: National Fire Protection Association, *Standard for the Installation of Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, MA, 2002.

SB-DO 2007: *TA-50-69 (WCRRF) Transformer Fire Barrier,* SB-DO: CALC 07-033, Safety Basis Division Office, Los Alamos National Laboratory, Los Alamos, NM, 2007.

5.0 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

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Acronyms and Abbreviations

AC	Administrative Control
ALARA	As Low As Reasonably Achievable
CFR	Code of Federal Regulations
CSE	Criticality Safety Evaluation
DBA	Design Basis Accident
DF	Design Feature
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSA	Documented Safety Analysis
EDS	Electrical Distribution System
FGE	Fissile Gram Equivalent
FPE	Fire Protection Engineer
FSS	Fire Suppression System
GBE	Glovebox Enclosure
HA	Hazard Analysis
HEPA	High-Efficiency Particulate Air
IMP	Implementation Procedure
IP	Institutional Policy
IPP	Institutional Policy and Implementation Procedure
ISD	Implementation Support Document
ISI	In-service Inspection
LANL	Los Alamos National Laboratory
LCO	Limiting Conditions for Operation
LCS	Limiting Control Settings
LFL	Lower Flammability Limit
LIR	Laboratory Implementation Requirement
LPR	Laboratory Performance Requirement
LPS	Lightning Protection System
MAR	Material-at-Risk
NEC	National Electrical Code
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration

NPH	natural phenomena hazard
OIT	Operator Interface Terminal
OST	Operational Support Tool
PAC	Programmatic Administrative Control
PC	Performance Category
PLC	Programmable Logic Controller
QA	Quality Assurance
RLWF	Radioactive Liquid Waste Facility
RPP	Radiation Protection Program
SAC	Specific Administrative Control
SC	Safety-Class
SL	Safety limit
SMP	Safety Management Program
SR	Surveillance Requirement
SS	Safety-significant
SSCs	Structures, Systems, and Components
SWB	Standard Waste Box
TA	Technical Area
TE/TI	Temperature Element/Temperature Indicator
TSR	Technical Safety Requirement
TRU	Transuranic
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
USQ	Unreviewed Safety Question
VOCs	Volatile Organic Compounds
wc	Water Column
WCG	Waste Characterization Glovebox
WCRR	Waste Characterization, Reduction, and Repackaging

5.1 INTRODUCTION

The technical safety requirement (TSR) document constitutes an agreement between the U.S. Department of Energy (DOE) and Los Alamos National Laboratory (LANL) regarding safe operation of the Waste Characterization, Reduction, and Repackaging Facility (WCRRF). TSRs are derived based on the safety functions and functional requirements that were determined to be essential in Chapter 3, *Hazard and Accident Analyses*, and in Chapter 4, *Safety Structures, Systems, and Components (SSCs).* In addition to those TSRs that are explicitly derived from Chapter 3 and Chapter 4, several other mandatory safety management programs (SMPs) are included in the TSR to ensure safe operation of the WCRRF.

The TSRs consist primarily of limiting conditions for operation (LCOs) for material-at-risk (MAR) inventory limits, fire suppression system (FSS), ventilation system (including exhaust system high-efficiency particulate air [HEPA] filters, and uninterruptible power supply) and confinement operability, facility combustible loading control, waste characterization glovebox (WCG) drum lift fixture, administrative controls (ACs), surveillance requirements (SRs), appropriate commitments to SMPs, and passive design features (DFs).

5.2 REQUIREMENTS

This section identifies the regulatory requirements that establish the safety basis of the WCRRF. The following standards and regulations were used in preparing this chapter:

- 10 Code of Federal Regulations (CFR) 830.205, *Technical Safety Requirements* (CFR 2001).
- DOE G 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements* (DOE 2001a).
- DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (DOE 1997a).
- DOE-STD-1186 2004, Specific Administrative Controls (DOE 2004a).
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Change Notice No. 3* (DOE 2006).
- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (DOE 2002).

5.3 TSR COVERAGE

This section provides assurances that TSR coverage for the facility is complete, i.e., the TSR document covers all identified SSCs, Specific ACs (SACs), and programmatic ACs. Table 5-1 provides a comprehensive list of TSR safety controls (i.e., safety-class SSCs, safety-significant SSCs, LCOs, TSR ACs, or SACs), which are a combination of Laboratory-mandated SMPs, the majority of which were identified in the hazard and accident analyses in Chapter 3. Since the TSRs are provided as a separate document, the discussion in this Documented Safety Analysis (DSA) refers to the type of TSR coverage to be implemented for each control.

5.3.1 Safety Limits Coverage

Safety limits (SLs) are limits on process variables associated with those physical barriers that, if exceeded, could directly cause the failure of one or more barriers that prevent the uncontrolled release of radioactive or other hazardous materials with the potential of consequences to the public above specified guidelines. Based on analysis results of Chapter 3, no SLs are required for the WCRRF.

5.3.2 Limiting Control Settings Coverage

Limiting Control Settings (LCSs) are settings on safety systems that control process variables to prevent exceeding SLs. Because no SLs are identified in Chapter 3, no LCSs are required.

5.3.3 Limiting Conditions for Operation and Surveillance Requirement Coverage

Limiting Conditions for Operation (LCOs) are selected to detail the operability requirements for MAR (inventory limits), equipment, or combustible loading, and to ensure that the practical definitive parameter limits are included in the LCO statement. The SRs define the minimum requirements necessary for the system or equipment to be considered operable. Based on the analysis results of Chapter 3, some groups of controls resulted in an LCO and corresponding SRs.

5.3.4 Facility Evaluation

The hazard events from the Hazard Analysis (HA), and the potential accidents from the DSA, Chapter 3, were evaluated and controls (SSCs and ACs) assigned. These SSCs and ACs are listed in Table 5.1. The credited controls identified in Table 5.1 are derived from unmitigated risk rank I, II, and III events. This table presents the controls as developed in Chapter 3. Further development of these controls is presented in Section 5.5.1.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
INITIAL CONDITIONS				
None				
SAFETY-CLASS SSCs				
Vehicle Barriers • The interconnected vehicle barriers (concrete Jersey barriers or equivalent or alternate design must be capable of stopping a vehicle gross weight of up to 72,000 lbs (based on a tractor/trailer carrying transportainers and waste containers) within 25 ft of the impact point moving at a velocity of up to 28 mph at a 25˚ impact angle or up to 9 mph at a 90˚ impact angle. • The gate configuration of vehicle barriers must be capable of stopping a vehicle gross weight of up to 72,000 lbs within 25 ft of the impact point moving at a velocity of up to 9 mph at a 90˚ impact angle. • Gates may be removed for emergency vehicle access in an emergency, and the gates may be removed during TRU waste shipment activities when the delivery truck is positioned in front of the gate entrance.	SC-SSC, DF/In-service Inspection (ISI)	Table 3-17 Section 4.3.1 Section 5.6.1	<u>HA Events</u> HSO-2, HSO-3, HSO-5, HSO-6, HSO-7, HSO-10, HSO-11, HSO-13, HSO-15, , HHO-3 <u>AA Events</u> Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire) Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire) Section 3.4.2.5, Loss of Confinement/Containment (Spill)	Prevent impacts between moving vehicles and TRU waste containers staged inside Building TA-50-69 or in outdoor transportainers. Prevent subsequent vehicle fuel pool fires from involving the TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Transuranic Waste Containers (design integrity and filtered vent) • TRU waste containers shall be of noncombustible construction (top, bottom, and sides) (DF/ISI). • TRU waste containers shall be of a design that has had a prototype meet the free drop tests specified in 49 CFR 173.465(c)(1) (CFR 1999). (DF/ISI). • TRU waste containers shall have a WIPP approved filtered vent to prevent build-up of flammable gases inside the container (DF/ISI).	SC-SSC, SS-SSC, DF/ISI	Table 3-17 Section 4.3.2 (outside) Section 4.4.7 (inside) Section 5.6.2	HA Events HSO-2, HSO-3, HSO-4, HSO-5, HSO-6, HSO-7, HSO-10, HSO-11, HSO-13, HSO-14, HSO-15, HSO-16, HSO-17, HSO-18, HSO-20, HSO-21, HSO-22, HSO-23, HSO-24, , HHO-2, HHO-3, HHO-4, HHO-5, HHO-6, HHO-7, HHO-8, HSI-3, HSI-4, HSI-5, HSI-8, HSI-9, HSI-10, HSI-12, HSI-13, HHI-2, HHI-4, HHI-5, HHI-6, HHI-7 AA Events Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire) Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires (Spill and Fire) Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.5, Loss of Confinement/Containment Section 3.4.2.6, Seismic Event and Fire Section 3.4.2.7, Wildfire Section 3.4.2.8, Lightning Strike Section 3.4.2.9, Aircraft-Crash-Induced Fire (External Event)	Provide primary confinement for TRU waste. Mitigate releases of TRU waste subjected to mechanical or thermal stresses from postulated accidents. Prevent accumulation of flammable gases inside the waste containers.
SAFETY-SIGNIFICANT SSCs				
Building TA-50-69 and WCG Fire Suppression System (FSS) Operability of the FSS shall be composed of : • An open and unobstructed flow path from the water supply tank to the Building TA-50-69 sprinkler heads. • Riser gauge static pressure of 48 psig or greater at the base of the riser. • Water supply tank contains 100,000 gallons or greater. • The temperature of Building TA-50-69 including the attic space is greater than 40ºF.	SS-SSC, LCO/SR	Table 3-17 Section 4.4.1 Section 5.5.2 National Fire Protection Association (NFPA) 13 and 72	HA Events HSI-3, HSI-4, HSI-5, HSI-10, HSI-12, HHI-1, HHI-2, HGB-2, HGB-3 AA Events Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.4, Drum Deflagration Accident Section 3.4.2.6, Seismic Event with Fire (NPH) Section 3.4.2.8, Lightning Strike	Limit the size and duration of fires in the WCG and in Building TA-50-69, thereby protecting the staged TRU waste and the building ventilation system HEPA filters from over temperature threats and minimizing the release of radioactive material from Building TA-50-69 to the environment.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Building TA-50-69 Structural Integrity • The Building TA-50-69 structure meets PC-2 seismic criteria (DF). • The Building TA-50-69 structure is designed to meet PC-2 wind and snow loading requirements (DF). • The interior walls of Building TA-50-69 must be constructed of noncombustible materials that provide a confinement barrier in conjunction with the confinement ventilation system (DF).	SS-SSC, DF/ISI, LCO/SR	Table 3-17 Section 4.4.2 Section 5.6.3	HA Events HSI-4, HSI-5, HSI-6, HSI-8, HSI-9, HSI-10, HSI-12, HSI-13, HHI-1, HHI-2, HHI-4, HHI-5, HHI-6, HHI-7, HGB-2, HGB-3, HGB-4, HGB-5, HGB-6, HGB-7, HGB-8, HGB-9, HGE-2 AA Events Section 3.4.2.3 Operational Fires Inside of Building TA-50-69 Section 3.4.2.4, Drum Deflagration Accident Section 3.4.2.5 Loss of Confinement/Containment Section 3.4.2.6, Seismic Event and Fire (for < Performance Category (PC)-2 seismic events) Section 3.4.2.8, Lightning Strike	Provide structural integrity to support safety SSCs. Prevent insult to MAR inside Building TA-50-69. Mitigates releases of MAR in conjunction with the confinement ventilation system.
• Building TA-50-69 Confinement Ventilation System • The FE-001, FE-002, and FE-003 HEPA filters are rated for a 12-hr continuous service of 250 °F. • HEPA filter plenum and ductwork must provide a functional confinement barrier in conjunction with the exhaust ventilation system. • The Building TA-50-69 shall maintain negative air pressure differential with respect to the atmosphere. • The Building TA-50-69 exhaust (FE-001, FE-002,	SS-SSC LCO/SR	Table 3-17 Section 4.4.3, 4.4.8, 4.4.9 Section 5.5.3 and 5.6.4	HA Events HSI-4, HSI-5, HSI-6, HSI-8, HSI-10, HSI-12, HSI-13, HHI-1, HHI-2, HHI-4, HHI-5, HHI-6, HHI-7, HGB-2, HGB-3, HGB-4, HGB-6, HGB-7, HGB-8, HGB-10 AA Events Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.4, Drum Deflagration Accident Section 3.4.2.5, Loss of Confinement/Containment Section 3.4.2.6, Seismic Event and Fire (for < Performance Category (PC)-2 seismic events) Section 3.4.2.8, Lightning Strike	Mitigates releases of MAR in conjunction with the WCG and confinement provided by the Building TA-50-69 structural integrity.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
and FE-003) HEPA filters shall be operable. They must be 99.95 % efficient and the pressure drop across the HEPA filter shall not exceed 3.5 inches wc. • The ventilation control system activates an alarm when the differential pressure between the building and the outside atmosphere is greater than –0.05 inches wc. • The ventilation control system activates an alarm when the differential pressure between the WCG and the main process area is greater than –0.1 inches wc. • The WCG shall be maintained at a negative pressure differential with respect to the main process area of Building TA-50-69. • Only one vehicle airlock door may be open at any one time. • At least one glovebox enclosure (GBE) airlock door shall remain closed. • The roof access port above the mezzanine is closed.				
Waste Characterization Glovebox • The WCG shall provide a primary confinement for waste material operations	SS-SSC, DF/ISI LCO/SR	Table 3-16 Section 4.4.5 Sections 5.6.7, 5.5.4, and 5.5.6	<u>HA Events</u> HSI-7, HSI-9, HSI-12, HGB-2, HGB-4, HGB-5, HGB-6, HGB-7, HGB-8, HGB-10 <u>AA Events</u> Section 3.4.2.3 Operational Fires Inside Building TA-50-69	The waste characterization glovebox (WCG) must provide primary confinement for visual inspection, waste characterization, and repackaging operations.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
and minimize releases to the main process area during normal operations, loss of ventilation, and following a PC-2 seismic event. • The drum lift fixture shall be capable of supporting a drum weighing at least 630 lbs during normal operations and PC-2 seismic events. • The drum lift fixture hoist holding brake shall be capable of stopping and holding a drum weighing at least 630 lbs when the lifting controls are released. • The drum lift fixture hoist shall be capable of limiting the lowering speed of a drum loaded to at least 630 lbs to 26 ft/min following loss of power.			Section 3.4.2.4, Drum Deflagration Section 3.4.2.6, Seismic Event and Fire (for < PC-2 seismic events) Section 3.4.2.8, Lightning Strike	The drum lift fixture must prevent drum drops and mitigate the consequences from malfunction and/or seismic events.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Uninterruptible Power Supply (UPS) • During normal operations, the UPS shall provide continuous 120 V conditioned power to the programmable logic controllers, the differential pressure sensors, operator interface terminals (OIT) and alarms of the confinement ventilation control system. • Upon loss of offsite power, the UPS shall provide continuous 120 V conditioned power to the programmable logic controllers, the differential pressure sensors, OITs, and alarms of the confinement ventilation control system for at least 1 hour.	SS-SSC (support system to confinement ventilation system) LCO/SR (confinement ventilation system)	Section 4.4.9	Supports confinement ventilation (see above)	Provides continuous, conditioned power to the control system for the confinement ventilation system for at least one hour upon loss of offsite power.
ADMINISTRATIVE CONTROLS				
Inventory Limits • ≤ 1800 plutonium equivalent curies (PE-Ci) total site inventory • ≤ 800 PE-Ci equivalent combustible waste inside Building TA-50-69	LCO/SR SC-SAC/LCO	Table 3-17 Section 4.5.7 Section 5.5.1	HA Events All AA Events All	The total WCRRF TRU waste inventory limits protect the initial conditions assumed in the accident analysis and ensure that the consequences determined in the accident scenario are not invalidated.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Procedures	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces the likelihood of personnel-initiated accidents by using written procedures to conduct all work. The development, review, approval, and configuration management process of the written procedure is the safety management program. ISM elements must be incorporated into facility-wide procedures and address work activities, identification of hazards and controls, worker actions and responsibilities, and the use and maintenance of equipment and SSCs.
Review and Audit Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces the likelihood of an accident by ensuring that management is involved in operations and that operators comply with safety programs.
SAFETY MANAGEMENT PROGRAMS INCLUDING PROGRAMMATIC (TSR-AC) AND SPECIFIC ADMINISTRATIVE CONTROLS (TSR-SAC)				
Unreviewed Safety Question (USQ) Program	TSR-AC SMP	10 CFR 830.203 (CFR 2003a)	HA/AA General SMP	Provides the general provisions for ensuring changes are within the risk envelope accepted by the DOE.
Emergency Preparedness Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces consequences of an accident through emergency response procedures, personnel communication systems, emergency drills, and other program elements that ensure effective evacuation.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Upon detection of an airborne release of radioactive contamination in Building TA-50-69, workers will evacuate per facility procedures and, if the Building TA-50-69 exhaust fans are inoperable, the vacuum pumps for the radiological monitoring equipment (CAMs and fixed-head air samplers) will be de-energized by the power cut-offs located outside Building TA-50-69.	TSR-AC	Section 4.4.3 Section 5.5.9.2	This control identified when performing system evaluation of the Building TA-50-69 confinement ventilation system in Chapter 4.	Prevents unfiltered release of airborne contamination to the outside environment.
Conduct of Operations	TSR-AC SMP	DOE O 5480.19 (DOE 2001b)	HA Events All AA Events All	Mitigates the consequences associated with facility operations through a program that includes management supervision, work planning, change control, and proper equipment selection.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Nuclear Criticality Safety Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Prevents the likelihood of a criticality by ensuring that the specified quantities of fissile material are not exceeded and that acceptable physical configuration is maintained.
Fire Protection Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Provides the general safety provisions for fire prevention and mitigation. Minimizes the probability of the ignition of a fire by controlling open flames, sparks, excessive heat, electrical discharges, and other ignition sources. This includes the use of NFPA 70 (NFPA 2002b) (National Electrical Code [NEC]), UL-listed, or equivalent electrical equipment that is properly grounded
Combustible Loading Control: Combustible and flammable loading within TA-50-69 shall be strictly controlled: • ≤ 0.60 lb/ft^2 on average in Building TA-50-69*. • No flammable liquids or gases, and no combustible liquids with NFPA Flammability Rating greater than 1, shall be stored or used within Building TA-50-69 when TRU waste is in the building, except three size-1 cylinders of P-10 gas and flammable or combustible liquids found in the TRU WASTE CONTAINER.	LCO/SR SC- SAC/LCO	Table 3-17 Section 4.5.1 Section 5.5.5	HA Events HSO-2 thru HSO-7, HSO-13, HSO-14, HSO-16, HSO-17, HSO-23, HSI-3, HSI-4, HSI-5, HSI-10, HSI-12, HHI-2, HGB-3, HGB-10, HGE-2 Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.6, Seismic and Fire Section 3.4.2.7, Wildfire Section 3.4.2.8, Lightning Strike	Outside: Ensures that combustible loading is minimized outside of Building TA-50-69 and properly located to limit fire growth and propagation. Inside: Minimization of the amount and continuity of combustible loading prevents a fire from propagating and impinging upon TRU waste, and it mitigates release of TRU waste by limiting fire size in Building TA-50-69.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Combustible Loading Control (continued) • No combustibles shall be stored within the WCG exclusion zone*.The WCG exclusion zone is 10 ft around the WCG, up to the GBE, or up to the walls of Room 102, whichever is less. • No combustible fuel package inside Building TA-50-69 may be greater than 50 lbs and must be separated from other combustibles ≥ 6 ft*, excluding the change rooms/rest rooms. • Combustible material inside and within 10 ft of the exterior of the transportainers shall be limited to those materials and equipment necessary to accomplish required tasks. * The following are <u>excluded</u> from the above limitations: - INVENTORY that is in the WCG or staged in BUILDING TA-50-69. - Combustible components of support equipment (e.g., wiring insulation, operator platforms and rubber mats) within the WCG Exclusion Zone and associated with WCG processing. - Drum liners or wrapping around DEGRADED/LOSS OF INTEGRITY drums that are inside BUILDING TA-50-69 being loaded, and working amounts of materials necessary to complete bag-on/off operations such as tape, cheesecloth, and extra operator gloves. - Hydraulic fluid within the engineered, closed-loop containment systems. - Combustible components associated with a forklift.				

