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Documented Safety Analysis for the B695 Segment

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Weapons and Complex Integration

Radioactive and Hazardous Waste Management Division

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Lawrence Livermore National Laboratory

Lawrence Livermore National Security, LLC

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AC	Administrative Control
ADM	Administrative
AEGL	Acute Exposure Guideline Level
ALARA	As low as reasonably achievable
ARES	Amateur Radio Emergency Services
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
ConOPs	Conduct-Of-Operations
CQT	Consequence Assessment Team
D&D	Decontamination and Decommissioning
DBE	Design basis earthquake
DBFl	Design basis flood
DBW	Design basis wind
DELCD	Dry Electrolytic Conductivity Detector
DF	Design feature
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DTSC	Department of Toxic Substances Control
DWTF	Decontamination and Waste Treatment Facility
EAL	Emergency Action Level
EIS	Environmental Impact Statement
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EPD	Environmental Protection Department
ERO	Emergency Response Organization
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety, and Health
ESH&Q	Environment, Safety, Health and Quality
EV/A	Emergency Voice/Alarm

FACU	Fire Alarm Control Unit
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Act
FGE	Fissile gram equivalent
FID	Flame Ionization Detector
FPE	Fire Protection Engineer
FPOC	Facility Point Of Contact
FSP	Facility Safety Plan
GAS	Gas absorption system
GC	Gas chromatograph
GC/MS	Gas chromatograph/mass spectrometer
HAZWOPER	Hazardous Waste Operations and Emergency Response
HC-2	Hazard Category-2
HEPA	High-efficiency particulate air
HP	Health Physics
HVAC	Heating, ventilating, and air conditioning
HWCL	Hazardous Waste Control Law
IC	Incident Commander
ICBO	International Conference of Building Officials
IH	Industrial Hygiene
IS	Industrial Safety
ISM	Integrated Safety Management
IWS	Integration Work Sheet
LCO	Limiting Condition for Operation
LCW	Low-conductivity water
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security
LLW	Low-level waste
LSC	Liquid Scintillation Counter
LWPA	Liquid Waste Processing Area
LWPB	Liquid Waste Processing Building
MAPP	Methylacetylene-propadiene
MAR	Material at risk
MOU	Memorandum of Understanding
MUSD	Maintenance Utilities Services Division
NARAC	National Atmospheric Release Advisory Center
NCAR	Nonconformance and Corrective Action Report

NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NIF	National Ignition Facility
NPDES	National Pollutant Discharge Elimination System
NPH	Natural phenomena hazard
OEL	Occupational Exposure Limit
OES	Office of Emergency Services
OJT	On-the-job Training
OSHA	Occupational Safety and Health Administration
PAG	Protective Action Guide
PAS	Passive Air Sampler
PATS	Packaging and Transportation Safety
PC-2	Performance Category 2
PE-Ci	Plutonium equivalent curies
PEL	Permissible Exposure Limit
PID	Photoionization detector
PLC	Programmable Logic Controller
POGS	Process Off-Gas System
POTW	Publicly Owned Treatment Works
PPE	Personnel protective equipment
PrHA	Process Hazard Analysis
PVC	Polyvinyl chloride
QA	Quality Assurance
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RHWM	Radioactive and Hazardous Waste Management
RWPA	Reactive Waste Processing Area
RWQCB	Regional Water Quality Control Board (State of California)
RWSA	Radioactive Waste Storage Area
SOP	Standard Operating Procedure
SP	Safety Plan
SS	Safety-significant
SSC	Structure, system, or component
STLC	Soluble Threshold Limit Concentration
SVOC	Semi-volatile organic compound
SWB	Standard waste box

SWPA	Solid Waste Processing Area
SWPB	Solid Waste Processing Building
TCLP	Toxic Characteristic Leaching Procedure
TEEL	Temporary Emergency Exposure Limit
TIM	Training Implementation Matrix
TLV	Threshold Limit Value
TQ	Threshold Quantities
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSD	Treatment, storage, and disposal
TSR	Technical Safety Requirement
TTLC	Total Threshold Limit Concentration
UBC	Uniform Building Code
UL	Underwriter's Laboratory
USQ	Unreviewed safety question
VOC	Volatile organic compound
WAC	Waste Acceptance Criteria
WCI	Weapons and Complex Integration
WIPP	Waste Isolation Pilot Plant
WDR	Waste Disposal Requisition
RHWM	Radioactive and Hazardous Waste Management (LLNL Division)
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

Ex.1 Facility Background and Mission

This Documented Safety Analysis (DSA) was prepared for the Lawrence Livermore National Laboratory (LLNL) Building 695 (B695) Segment of the Decontamination and Waste Treatment Facility (DWTF). The report provides comprehensive information on design and operations, including safety programs and safety structures, systems and components to address the potential process-related hazards, natural phenomena, and external hazards that can affect the public, facility workers, and the environment. Consideration is given to all modes of operation, including the potential for both equipment failure and human error.

The facilities known collectively as the DWTF are used by LLNL's Radioactive and Hazardous Waste Management (RHWM) Division to store and treat regulated wastes generated at LLNL. RHWM generally processes low-level radioactive waste with no, or extremely low, concentrations of transuranics (e.g., much less than 100 nCi/g). Wastes processed often contain only depleted uranium and beta- and gamma-emitting nuclides, e.g., ^{90} Sr, ^{137}Cs, or ^{3}H. The mission of the B695 Segment centers on container storage, lab-packing, repacking, overpacking, bulking, sampling, waste transfer, and waste treatment. The B695 Segment is used for storage of radioactive waste (including transuranic and low-level), hazardous, nonhazardous, mixed, and other waste. Storage of hazardous and mixed waste in B695 Segment facilities is in compliance with the Resource Conservation and Recovery Act (RCRA).

LLNL is operated by the Lawrence Livermore National Security, LLC, for the Department of Energy (DOE). The B695 Segment is operated by the RHWM Division of LLNL. Many operations in the B695 Segment are performed under a Resource Conservation and Recovery Act (RCRA) operation plan, similar to commercial treatment operations with best demonstrated available technologies. The buildings of the B695 Segment were designed and built considering such operations, using proven building systems, and keeping them as simple as possible while complying with industry standards and institutional requirements. No operations to be performed in the B695 Segment or building system are considered to be complex. No anticipated future change in the facility mission is expected to impact the extent of safety analysis documented in this DSA.

Ex.2 Facility Overview

The B695 Segment includes Building 695, Building 696S, and associated yard areas. **Figure 1-1** shows the layout of the buildings in the segment. The B695 Segment is located in the northeast quadrant of the LLNL main site. The LLNL main site is roughly 3.2 km^2 in size and is located approximately 64 km east of San Francisco in the Livermore Valley in southern Alameda County, California. Distances, in the four ordinal directions, from the B695 Segment to the LLNL site boundaries are: North, 0.18 km; East, 0.17 km; South, 1.5 km (approximate); and West, 1.5 km (approximate). The B695 Segment is bounded by the North Outer Loop to the South; DWTF Storage Area to the East; the LLNL site boundary to the North; and Avenue T to the West (Figure 1-1 shows details). The National Ignition Facility (NIF) is located on the south side of the B695 Segment across North Outer Loop. Other onsite LLNL facilities that could be primarily affected by a potential release of radioactive materials from the B695 Segment directly support waste management operations and are nuclear facilities themselves having larger inventories of radionuclides.

Significant external interfaces include utilities, fire support, and medical support. Electrical power is provided to LLNL by Western Area Power and PG&E via overhead lines to the Laboratory redistribution substations. Power distribution to the northeastern portion of the LLNL main site, in which the B695 Segment is located, is via underground lines. LLNL main site water supply is from the Hetch Hetchy Aqueduct, which currently supplies all site needs. The South Bay Aqueduct is a source of backup water supply for the LLNL main site. LLNL maintains a large staff of emergency response personnel, including an onsite Alameda County Fire Department, ambulance services, security services, and a fully staffed medical facility. A communications system is maintained specifically for emergency control purposes.

Ex.3 Facility Hazard Classification

Hazard Category

The B695 Segment is a Hazard Category 3 nuclear facility. The facility fissile material inventory controls mitigate the possibility of a criticality event, and the facility will not exceed HC-2 threshold quantities identified in Table A-1 of DOE-STD-1027-92, Change Notice No. 1, Attachment 1, Threshold Quantities for a HC-2 Nuclear Facility. RHWM has determined that operations can be performed using 56 plutonium-equivalent curies (PE-Ci) as the inventory limit for radionuclides in the facility. Furthermore, the total quantity of trace chemicals in the facility are maintained below their individual TPQs established in 10 CFR 1910.119 and in 40 CFR 355, except sulfuric acid which is limited to 400 gallons in the storage tank. The initial chemical categorization is moderate hazard based on inventory of sulfuric acid/hydrogen peroxide, but final categorization is low hazard based on the estimate of consequences determined by conservative modeling.

Segmentation

The B695 Segment consists of B695, the solid waste processing area (SWPA) in B696 (referred to as B696S), and their associated yard areas. Figure 2-1 shows the segmentation and boundary area. Segmentation is used to avoid placing excessive requirements on co-located operations at the DWTF. Segmentation of the B695 Segment, with respect to the remainder of RHWM facilities, was performed by considering future operations in the DWTF as well as existing operating facilities. Many areas in and around DWTF Radioactive and Hazardous Waste Management Division facilities include operations with little or no radionuclides. Walls, fences and gates, and/or separation isolate support structures for the nuclear segment. The segmentation is consistent with DOE-STD-1027-92, Change Notice No. 1, Attachment 1, Hazard Categorization of DOE Nuclear Facilities, Facility Segmentation, and the concept of independent facility segments are applied where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon. See Appendix E of this DSA for further details on segmentation of DWTF.