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Hot work Prohibition • No hot work may be performed in Building TA-50-69 when TRU waste is present.	TSR-SAC	Table 3-17 Section 4.5.2 Section 5.5.10.5	HA Events HSO-4, HSO-5, HSI-5, HGB-10, HGE-2 AA Events Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires Section 3.4.2.3, Operational Fires Inside of Building TA-50 69	Reduces the probability of a fire igniting that could threaten exposed TRU waste.
Prohibit storage, staging, or processing of inventory within the GBE. • Inventory shall not be stored, staged, or processed within the confines of the GBE.	TSR-SAC		HA Events HGE-1, HGE-3, HGE-4, HGE-5,	Prohibiting the storage, staging, and processing of inventory within the GBE preserves an initial condition assumption for the hazard analysis, that the GBE contains only residual contamination.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Vehicle Fuel Restrictions • Propane, gasoline or diesel-fueled vehicles shall not be used anywhere at the WCRRF when TRU waste is present at WCRRF. [Exception: 1) emergency vehicles in case of an emergency 2) Equipment with less than 5 gallons of fuel may be used for grounds maintenance and for snow and ice removal.]	TSR-SAC	Table 3-17 Section 4.5.3	HA Events HSI-3, HSI-4, HHI-2, HSO-2, HSO-3, HSO-4, HSO-5, HSO-6, HSO-7, HSO-10, HSO-16, AA Events Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire) Section 3.4.2.2, Operational Fires Outside of Building TA-50 Involving Liquid Fuel Pool Fires Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.5, Loss of Confinement/Containment (Spill)	The prohibition of propane, gasoline, and diesel-fueled vehicles in the WCRRF prevents explosions and minimizes the potential for fires that will impact TRU waste.
Diesel Generator Refueling Exclusion • Refueling of the diesel generator is prohibited when TRU waste containers are in Building TA-50-69.	TSR-SAC	Table 3-17 Section 4.5.10	HA HSO-16 AA Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles (Fire)	This control prevents fuel pool fires associated with the diesel generator refueling from affecting TRU waste inside Building TA-50-69.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Extra Fire Controls for High-MAR Processing in WCG • The WCG shall be equipped with three 1-liter containers of carbon spheroids or Met-L-X when the glovebox inventory is > 300 PE-Ci of equivalent combustible waste. • A stationary fire watch shall be in place when the WCG contains inventory > 300 PE-Ci of equivalent combustible waste, in order to extinguish small, early developing fires, in coordination with WCG operators. • WCG operators shall be trained in glovebox fire suppression techniques in order to extinguish small, early developing fires when processing INVENTORY > 300 PE-Ci of equivalent combustible waste, in coordination with the stationary fire watch.	TSR-SAC	Table 3-17 Section 4.5.16	AA Section 3.4.2.3, Operational Fires Inside Building TA-50-69 (Fire)	A stationary fire watch and the use of fire control agents by trained operators mitigates the effects of a fire in the WCG during the processing of a parent drum containing > 300 PE-Ci of combustible equivalent waste. This control ensures appropriate fire suppression tools are available in the WCG and workers are trained to detect fires in order to safely extinguish small, early developing fires.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Vehicle Access System • Vehicle Access System barriers must be located such that the impact vehicle stops at least 25 ft from TRU waste containers staged in Building TA-50-69 or in transportainers to prevent up to a 100-gal. diesel fuel pool fire from impinging on waste containers. • The gates of the Vehicle Access System may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance of the gate to inadvertent vehicle impact, and during these times, it is acceptable to temporarily remove the gate.	TSR-SAC	Table 3-17 Section 4.5.9 Section 5.5.10.6	HA Events HSO-2, HSO-3, HSO-5, HSO-6, HSO-7, HSO-10, HSO-11, HSO-13, HSO-15, HHO-3, HSI-3 AA Events Section 3.4.2.1, Operational Fires Outside of Building TA-50-69 Involving Ordinary Combustibles Section 3.4.2.2, Operational Fires Outside of Building TA-50 Involving Liquid Fuel Pool Fires Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.5, Loss of Confinement / Containment	The implementation of a Vehicle Access System prevents vehicle impacts and subsequent fuel pool fires that could impinge upon TRU waste in Building TA-50-69 and TRU waste containers staged in transportainers.
Radiation Protection Program (RPP)	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces the likelihood of worker exposure to radioactive material or radiation through a program that implements 10 CFR 835, *Occupational Radiation Protection* (CFR 2003b). This includes posting and labeling, ALARA, training, and contamination control.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Maintenance Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces consequences or likelihood of failure of safety systems. Maintenance of the Lightning Protection System (LPS) helps to provide limited reduction in the frequency of lightning induced facility fires.
Configuration Management Control Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces the likelihood of an accident caused by using improperly maintained, superseded, canceled, or outdated documents, drawings, procedures, and operating aides. The SMP also ensures that, through the USQ process, all changes, modifications, discoveries, and as found conditions are reviewed for safety basis changes.
Hazardous Material and Waste Management Program	TSR-AC SMP	Laboratory Requirements	HA/AA General SMP	Reduces the likelihood of hazardous material accidents such as fires or toxic releases through a program that ensures proper handling of hazardous materials by procedures for their use and storage. The program also defines and ensures implementation and training.
Transportainer Placement • Support structures shall not elevate transportainers containing TRU waste containers greater than 4 ft above ground level. • Transportainers containing TRU waste shall be located greater than 35 ft away from Building TA-50-69.	TSR-SAC	Table 3-17 Section 4.5.7	HA Events HSO-18, HSO-22, HSO-23, HSI-8, HSI-9, HSI-12 AA Events Section 3.4.2.5, Loss of Confinement/Containment Section 3.4.2.6, Seismic and Fire	Restricting the transportainer staging height minimizes the likelihood of a TRU waste container failing if the transportainer supports fail. Locating the transportainers away from Building TA-50-69 prevents TRU waste containers from being impacted by a building collapse.

Table 5-1. TSR Credited Controls From Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
TRU Waste Containers Staged in Transportainers: • TRU waste containers shall be placed within the transportainers and container lids shall remain closed when staged outside the Building TA-50-69 structure.	TSR-SAC	Table 3-17 Section 4.5.8	HA Events HHO-2, HHO-3, HHO-7, HHO-8, HSO-2, HSO-3, HSO-6, HSO-7, HSO-10, HSO-11, HSO-13, HSO-14, HSO-15, HSO-16, HSO-17, HSO-18, HSO-20, HSO-21, HSO-22, HSO-23, HSO-24, HSI-8, HSI-9, HSI-12 AA Events Section 3.4.2.2, Operational Fires Outside of Building TA-50 Involving Liquid Fuel Pool Fires Section 3.4.2.5, Loss of Confinement/Containment (Spill) Section 3.4.2.6, Seismic and Fire Section 3.4.2.7, Wildfire Section 3.4.2.8, Lightning Strike Section 3.4.2.9, Aircraft-Crash-Induced Fire (External Event)	The requirement to stage TRU waste containers inside of secondary containment (i.e., transportainers) while in outdoor staging minimizes the release of TRU waste from external fires involving the TRU waste containers.
TRU Waste Container Staging Practices: • TRU waste containers shall not be stacked and shall not be lifted higher than 4 ft, except for the WCG drum lift and lifts during loading or unloading from delivery trucks.	TSR-SAC	Table 3-17 Section 4.5.5	HA Events HSO-2, HSO-10, HSO-11, HSO-15, HSO-21, HSO-22, HSO-23, HHO-2, HHO-3, HHO-4, HSI-8, HSI-12 AA Events Section 3.4.2.2, Operational Fires Outside of Building TA-50-69 Involving Liquid Fuel Pool Fires Section 3.4.2.5, Loss of Confinement / Containment Section 3.4.2.6, Seismic and Fire	The restriction on TRU waste container stacking and lift height prevents the release of material by reducing the likelihood of a container failure caused by a drop from an elevated position.

Table 5-1. TSR Credited Controls from Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
TRU Waste Container Inspection: • Verify that the TRU waste container is of noncombustible construction (top, bottom, and sides) and is of a design that has had a prototype meet the free-drop tests specified in 49 CFR 173.465 (c)(1) (CFR 1999). • Verification that TRU waste container is integral and shows no signs of degradation (see details in Section 4.5.4.5); • Verification that TRU waste container is equipped with vents, and the vents are free of obvious obstructions; • Verification of documentation indicating the headspace gas concentration of the received TRU waste containers and any interior drums has been performed and is < 4% hydrogen concentration and < 8000 ppm for volatile organic compounds (VOCs).	TSR-SAC	Table 3-17 Section 4.5.4	HA Events HSO-7, HSO-9, HSO-25, HSO-26, HHO-1, HHO-4, HHO-5, HHO-6, HSI-6, HHI-1, HHI-2, HGB-2, HGB-3 AA Events Section 3.4.2.2, Operational Fires Outside of Building TA-50 Involving Liquid Fuel Pool Fires Section 3.4.2.3, Operational Fires Inside of Building TA-50-69 Section 3.4.2.4, Drum Deflagration Accident	TRU waste container inspections prevent flammable gas deflagrations and ensure that containers can mitigate other accidents involving containerized waste.
Hoisting and Rigging Program	TSR-AC SMP	DOE-STD-1090-2001 (DOE 2004b)	HA/AA General SMP	Reduces the likelihood of a spill caused by mechanical failure of hosting and rigging equipment, by improper lifting methods, and by operator error.

Table 5-1. TSR Credited Controls from Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
A critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss of integrity TRU drums when not secured in a TRU waste container.	TSR-SAC	Table 3-17 Section 4.5.11 Section 5.5.10.14	HA events HHI-4, HHI-5, HHI-6, HHI-7 AA Events Section 3.4.2.5, Loss of Confinement / Containment	The use of a critical lift plan minimizes the probability of impacts and drops involving degraded or loss-of-integrity drums.
Quality Assurance (QA) Program	TSR-AC SMP	Laboratory Process Requirements	HA/AA General SMP	Reduces the likelihood of accidents though a program that ensures commitments made in the safety analysis are properly implemented. Reduces the consequences of accidents through a program that ensures commitments made in the safety analysis are properly implemented.
Occurrence Reporting Program	TSR-AC SMP	Laboratory Process Requirements	HA/AA General SMP	Reduces the likelihood or limits the consequences of an accident by reporting an accident and investigating the cause to learn from mistakes to ensure that they are not repeated.
Qualification and Training Program	TSR-AC SMP	Laboratory Process Requirements	HA/AA General SMP	Minimizes the probability of accidents caused by improper forklift operations.
Document Control	TSR-AC SMP	Laboratory Process Requirements	HA/AA General SMP	Maintains WCRRF operations and facility records (including TSR compliance documentation) in accordance with the WCRRF QA Program and LANL requirements.
Use of drum lid restraints when Breaching Unvented 30- to 5-gallon Waste Packages in WCG	TSR-SAC	Table 3-17 Section 4.5.12 Section 5.5.10.7	HA Events HGB-2 AA Events Section 3.4.2.4 Drum Deflagration	The safety function of a lid restraining device is to provide physical protection in the WCG in case of a lid ejection, and to minimize material release (e.g., prevents unconfined burning of material) when breaching an unvented, sealed 30- to 5-gallon waste package.

Table 5-1. TSR Credited Controls from Chapter 3 Hazard and Accident Analyses

Control	Designation	References	Accident and HA Scenario Bases	Safety Function
Use of nonsparking tools or processes / de-energization of WCG electric receptacles when processing unvented, sealed 30- to 5-gallon packages within the WCG.	TSR-SAC	Table 3-17 Section 4.5.13 Section 5.5.10.8	HA Events HGB-2 AA Events Section 3.4.2.4 Drum Deflagration	When breaching unvented, sealed waste packages within the WCG, the use of nonsparking tools or processes and the de-energization of WCG electric receptacles prevents the occurrence of sparks, thereby preventing the ignition of a potentially flammable atmosphere within the WCG.
Grounding waste packages before breaching unvented, sealed waste packages.	TSR-SAC LCO/SR	Table 3-17 Section 4.5.14 Section 5.5.10.9	HA Events HGB-2 AA Events Section 3.4.2.4 Drum Deflagration	The safety function of the ground is to reduce the probability for a spark during the opening of unvented 30- to 5-gallon waste package within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere with the WCG.

5.4 DERIVATION OF FACILITY MODES

The WCRRF consists of operational units (e.g., Building TA-50-69 and the outdoor transportainer area) that perform specific, often independent, functions in support of the WCRRF mission. The WCRRF operations can be in different modes (e.g., outside operations may be allowed when Building TA-50-69 is in cold standby).

The Facility operations occur in the following three modes, ranging from the highest to lowest levels of activity: (1) Operation, (2) Warm Standby, and (3) Cold Standby. These three modes are defined in Table 5.2:

Table 5-2. Mode Description for the WCRRF

MODE	DESCRIPTION
COLD STANDBY	In COLD STANDBY MODE, all INVENTORY has been removed from the WCRRF or BUILDING TA-50-69, except for surface contamination and sources used for equipment calibration, and facility-generated non-TRU waste. Activities allowed in this MODE are decontamination, maintenance, facility modifications, and calibration of equipment.
WARM STANDBY	In WARM STANDBY MODE, all INVENTORY shall be in a SAFE CONFIGURATION, except for surface contamination and sources used for equipment calibration, and facility-generated radioactive waste. Only the following activities are allowed in WCRRF or BUILDING TA-50-69 during WARM STANDBY MODE: Staging the retained INVENTORY in closed WASTE CONTAINERS. Handling, transfer, shipping or associated activities (for example, gamma spectroscopy analysis) involving closed WASTE CONTAINERS. Other activities allowed in this mode are decontamination, maintenance, calibration of equipment, and associated activities necessary to maintain the authorization basis (e.g., SURVEILLANCE REQUIREMENTS, permit driven inspections).
OPERATION	During OPERATION, waste processing and repackaging activities are allowed within BUILDING TA-50-69. All WASTE CONTAINER transfer, handling, staging, shipping, receiving, and activities to support operations are also allowed within WCRRF.

5.5 TSR DERIVATION

Based on the hazard and accident analyses, which are presented in Chapter 3, LCOs and associated SRs are identified to ensure the Facility's transuranic (TRU) waste inventory limits, operability of the FSS, the building, the glovebox confinement ventilation system, facility combustible loading control, and WCG drum lift. No safety limits or limiting control settings are required.

TSR coverage is also required for vehicle barriers and TRU waste containers (design integrity and filtered vent), which are DFs identified as safety-class SSCs. Other major contributors to defense–in-

depth and barriers to significant releases include the Building TA-50-69 FSS, structural integrity, confinement ventilation system (and support system), and the waste characterization glovebox (including the WCG drum lift fixture). Table 5-1 identifies the LCOs, safety-class SSC, safety-significant SSCs, DFs, SMPs, and SACs that are implemented through their associated SMPs, and programmatic controls that have been dictated by 10 CFR 830 and DOE G 423.1-1. All other controls or systems identified in the hazard analyses and listed in Table 5-1 are addressed in relevant SMPs outlined later in this chapter.

Administrative Controls are relied upon to eliminate hazards, and when other engineered features or passive barriers are not available to mitigate analyzed accidents. The Administrative Controls discussed here were identified in the Hazard and Accident Analyses and are also addressed in Chapter 4. A graded approach is used to discuss the applicable SMPs, rather than following the outline of DOE-STD-3009. Some of the specific programs cited are elements of other LANL programs. The TSR minimum staffing requirements will ensure that adequate trained and qualified personnel are available to perform operations as well as the required safety functions identified in this section and in the TSR.

5.5.1 Inventory Limits LCO

The accident scenario in Chapter 3 of the BIO considered inventory limits for accidents within Building TA-50-69. The accident that produced the highest dose consequence to the public was a WCRRF fuel pool fire that consumed the WCRRF inventory limit listed below. These limits are to allow the repackage or remediation at WCRRF of above-ground TRU waste containers with > 56 PE-Ci to effect their removal from TA-54, Area G and shipment to the Waste Isolation Pilot Plant (WIPP). This capability is currently not available in any other nuclear facility at LANL.

The inventory for WCRRF SHALL be limited to the following:

- Building TA-50-69 ≤ 800 PE-Ci of equivalent combustible waste
- Total WCRRF ≤ 1,800 PE-Ci.

Surveillance Requirements:

- Verify that Building TA-50-69 inventory will remain ≤ 800PE-Ci of equivalent combustible waste before introducing any additional inventory into Building TA-50-69.
- Verify that WCRRF inventory will remain ≤ 1,800 PE-Ci before introducing any additional inventory into WCRRF.

5.5.2 Fire Suppression System LCOs

The FSS must remain operable while the Facility is in the Operation or Warm Standby mode. To demonstrate its operability, the SR verifies that the FSS meets the NFPA 25 (NFPA 2002a) criteria. The FSS operability shall comprise the following:

- An open and unobstructed flow path from the water supply tank to the Building TA-50-69 and WCG sprinkler heads.
- Riser gauge static pressure of 48 psig or greater at the base of the riser.
- Water supply tank contains 100,000 gallons or greater.
- The temperature of Building TA-50-69 including the attic space is greater than 40 ºF.

Surveillance Requirements:

- Verify daily that the static gauge pressure is greater than or equal to 48 psig at the base of the riser.
- Verify weekly that the water supply tank contains a minimum of 100,000 gallons of fire water.
- Verify weekly that valve FS-V-017 to the WCG sprinkler head is in the open position.
- Verify monthly that the post indicator valves are locked in the open position.
- Perform a monthly valve alignment inspection.
- Perform an annual hydrant flow test.
- Perform an annual main drain test.
- Perform an annual calibration of the static pressure gauge on the FSS riser.
- Verify daily that the temperature reading of TE/TI-001 and TE/TI-002 are greater than 40 ºF and have been greater than 40ºF for at least 48 hours.
- Perform an annual instrument loop verification and interlock check for TE/TI-001 and TE/TI-002.

5.5.3 Building TA-50-69 Confinement Ventilation System LCOs

The building confinement ventilation system includes the building structure, glovebox enclosure (GBE) exhaust system HEPA filters, welding hood exhaust system HEPA filters (operated only when local exhaust is required), main process area exhaust system HEPA filters, ventilation control system, personnel doors, and the vehicle airlock. These components collectively form the confinement barrier that mitigates the public consequences of all internal and external accidents that involve a release of radioactive material, excluding seismic and wind natural phenomena hazard (NPH) events inside the building, by preventing or significantly reducing the release from the building to the outside atmosphere. Confinement provided by the building confinement ventilation system contributes significantly to potential release reduction. Thus, the building confinement ventilation is designated as a safety-significant SSC for these events based on the accident analysis. As required by DOE-STD-3009 (DOE 2006), support systems required for operability of the confinement ventilation system are also required to be safety-significant. Because of this, the UPS is also considered a safety-significant SSC.

The TSRs include an LCO/SR on the Building Confinement Ventilation System and its UPS support system. The Electrical Distribution System (EDS) powers the ventilation fans which maintain the differential pressure between the WCG and the process area, and between the process area and the environment, to minimize the spread of contamination during normal operation. Upon loss of EDS power, the ventilation fans will become inoperable. Availability of electrical power and operation of the ventilation fans is not credited with accident mitigation or required for the achievement of the confinement function of the system (in conjunction with the Building's structural integrity). Fan inoperability is covered by the LCO on differential pressure and no specific LCO coverage of the EDS is required. The exhaust HEPA system confinement is tested periodically and when HEPA filters are replaced. Confinement provided by the personnel doors is manually controlled and is not included in the TSRs based on the redundancy of the doors and the short duration of openings for personnel access.

The system includes a programmable logic controller (PLC) that controls the sequencing and overall function of the ventilation components of the system to maintain negative pressure in the facility and glovebox to minimize the spread of contamination during normal or abnormal operation. The PLC does not control the credited confinement function of the confinement ventilation system. Connected to the PLC is the interlock for the glovebox and room ventilation systems, as well as the supply and exhaust

interlocks. The PLC monitors the differential pressure between the building and the outside atmosphere, and the differential pressure between the WCG and the main processing area. The PLC activates a time-delayed alarm when the differential pressure is greater than the credited setpoint (-0.05 inches wc for the building). The credited differential pressure setpoint is the minimum operable differential pressures carried forward to the TSR, but operating practices and procedures implement more conservative differential pressure limits. The WCG is the primary confinement boundary once the TRU containers are opened in the WCG. Building TA-50-69 confinement is an additional means of confinement for radioactive materials outside the WCG. Building TA-50-69 confinement ventilation shall comprise the following:

- Building TA-50-69 shall maintain a negative pressure differential with respect to the atmosphere (as indicated by a building differential pressure less than –0.05 inches wc).
- Building TA-50-69 exhaust (FE-001 and FE-002) HEPA filters shall be operable. That is, the in-place efficiency of the HEPA filters shall be at least 99.95%, and the pressure drop across the HEPA filter stage shall not exceed 3.5 inches wc.
- The ventilation control system activates an alarm when the differential pressure between the building and the outside atmosphere is greater than –0.05 inches wc.
- Building TA-50-69 confinement integrity is intact (one vehicle airlock door closed and roof access port closed).
- The UPS shall provide power to required loads for at least 1 hour upon loss of offsite power.

Surveillance Requirements:

- Conduct an annual in-place HEPA filter aerosol efficiency test of the air exhaust system HEPA filters (FE-001 and FE-002) and demonstrate that in-place filter efficiency of each stage of HEPA filters is at least 99.95% for each filter plenum. The efficiency test will be performed annually and after replacing filters or performing maintenance.
- Verify daily that the pressure drop across the air exhaust trains (FE-001 and FE-002) HEPA filters does not exceed 3.5 inches wc.
- Perform a channel functional test quarterly to verify that the ventilation control system activates an alarm when the differential pressure between Building TA-50-69 and the outside atmosphere is greater than –0.05 inches wc.
- Verify daily that Building TA-50-69 pressure is negative with respect to the outside atmosphere, as indicated by a building differential pressure less than –0.05 inches wc.
- Verify daily that Building TA-50-69 confinement integrity exists.
- Perform a channel calibration annually on the differential pressure gauge control loops used on the Building TA-50-69 confinement ventilation system and the FE-002 HEPA filters used to perform SR for verification that the pressure drop across the air exhaust train (FE-002) HEPA filters does not exceed 3.5 inches wc, and verification that the Building TA-50-69 pressure is negative with respect to the outside atmosphere, as indicated by a building differential pressure less than –0.05 inches wc.
- Verify annually that the UPS is capable of providing power to required loads for at least 1 hour.
- On an annual basis, calibrate the differential pressure gauge on the FE-001 HEPA filters used to perform the surveillance for verification that the pressure drop across the air exhaust trains HEPA filters does not exceed 3.5 inches wc.

5.5.4 Waste Characterization Glovebox Confinement Ventilation LCOs

The WCG ventilation system (FE-003 Exhaust Train) is the primary confinement boundary for the WCG and the GBE. The WCG is a confined workspace in which visual inspection, waste processing, and repackaging (sort segregation) operations are performed. The safety function of the WCG is to provide a passive confinement for these operations. The GBE will not be used for handling TRU waste, but will continue to maintain confinement for internal contamination. The WCG and GBE will be maintained at a negative pressure relative to Building TA-50-69 operating areas to contain contamination within the enclosed gloveboxes, and their common ventilation system and the ventilation control system will activate an alarm if the required differential pressure is not maintained. Thus, the Waste Characterization Glovebox Confinement Ventilation System is designated as a safety-significant SSC for these events based on the accident analysis. As part of the WCG confinement ventilation system, the physical enclosure of the GBE (including dampers and airlock doors that are relied upon to control confinement and exhaust flow) is considered and treated as a safety-significant SSC. As required by DOE-STD-3009 (DOE 2006), support systems required for operability of the WCG confinement ventilation are also required to be safety-significant. Because of this, the UPS is also considered a safety-significant SSC.