Ex.4 Safety Analysis Overview

Facility Operations Analyzed in the DSA

The following waste storage and handling operations occur in the B695 Segment:

- Receiving, moving, staging, sorting, segregating, size reducing, and repackaging hazardous and nonhazardous solid waste, including Toxic Substance Control Act (TSCA)-regulated waste.
- Lab-packing and overpacking operations.
- Moving, staging, storing, and repackaging radioactive and regulated waste.
- Sorting, segregating, and repackaging radioactive and regulated waste in the B696S glove box and Waste Packaging Unit.
- Sewer waste management to meet discharge standards.
- Waste sampling, transferring, and bulking.
- Waste blending, evaporation, centrifugation, filtration, solidification, and small-scale treatment.

The hazard analysis presented in this DSA uses a graded approach, as defined in DOE-STD-1027-92, Change Notice No. 1, to determine the level of analysis to be applied to each identified hazard. The Process Hazard Analysis (PrHA) methodology was employed to identify and characterize hazards and to perform a systematic evaluation of potential hazardous events. From the hazard analysis team's knowledge and experience with the segment's systems and operations, accident scenarios were developed on the basis of identified hazards. The methodology used to support the hazard evaluation was a modification of the hazard analysis method described in the American Institute of Chemical Engineers, Guidelines for Hazard Evaluation Procedures, and is consistent with DOE-STD-3009-94, Change Notice No. 3. In general, the hazard evaluation consisted of a three-step process to:

1. Systematically evaluate hazards and develop accident sequences.
2. Qualitatively assess frequencies and consequences to determine the potential impact on health and safety of the public and workers.
3. Use the results to identify appropriate preventive and mitigative controls.

Facility equipment, material, environmental factors, and support were considered on a macroscopic level. The PrHA is applicable for relatively simple systems and procedures and for identifying potential accidents.

Significant Hazards

The following conditions, which could impact the radioactive material inventory at the B695 Segment and potentially lead to a release, were investigated:

- Operational events, including vehicle accidents, equipment malfunctions, chemical reactions, spills, fires, and explosions.
- Natural phenomena, including flooding (design-basis flood), extreme wind (design-basis wind), earthquake (design-basis earthquake), and lightning.
- External events, including accidents at nearby facilities, toxic chemical release, fire, projectile, and aircraft accidents.
- Criticality events, including liquid and solid waste processing, and container storage.

The principal hazards in the B695 Segment are in the form of chemical and radioactive material. Scenarios identified in the PrHA involve liquid spills, solid spills, fires, and deflagrations caused by one or more of the following: vehicle accidents, equipment malfunction, and chemical reactions. Some scenarios could involve human error.

In addition, chemical hazards were evaluated. The ALOHA[tm] air-release modeling software package was used to analyze potential offsite impacts resulting from chemical hazards associated with B695 Segment operations. ALOHA, which stands for Areal Location of Hazardous Atmospheres, was developed for and adopted by the EPA Chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office (NOAA) of Response and Restoration. Its purpose is to assist chemical emergency planners and first responders in predicting how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release. To meet the requirements for a low chemical hazard facility, air releases cannot lead to exposures that would exceed TEEL–2 thresholds offsite and TEEL-3 thresholds to the receptor at 100 meters. In all cases, results of the modeling yielded TEEL values that do not exceed the threshold values that would classify this facility as a greater risk than low hazard.

Preventive and Mitigative Features

The following are safety-significant SSCs at the B695 Segment:

- Approved TRU waste containers for storage of TRU waste.
- B695 and B696S structural systems and significant appurtenances (i.e., crane seismic restraints).
- The partition between B696S and B696R.

The following are specific administrative controls at the B695 Segment identified from the PrHA:

- The total radioactive material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalent (FGE).
- The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 FGE based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the National Environmental Policy Act (NEPA) limits.
- All TRU waste shall be stored in approved TRU waste containers.
- TRU waste stored in approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.
- TRU waste shall not be staged outside the building for more than 36 hours.

The following are programmatic controls at the B695 Segment identified from the PrHA:

- Configuration Management Program as part of Chapter 17 (Management, Organization, and Institutional Safety Provisions)

- In-service Inspection & Test Program and Maintenance Program as part of Chapter 10 (Initial Testing, In-Service Surveillance, and Maintenance)
- Emergency Preparedness Program Chapter 15
- Hazardous Material Protection Program Chapter 8
- Radiation Protection Program Chapter 7
- Fire Protection Program as part of Chapter 11 (Operational Safety)
- Traffic Control Program as part of Chapter 11 (Operational Safety)
- Training Program as part of Chapter 12 (Procedures and Training)
- Criticality Safety Program Chapter 6

Ex.5 Organizations

The following organizations are involved with construction, operation, or support of the B695 Segment:

- Architect–engineer responsible for facility design: Parsons Infrastructure and Technology Group, Inc., Pasadena, California.
- Prime contractor responsible for construction: GSE Inc., Livermore, California.
- Facility operation: RHWM.
- Facility maintenance: Maintenance requirements and frequency are set by RHWM. Maintenance is performed by RHWM maintenance personnel and by personnel from LLNL Plant Engineering, and Hazard Control.
- Facility safety: Joint responsibility of the Environmental Protection Department, RHWM, onsite Alameda County Fire Department, and Hazard Control Department ES&H Team 1.
- DSA development: This DSA was developed by RHWM personnel and reviewed by other institutional organizations, including Safety Basis Division personnel.

Ex.6 Safety Analysis Conclusions

As a result of the hazard evaluation, no specific design or operational safety improvement changes were identified. It is concluded that the overall mitigated risk to workers, the public, and the environment from activities and operations at the B695 Segment is low. No issues significant to the facility safety basis currently recognized by facility operators require further resolution.

Ex.7 DSA Organization

The structure and content of the 17 chapters of this DSA follow the format delineated in DOE-STD-3009-94, Change Notice No. 3. In addition, Appendix A presents the results of the Process Hazards Analysis (PrHA) performed on the B695 Segment for waste operations, natural phenomena hazards, and external events. Appendix B describes the approach used in, and presents results of, the chemical hazards analysis. Appendix C describes methodology to normalize TRU and non TRU isotopes to plutonium-equivalent Curies (PE-Ci). Appendix D lists design parameters for the B695Segment. Appendix E contains the Segmentation Justification for the B695 Segment of the DWTF.

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CHAPTER 1
SITE CHARACTERISTICS

1.1 Introduction

This chapter provides an overview of the Building 695 (B695) Segment, focusing on a description of site characteristics necessary for understanding the facility and its operations, as discussed in this Documented Safety Analysis (DSA). Information is provided that supports the assumptions in the hazard and accident analyses used to identify and analyze potential external and natural phenomena accidents. Supportive information is provided in the sections on site description (geography, demography), environmental description (meteorology, hydrology, and geology), natural phenomena threats, external artificially created threats, nearby facilities, and the validity of existing environmental analyses.

The B695 Segment is a low chemical hazard, Hazard Category 3 nuclear facility. Most of Chapter 1 is an overview of the facility, site characteristics, and facility boundaries. Complete discussions of geology, seismology, demography, local and regional meteorology, climatology, regional land- and water-use patterns, and hydrology are presented in Volume I, Section 4, of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE2005). The EIS/EIR provides additional information on the physical and geological setting of Lawrence Livermore National Laboratory (LLNL).

1.2 Requirements

This report was prepared in accordance with U. S. Department of Energy 10 CFR 830, Subpart B and DOE Standard 3009-94, Change Notice 3. Various references in the requirements sections of this report have been cited in Chapters 1 through 17. The references include applicable requirements that are derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other necessary requirements.

1.3 Site Description

The B695 Segment is within the DWTF area, which is located in the northeast corner of the LLNL site between North Outer Loop Drive and the site boundary. **Figure 1-1** shows the general layout of the B695 Segment, and **Figure 1-2** shows the location of the DWTF within the LLNL site. The B695 Segment is described in more detail in Chapter 2.