The TSRs include an LCO/SR on the WCG confinement ventilation system. The EDS powers the ventilation fans which maintain the differential pressure between the WCG and the process area to minimize the spread of contamination during normal operation. Upon loss of EDS power, the ventilation fans will become inoperable. Electrical power is not credited with accident mitigation or required for the achievement of the confinement function of the WCG (in conjunction with the building's structural integrity). Fan inoperability is covered by the LCO on differential pressure and no specific LCO coverage of the EDS is required. UPS operability is covered in the Building TA-50-69 Confinement Ventilation LCO/SR and is not repeated for the WCG confinement ventilation LCO/SR because, upon loss of UPS, ventilation fans fail and their failure is covered by the applicable LCO/SR.

The system includes a programmable logic controller (PLC) that controls the sequencing and overall function of the ventilation components of the system to maintain negative pressure in the facility and glovebox, to minimize the spread of contamination during normal or abnormal operation. The PLC does not control the credited confinement function of the confinement ventilation system. Connected to the PLC is the interlock for the glovebox and room ventilation systems, as well as the supply and exhaust interlocks. The PLC monitors the differential pressure between the building and the outside atmosphere, and the differential pressure between the WCG and the main processing area. The PLC activates a time-delayed alarm when the differential pressure between the WCG and the process area is greater than the credited setpoint (-0.1 inches wc for the WCG). Maintenance of a negative pressure differential within the glove box is necessary to control the release of dispersible radioactive material to the workplace atmosphere in the event the glovebox confinement is compromised. The credited differential pressure setpoint is the minimum operable differential pressures carried forward to the TSR, but operating practices and procedures implement more conservative differential pressure limits. The conservative limits that are implemented for normal operation also assure the face velocity would be sufficient to meet Radiation Protection Program requirements for worker safety in the event of a failed glove.

- WCG atmosphere shall be maintained negative with respect to the main process area of Building TA-50-69 (as indicated by a differential pressure less than –0.1 inches wc).
- The ventilation control system activates an alarm when the differential pressure between the WCG and the main process area is greater than –0.1 inches wc.
- The WCG (FE-003) HEPA filters shall be operable as demonstrated by:

- The combined in-place efficiency of the two stages of HEPA filters shall be at least 99.95%.
- The pressure drop across any HEPA filter stage shall not exceed 3.5 inches wc.

- At least one GBE airlock door shall remain closed.

Surveillance Requirements:

- Conduct a combined in-place HEPA filter aerosol efficiency test of the two stages of air exhaust system HEPA filters (FE-003) and demonstrate that in-place filter efficiency is greater than 99.95% for the combined two stages of HEPA filters annually and after filter replacement or maintenance.
- Verify daily that the pressure drop across the FE-003 credited HEPA filters does not exceed 3.5 inches wc.
- Verify daily that the WCG glovebox pressure differential is at a negative pressure with respect to the inside of Building TA-50-69, as indicated by a differential pressure of less than -0.1 inches wc.
- Perform a channel functional test quarterly to verify that the ventilation control system activates an alarm when the differential pressure between the WCG and the main process area is greater than –0.1 inches wc.
- Ensure daily that at least one GBE airlock door is closed.
- Perform a channel calibration annually of the differential pressure gauge control loops used on the WCG Confinement Ventilation System and on the FE-003 exhaust HEPA filters used to perform SR for verification that the pressure drop across the FE-003 credited HEPA filters does not exceed 3.5 inches wc and verification that the WCG glovebox pressure differential is negative pressure with respect to the inside of Building TA-50-69 as indicated by a differential pressure of less than –0.1 inches wc.

5.5.5 Combustible Loading LCO

To reduce the threat of uncontrolled fire loadings and the spread of fire, a strategy for minimizing the fire loading in Building TA-50-69 and outside the building is necessary. Fire loading is composed of two elements: fixed combustibles (permanently installed in the WCRRF) and transient combustibles (not permanently installed in the WCRRF). Combustible Loading controls with appropriately derived limits are established to minimize the amount of fixed and transient combustibles within the facility that could fuel and sustain a fire. By minimizing the combustibles within the facility, the program reduces the fuel-component of the fire and improves suppression effectiveness. As a result, significant reductions in off-site dose consequences can be achieved.

Transient combustible and flammable loading within the WCRRF shall be strictly controlled as follows:

1. ≤ 0.60 lb/ft^2 on average in Building TA-50-69.*
2. No flammable liquids or gases, and no combustible liquids with NFPA Flammability Rating greater than 1, shall be stored or used within Building TA-50-69 when inventory is in Building TA-50-69, except three Size-1 cylinders of P-10 gas and flammable or combustible liquids found in the TRU WASTE CONTAINER.
3. No combustibles shall be stored within the WCG exclusion zone.* The WCG exclusion zone is 10 ft around the WCG, up to the GBE, or up to the walls of Room 102, whichever is less.

4. No combustible fuel package inside Building TA-50-69 may be greater than 50 lbs and must be separated from other combustibles by ≥ 6 ft*, excluding the change rooms/rest rooms.
5. Combustible materials inside and within 10 ft of the exterior of the transportainers shall be limited those materials and equipment necessary to accomplish required tasks.

* The following are excluded from the above limitations:

- INVENTORY that is in the WCG or staged in BUILDING TA-50-69.
- Combustible components of support equipment (e.g., wiring insulation, operator platforms and rubber mats) within the WCG Exclusion Zone and associated with WCG processing.
- Drum liners or wrapping around DEGRADED/LOSS OF INTEGRITY drums that are inside BUILDING TA-50-69 being loaded, and working amounts of materials necessary to complete bag-on/off operations such as tape, cheesecloth, and extra operator gloves.
- Hydraulic fluid within the engineered, closed-loop containment systems.
- Combustible components associated with a forklift.

A description of representative fuel packages is found in Appendix 3D in the WCRRF BIO.

Surveillance Requirements:

- Perform a quarterly Building TA-50-69 combustible material inventory inspection to verify that the inventory is less than or equal to 0.60 lb/ft^2 on average in Building TA-50-69, allowing for the listed exclusions. (Performed by the Fire Protection Engineer [FPE]).
- Perform daily a Building TA-50-69 combustible material inventory inspection to verify that no flammable liquids or gases, and no combustible liquids with NFPA Flammability Rating greater than 1, are stored or used when TRU waste containers are in Building TA-50-69. This excludes three size=1 cylinders of P-10 gas and flammable or combustible liquids found in the TRU WASTE CONTAINER.
- Verify daily that no combustibles are stored within the WCG exclusion zone, allowing for the listed exclusions.
- Verify daily that no combustible fuel package inside Building TA-50-69 is greater than 50 lbs and that combustibles are separated from other combustibles by 6 ft, excluding the change rooms/rest rooms and allowing for the listed exclusions.
- Verify weekly that combustible materials and equipment inside and within 10 ft of the exterior of the transportainers are limited to those necessary to accomplish required tasks. Allowable combustibles include items such as waste container labeling, lid restraints, and plastic/rubber wheeled dollies that are required for operations.

5.5.6 WCG Drum Lift Fixture

To prevent and mitigate the consequences of drops of drums that are being lifted for repackaging in the WCG, a drum lift fixture is used. The WCG drum lift fixture is used to lift a vertical drum sitting on the floor and position the drum horizontally against the side of the WCG. The height of the lift is approximately 61 inches.

The drum is positioned against the trolley and attached to the trolley with two steel drum restraining straps. The trolley is then pulled along the trolley support rail by a cable attached to an electric hoist. The

trolley rails are supported by a tubular steel frame anchored to the concrete floor. The electric hoist and the cable are enclosed by the tubular steel frame. The hoist is operated manually by an operator. The drum lift fixture is designed to lift a drum weighing up to 630 lbs. All drums are weighed before being placed on the drum lift fixture. The electric hoist is equipped with a holding brake to limit the speed of drum fall in the event of loss of power or to hold the drum when the controls are released.

The WCG drum lift fixture prevents drums from dropping and mitigates the consequences from malfunction and/or seismic events. The WCG drum lift fixture operability shall be demonstrated by the following:

- The drum lift fixture shall be capable of supporting a drum weighing at least 630 lbs. during normal operations and PC-2 seismic events.
- The drum lift fixture hoist holding brake shall be capable of stopping and holding a drum weighing at least 630 lbs when the lifting controls are released.
- The drum lift fixture hoist shall be capable of limiting the lowering speed of a drum loaded to at least 630 lbs to 26 ft/min following loss of power.

Surveillance Requirements:

- Before the lift, weigh the drum to be lifted to ensure that it is less than 630 lbs.
- Verify daily that there is no visual indication of degradation of holding bands, holding band hinges, including associated welds, and rollers that might affect lifting or seismic capability.
- Verify annually that there is no visual indication of cracked welds, missing fasteners, loose parts, excessive wear, or unusual deformation of the drum lift fixture that might affect lifting or seismic capability.
- Perform annually a drum lift fixture dummy load test of at least 788 lbs.
- Perform annually a drum lift fixture hoist holding brake test to verify that it is capable of stopping and holding a drum weighing at least 788 lbs when the lifting controls are released.
- Perform annually a drum lift fixture hoist test to verify that it is capable of limiting the lowering speed of a drum loaded to at least 788 lbs to 26 ft/min following loss of power.

5.5.7 Grounding Waste Packages before Breaching Unvented, Sealed 30- to 5-Gallon Metal Waste Packages in WCG LCO

The safety function of the ground is to reduce the probability for a spark during the opening of unvented 30- to 5-gallon waste package within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere with the WCG.

Ground must be able to bound through insulating paint or plastic wrap on 55-gallon drum and unvented, sealed waste package to be opened in the WCG.

When processing a positively sealed 30- to 5-gallon metal WASTE PACKAGE in the WCG, the following shall be fulfilled:

- The parent 55-gallon drum bagged on to the WCG and metal WASTE PACKAGE shall be grounded when the metal WASTE PACKAGE is breached and for 30 minutes after the removal of the lid and lid restraining device.

Surveillance Requirements:

- Before breaching the WASTE PACKAGE, VERIFY that the parent 55-gallon drum bagged on to the WCG and metal WASTE PACKAGE are grounded.

5.5.8 Procedures

Procedures are established, implemented, and maintained in accordance with LANL requirements governing conduct of operations. Facility-specific guidance for initiating, preparing, revising, reviewing, approving, controlling, and issuing operating procedures will be provided.

Procedures are not limited to those items specifically identified as procedure types (for example, operating, chemistry, system, test, surveillance, and emergency plan), but could include anything described in the Safety Basis that defines or describes activities or controls over the conduct of work. Changes to these activities or controls qualify as changes to procedures as described in the Safety Basis, and therefore must be evaluated as a potential USQ.

5.5.9 Review and Audit

5.5.9.1 General

This section summarizes the programs that ensure independent oversight, safety review, USQ determination, and appraisal of safety performance in accordance with LANL requirements.

5.5.9.2 Management Self-Assessments

A program is implemented in accordance with LANL requirements, requiring that line management periodically review activities to ensure that they are conducted in a safe manner. Examples of elements that should be reviewed include, but are not limited to, the following:

- Procedures;
- USQ determinations;
- Programs;
- Building/Facility changes and modifications;
- Facility operation;
- Maintenance and testing;
- Laboratory, DOE, and industry issues for potential generic safety significance; and
- TSR compliance.

5.5.9.3 Independent Reviews

Reviews are conducted by individuals independent of the line management organizations. The objective of the independent review program is to assist line management in assessing work performance and identifying areas for improvement. Examples of subjects that independent reviews should evaluate include, but are not limited to, the following:

- TSR implementation;
- USQ determinations;
- Proposed changes to the TSRs;
- Occurrence reports; and
- Configuration management control program implementation.

5.5.9.4 Audits

A Laboratory audit program is established and conducted by a group independent of the facility or operations personnel to assess whether operations are in accordance with the WCRRF Safety Basis, including the TSRs, and with Laboratory requirements. Examples of subjects the audit program should include are the following:

- Conformance with the TSRs
- Training and qualifications of the WCRRF and operations staff
- Program implementation
- Effectiveness of control action
- QA program adherence

5.5.10 Safety Management Programs, including Programmatic and Specific Administrative Controls

Based on the information in DOE-STD-1027 (DOE 1997a), it was determined that the WCRRF is a Hazard Category 2 Non-Reactor Nuclear Facility because of the inventory and potential for criticality. The operational controls were developed to reduce the frequency and consequence of a credible accident leading to an uncontrolled release of radioactive materials or hazardous materials. The credited controls consist of DFs that are credited assafety-class andsafety-significant, as well as controls preserving selected elements of the SMPs. The use of DFs, in conjunction with ACs, supports the safe operation of the WCRRF and effectively controls hazards. The limits and controls specified in this section shall be incorporated into written procedures or instructions and approved by project management. As part of the graded approach, only those programs with credited programmatic attributes and specific elements are listed in this section.

5.5.10.1 Unreviewed Safety Question Program

The USQ program is implemented as a part of the Configuration Management Program and maintained in accordance with LANL requirements (OST300-00-06B, *LANL Unreviewed Safety Question Procedure* [LANL 2004], or successor documents). As required by 10 CFR 830.203(f) (CFR 2003a), a summary of all USQ determinations performed since the last submittal will be submitted to DOE on an annual basis.

5.5.10.2 Emergency Preparedness Program

An emergency preparedness program is implemented and maintained in accordance with LANL requirements (Laboratory Performance Requirement [LPR] 403-00-00/Laboratory Implementation Requirement [LIR] 403-00-01, *Emergency Management/Los Alamos National Laboratory Emergency Management*, or successor documents). The program addresses emergency preparedness planning, including activation of emergency organizations, notification processes, protective actions, emergency

facilities and equipment, training and exercises, recovery actions, and assessment actions. The following element of the Emergency Preparedness program is credited and implemented in WCRRF procedures:

- Upon detection of an airborne release of radioactive contamination in Building TA-50-69, workers will evacuate per facility procedures and, if the Building TA-50-69 exhaust fans are inoperable, the vacuum pumps for the radiological monitoring equipment (CAMs and fixed-head air samplers) will be de-energized by the power cut-offs located outside Building TA-50-69.

5.5.10.3 Conduct of Operations

A Conduct of Operations program is implemented and maintained in accordance with LANL requirements on Conduct of Operations (Implementation Procedure (IMP) 315/Implementation Support Document [ISD] 315-1, *Conduct of Operations/Conduct of Operations Manual*, or successor documents), which requires that specified performance criteria be considered when accepting or authorizing work, identifying the risks to operations, and developing and implementing the controls needed to perform the work safely and securely.

5.5.10.4 Nuclear Criticality Safety Program

The Nuclear Criticality Safety Program is implemented to prevent inadvertent nuclear criticality and to provide proper response to an inadvertent nuclear criticality. General limits and controls (engineered and administrative) are applied to fissile material operations to ensure subcritical configurations under all normal and credible abnormal conditions whenever fissile materials are present. The LANL Nuclear Criticality Safety Program is implemented and maintained for WCRRF operations in accordance with LANL requirements (Institutional Policy and Implementation Procedure [IPP] 130/ISD130-1, *Nuclear Criticality Safety/Nuclear Criticality Safety Program Manual*, or successor document s).

5.5.10.5 Fire Protection Program

A fire protection program will be established and maintained based on LANL requirements (LIR402-910-01, *LANL Fire Protection Program*, or successor documents). This program develops and maintains effective fire protection and control measures for the protection of personnel and structures within WCRRF. The program includes an ignition source control program

The following elements of the Fire Protection Program are credited as SACs:

- No hot work may be performed in Building TA-50-69 when TRU waste is present.

Basis: *Hot work activities are a common ignition source of industrial fires. Prohibiting hot work while TRU waste is present in the process areas eliminates a major contributor to the frequency of fire events that can result in the release of material.*

- Propane, gasoline, or diesel-fueled vehicles shall not be used anywhere at the WCRRF when TRU waste is present at the WCRRF. Exceptions: (1) Emergency vehicles in the case of any emergency. (2) Equipment with less than 5 gallons of fuel may be used for grounds maintenance and for snow and ice removal.

Basis: *Propane, gasoline, and diesel-fueled vehicles operating inside of the WCRRF represent a large energy source that can contribute fuel to a fire or generate missiles. Prohibition on these types of vehicles mitigates the magnitude of potential fires near waste containers. An exception to respond to emergencies, or for grounds maintenance and snow removal (equipment with up to 5 gallons), is necessary to protect the facility and to efficiently conduct facility operations. This value was considered adequate and reasonable for grounds maintenance and snow removal activities.*

- Refueling of the diesel generator is prohibited when TRU waste containers are in Building TA-50-69.

Basis: *Large leaks that occur during refueling of the diesel fuel generator can contribute fuel to a fire that can spread to Building TA-50-69, affecting TRU waste containers within Building TA-50-69. Prohibition of refueling the diesel generator while TRU waste containers are inside Building TA-50-69 prevents this occurrence. The diesel generator is located far away from transportainers on the south side of Building TA-50-69, so any diesel fuel spills will not affect TRU waste containers that are staged in the transportainers.*

- Extra Fire Controls for High-MAR Processing in WCG

Basis: *Operational experience at LANL indicates that glovebox fires to date have been localized and adequately addressed as incipient fires by glovebox operators. This control supplements the WCG Fire Suppression System and ensures that the appropriate fire suppression tools are in place to allow the STATIONARY FIRE WATCH or glovebox operator to manually respond upon detection of a small, early developing fire that could be caused by pyrophoric material contained within the waste being processed. Carbon spheroids and Met-L-X are recommended fire-fighting agents and are listed in Table A.13.3.3 of NFPA 484, Standard for Combustible Metals. Three containers are required in the glovebox to provide ready access throughout the glovebox to fight fires. Each container shall have sufficient material to completely cover a small pyrophoric metal fire (based on engineering judgment, this is estimated to be 1 liter in each container). When TRU waste containing > 300 PE-Ci of EQUIVALENT COMBUSTIBLE WASTE is in the WCG, because of the higher potential consequences of a fire involving this material, a dedicated STATIONARY FIRE WATCH shall be in place while glovebox operations occur. Operators or support personnel are trained to perform a STATIONARY FIRE WATCH and to use the fire-fighting equipment and agents provided in the WCG. The training ensures that the WCG operator and STATIONARY FIRE WATCH can detect small, early developing fires, are aware of the hazards, and can manually apply the fire suppression material to small, early developing fires within the WCG.*

5.5.10.6 Vehicle Access System SAC

- Vehicle access system barriers must be located such that the impact vehicle stops at least 25 ft from the TRU waste containers staged in Building TA-50-69 or in transportainers to prevent up to a 100-gal. diesel fuel pool fire from impinging on waste containers.
- The gates of the vehicle access system may be removed at any time for emergency access. Delivery of the TRU waste containers occurs at the gates of the vehicle access system. When these transport activities take place, the transportation vehicle blocks the entrance of the gate

to inadvertent vehicle impact, and during these times it is acceptable to temporarily remove the gate.

Basis: *The Vehicle Access System barriers are passive design features and are included in the design features portion of the TSR document. As passive design features, the vehicle barriers are not expected to change or to experience operability degradation over time. A separation distance of 25 ft between the vehicle fuel and TRU waste containers prevents a 100-gal. diesel fuel pool fire from impinging upon TRU waste.*

5.5.10.7 Drum Lid Restraints

- A lid restraining device shall be installed onto unvented, sealed 30- to 5-gallon waste packages when the lid is removed. Before breaching the waste package, the lid restraining device shall be inspected for degradation and proper installation.
- After the removal of the lid and lid restraining device, WCG operations shall cease for 30 minutes.

Basis: *The use of lid restraining device mainly protects glovebox workers working within the WCG, from any flying debris from a lid ejection if a waste package over-pressurization or deflagration were to occur. In addition, the glovebox is protected from flying debris breaching its confinement integrity. The lid restraining device has been demonstrated through testing or analysis to restrain an ejected lid during a drum deflagration. DOE Standard 5506, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities (DOE 2007), cites results of Idaho Drum Deflagration Tests. Several drums were filled with representative combustible/metal waste matrices; the drums were also pressurized with a flammable gas mixture comprised of oxygen, hydrogen, and nitrogen. The test drums were then subjected to sparks, a drill bit puncture, or a 12-foot drop. The results showed that puncturing or dropping the test drum did not result in a deflagration. In the 12-foot drop test, when the drum impacted the ground, it rotated a complete 180 degrees, yet it did not deflagrate nor did it show signs that a fire occurred within the drum. This indicates that movement of metal items within the test drums did not produce enough of a spark to ignite the flammable gas mixture. Extending this result to WCG operations, it is not expected that handling an unvented, sealed drum, such as removing the lid from the drum, will most likely not cause the drum to deflagrate if a flammable gas mixture is present within the drum. The drums that deflagrated in the Idaho tests, were the ones that were impacted with a soft (20 milli-Joules) or hard (5 Joules) spark. Extending this particular result to WCG operations indicates that by preventing the occurrence of sparks, a deflagration will not occur if a flammable gas mixture exists with the waste package when it is breached.*

When breaching unvented, sealed waste package within the WCG, the use of nonsparking tools and grounding the metal waste packages and parent 55-gallon drum will prevent the introduction of sparks. Again, as indicated by the drum deflagration tests, spark production within the waste matrix by metal waste items rubbing against each other by the movement of an unvented, sealed waste package is not sufficient to cause a deflagration of a flammable gas mixture within the container. However, unvented, sealed waste package should be handled with care. After the unvented, sealed waste package is breached, the lid and lid restraining device can be removed.

LANL Calc. CALC-07-50-069-000-0005-M-R-0, demonstrates that the maximum hydrogen concentration of 7.4% is possible in the WCG if 90% of a pressurized (11 psig) 30-gallon waste packages is instantaneously released. The calculation cites that the overall concentration at the

exhaust fan will not exceed flammable hydrogen concentrations due to the larger ductwork volume and ventilation flow rate at the common WCG and GBE exhaust header. The calculation further demonstrates that this type of instantaneous release is not possible due to the glovebox ventilation and drum configuration. The WCG ventilation sweeps away the hydrogen as it diffuses from the waste package, and after 30 minutes and with minimal WCG air flow (35 cubic foot per minute), the hydrogen concentration in the WCG and at the waste package opening are below flammable hydrogen concentrations.

This control is only applicable to unvented, sealed waste packages with a volume of 30- to 5-gallons. Using the same calculations in LANL Calc. CALC-07-50-069-000-0005-M-R-0, the WCRRF Safety Basis Addendum No. 2, shows that breaching unvented, sealed waste packages with volumes smaller than 5-gallons will not cause the overall WCG atmosphere to experience a flammable gas concentration near 4% hydrogen concentration. The application of a lid restraining device on these smaller containers is not practical; however, the control for the use of nonsparking tools and the de-energizing of WCG receptacles, is considered sufficient to prevent any flammable gas mixture to deflagrate in waste packages smaller than 5 gallons, and thus lid ejection from deflagration will not occur. Lid ejection from breaching a pressurized waste package less than 5 gallons is not expected to cause physical damage.

5.5.10.8 Nonsparking Tool or Processes/De-energization of the WCG Electrical Receptacles

- Tools or processes used to breach an invented waste package shall be nonsparking.
- Before breaching the unvented waste package within the WCG, receptacles in the WCG shall be de-energized.
- The WCG receptacles shall not be re-energized until 30 minutes have elapsed after removing the lid and lid restraining device.

Basis: *This control is credited to reduce ignition sources during the opening of unvented 30- to 5-gallon WASTE PACKAGES, thereby reducing the probability of a deflagration or explosion.*

5.5.10.9 Grounding Waste Packages before Breaching Unvented, Sealed Waste Packages

- The parent 55-gallon drum bagged on to the WCG and metal waste package shall be grounded when the metal waste package is breached and for 30 minutes after the removal of the lid and lid restraining device.

Basis: *The safety function of the ground is to reduce the probability for a spark during the opening of unvented 30- to 5-gallon waste packages within the WCG, thereby minimizing the potential for igniting a potentially flammable atmosphere within the WCG.*

Implementing these controls prevents a fire from occurring and reduces the likelihood of a fire becoming a threat to the health and safety of the public and the environment. These controls are also important in protecting WCRRF personnel and the WCRRF property from fire risks. In addition, the FPP minimizes the possibility of important DOE/National Nuclear Security Agency (NNSA) programs being delayed as a result of fire damage.

5.5.10.10 Radiation Protection Program

A Radiation Protection Program is established and maintained based on the criteria in LANL requirements (ISD121-1, *Radiation Protection*, or successor documents). These documents comply with the requirements of 10 CFR 835, *Occupational Radiation Protection* (CFR 2003b). Radiation protection training is required to help ensure that radiation doses are kept as low as reasonably achievable (ALARA) at the WCRRF.

5.5.10.11 Maintenance Program

The WCRRF has established a maintenance program based on the criteria established in LANL requirements (ISD951-1, *LANL Conduct of Maintenance Manual*, or successor documents). At the WCRRF, maintenance shall be managed in accordance with the policy on using the graded approach by a combination of the following:

- Review and approval of applicable maintenance procedures and instructions in accordance with LANL requirements.
- Monitoring maintenance work performed on the WCRRF institutional and programmatic equipment.
- Maintenance of safety SSCs and forklifts that handle TRU waste containers.

As a contributor to defense-in-depth in limiting the frequency of a lightning strike, the Lightning Protection System (LPS) is maintained according to the following requirements which are derived from NFPA 780, Chapter 4 and Chapter 7, as indicated in Section 2.4 and Section 2.7 of LANL Report EP-DIV-REPORT-08, *Technical Basis Document for the Lightning Protection Systems in the Environment & Waste Management Facility Operations (EWMO) Division*, or successor LANL document [LANL 2008].

1. Following a lightning strike or on an annual basis, the LPS is visually inspected for signs of degradation:
   a. There are no loose connections that might result in high resistance;
   b. No part of the system has been degraded by corrosion;
   c. All down conductors and grounding electrodes are intact (continuity exists);
   d. All conductors and system components are fastened securely to the mounting surfaces;
   e. There have been no additions or alterations to the protected structure that would require additional protection; and
   f. There is no visual indication of damage to surge protection.
2. Tests every 3 years to ensure continuity of those parts of the system that were concealed (built-in) during the initial installation and that are not now available for visual inspection.
3. Tests every 3 years to ensure the ground resistance of the grounding electrode termination system and its individual grounding electrodes are less than 200 ohms.

5.5.10.12 Configuration Management Program

The configuration management program is implemented and maintained for the WCRRF in accordance with LANL requirements (LIR240-01-01, *Facility Configuration Management*, or successor documents).

The purpose of this program is to identify and document the technical baseline of configuration control items to protect equipment integrity. LANL requirements ensure that changes to the technical baseline are properly identified, developed, assessed (technically reviewed and validated), approved, scheduled, implemented, and documented.

5.5.10.13 Hazardous Material and Waste Management

A hazardous material and waste management program is established and maintained based on LANL requirements (LIR402-510-01, *Chemical Management*, and LIR404-00-02, *General Waste Management Requirements*, or successor documents). The program controls personnel exposure to hazardous materials by identifying and limiting contact with hazardous materials, adhering to established occupational exposure limits, implementing administrative and engineered controls, and using personal protective equipment.

The following elements of the Hazardous Material and Waste Management program are TSR-level SACs:

- Support structures shall not elevate transportainers that contain TRU waste containers greater than 4 ft above ground level.
- Transportainers containing TRU waste shall be located greater than 35 ft away from Building TA-50-69.

Basis: *This height limit protects the safety function of the containers staged in the transportainer. The DOT 7A TRU waste containers are rated to survive a 4-ft fall without release of contents. Transportainers with TRU waste must also be located away from Building TA-50-69 to prevent impact from seismic collapse of the building. The distance of 35 ft was selected because it is approximately 1½ times the building height.*

- TRU waste containers shall be placed within the transportainers and container lids shall remain closed when staged outside the Building TA-50-69 structure.

Basis: *The requirement to stage TRU waste containers inside of secondary containment (i.e., transportainers) while in outdoor staging minimizes the release of TRU waste from grass wildland fires involving the TRU waste containers. Secured TRU waste container lids prevent spills and protect the TRU waste from accidents.*

- TRU waste containers shall not be stacked and shall not be lifted higher than 4 ft, excluding the WCG drum lift and lifts during loading or unloading from delivery trucks.