Figure 1-1. Layout of the B695 Segment

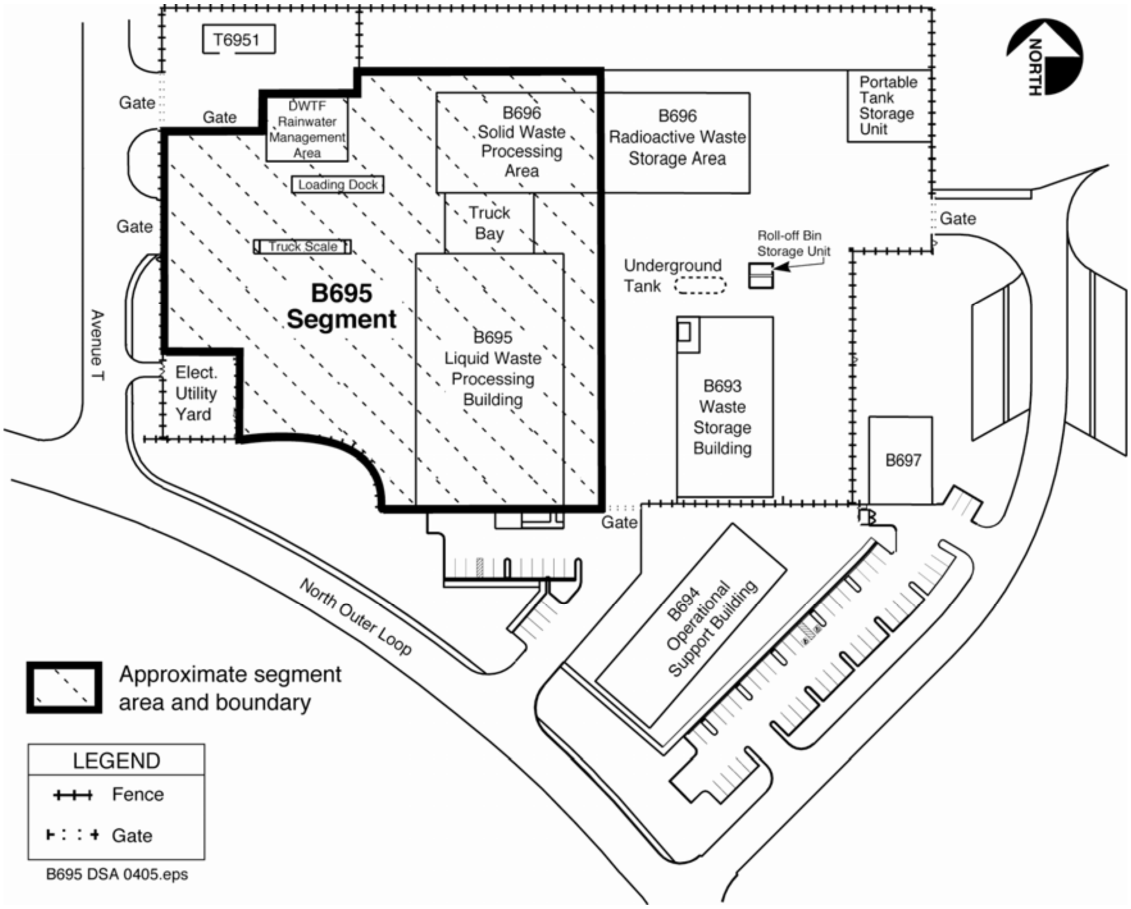
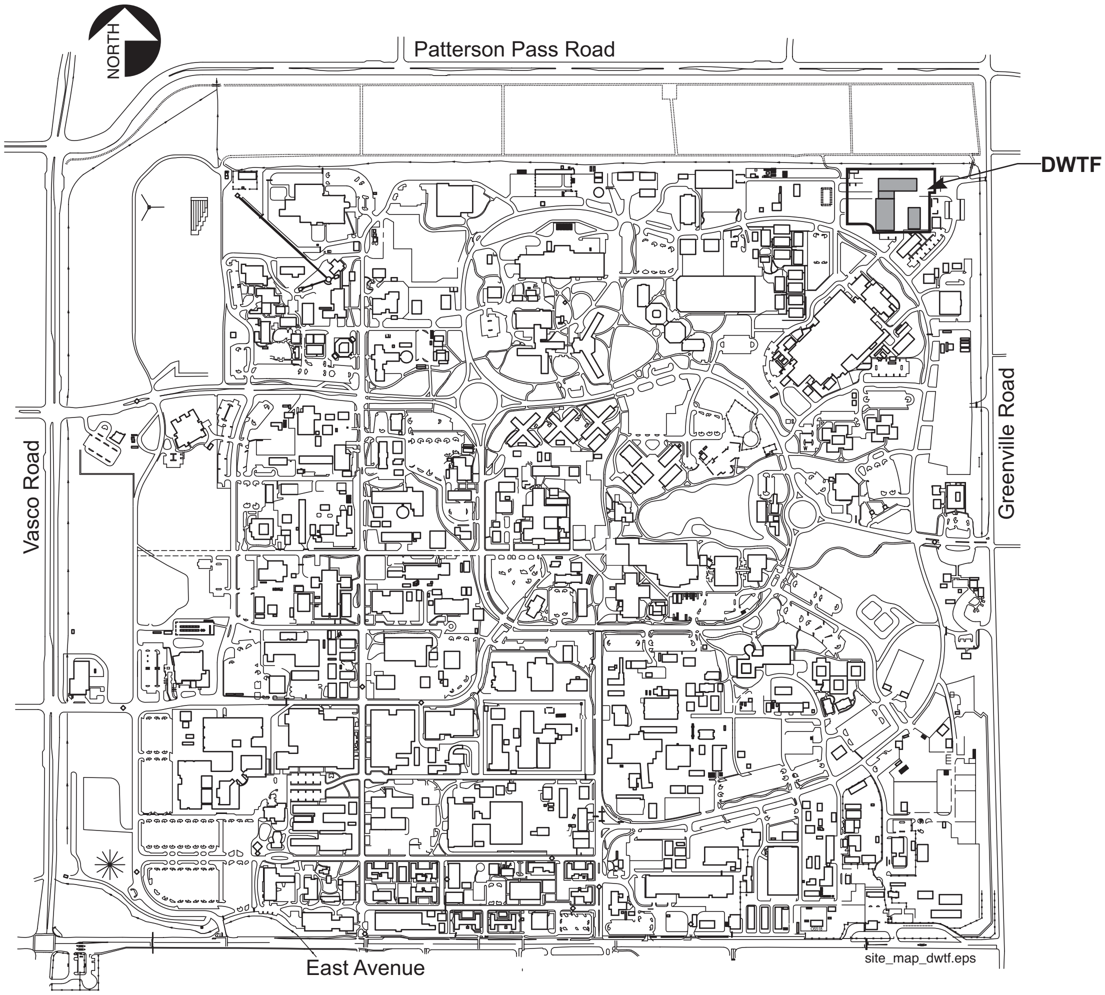


Figure 1-2. Layout of LLNL site and location of the DWTF



1.3.1 Geography

LLNL occupies an area of approximately 3.2 km^2 (1.3 mi^2, or 821 acres) approximately 64 km (40 mi) east of San Francisco at the southeast end of Livermore Valley in Alameda County, California. The Livermore Valley is surrounded by hills that define the region and open space around the development on the valley floor. The terrain in the vicinity of the LLNL site ranges from relatively flat land to gently rolling hills. The hills east and south of LLNL gradually become steeper as they trend eastward to form the Altamont Hills of the Diablo Range.

The topographic surface at the LLNL main site is of low relief and slopes gently to the northwest. Site elevation is 675 ft above sea level at the highest point in the southeast corner. Slopes or grades of the surrounding area range from 1% to 3.4%, except for the few stream banks or sides of drainage ditches, where slopes or grades average 50%.

Significant man-made features include an earth fill embankment on the Arroyo del Valle forming the Del Valle Reservoir 11 km southwest of the site. Livermore Municipal airport is located 10 km west of the site. The local DWTF elevation is approximately 600 feet (611 ft NGVD) and no major bodies of water threaten DWTF for any Natural Phenomenon Hazard.

1.3.2 Demography

The city of Livermore's central business district is located approximately 5 km (3 mi) to the west of the LLNL main site. The LLNL main site is bordered on the east by Greenville Road, on the north by Patterson Pass Road, on the west by Vasco Road, and on the south by East Avenue. The area surrounding the DWTF and the LLNL site is generally rural and surrounded by hills. Rural residences and grazing land are the primary land uses to the south and east of the site. The rural character continues to the southwest, where large vineyards are located. West of the site, existing and newly constructed residential areas of the city of Livermore extend to the LLNL site boundary. The area extending north from LLNL to Interstate Highway 580 is industrial and includes research, business, and industrial sites. Primary features in this area are one- and two-story industrial buildings, business parks, and railroad lines that traverse the area. The population of Alameda County in the year 2001 was 1,476,000 (State of California 2002).

1.4 Environmental Description

1.4.1 Meteorology

The mean annual temperature at LLNL for the 30-year period from 1951 through 1980 was 14°C (58°F). The Livermore Valley has mild, rainy winters and warm, dry summers. Most rainfall occurs between October and April. The greatest and lowest annual rainfalls on record were 30.6 in. (1982–83) and 6.1 in. (1975–76 and 1976–77), with a 25-year average of 13.3 in. (Thorpe 1990).

During summer months, winds are predominantly from the south or southwest, as a result of sea breeze. During winter months, winds are more evenly distributed because of the passage of winter storms and because of the smaller temperature differential between the land surface and ocean water. Wind speeds measured at the 10-m meteorological tower located at the LLNL site range from calm winds (0 to 1 m/sec) to more than 10.8 m/sec. The frequency of wind speed greater than 10.8 m/sec is 0.07% of the time. The frequency of wind speeds ranging from 0 to 1.3 m/sec is 39% of the time, due to typically calm nights.

Table 1-1 summarizes meteorological data for the Livermore site (Gouveia 1989).

Table 1-1. Meteorological data for the Livermore site

Stability class	A	B	C	D-day	D-night	E	F
Annual normalized frequency (%)	10.8	5.8	11.7	14.7	25.2	12.8	19.0
Z_m (height of inversion layer, m)	1200	1050	900	750	700	570	400

1.4.2 Hydrology

LLNL is located at the eastern end of the Livermore Valley groundwater basin. Recharge to the basin is largely from arroyos that originate in the foothills, including Arroyo Seco and Arroyo Las Positas, which cross the LLNL site. The B695 Segment is not located within the 100-yr flood plain. No springs are identified on the USGS (1981) topographic map within 1 mile of the LLNL main site. Components of the public water supply system within 1 mile of the LLNL main site include the South Bay Aqueduct and the Patterson Pass Reservoir and Water Treatment Plant.