Basis: *TRU waste containers are rated for 4-ft drops. This control also protects the design basis for the TRU waste containers, which are tested and certified to survive a 4-ft drop with their functional requirement of containment intact. Delivery truck beds used at LANL are approximately 51 inches above grade. Lift heights when TRU waste containers are loaded or unloaded from delivery trucks are slightly greater than 51 inches. Energy causes damage to the drum as a result of a drum drop and the TRU waste drums are tested to 4000 ft.-lbs (1000 lb drum dropped from a height of 4 ft.); for an equivalent amount of damage to a 630=lb drum, the drums would have to be dropped from about 6.3 ft. (75.6 inches). The SWBs are more robust than drums, so they can be expected to survive drops during unloading and loading operations. In addition, the requirement for trained and qualified forklift operators and spotters minimizes the probability of*

TRU waste container drops during delivery truck loading or unloading operations. Therefore, the TRU waste container lift height incurred during loading or unloading the TRU waste containers of around 51 inches during loading or unloading from delivery trucks is excluded from the prohibition on lifts greater than 4 ft The WCG drum lift requires lifts of 61 inches and is a safety-significant control to prevent drum drop events and compensates for lifts of degraded or loss of integrity drums that may not meet the 4-ft drop test.

- Incoming TRU waste at WCRRF shall be visually inspected upon arrival (before the containers are placed in storage) to ensure that the containers meet the following minimum performance criteria:

1. Verify that the TRU waste container is of noncombustible construction (top, bottom, and sides) and is of a design that has had a prototype meet the free-drop tests specified in 49 CFR 173.465(c)(1) (CFR 1999).
2. Verify that the TRU waste container is integral and shows no signs of degradation by verifying the following:

    a. The TRU waste container is not obviously degraded.

    Discussion: Obviously degraded means clearly visible and potentially significant defects in the TRU waste container or TRU waste container surface.

    b. There is no evidence that the TRU waste container is, or has been, pressurized.

    Discussion: Pressurization can be indicated by a fairly uniform expansion of the sidewalls, bottom, or top. Past pressurization can be indicated by a notable outward deflection of the bottom or top. Verify that the drum is not warped.

    c. There is no potentially significant rust or corrosion such that wall thinning, pinholes, or breaches are likely or the load bearing capacity is suspect.

    Discussion: Rust shall be assessed in terms of its type, extent, and location. Pitting, pocking, flaking, or dark coloration characterizes potentially significant rust or corrosion. This includes the extent of the TRU waste container surface area, covered, thickness, and, if it occurs in large flakes or built-up (caked) areas. Rusted TRU waste containers may not be accepted if:

        i. Rust is present in caked layers or deposits.
        ii. Rust is present in the form of deep metal flaking, or built-up areas of corrosion products. In addition, the location of rust should be noted; for example, on a drum: top lid; filter region; locking chine; top one-third, above the second rolling hoop; middle one-third, between the first and second rolling hoops; bottom one-third, below the second rolling hoop; and on the bottom. TRU waste containers may still be considered acceptable if the signs of rust show up as:
            1. Some discoloration on the TRU waste container.
            2. If rubbed, rust would produce fine grit or dust or minor flaking (such that wall thinning does not occur).

    d. There are no split seams, tears, obvious holes, punctures (of any size), creases, broken welds, or cracks.

Discussion: TRU waste containers with obvious leaks, holes or openings, cracks, deep crevices, creases, tears, broken welds, sharp edges or pits, are either breached or on the verge of being breached.

e. The TRU waste container improperly closed.

Discussion: Inspect the fastener and fastener ring (chine), if applicable, for damage or excessive corrosion. Check the alignment of the fastener to ensure that it is in firm contact around the entire lid and the TRU waste container will not open during transportation.

f. There are no dents, scrapes, or scratches that make the TRU waste container's structural integrity questionable or prevent the top and bottom surfaces from being parallel.

Discussion: Deep gouges, scratches, or abrasions over wide areas are not acceptable. If top and bottom surfaces are not parallel, this would indicate that the container is warped. Dents should be examined to determine their impact on structural integrity.

g. There is no discoloration which would indicate leakage or other evidence of leakage of material from the TRU waste container.

Discussion: Examine the TRU waste container regions near vents, top lid fittings, bottom fittings, welds, seams and intersections of one or more metal sheets or plates. TRU waste containers must be rejected if evidence of leakage is present.

h. The TRU waste container is not bulged.

Discussion: For the purposes of this examination, bulging is indicated by:

i. A fairly uniform expansion of the sidewalls, bottom, or top (e.g., in the case of a drum, either the top or bottom surface protrudes beyond the planar surface of the top or bottom ring,
ii. A protrusion of the side wall (e.g., in the case of a drum, beyond a line connecting the peaks of the surrounding rolling hoops or a line between a surrounding rolling hoop and the bottom or top ring), or
iii. Expansion of the sidewall (e.g., in the case of a drum, such that it deforms any portion of a rolling hoop).

3. Verify that the TRU waste container is equipped with WIPP-approved filtered vents, and the vents are free of obvious obstructions; and,
4. Verify receipt documentation indicating that the headspace gas concentration of the received TRU waste containers and any interior drums has been performed and is < 4% hydrogen concentration and < 8000 ppm for VOCs, and the interior drum is equipped with WIPP-approved filtered vents, and the vents are free of obvious obstructions.

Containers that do not meet the above requirements shall not be accepted at the site. Degraded drums or drums with loss of integrity that have been overpacked into a protective container to ensure protection and containment of contents may be accepted if the outer container meets all of the inspection acceptance criteria, and the inner drum has fulfilled inspection criteria 4.

Basis: *TRU waste containers must meet the minimum performance requirements assumed in the accident analysis. Container integrity is ensured by confirming that the drum is of the correct design (all-metal construction; has had a prototype to meet the 49 CFR 173.465c(1) free-drop test) and inspecting for secure lids, corrosion, damage, and leaks in order to correct degraded drum conditions before an accident can occur. TRU waste drums are known to generate hydrogen, an extremely flammable and potentially explosive gas. Hydrogen is lighter than air, and, because of the small molecule size, is one of the most difficult gases to contain. The small molecule size also results in high buoyancy and diffusivity, so leaked hydrogen rises and dilutes quickly. The TRU waste may also contain volatile organic compounds (VOCs) which can evaporate and accumulate within the headspace of enclosed containers. The presence of an adequately sized vent that is free of obstructions significantly minimizes the potential that hydrogen gas and flammable vapors will accumulate above flammable concentrations. Bulging of a drum is an indicator of inoperable vents and gas generation/ accumulation. Proper vent design and condition helps release the accumulated gases. Restricting the flammable gas concentrations to less than 4% hydrogen concentration and < 8000 ppm for VOCs provides for an adequate margin of safety to ensure that the ignition of flammable gases is prevented.*

- Inventory shall not be stored, staged, or processed within the confines of the GBE.

Basis: *No inventory will be brought into the GBE for storage, staging, or processing. Prohibiting the, and processing of TRU waste inventory within the GBE preserves an initial condition assumption for the hazard analysis, and limits the amount of radiological material that could be released in a GBE accident to the residual contamination that remains from past operations. The residual contamination within the GBE is assumed to be no greater than 10% of the Hazard Category 3 limit.*

5.5.10.14 Hoisting and Rigging Program

A hoisting and rigging program is established and maintained in accordance with LANL requirements (ISD101-25, *Cranes, Hoists, Lifting Devices, and Rigging Equipment*, or successor documents). The program ensures that lifting devices used for moving TRU waste containers in Building TA-50-69 meet the load rating required. The rigging also must be inspected and tested. Implementing this program reduces the likelihood of dropping a container or component during TRU waste container handling operations. The program requires the use of spotters during TRU waste container forklift operations.

The program includes the following elements as SACs:

- A critical lift plan shall be implemented for lifts and forklift movements involving degraded or loss-of-integrity TRU drums when not secured in a TRU waste container.

Basis: *The assurance that hoisting and rigging equipment is rated and certified for their loads, and operators and riggers are qualified to perform the lifts, significantly reduces the probability for drops of containers.*

5.5.10.15 Quality Assurance Program

A quality assurance (QA) Program is established, implemented, and maintained at the WCRRF. The QA Program controls the integrity and reliability of safety-class/SS-SSCs and implementation of other safety management programs. The elements of the WCRRF QA Program follow LANL requirements (Institutional Policy [IP] 330, *Quality Assurance Program*, or successor documents).

5.5.10.16 Occurrence Reporting

An occurrence reporting program is established, implemented, and maintained at the WCRRF in accordance with LANL requirements (ISD322-3, *Manual for Communicating, Investigating, and Reporting Abnormal Events*, or successor documents). This program satisfies the requirements of DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information* (DOE 2003), in reporting operations information. Investigations of occurrences having environmental protection, safety, or health-protection significance are performed in compliance with DOE O 225.1A, *Accident Investigations* (DOE 1997b).

5.5.10.17 Qualification and Training

The WCRRF training and qualification program is in accordance with LANL requirements (ISD781-1, *Conduct of Training Manual*, or successor documents) and DOE O 5480.20A (DOE 2001b). The program ensures that personnel who are responsible for WCRRF operations, process operations, vehicle operation, maintenance, and technical support are trained and qualified/certified, as applicable, to accomplish their safety-related responsibilities. Line management ensures that personnel receive the training required through the use of a Training Implementation Matrix in accordance with DOE O 5480.20A (DOE 2001b).

5.5.10.18 Document Control

WCRRF operations and facility records (including TSR compliance documentation) shall be retained in accordance with the WCRRF QA Program and LANL requirements (IPP1020, *Document Control and Records Management*, or successor documents).

5.6 DESIGN FEATURES

The following SSCs were identified in the hazards analysis in Chapter 3. They are listed in Table 5-1 as safety-class or safety-significant passive DFs. They are also included in the Design Features section of the TSR document. In addition, actions to ensure their continued reliability are also addressed in the TSRs. More complete descriptions of these features are provided in Chapters 2 and 4 of this DSA.

5.6.1 Vehicle Barriers

Vehicle barriers are designated as safety-class-SSCs based on their ability to provide protection to waste containers staged inside Building TA-50-69 or in outdoor transportainers against impacts by vehicles that could result in the release of the container contents. The vehicle barriers also prevent subsequent vehicle fuel pool fires from involving TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.

Properly positioned and connected vehicle barriers provide protection against motor vehicles inadvertently impacting TRU waste containers at the WCRRF. Vehicle barriers are standard traffic control obstacles that absorb or redirect the momentum of errant vehicles to prevent impact with TRU

waste containers. The movable concrete barriers are interconnected and are positioned in strategic locations at WCRRF to prevent accidental vehicle impacts to TRU waste containers that are staged in Building TA-50-69, or in outdoor transportainers, that result in material releases. The vehicle barriers are also placed to provide a sufficient separation distance between any subsequent fuel pool fire and the TRU waste containers. The interconnection of the barriers as part of the WCRRF's Vehicle Access System includes gated areas with removable connections. Barrier design and integrity are ensured by this TSR Design Feature. Proper placement of the vehicle barriers is ensured through the SAC for Vehicle Access System. Annual In-Service Inspections ensure the integrity of the barriers and interconnecting wire rope and hardware.

The performance criteria for the vehicle barriers are as follows:

- The interconnected vehicle barriers (concrete Jersey barriers or equivalent or alternate design must be capable of stopping a vehicle gross weight of up to 72,000 lbs (based on a tractor/trailer carrying transportainers and waste containers) within 25 ft of the impact point moving at a velocity of up to 28 mph at a 25˚ impact angle or up to 9 mph at a 90˚ impact angle.
- The gate configuration of vehicle barriers must be capable of stopping a vehicle gross weight of up to 72,000 lbs within 25 ft of the impact point moving at a velocity of up to 9 mph at a 90˚ impact angle.
- Gates may be removed for emergency vehicle access in an emergency, and the gates may be removed during TRU waste shipment activities when the delivery truck is positioned in front of the gate entrance.

Table 5-3 identifies the ISI requirements for the Vehicle Barriers.

Table 5-3. In-Service Inspection Actions for Vehicle Barriers

In-Service Inspection Actions	Frequency
The physical integrity of the vehicle barriers shall be inspected to identify any abnormalities that may develop, such as deterioration of concrete and degradation of wire rope and connectors, including corrosion and loose connections.	Annually
The physical placement of the vehicle barriers shall be inspected to ensure that their distance is at least 50 feet from TRU waste container storage.	Annually

Basis: *Vehicle barriers are designated as SC-SSCs based on their ability to provide protection to waste containers staged inside Building TA-50-69 or in outdoor transportainers against impacts by vehicles that could result in the release of the container contents. The vehicle barriers also prevent subsequent vehicle fuel pool fires from involving TRU waste by providing sufficient separation distance between pooled fuel and the TRU waste containers.*

Properly positioned and connected vehicle barriers provide protection against motor vehicles inadvertently impacting TRU waste containers at the WCRRF. Vehicle barriers are standard traffic control obstacles that absorb or redirect the momentum of errant vehicles to prevent impact with TRU waste containers. The movable concrete barriers are interconnected and are positioned in strategic locations at WCRRF to prevent accidental vehicle impacts to TRU waste containers that are staged in Building TA-50-69, or in outdoor transportainers, that result in

material releases. The vehicle barriers are also placed to provide a sufficient separation distance between any subsequent fuel pool fire and the TRU waste containers. The interconnection of the barriers as part of the WCRRF's Vehicle Access System includes gated areas with removable connections. This TSR Design Feature ensures vehicle barrier design, integrity, and placement. Proper placement of the vehicle barriers is also ensured through the SAC for the Vehicle Access System. Annual In-Service Inspections ensure the integrity of the barriers and interconnecting wire rope and hardware as well as the placement of the barriers. Fifty feet is the setback distance because the vehicle barriers may move up to 25 ft due to vehicle impact, and another 25 ft is required to protect TRU waste containers from a 100-gallon diesel fuel spill and fire.

5.6.2 Transuranic Waste Containers (Outside Building TA-50-69)

The TRU waste containers are designated as safety-class SSCs based on their ability to reduce risks (i.e., frequency or consequence) to the public and workers by limiting the amount of radioactive material that would be released during an accident involving a fire or an impact, and by preventing the accumulation of flammable gases inside the containers when the TRU waste containers are staged outside Building TA-50-69. When the TRU waste containers are within Building TA-50-69, they are opened for processing. Once the TRU waste containers are opened, they continue to serve a safety-significant function based on their ability to reduce risks to the worker by limiting the amount of radioactive material that would be released during a postulated fire event. Although these containers serve both a safety-class and safety-significant function, they are designated as safety-class SSCs, since it is the higher of the two designations.

The safety functions of TRU waste containers are as follows:

- Provide primary confinement for TRU waste. (SC safety function)
- Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents. (SC safety function)
- Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents. (SC safety function)
- Prevent accumulation of flammable gases inside the waste containers. (SC safety function)

The TRU waste containers must be capable of confining the waste material and preventing it from escaping to the environment. Confinement must be maintained during long storage periods by resisting external and internal degradation. The TRU waste containers must be capable of withstanding operational loads associated with handling, lifting, transporting, and stacking, and external environmental stresses (e.g., temperature, pressure, precipitation) that might be experienced during normal operations.

The performance criteria for the TRU waste containers are as follows:

- TRU waste containers shall be of noncombustible construction (top, bottom, and sides) (DF).
- The TRU waste drum shall be of a design that has had a prototype meet the free drop tests specified in 49 CFR 173.465(c)(1) (CFR 1999) (DF).
- TRU waste containers shall have a WIPP-approved filtered vent to prevent build-up of flammable gases inside the container (DF).

Only TRU waste containers meeting the performance requirements are accepted for receipt into the WCRRF for processing. The SAC described in Section 4.5.4, *TRU Waste Container Inspection*, includes

a detailed receipt inspection for TRU waste containers before acceptance at WCRRF. Because of this SAC and the short residence time at WCRRF, no additional ISI is required.

Basis: *The TRU waste containers are credited as safety-class components to protect the inventory from accidents in the WCRRF yard area only. Once the TRU waste containers are brought into Building TA-50-69, their safety function is considered safety-significant based on the lower inventory limits inside Building TA-50-69. The TRU waste containers in the WCRRF yard area protect the inventory from seismic events, fires, deflagrations, and drop scenarios. The noncombustible construction minimizes the release of inventory from potential fires in the transportainers. Tests have shown that fires involving ordinary combustibles can, at most, overpressurize the TRU waste containers, leading to a breach of drum lids and a minor release of contamination. Fires involving liquid fuel can overpressurize drums so fast that the drums' lids and a portion of the drums' contents can be expelled. For this reason, other controls in the TSRs prohibit liquid fuel in the WCRRF while TRU waste containers are present. The TRU waste containers are also of a design that has been tested in four-foot free-drop tests. This qualification protects the inventory from seismic impacts and drop events during handling. The vents on the drums allow any flammable gas generated by the TRU waste to safely vent out of the TRU waste container. This prevents the possibility of a drum deflagration or explosion during handling due to the build-up of flammable gas concentrations in the TRU waste container. Because of the detailed receipt inspection of the TRU waste containers before acceptance at WCRRF, no additional ISI is required.*

5.6.3 Building TA-50-69 Structural Integrity

The building is designated a safety-significant SSC based on its ability to provide structural integrity to support safety SSCs; prevent insult to MAR inside the building; and, in conjunction with the confinement ventilation system, provide confinement to mitigate the release of MAR. Building TA-50-69 is a one-story, high-bay building with a floor area of approximately 2712 ft^2. The Building TA-50-69 structure meets PC-2 performance criteria for seismic, wind, and snow loading. The limited life of the activities addressed in this BIO, relative to the return period of a seismic or wind event of severity greater than PC-2 (DOE-STD-1020-2002), significantly reduces the risk associated with seismic events greater than PC-2.

The performance criteria for Building TA-50-69 that are not addressed in Section 5.5.3 are as follows:

- The Building TA-50-69 structure meets PC-2 seismic criteria. (DF)
- The Building TA-50-69 structure is designed to meet PC-2 wind and snow loading requirements (DF).
- The interior walls of Building TA-50-69 must be constructed of noncombustible materials that provide a confinement barrier in conjunction with the confinement ventilation system. (DF)

Table 5-4 identifies the ISI actions for Building TA-50-69.

Table 5-4. In-Service Inspection Actions for the Building TA-50-69.

In-Service Inspection Actions	Interval
Visually inspect Building TA-50-69 to verify that the building structure has not deteriorated and has not been modified, penetrated, or otherwise altered in such a manner as to compromise the structural strength and confinement capability.	Annually

Basis: *Building TA-50-69 provides a confinement barrier for potential releases inside the building. To provide this confinement barrier, Building TA-50-69 must meet PC-2 design requirements for seismic events, high winds, and snow loading. The Building TA-50-69 structure has been analyzed to demonstrate that it meets all of these requirements. The ISI is performed annually to ensure that no degradation has occurred that would invalidate the assumptions in the analyses.*

5.6.4 Building TA-50-69 Confinement Ventilation System

The Building TA-50-69 confinement ventilation system is the final barrier between the environment and the facility. The safety function of the confinement ventilation system is to mitigate releases of MAR in conjunction with the WCG and Building TA-50-69 structural integrity. This means that the structure and installed filters must remain functional barriers to radioactive material and withstand damage during derivative design basis accidents (DBAs). This also means that negative differential pressure must be maintained between the WCG and the process area, and a differential pressure must be maintained between the process area and the environment.

The performance criteria for Building TA-50-69 that are not addressed in Section 5.5.3 are as follows:

- The FE-001, FE-002, and FE-003 exhaust train HEPA filters are rated for a 12-hr continuous service of 121 °C (250°F).
- HEPA filter plenum and ductwork must provide a functional confinement barrier in conjunction with the exhaust ventilation system.

The TA-50-69 Confinement Ventilation System is also covered in the TSR by an LCO (see 5.5.3).

Table 5-5. In-Service Inspection Actions for Confinement Ventilation System

In-Service Inspection Actions	Frequency
Visually inspect the Building TA-50-69 and WCG/GBE air exhaust ductwork for degradation or unauthorized modifications.	Annually

Basis: *The exhaust HEPA filters in FE-001, FE-002, and FE-003 must be rated for 12 hrs of continuous service at 250°F. This requirement is based on a fire in the WCG that creates temperatures of approximately 3,000°F. The exhaust air from the WCG is mixed with exhaust from the GBE at about a 9:1 ratio that cools the combustion gases below 250°F before it reaches the HEPA filter plenum, as documented in CALC-11-TA50-0069-006, FE-003 Exhaust Train Temperature [LANL 2011]. This ensures that a fire in the WCG will not challenge the HEPA filters. A time of 12 hr was selected as a conservative time to extinguish the fire. The HEPA filters on FE-001 and FE-002 are protected by the fire suppression system, which will actuate and cool combustion gases*

so that these filters are not challenged. This performance criterion is applicable for procurement of new filters, and no ISI is required.

The HEPA plenum and ductwork is a confinement barrier for potential releases inside the building. To provide this confinement barrier, the HEPA plenum and ductwork must remain intact during normal operations and seismic, wind, and fire events. The HEPA plenums and ductwork are constructed of steel and stainless steel. With the protection of the fire suppression system, the structural integrity of the HEPA plenum and ductwork will not be challenged. The HEPA plenum and ductwork have not been evaluated for seismic or wind, which is an identified vulnerability in the BIO. The ISI is performed annually to ensure that no degradation has occurred that would diminish the capability of the HEPA plenum or ductwork to perform its safety function. For FE-001, the inspection will include the HEPA plenum and up to and including the exhaust fan housing. For FE-002, the inspection will include the ductwork from building TA-50-69 up to and including the HEPA plenum. For FE-003, the inspection will include the ductwork from the WCG/GBE up to and including the exhaust fan housing.

5.6.5 Deleted

Table 5-6. Deleted

5.6.6 Deleted

Table 5-7. Deleted

5.6.7 Waste Characterization Glovebox

The WCG is designated as safety-significant SSC based on its ability to confine radiological material during normal and off-normal conditions. During loss of ventilation or overpressurization events, the WCG provides confinement of radiological material, protecting the glovebox worker from large quantities of airborne contamination. The WCG structure, in conjunction with the WCG confinement, also provides primary confinement of airborne radiological contamination during normal operations and seismic events (see Section 5.5.4).

The performance criterion for the WCG is as follows:

- The WCG shall provide primary confinement for waste material operations and minimize releases to the main process area during normal operation, loss of ventilation, and following a PC-2 seismic event.

Table 5-8 below identifies the ISI requirements for the WCG.

Table 5-8. In-Service Inspection Actions for the WCG

In-Service Inspection Actions	Frequency
Visually inspect the WCG for structural and confinement deterioration.	Annually

Basis: *The WCG serves as a primary confinement barrier to prevent releases from TRU waste during drum repackaging. In conjunction with the WCG ventilation system, the WCG is effective at protecting workers and the public from potential contamination releases. The WCG has been evaluated to withstand PC-2 seismic events. The ISI is performed annually to ensure that no degradation has occurred that would invalidate the assumptions in the analyses.*

5.6.8 TRU Waste Containers (Inside Building TA-50-69)

The TRU waste containers are designated as safety-significant SSCs based on their ability to reduce risks (i.e., frequency or consequence) to workers by limiting the amount of radioactive material that would be released during an accident involving a fire.

The safety functions of TRU waste containers are as follows:

- Provide primary confinement for TRU waste. (SS safety function)
- Mitigate releases of TRU waste subjected to mechanical stresses from postulated accidents. (SS safety function)
- Mitigate releases of TRU waste subjected to thermal stresses from postulated accidents. (SS safety function)
- Prevent accumulation of flammable gases inside the waste containers. (SS safety function)

The TRU waste containers in Building TA-50-69 may be degraded/loss-of-integrity drums with TRU waste. The TRU waste containers must meet the following performance criteria in Building TA-50-69:

- TRU waste containers shall be of noncombustible construction (top, bottom, and sides), excluding any protective covering applied to the drum.
- The TRU waste drum shall be of a design that has had a prototype meet the free drop tests specified in 49 CFR 173.465(c)(1) (CFR 1999).
- TRU waste containers shall have a WIPP-approved, filtered vent to prevent build-up of flammable gases in the container.
- Degraded and loss-of-integrity drums shall be wrapped with a protective covering as a conservative measure.

Only TRU waste containers meeting the performance requirements are accepted for receipt into the WCRRF for processing. Section 5.9.9 includes a detailed receipt inspection for TRU waste containers before acceptance at WCRRF. Because of this SAC and the short residence time at WCRRF, no additional ISI is required.

Table 5-9 identifies the ISI requirements for the TRU waste containers.

Table 5-9. In-Service Inspection Actions for the TRU Waste Containers

In-Service Inspection Actions	Frequency
Ensure that a known degraded drum or TRU waste container exhibiting signs of loss of integrity is wrapped in protective covering.	After removing the TRU waste container from overpack.

Basis: *The TRU waste containers are credited as safety-class components to protect the inventory from accidents in the WCRRF yard area only. Once the TRU waste containers are brought into Building TA-50-69, their safety function is considered safety-significant based on the lower inventory limits and associated accident consequences inside Building TA-50-69. Some drums that require repackaging in Building TA-50-69 may be degraded or exhibit loss of confinement. These drums will be overpacked in safety-class TRU waste containers before being accepted at WCRRF. Once these drums are moved into Building TA-50-69, they will be removed from the overpack containers. After inner drums are removed from their overpacking, the drums must be inspected. Any degraded drum or loss of integrity drum must be wrapped in protective covering for contamination control. If the protective covering is damaged, the protective covering must be repaired.*

The TRU waste containers in Building TA-50-69 protect the inventory from seismic events, fires, deflagrations, and drop scenarios. The noncombustible (excluding any protective covering applied to the drum) construction minimizes the release of inventory from potential fires in Building TA-50-69. Tests have shown that fires involving ordinary combustibles can, at most, overpressurize the TRU waste containers, leading to a breach of drum lids and a minor release of contamination. Fires involving liquid fuel can overpressurize drums so fast that the drums' lids and a portion of the drums' contents can be expelled. For this reason, other controls in the TSRs prohibit liquid fuel in the WCRRF while TRU waste containers are present. The TRU waste containers are also of a design that has been tested in four-foot free-drop tests. This qualification protects the inventory from seismic impacts and drop events during handling. Degraded drums or loss of integrity drums may not meet this qualification, and additional controls are put in place through critical lift plans and the safety-significant drum lift on the WCG to prevent handling accidents with these drums. The vents on the drums allow any flammable gas generated by the TRU waste to safely vent out of the TRU waste container. This prevents the possibility of a drum deflagration or explosion during handling due to the build-up of flammable gas concentrations in the TRU waste container. Verification of the filtered vent opening and the TRU waste container is covered under Section 5.5.9.9 for the outer drum and no further ISI is required. If an inner drum is removed from an overpack, it must be inspected and if it is a degraded drum or exhibits loss of integrity, it must be wrapped in protective covering.

5.7 INTERFACE WITH TSR FROM OTHER FACILITIES

The WCRRF hazard analysis did not identify any formal TSR relationships between adjacent or nearby LANL facilities, because the WCRRF waste container acceptance procedures TSR-AC provides sufficient knowledge and control of radioactive material received at the WCRRF. Metal TRU waste containers that fail to comply with the WCRRF acceptance criteria are not accepted and are outside the scope of the WCRRF TSRs. However, the following safety basis documents have a direct interface with WCRRF operations:

- Transportation Safety Document (TSD). Metal TRU waste containers are transported to and from the WCRRF under this safety basis. The TSR interface is defined by delivery vehicle movement. Upon receipt of a TRU waste shipment, the TSD governs and applies until the vehicle comes to a complete stop at the required location for unloading. For loading activities, the WCRRF Safety Basis applies until all containers are loaded, tied down, and the truck starts moving.
- Documented Safety Analysis for TA-54, Area G. Type 7A TRU waste containers are shipped from Area G to WCRRF. Waste containers coming from Area G must be Type 7A, vented,

and verified to contain ≤ 4% hydrogen concentration and ≤ 8000 ppm volatile organic compounds in their headspaces, including any of the overpacked drums. Degraded drums or drums showing loss of integrity which are overpacked into TRU waste containers must also contain a vent and have undergone headspace gas analysis.

- The TA-50 Radioactive Liquid Waste Facility (RLWF) is connected to Building TA-50-69 floor drains by a pipe to collect fire suppression water. The tanks at the TA-50 RLWF currently do not have the capacity to hold all of the potential fire suppression water from Building TA-50-69, but a new tank farm is being constructed that will provide adequate capacity to support TA-50-69 operations.

5.8 REFERENCES

CFR 1999: *General Requirements for Shipments and Packaging*, 49 CFR 173, U.S. Government Printing Office, Washington D.C., October 1, 1999.

CFR 2001: *Technical Safety Requirements,* 10 CFR 830.205, U.S. Government Printing Office, Washington, D.C., January 1, 2001.

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CFR 2003b: *Occupational Radiation Protection*, 10 CFR 835, U.S. Government Printing Office, Washington, D.C., January 1, 2003.