Within the Livermore Valley, uppermost saturated sediments are commonly unconfined. Interbeds and interlenses of low-conductivity sediments within the saturated zone act as local aquitards, which tend to confine the deeper water-bearing zones (Thorpe 1990). The two most important formations that contain groundwater are Quaternary alluvial deposits and the Plio-Pleistocene Livermore Formation. The Livermore Formation is generally of lower permeability than the overlying deposits, but it commonly contains significant water-bearing zones. The LLNL area groundwater locally recharges by percolation through the valley alluvium and by infiltration via Arroyo Seco and Arroyo Las Positas as well as from unlined drainage ditches. A recharge basin located south of the LLNL main site is a significant source of groundwater recharge. The basin receives treated groundwater from the southwest portion of the LLNL main site. An artificially constructed drainage retention basin, (located near the center of the LLNL main site, has been lined to prevent infiltration of storm water and treated groundwater from proposed groundwater extraction well locations.

The depth to the water table beneath the LLNL main site currently ranges from approximately 30 to 110 ft. Groundwater ranges from excellent to poor quality and has been used for industrial, agricultural, and domestic purposes (CDWR 1974).

In general, groundwater flows toward the east–west longitudinal axis of the Livermore Valley and then in a westward direction to the gravel pit mines and municipal water supply wells near Livermore and Pleasanton. Vertical movement of water between the lower member of the Livermore Formation and the overlying alluvial sediments is restricted by permeability differences and by internal stratification within these sedimentary units. At the LLNL main site, the upper 15 to 60 ft of the lower member of the Livermore Formation is known to act as an aquitard (Thorpe 1990). Under the LLNL main site, contact between distinctively colored units in the lower member of the Livermore Formation generally dips to the west and is found between approximately 25 and 400 ft below ground surface. For a 2000 year flood, the flood depth has been estimated to be 9 inches.

1.4.3 Geology

The LLNL main site lies in the California Coastal Range province between San Francisco Bay to the west and the northern San Joaquin Valley to the east. The Livermore Valley is generally of low relief, but contains scattered groups of hills that rise to 150 ft above the valley floor. The valley is surrounded by the Tassajara Hills and Mount Diablo to the north, the Altamont Hills to the east, the Diablo Range to the south, and the Hayward Hills to the west.

The Livermore Valley is an east–west-trending synclinal structure composed primarily of gently deformed alluvial deposits overlying complexly deformed Cenozoic and Mesozoic rocks. The California Coast Range in the Livermore region consists of north-to-northwest-trending mountain ranges and valleys bounded by faults. Most faults in the region are right-lateral strike-slip faults associated with the San Andreas Fault system. The Calaveras Fault to the west, and the Greenville Fault to the east, border the Livermore Valley.

The oldest rock units exposed in the Livermore area consist of the highly deformed sedimentary, igneous, and metamorphic rocks of the Jurassic–Cretaceous Franciscan Assemblage. The Cretaceous Great Valley Sequence, consisting of alternating beds of sandstone, siltstone, and shale, structurally overlies these rocks. Both of these units are intricately folded and faulted in the mountains surrounding the Livermore

Valley. More gently folded Tertiary sedimentary and igneous rocks overlie the Franciscan Assemblage and the Great Valley Sequence.

In the Livermore Valley, valley fill deposits are composed of as much as 4000 ft (1220 m) of Late Tertiary to Holocene fluvial and lacustrine sediments, according to California Department of Water Resources (CDWR 1974). The oldest Livermore Valley fill deposit is the Plio–Pleistocene Livermore Formation, which has been divided into two members based on lithology and depositional environment. The lower member of the Livermore Formation consists of a poorly cemented pebble conglomerate, sandstone, and greenish-gray claystone of late Pliocene age (Dibblee 1980). The upper member consists of light reddish-gray, cobble-pebble gravel with varying amounts of claystone of Pleistocene age (Dibblee 1980).

1.5 Natural Phenomena Threats

This section identifies specific natural phenomena events, such as design-basis earthquakes (DBEs), considered to be potential accident initiators. Natural phenomena threats used in the evaluation of the B695 Segment are supported by information contained in Chapter 3, "Hazard and Accident Analyses," and in Appendices A and B.

1.5.1 Earthquakes

The 2005 LLNL EIS (DOE 2005) provides details of the local and regional faults as well as historic earthquake data. The potential for seismic hazards at the Livermore Site are presented in the 2005 LLNL EIS and summarized below.

Strong earthquake ground motion is responsible for producing almost all of the damaging effects of earthquakes, except for surface-fault rupture. The intensity of ground motion or shaking that could occur at LLNL as a result of an earthquake is related to the size of the earthquake, its distance from LLNL, and the response of the geologic materials beneath LLNL. Ground shaking generally causes the most widespread effects, not only because it propagates considerable distances from the earthquake source, but also because it may trigger secondary effects from ground failure and water inundation. Potential sources for future ground motion at the LLNL Main Site include the major regional faults, as well as the local faults. (DOE 2005)

A recent U.S. Geological Survey (USGS) study of the likelihood of major earthquakes in the San Francisco Bay Area has determined that there is a 62 percent probability of one or more earthquakes with a magnitude of 6.7 on the Richter Scale or greater occurring within the next 30 years. The study concluded that the probability of these earthquakes occurring along the Calaveras and Greenville faults, and the Mt. Diablo Thrust Fault within the next 30 years was 11 percent, 3 percent, and 3 percent, respectively. The study calculated that there was a 50-percent chance of the Livermore area exceeding a ground shaking of Modified Mercalli (MM) intensity VII to VIII. The Association of Bay Area Governments has mapped the distribution of ground-shaking intensity. A large earthquake on the Greenville Fault is projected to produce the maximum ground-shaking intensities in the Livermore area with intensity ranging from strong (MM VII) to very violent (MM X). The MM IX level is associated with damage to buried pipelines and partial collapse of poorly built structures. (DOE 2005)

Seismic hazard analyses have been performed for the LLNL Main Site to quantify the hazard. The analyses identify the probability of exceeding a given peak ground acceleration. The frequency of the design-basis earthquake (DBE) for the Waste Storage Facilities required by DOE-STD-1020-94, Change Notice 1 (DOE 1994a) is 1×10^{-3}/yr. The maximum horizontal peak ground acceleration at the Livermore Site for return periods of 1,000 years is 0.57g (DOE 1994b).

DOE-STD-1020-2002 (DOE 2002) modified the criteria for PC-1 and PC-2 evaluations compared to DOE-STD-1020-94, Change Notice 1 (DOE 1994a). The new criteria are based on the 2000 IBC rather than the 1997 UBC. The differences in the two building codes are minor (Coats 2004). Executive Order 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings," references the 2000 IBC, and requires reevaluation of structural integrity under certain circumstances. Based on a seismic screening and evaluation of conditions conducted as required by Executive Order 12941, and the minor changes to the code, none of the RHWM facilities meet the criteria requiring reevaluation (Coats 2004).

The potential for surface faulting within the LLNL Main Site is very low, although the potential for surface faulting does exist south of the LLNL Main Site. Based on the fairly deep groundwater levels, the uniformly distributed, poorly sorted sediments beneath the site, and a relatively high degree of sediment compaction, the potential for damage from liquefaction (saturated soil behaves like a fluid from shaking) at the LLNL Main is quite low. Insignificant potential for seismically induced landslides exists at the Livermore Site because of the relatively flat land surface (DOE 2005).

1.5.2 Floods

The B695 Segment is located above the 100-yr flood plain (DOE 2005). The design-basis flood (DBFl) for a performance category 2 (PC-2) facility at LLNL has a return period of 2000 years (DOE 2002). The two sources of flooding at LLNL are from the Arroyo Las Positas and the Arroyo Seco. The Arroyo Seco is not near the B695 Segment

The Arroyo Las Positas approaches LLNL from the east and travels around the site along the eastern and northern borders. A storm flood study was conducted for the DWTF based on historical data and the local surrounding area (Lin 1998). The overflow of this Arroyo during a 2,000 year flooding event has been estimated to impact the DWTF with floodwater approximately nine inches above the existing grade. The conclusions show no major flood damage to buildings within the DWTF from a 2,000-year frequency precipitation event.

1.5.3 Wind

The design-basis wind (DBW) for a PC-2 facility at LLNL is 72 mph at 10 m above ground (DOE 1994). DOE-STD-1020-2002 (DOE 2002) modified the wind criterion for PC-1 and PC-2 evaluations. The new criterion is based on a "peak gust" condition rather than "fastest mile" condition. Codes and standards have been changed to reflect the use of "peak gust" wind speeds with the intent of keeping design loads essentially the same (Coats 2004). The B695 Segment is designed and constructed to withstand the effects of the DBW. This includes the truck bay roof and framing between B695 and B696S with the design basis loads per ASCE 7-93.

1.5.4 Lightning

The Livermore Valley rarely experiences severe weather. Thunderstorms occur fewer than 10 days per year and are not intense. Over the past 10 years, only four lightning strikes have been recorded within a 2-

mile radius of the LLNL Livermore site. There were no recorded instances of lightning strikes within the boundaries of the Livermore site during the last 10 years.

1.6 External Man-Made Threats

The nearest public airport to LLNL is the Livermore Municipal Airport, which is located 10 km west of the site. The airport primarily services single-engine aircraft, with some use by twin-engine planes and corporate jets. Accordingly, Chapter 3 must address the issue of an airplane crash into the B695 Segment.

1.7 Nearby Facilities

Nearby facilities considered in the B695 Segment safety analysis include the National Ignition Facility (NIF), located approximately 800 ft to the south; B691, located 600 ft to the southeast; and B697. In addition, the DWTF Storage Area is within the DWTF complex. It is not expected that these facilities or other facilities on the LLNL main site or nearby will impact the B695 Segment.

1.8 Validity of Existing Environmental Analyses

No significant discrepancies exist or indicate the need to revise the Livermore Site Hazardous Waste Facility Permit (LLNL latest revision). Variations exist in the DSA hazard and accident analysis assumptions for radioactive waste relative to the assumptions used in the 2005 LLNL EIS (DOE 2005) for which a Record of Decision was signed in November 2005 (FR 2005). The Facility Safety Plans will control operations to be consistent with the assumptions used in the 2005 LLNL EIS or superseding documents.

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CHAPTER 2
FACILITY DESCRIPTION

2.1 Introduction

This chapter describes the facilities, equipment, operations, and confinement and safety support systems of the Building 695 (B695) Segment of the Decontamination and Waste Treatment Facility (DWTF) located at Lawrence Livermore National Laboratory (LLNL). The facilities, known collectively as the DWTF, are used by LLNL's Radioactive and Hazardous Waste Management (RHWM) Division to store and treat regulated wastes generated at LLNL. Information in this chapter is used to identify hazards and potential accidents associated with operations, natural phenomena, and external events related to the B695 Segment.

Design codes, standards, regulations, and orders that establish the requirements applicable to engineering design and operation of the B695 Segment are listed in Section 2.2. Only those requirements that are pertinent to the safety analysis are included.

An overview of the current buildings and equipment configurations for the B695 Segment is presented in Section 2.3. Many processes are used to treat the diverse waste streams generated at LLNL. The layout and construction of B695 Segment buildings and process equipment that are significant to hazard and accident analyses are described in detail in Section 2.4. Process units are usually self-contained, small, and easily movable with forklifts. Such adaptability allows RHWM to tailor operations to match the types and quantities of hazardous and radioactive wastes generated.

The expected waste management activities and the capacities and throughput of each process and its respective equipment, instrumentation, control systems, and other operational considerations are detailed in Section 2.5.

The confinement, safety support, utility distribution, auxiliary systems, and associated support facilities are described in Sections 2.6, 2.7, 2.8, and 2.9, respectively. Structures, systems, and components (SSCs) that perform confinement functions are discussed in Section 2.6. Safety support systems that are not specific to processes at the B695 Segment, such as fire protection, and hazardous material monitoring, are described in Section 2.7. Utilities distribution systems, both external to and within the B695 Segment, are described in Section 2.8 at a level of detail necessary to understand the potential impact of utilities on operations at the B695 Segment. Facility components and systems not covered in the preceding sections are addressed in Section 2.9.

2.2 Requirements

The B695 Segment is designed to meet applicable federal, state, and local laws and regulations and Department of Energy (DOE) directives in NNSA/LLNS Contract (NNSA/LLNS 2007), as well as applicable LLNL requirements. A list of key requirements is provided below.

U.S. Department of Energy

DOE O 420.1A	Facility Safety (2002)
DOE O 435.1	Radioactive Waste Management (1999)
DOE O 440.1A	Worker Protection for DOE and Contractor Employees (1998)
DOE O 5400.5, Change Notice No. 2	Radiation Protection of the Public and the Environment (1993)
DOE O 5480.19, Change Notice No. 1	Conduct of Operations Requirements for DOE Facilities (1992)
DOE O 5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities (1994)
DOE O 5480.4, Change Notice No. 4	Environmental Protection, Safety, and Health Protection Standards (1993)
DOE O 6430.1A	General Design Criteria (1989)
DOE G 420.1-2	Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear and Nonnuclear Facilities (2000)
DOE-STD-1020-2002	Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities (2002)
DOE-STD-1021-93, Change Notice No. 1, reaffirmed 2002	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components (2002)
DOE-STD-1022-94, Change Notice No. 1, reaffirmed 2002	Natural Phenomena Hazards Characterization Criteria (2002)
DOE-STD-1023-95, Change Notice No. 1, reaffirmed 2002	Natural Phenomena Hazards Assessment Criteria (2002)
DOE-STD-1027-92, Change Notice No. 1	Hazard Categorization and Accident Analysis Techniques (1997)
DOE-STD-3009-94, CN 3	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports (2006)
DOE-STD-3014-96	Accident Analysis for Aircraft Crash into Hazardous Facilities

Code of Federal Regulations (CFR)

10 CFR 820	Procedural Rules for DOE Nuclear Activities
10 CFR 830, Subpart A	Nuclear Safety Management - Quality Assurance Requirements
10 CFR 830, Subpart B	Nuclear Safety Management - Safety Basis Requirements
10 CFR 835	Occupational Radiation Protection
29 CFR 1910	Occupational Safety and Health Standards
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 761	Toxic Substances Control Act
49 CFR 173	General Requirements for Shipments and Packagings

California Code of Regulations (CCR)

22 CCR 66264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
22 CCR 66262	Standards Applicable to Generators of Hazardous Waste

LLNL Manuals and Reports

UCRL-MA-133867	LLNL *Environment, Safety, and Health Manual* (LLNL latest revision)

Other Requirements

American Conference of Governmental Industrial Hygienists, *Industrial Ventilation Manual* (ACGIH 1998)

California Environmental Protection Agency, Department of Toxic Substances Control, *Livermore Site Hazardous Waste Facility Permit,* Permit No. 99-NC-006, EPA ID: CA 2890012584 (latest version).

Other Environmental Statutes and Regulations

Clean Air Act: National Emission Standards for Hazardous Air Pollutants

Bay Area Air Quality Management District Rules and Regulations

California Air Resources Act

Clean Water Act: Pretreatment Standards for Discharges to Publicly Owned Treatment Works (POTW)

National Pollutant-Discharge-Elimination System

City of Livermore Wastewater Discharge Permit #1250A

California Regional Water Quality Control Board (RWQCB), Water Quality Management Plan

Code of the City of Livermore of Discharge Limits to Sanitary Sewer (sections 18.62, 18.62.2, 18.62.3, 18.62.4, and 18.62.5)

Design Codes and Standards

The primary design code standard is DOE O 6430.1A (April 1989). Specific codes and standards used for SSCs for the B695 Segment (i.e., B696S and B695) are in this order and cited in the Title IIIA and B construction documents.

2.3 Facility Overview

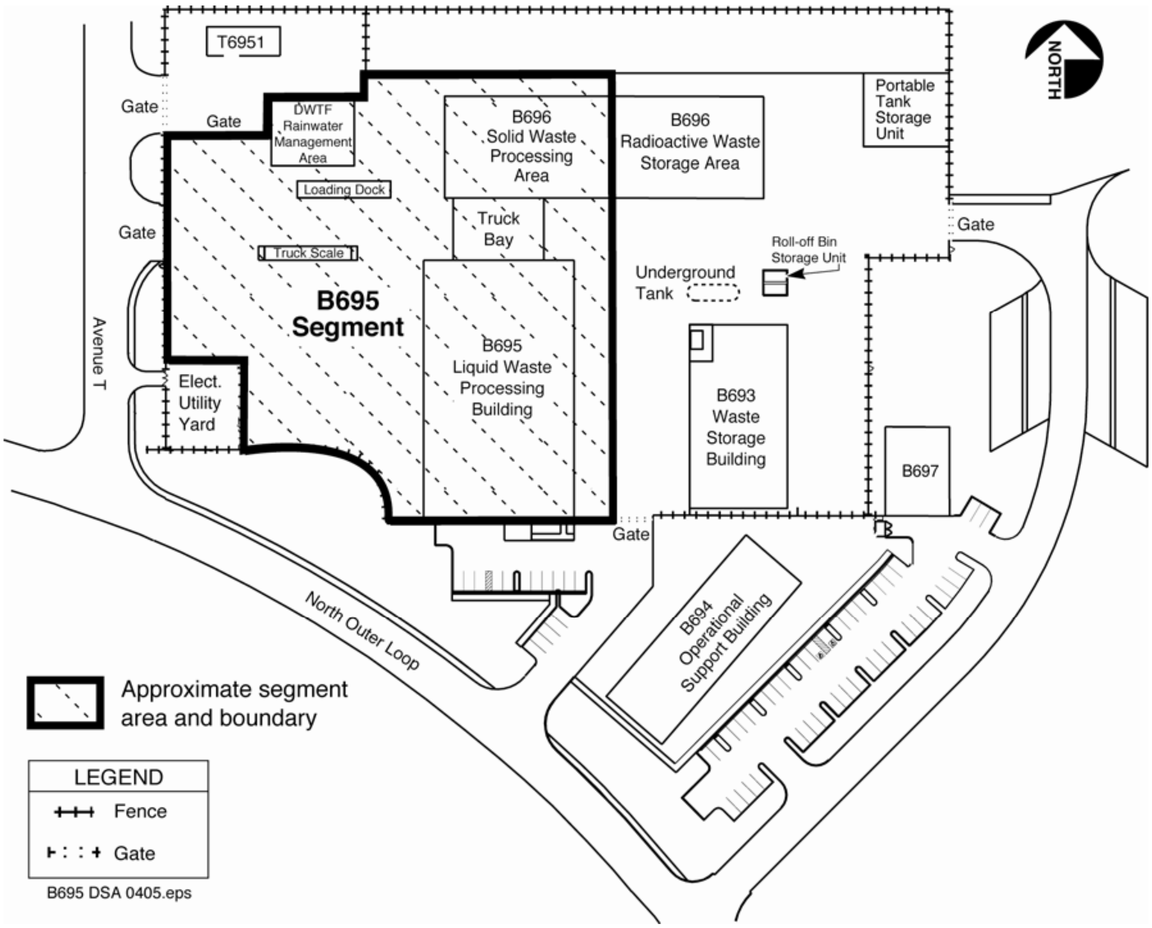
The location of the DWTF at the LLNL main site is shown in Chapter 1, Figure 1-2. Activities typically conducted in the B695 Segment include container storage, lab-packing, repacking, overpacking, bulking, sampling, waste transfer, and waste treatment. **Figure 2-1** shows the approximate area and boundary of the B695 Segment. This segment covers B695, B696S, and the asphalt area within the DWTF fenceline to the west. Nonnuclear areas adjacent to the B695 Segment include:

- T6951 maintenance area: This area is separated from the nuclear facility by fences and gates. It contains only small amounts of solvents and lubricants for maintenance purposes, compressed gas cylinders, and fueled vehicles, and does not contain radionuclides.
- DWTF electrical utility yard: This area is separated from the nuclear facility by fences. It contains only fuel for the generator and does not contain radionuclides.