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CHAPTER 6. PREVENTION OF INADVERTENT CRITICALITY

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Acronyms

ANS	American National Standards
ANSI	American National Standards Institute
CAS	Criticality Alarm System
CLSA	Critical Safety Limit Approval
CSE	Criticality Safety Evaluation
CSO	criticality safety officer
NCSC	Nuclear Criticality Safety Committee
NCSG	Nuclear Criticality Safety Group

6.1 INTRODUCTION

Operations that involve fissile materials may pose the risk of a criticality accident. A criticality accident could result in large, prompt neutron and gamma-ray exposures, up to and including lethal doses, to workers who perform hands-on operations. All operations at LANL involving significant quantities of fissile materials are reviewed for criticality safety. Limits in the form of engineered features and administrative requirements are applied to prevent a criticality accident. The limits associated with each activity provide assurance that risks are maintained at an acceptably low level.

This chapter describes the criticality safety program that is in place to provide the assurance that necessary criticality limits exist for all fissile material operations.

6.2 REQUIREMENTS

Document Number	Title/Description
10 CFR 830	Nuclear Safety Management
ANSI/ANS-8 series	Nuclear Criticality Safety, American National Standards Institute
DOE Order 420.1B	Facility Safety

6.3. CRITICALITY CONCERNS

Operations at LANL involve the use of many actinides, with some present in sufficient amounts that they could pose a criticality accident hazard. The fissile isotopes of major interest are ^{239}Pu, ^{233}U, and ^{235}U. Significant quantity operations require appropriate criticality safety guidance.

For implementation, a *significant quantity* of fissile/fissionable materials for the more common materials in use at LANL is defined as the following:

- 450 g of ^{239}Pu, **or**
- 500 g of ^{233}U, **or**
- 700 g of ^{235}U, **or**
- 450 g of fissile-equivalent combinations of ^{239}Pu, ^{233}U, ^{235}U, **or**
- 5,000 g for plutonium containing >75% ^{238}Pu, **or**
- 5,000 g for plutonium containing >75% ^{242}Pu, **or**
- 5,000 g for ^{241}Am containing <1% plutonium

> **NOTE:** Operations that comply with specific written guidance given under the authority of previous institutional policy significant-quantity definitions remain valid and are not required to be revisited. New operations, or changes to existing operations, are governed by the significant quantity fissile/fissionable material definitions of this policy.

These isotopes may be present in any form (for example, solutions, oxides, compounds, and metals). For the less common fissile/fissionable material, a significant quantity is defined to be equivalent to the single parameter subcritical limits of ANSI/ANS-8.15, *Nuclear Criticality Control of Special Actinide Elements* (ANSI 1981). When clarification is required, the Nuclear Criticality Safety Group (NCSG) is consulted.

Uranium enrichments vary from depleted to highly enriched (>80 wt%). The plutonium is typically weapons-grade (about 6 atom percent of ^{240}Pu). The exception is heat-source applications, which generally have isotopic composition ≥75 wt% of ^{238}Pu (including its decay product, ^{234}U).

6.4 CRITICALITY CONTROLS

Criticality safety limits, requirements, and engineered features are implemented to ensure subcritical configurations under all normal, abnormal, or upset conditions. The controls used to prevent a criticality accident, and the methods used to implement these controls, are developed as part of the criticality safety evaluation (CSE) for these operations. In each case, the double-contingency principle in criticality safety is incorporated in the evaluation and the identification of the criticality controls. Criticality controls are of two general types, engineered and administrative. The following sections briefly describe these controls and the application of the double-contingency principle.

6.4.1 Engineering Controls

Criticality safety for metals is largely inherent in the shapes and masses that are handled. Oxides and nonhydrogenous compounds are typically staged in containers that have volumes small enough to ensure subcriticality for individual containers, even for container-flooding or reflection-upset conditions. Fixed storage racks are designed and constructed with fixed spacing that is sufficient to ensure subcriticality for the allowed fissile material loadings. Some items may be packaged in drums or dollies that provide fixed spacing for floor storage/staging. Engineered features for fissile solutions are typically implemented by limiting the dimensions of process vessels.

6.4.2 Administrative Controls

Administrative controls include limits on fissile quantities; a rigorous procedure review and approval process; and a formal, comprehensive training program. Mass limits for specific locations and workstations are a common administrative requirement. The LANL fissile material accountability system is an important tool that helps workers adhere to the mass limits. A variety of other administrative limits may be used. Examples include limits on moderating or reflecting materials and spacing requirements. Operations personnel are trained on the procedures and the criticality limits for their operations. The keys to safe operations are worker and first-line supervisor knowledge, awareness, and safety consciousness in following written and approved procedures. In the event of either a suspected criticality limit violation or an emergency evacuation alarm, there are governing procedures, and personnel are trained on how to respond.

6.4.3 Application of Double Contingency

The double-contingency principle states:

> Process designs should incorporate factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

Here, a *change in process conditions* is understood to mean a situation that is significantly outside the normal range of relevant process parameters such as mass or moderation. This *change* may be caused by one or more events (for example, failure to correctly record the mass in a container).

The double-contingency principle implies that one should have limits on multiple relevant process parameters. Providing multiple limits or barriers (i.e., defense–in-depth) is a fundamental approach to safety. Hence, the double-contingency principle is useful for developing criticality limits. However, the principle is secondary to the fundamental precept of determining that the entire process will be subcritical under both normal and credible abnormal conditions because the double-contingency principle cannot be applied to every situation. For example, contaminated waste collection typically relies solely on mass limits.

6.5 CRITICALITY SAFETY PROGRAM

Criticality safety is a line management responsibility, with significant support provided by the NCSG. Oversight is provided by various review mechanisms, such as focused or special review committees [e.g., Nuclear Criticality Safety Committee (NCSC)], the NCSG, management self-assessments, and external review entities. The Laboratory has long recognized the importance of a multifaceted criticality safety program to minimize the risk of a criticality accident.

6.5.1 Criticality Safety Organization

The organization of the criticality safety program is based on three key components:

- Line organizations that are responsible for fissile material activities
- The Nuclear Criticality Safety Group
- An oversight program that includes periodic review

The group leader of the organization that requests the criticality safety limits approves them based on the technical recommendations from the NCSG.

6.5.1.1 Nuclear Criticality Safety Group

An institutional-level organization, the NCSG provides day-to-day guidance on criticality safety to operating groups and organizations that work with significant quantities of fissile materials. Functions and services provided by the NCSG include the following:

- Developing guidance in the form of documented CSEs for significant quantity fissile/fissionable operations as requested by organizations, programs, and projects in accordance with applicable federal and state governmental standards and regulations.
- Developing guidance for the design, construction, maintenance, and operation of equipment and facilities that are used to receive, store, transport, or process significant quantities of fissile/fissionable materials as requested by organizations, programs, and projects in accordance with applicable federal and state governmental standards and regulations.
- Providing guidance on the establishment and implementation of criticality safety administrative requirements and engineered features.
- Participating in periodic assessments of the Nuclear Criticality Safety Program as implemented by the operating organizations.
- Interpreting and providing guidance on the implementation of DOE orders, ANSI standards, and the LANL Nuclear Criticality Safety Program.
- Maintaining familiarity with LANL significant-quantity operations.
- Providing criticality safety guidance to the DOE and its management and operating contractors about LANL facility issues.
- Providing criticality safety training to LANL operating groups as requested.

6.5.1.2 Laboratory Nuclear Criticality Safety Committee

The institutional NCSC is composed of experienced LANL staff with practical and theoretical work experience pertaining to fissile material operations. The NCSC reports to the Laboratory Director. Functions performed by the committee include the following:

- Periodic review and appraisal of the criticality safety program at LANL.
- Reporting as needed to the Laboratory Director's Office on the LANL criticality safety posture.

6.5.2 Criticality Safety Plans and Procedures

As a part of the review and appraisal process, the NCSG reviews procedures involving processing, handling, staging, or transporting significant quantities of fissile materials. Operating groups review their procedures periodically (typically every two years) for content and correctness. Procedures are revised whenever a change is made to an operation.

6.5.3 Criticality Safety Training

The most important training that personnel receive is on-the-job training. On-the-job training includes certification of workers to process-specific procedures for processing, handling, staging, or transporting fissile material. The NCSG provides additional criticality safety training to groups, teams, or individuals when requested. This additional training is tailored to the audience, with emphasis on the limits relevant to their activities.

6.5.4 Determination of Operational Nuclear Criticality Limits

The determination of operational nuclear criticality limits is based on the fundamental guidance for nuclear criticality safety from ANSI/ANS 8.1, *Nuclear Criticality Safety in Operations with*

Fissionable Materials Outside Reactors, Section 4.1.2, "Process Analysis," (ANSI 1988) which states:

> Before a new operation with fissionable materials is begun or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions.

At LANL, all CSEs are based on this fundamental guidance.

6.5.5 Criticality Safety Evaluations and Limits

Limits to ensure criticality safety are based on identifying credible abnormal conditions for each process. The influences of neighboring operations are also considered. An important aspect of the criticality safety program is the extensive communication between the NCSG and operations personnel. This communication includes determining the range and credibility of potential abnormal conditions (or credible upsets). These abnormal conditions are associated with the parameters that influence criticality safety: mass, volume, concentration/density, moderation, reflection, poisons, enrichment, interaction (spacing), and geometry (shape). Criticality safety limits are developed jointly by operations personnel, including management as appropriate, and the NCSG staff.

The CSEs are performed using professional judgment and a graded approach for the particular activity. Evaluations may include comparison to experimental values, comparison to generally accepted subcritical or critical limits, simple computational methods, and computer code results. Simple computational methods include buckling, density scaling, solid angle, and limiting surface density. Computational codes that are commonly used by the NCSG include discrete ordinate codes (e.g., DANTSYS) and Monte Carlo codes (e.g., KENO and MCNP). These codes may use multigroup or continuous-energy cross-section libraries. All computational codes relied on for determining the safety margin for an actual operation are validated in accordance with applicable standards and regulations.

The CSEs are peer-reviewed for adequacy and technical correctness. Completed CSEs are provided to the requester, and the NCSG keeps copies on file. The CSEs recommend limits that provide a safety margin sufficient to accommodate credible process upsets through a combination of engineered features and administrative requirements.

6.5.6 Criticality Safety Inspections/Audits

Each operating organization conducts periodic safety reviews of its operations, and includes the NCSG for areas where significant quantities of special nuclear material are handled, stored, or processed. Laboratory management is responsible for conducting walkaround reviews of their operations, including criticality safety where applicable.

In addition, the NCSC conducts periodic criticality safety appraisals. These appraisals are conducted by a multidisciplinary team that includes an NCSG staff member. Results of all appraisals are documented, with copies distributed to the respective groups, division management, and the NCSG.

6.5.7 Criticality Infraction Reporting and Followup

At LANL, all criticality safety limit infractions are reviewed according to the applicable DOE orders and LANL program or procedure. These reviews are based on an evaluation of the criticality-limit infraction. This process includes determining the severity of the infraction and subsequent reporting commensurate with the severity level. Once a potential criticality limit infraction has been discovered, the following steps are taken.

Table 6-1. Reporting and Followup of Criticality Infraction

Personnel	Action
Operating, Supervision, or Other Personnel	1. If it is suspected or known that an infraction has occurred: a. Stop work as soon as safely possible. b. Step away from the situation (arms length or greater). c. Control access. Do not allow personnel into the area until directed to do so by management or supervision. d. Do not attempt to recover from the situation (e.g., moving items, collecting solution from leaking vessels). e. Notify supervision and/or management. 2. Provide information to supervision, management, and the NCS organization for the events surrounding the possible infraction as requested. Note: Process supervision, operating and facility management, and the NCS Group will make a joint determination that a criticality safety infraction has occurred.
Operating Organization Supervision and Management	1. Respond to any situation that is known or suspected to be outside the NCS **limits** as defined in CSLAs, NCS-related procedures, or NCS-related implementing documents. 2. Make any required notifications, e.g., operations center, facility management, occurrence reporting organization. 3. Notify the NCS Group 4. Gather information regarding the specifics of the suspected infraction. Note: It is not necessary to gather causal information at this point. 5. Consult relevant Criticality Safety Evaluation Documents, CSLAs, postings, or other implementing documents as necessary. 6. Work with the NCS Group, facility management, and other relevant personnel, e.g., CSO, process subject matter experts, as necessary and determine if an infraction has occurred. 7. If an infraction has NOT occurred, a. No further action is required. b. Process supervision may authorize resumption of work.

	c. The incident should be examined by process supervision and the NCS Group to determine if i. Lessons learned should be communicated to other personnel. ii. Improvements can be implemented to reduce future misunderstandings. 8. If an infraction HAS occurred, a. Work with the NCS Group, facility management, and other relevant personnel to develop and implement corrective actions as soon as safely possible. Note: Depending on the severity of the event and the complexity of the corrective actions, the instructions may be verbal (phone, radios, etc.) or in writing. b. Assess the infraction against the reporting criteria in applicable Department of Energy Orders and make notifications as warranted. c. The NCS Group should be consulted as soon as possible to assign a severity index and to determine if the infraction is reportable. If the NCS Group cannot be contacted, categorize the event or condition at the higher level under consideration. Infractions must also be reviewed under other categories of DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information*, to determine if the infraction is reportable. d. Notification as to the suspected infraction and severity index must then be made to the appropriate directorates. 9. After the notification and corrective action process, perform critiques or reviews with appropriate personnel to determine a. Causes, b. Whether lessons learned should be communicated to other personnel, and c. If improvements can be implemented to reduce or eliminate the likelihood of future recurrence. 10. Document, as appropriate, the results of critiques or reviews. Enter agreed upon remedial, improvement, or corrective actions into the appropriate monitoring system to ensure that the actions are completed and monitored to closure. 11. Communicate Lessons Learned, if applicable, to appropriate personnel within the operating organization and to management of other organizations involved in the situation.

Lessons learned from operational experience and criticality limit infractions are incorporated into criticality-limit evaluations, as appropriate. In its history of fissile material operations at LANL, only minor procedural violations have been observed and none has resulted in significant inroads into criticality safety margins.

6.6 CRITICALITY INSTRUMENTATION

The purpose of a Criticality Alarm System (CAS) is to reduce risk to personnel by initiating prompt evacuation if a criticality accident occurs. Evaluation of the overall risk should recognize

that hazards result from false alarms and subsequent sudden interruption of operations and relocation of personnel. Therefore, the decision to install a CAS is based on an evaluation of net risk. The need for an alarm system is evaluated for all activities involving significant quantities of fissile material. Where a CAS is installed, appropriate emergency response plans or procedures are implemented and maintained. For WCRRF, the evaluation of the need for a CAS, in accordance with ANSI/ANS 8.3, has determined that a CAS is not required.

6.7 REFERENCES

ANSI 1981: *Nuclear Criticality Control of Special Actinide Elements,* ANSI/ANS-8.15-1981; R2005, American National Standards Institute, Washington, D.C., 1981.

ANSI 1988: *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, ANSI/ANS 8.1-1998, American National Standards Institute, Washington, D.C., 1988.

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