- Existing trees north of B696: This area does not contain hazardous chemicals or radionuclides and is separated from the B695 Segment by a minimum distance of 20 ft.

The following sections provide a brief description of the B695 Segment and associated activities. This segment is used to manage solid, liquid, and gaseous wastes, some of which is regulated under the Resource Conservation and Recovery Act (RCRA). RHWM generally processes low-level radioactive waste with no, or extremely low, concentrations of transuranics (e.g., much less than 100 nCi/g). Wastes processed often contain only depleted uranium and beta- and gamma-emitting nuclides, e.g., ^{90} Sr, ^{137}Cs, ^{3}H.

Figure 2-1. Layout of the B695 Segment



Building 695

Figure 2-2 shows the layout of B695, and **Figure 2-3** shows the B695 mezzanine. B695 is used to store and treat radioactive, mixed, and hazardous waste, and it also contains equipment used in conjunction with waste processing operations to treat various liquid and solid wastes. Portable equipment may be rearranged. For the purpose of this document, B695 is divided into the following areas.

1. The liquid-waste processing area (LWPA) is a high bay that houses various unit operations, such as the Tank Farm for storing and treating wastewater, evaporators, waste water filtration module, bulking station, centrifuge, and waste blending station.

2. The B695 airlock is used for transferring and storing containers, and it may house various portable treatment units when space permits.

3. Processing rooms east of the B695 airlock house the chopper, solidification unit, and debris washer.

4. The reactive materials area includes the reactive waste processing area (RWPA), four reactive waste storage rooms used for segregated storage of reactive wastes (e.g., water-reactive materials), and the reactive materials cell. The RWPA includes acid fume hoods and the combination, inert, and radioisotope glove boxes. This area may also include units such as the mercury amalgamation unit, small laboratory operation hardware, and pressure reaction vessel. The reactive materials cell contains a walk-in fume hood and is a general-purpose area used for operations such as repackaging, uranium deactivation, and other bench-scale processes.

5. The small-scale treatment lab is operated primarily as a wet lab for sample preparation. When needed it is operated in a manner similar to the reactive-materials area and may include units such as the mercury amalgamation unit, small laboratory operation hardware, and pressure reaction vessel.

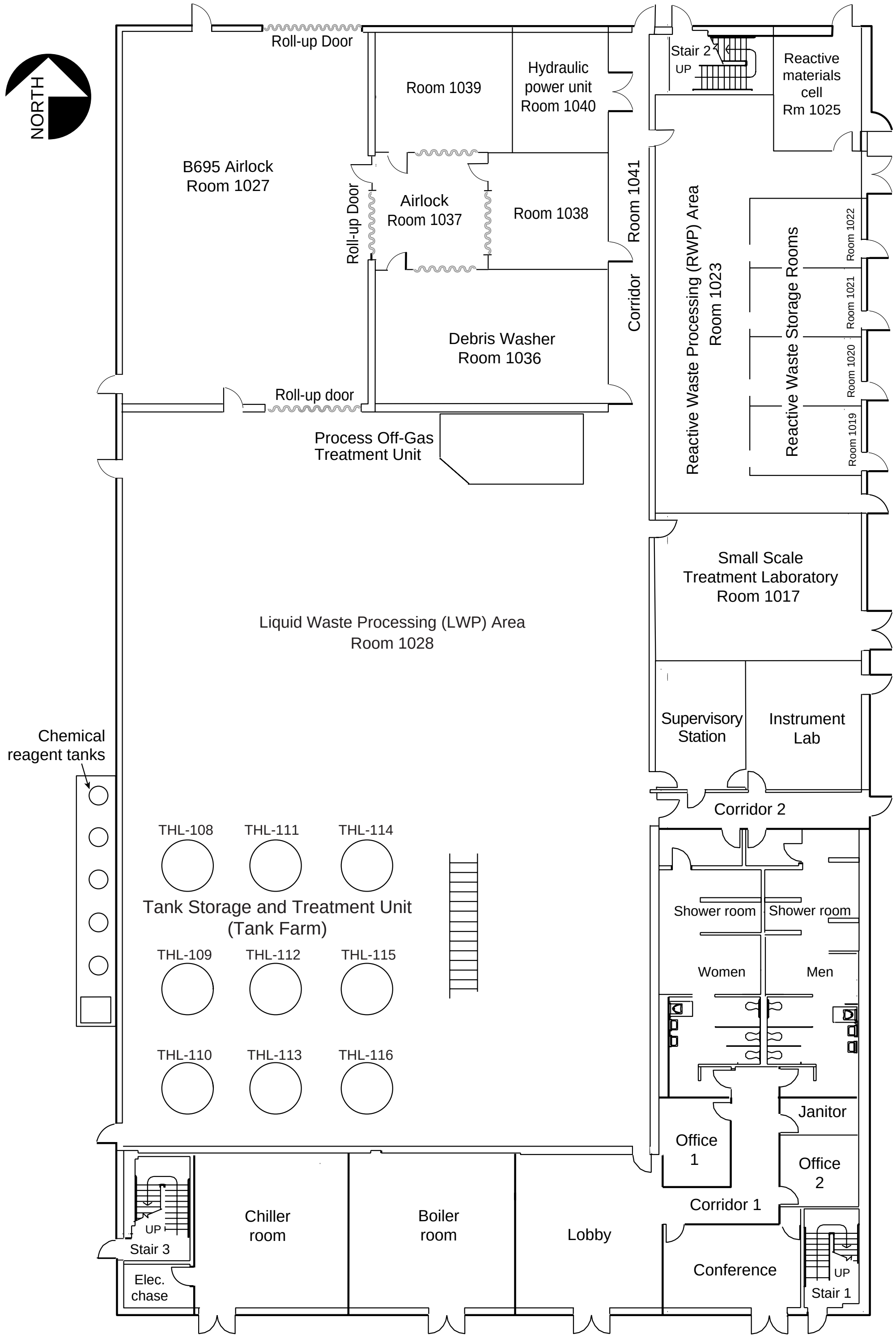
6. The instrument laboratory houses various analytical instruments, such as a gas-chromatograph/mass spectrometer (GC/MS), X-ray fluorescence (XRF) spectrometer, and a dry electrolytic conductivity detector (DELCD), and is used for real-time radiological and almost real-time metals and VOCs analyses to aid in treating mixed and radioactive wastes and developing improved treatment processes.

7. B695 Mezzanine. This area contains air-handling units, water heater, communications equipment, standard industrial light shop equipment to support maintenance activities, and some power distribution (e.g., those items normally found in industrial complexes). The north section of the mezzanine contains high-efficiency particulate air (HEPA) filters for particulate removal from building air and process vents.

8. B695 Lobby, Office Space, Locker Rooms, and Utility Rooms. These areas contain only materials normally found in industrial office complexes.

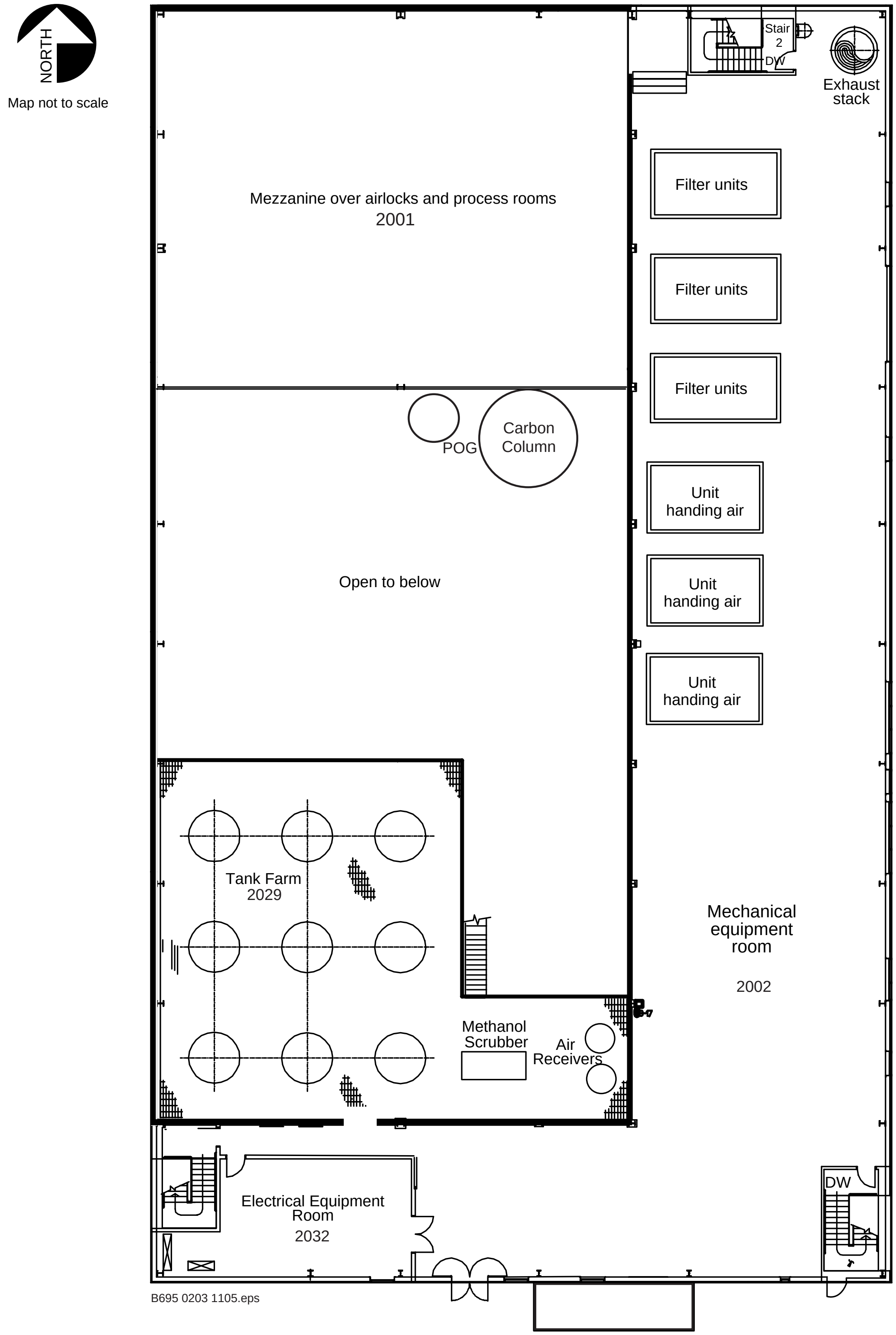
Equipment was selected specifically to treat the waste streams RHWM expects will be generated at LLNL. However, some wastes might have unique characteristics that preclude treatment by existing equipment and shipment to an offsite treatment, storage, and disposal (TSD) facility. Because unique wastes are generated infrequently, installing dedicated equipment is neither practical nor cost effective. Bench-scale, tabletop treatment processes can be developed on a case-by-case basis and conducted in one or more of the reactive materials area work stations.

Figure 2-2. Building 695 floor plan and equipment



B695 DSA 0202 1105.eps

Figure 2-3. Building 695 mezzanine



Building 696 Solid Waste Processing Area

The Building 696 solid waste processing area (SWPA), also referred to as B696S in this report, is used primarily to manage solid radioactive waste. A general layout of B696 is shown in **Figure 2-4**. Operations specific to the SWPA include sorting and segregating LLW and TRU waste, radioactive and hazardous waste storage, lab-packing, sampling, and crushing empty drums that previously contained LLW or hazardous waste. The B696 SWPA may be used to store hazardous and mixed waste in compliance with Resource Conservation and Recovery Act (RCRA).

Yard Area of B695 Segment

The west yard area includes the B696 covered truck bay located directly between the south side of B696S and the north end of B695. The truck bay is used to receive incoming vehicles delivering waste containers, stage waste shipments and for loading waste transport vehicles. To the west of B696S is a truck scale and a ramped loading dock used for loading and unloading vendor supplies and some waste transport vehicles. The DWTF Rainwater Management Area is located in the northwest portion of the B695 Segment yard. This area is a sloped pad to the west of B696S that provides secondary containment. It is used to store tankers containing dilute concentrations of radioactive and hazardous materials, e.g., rainwater. The most common storage containers are tankers that have nominal volumes of 5,000 to 7,000 gal. The containment pad is capable of holding approximately 18,000 gal. This area also contains a sewer release access point used for waste effluent release. The B695 Segment yard area contains storage sheds and transportainers for miscellaneous equipment and supplies. The area of the B695 Segment yard on the southwest side of B695 includes chemical reagent storage tanks, external condensers for the evaporator, and a small metal storage shed.

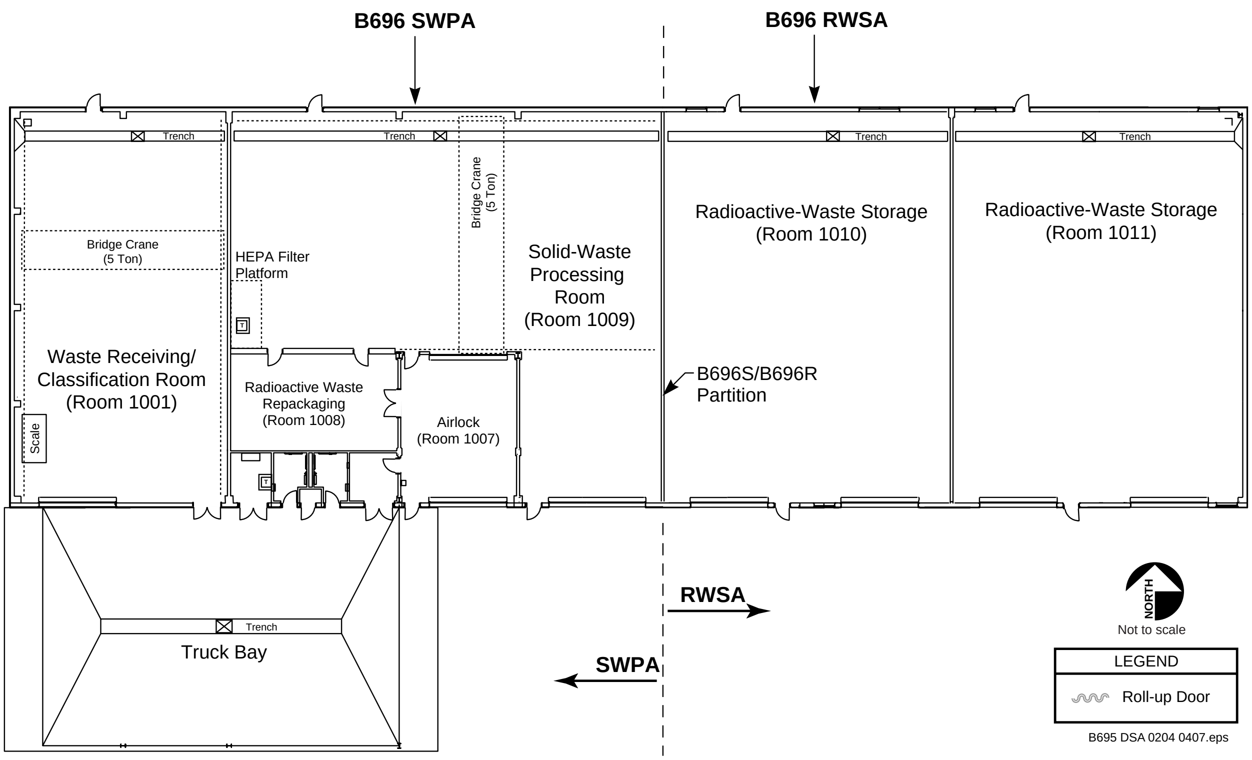
2.4 Facility Structure

B695 and B696S were designed in accordance with DOE-STD-1020-94. The buildings meet Performance Category 2 (PC-2) criteria for natural phenomena hazards outlined in that standard.

Seismic analyses were performed using the Static Force Method detailed in DOE-STD-1020-94 for PC-2 structural systems and components. The analyses were performed using a peak ground acceleration of 0.57g. Design and construction of the facility meet or exceed requirements resulting from these calculations. None of these facilities require seismic reevaluation based on DOE-STD-1020-2002 criteria. In addition, RHWM is in compliance with the LLNL Seismic Safety Program for appurtenances such as the B696 cranes, the B696S glove box hoist, and skid mounted equipment.

Assumed wind loads are based on a fastest-mile wind speed of 72 mph coupled with a facility importance factor of 1.07 in accordance with DOE-STD-1020-94 and ASCE 7. The lateral load-resisting system consists of steel bracings, support struts, and columns, and it is designed to withstand wind loads resulting from the fastest-wind value mentioned previously.

Figure 2-4. Building 696 floor plan



Factory composite-metal building panels are used for exterior walls of B695. The roof is formed-metal decking supported on metal purlins.

The SWPA, located at the west end of B696, is a one-story, structural steel frame building measuring approximately 83 ft × 135 ft × 35 ft high. The building's exterior walls are metal panels on steel girts with a sloped, corrugated metal roof. As shown in Figure 2-4, the SWPA includes the waste receiving/classification room, solid waste processing room, a room that houses the B696S glove box, and an airlock. The drum crushers are located in Room 1009, the B696S glove box is located in Room 1008, and a fume hood and ventilated workstations are provided for waste management operations, e.g., lab-packing, in Room 1001. Five-ton industrial bridge cranes are located in both Rooms 1009 and 1001. An electric forklift battery charger is located in Room 1007.

The B696 truck bay that separates B695 from B696 is a 12-in concrete slab with polymeric coating measuring approximately 80 ft long by 50 ft wide. The pad is sloped towards a central trench. The truck bay is covered with a roof that prevents direct precipitation, and run-on is prevented because the adjacent asphalt drive slopes away from the containment area. However, rainwater can be blown in the open east and west ends of the truck bay. The truck bay roof has a flexible engineered seismic expansion joint at its interface with B695. The truck bay is protected by an automatic, dry-pipe, fire-suppression sprinkler system.

Water from the fire sprinkler system, rainwater, and/or process spills occurring in the truck bay drain into a 20,000-gal underground storage tank via the central trench. The underground storage tank is made of fiberglass-reinforced plastic with a level detection system. It provides retention capacity for other DWTF areas, including B693 Room 1014, B695 Reactive Waste Storage Rooms and Processing Area, and B697. The tank has a connection so that contents can be removed via a suction truck. A portable pump or vacuum tanker is used to remove precipitation and other accumulated liquids from the trench.

A loading dock is provided to facilitate truck loading and unloading. A concrete ramp, with handrails on both sides, slopes up to the flat 15-ft by 15-ft dock. The dock and ramp consist of an 8-in-thick reinforced concrete slab on a compacted base. Bumpers are provided to minimize damage from vehicle impact. A truck scale is located south of the loading dock and is level with the B695 Segment yard asphalt. Truck weights are measured by driving onto the scale.

2.5 Process Description

On the basis of chemical inventories, the RHWM operating facilities have been characterized as low chemical hazard facilities through facility screening, as documented in RHWM Facility Screening Reports. Material type and quantity of hazardous wastes have been established for RHWM facilities in the California Environmental Protection Agency, Department of Toxic Substances Control, *Livermore Site Hazardous Waste Facility Permit*, Permit No. 99-NC-006, EPA ID: CA 2890012584 (including Part A and Part B Permit Applications for Hazardous Waste Treatment and Storage Facilities Livermore Site)(Cal EPA - latest revision).

Hazardous materials can be characterized as having chemical and radiological properties similar to those at other sites in the DOE and commercially throughout the nation. Some chemicals are used to process waste through unit operations, and wastes themselves have chemical constituents. Wastes also contain radioactive constituents and may be mixed with the hazardous constituents. B695 is a RCRA permitted facility. B696S operations also comply with RCRA.

In general, with the exception of sampling, equipment maintenance, and sewering preparations (e.g., pH adjustments), activities do not require direct handling of hazardous materials because materials are containerized. During sampling and maintenance activities, handling is usually not as significant as in unit operations (see Table 2-1) because quantities of hazardous materials are smaller (e.g., small samples and less time spent for sampling, residues left in pump cavities during field maintenance).

Waste categorized as liquids (sometimes sludge) is processed through the Tank Farm, bulking, blending, evaporation, centrifugation, filtration, and/or solidification unit operations. The aggregate waste feed is primarily water with solvent concentrations, typically hundreds of parts per million, and regulated metal constituents (primarily as transition metal salts) usually less than 100 parts per million. Waste categorized as solids (sometimes sludge) is processed through shredding, debris washing, drum crushing, the drum rinse station, the uranium deactivation unit and the B696S glove box unit operations. The aggregate waste feed contains a variety of materials, such as earthen and construction-related, wood, paper, and plastics. Such wastes have similar constituents to waste categorized as liquids. Solvent contamination in the wastes is usually less than 100 parts per million, and transition metals are usually less than one percent.

Waste is also treated by small-scale treatment activities. Wastes treated by these processes can be solids, liquids, and gases; and the wastes can be more concentrated than the larger scale treatment processes and meet RCRA criteria for reactivity. These wastes are treated in small quantities and are limited under RCRA permit conditions. Such treatment can be done in hoods, glove boxes, or bench-top and floor areas, as determined appropriate by laboratory policy (e.g., input from chemists, engineers, or safety professionals). Similar to small-scale treatment (e.g., small quantities, RCRA reactivity, concentration) are processes such as labpacking, passivation, and instrument laboratory work. On the order of thousands of chemicals and chemical constituents are found as wastes or waste constituents. However, in general, as hazardous properties and concentrations increase, waste quantities decrease.

Radioactive contamination includes many isotopes representing all modes of decay, but the aggregate waste treated is seldom TRU and is generally less than a few microcuries per gram of any isotope (less than 100 nCi per gram for TRU isotopes). Chapter 3 and associated appendices discuss hazard evaluation in relation to radioactive and chemical constituents.

Activity and process descriptions presented herein are based on the planned operation of B695 Segment treatment units and waste handling operations. In general, the following industry-standardized waste storage and handling activities occur in the B695 Segment:

- Receiving, moving, staging, sorting, segregating, size reducing, and repackaging hazardous and nonhazardous solid waste, including Toxic Substance Control Act (TSCA)-regulated waste.
- Lab-packing and overpacking operations.
- Moving, staging, storing, and repackaging radioactive and regulated waste.
- Sorting, segregating, and repackaging radioactive and regulated waste in the B696S glove box and Waste Packaging Unit.
- Sewer waste management to meet discharge standards.
- Waste sampling, transferring, and bulking.

RHWM implements Integrated Safety Management (ISM) through processes such as Integration Worksheets (IWS), procedures and training, identifying the scope of work and the associated hazards and controls. Proposed activities are subject to the Unreviewed Safety Question (USQ) process to identify whether they are compliant with the current safety basis. In addition, the Configuration Management process ensures consistency between design requirements, physical configuration, and documentation of configuration items.

Waste Storage Activities

Any of the B695 Segment areas can be used for storage of TRU waste, LLW, hazardous, nonhazardous, mixed, and other waste. Storage of hazardous and mixed waste in B695 Segment facilities is performed in compliance with Resource Conservation and Recovery Act (RCRA) requirements. B695 and B696S are RCRA Part B-permitted to allow storage of hazardous and mixed waste for periods longer than 90 days. B695 and B696S are also permitted for hazardous and mixed waste treatment activities. Such storage and treatment functions are specifically mandated by state and Federal Resource Conservation and Recovery Act (RCRA) requirements.

Containers are kept closed except for inspection or when wastes are being processed, added, or removed (e.g., during sampling, bulking, repackaging, or lab-packing operations) or when a container is in place for treatment. For example, a container would be placed near the treatment unit operation, opened, and the waste processed. In storage, containers are secured (e.g., lids closed, bungs tightened) as part of RCRA requirements. However, some waste containers can be vented to prevent pressure buildup. This practice, consistent with RCRA, is sometimes done for containers in process. For example, gas-permeable caps may be used on organic waste containers to comply with fire safety standards. To comply with air emission requirements (e.g., 22CCR 66264) or to control other types of releases (e.g., radionuclides), such as required by the DOE Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC), the container vents are fitted with HEPA or carbon filters. All Approved TRU Waste Containers meet the free drop test performance criteria for Type A packaging (49 CFR 173.465(c)(1)). Most TRU waste is stored in vented containers. Containers that were accepted as containing LLW but on assay were reclassified as TRU (LLW/TRU conversions) may be unvented. TRU Oversize Boxes are not vented. Vents reduce the chance of hydrogen buildup, hence, pressure build-up or deflagration. Some wastes already in storage (e.g., oversized boxes) allow venting through the gasket between the lid and the box. Actual credited controls and initial conditions are identified in Chapter 3.

Tanker Truck Staging

Tanker trucks, nominally 5,000 to 7,000 gal, are staged for loading and unloading purposes throughout the B695 Segment. Tanker trucks contain a variety of wastes (e.g., mixed, low-level, hazardous, and nonhazardous). No utilities other than yard lighting and eyewash/safety shower equipment are provided in the yard. Temporary secondary containment is required by the Hazardous Waste Facility Permit for RCRA waste transfers. The truck bay, addressed in Section 2.6, has its own secondary containment system.

Waste Handling Activities

For purposes of this DSA, the term “waste handling” denotes any transport or other movement, weighing, transfer, overpacking, repackaging, or sampling of waste within the B695 Segment. Containers are frequently transported manually (hand carried or by drum dolly) or by vehicles such as forklifts. Some containers, such as portable blending containers and steel boxes, have skids to facilitate transport via forklift. Operators may also use drum grabbers and hooks to facilitate container transport via forklift. Pickup and flatbed trucks are also used to transport containers.

Liquid waste is normally transported in portable containers and tanker trucks. Most liquid waste is treated at the LWPA in B695. However, some waste containers may be placed into a container storage area. Liquid waste transfer operations are conducted throughout the segment, but they are most frequently conducted within the buildings and in the truck bay between B695 and B696S.

Sampling of waste other than TRU waste can be conducted in all buildings and container storage areas. Waste sampling operations generally involve transferring only small quantities of waste into small-volume containers.

When containers are opened for sampling or other waste handling activities, sampling procedures, processing plans, work permits, and/or integration worksheets discuss controls and monitoring when required. Chapter 9 discusses protocols for developing and implementing controls and monitoring of waste handling activities.

Loading Dock and Truck Weigh Operations

Trucks carrying waste offsite are weighed using a grade-level truck scale located south of the loading dock in the B695 Segment. Trucks are driven onto the scale, and the gross weight is read. Trucks may be loaded and unloaded at the loading dock.

Truck Bay and Airlock Operations

The B696 truck bay is used as a loading and unloading zone for hazardous, radioactive, and mixed waste, including TRU and mixed TRU waste, shipped to and from B695 and B696S. Routine handling operations include moving drums by hand and forklift, and portable containers by truck and forklift.

The Room 1027 airlock in B695 is used for staging, storing, loading, and unloading of containerized waste, materials, and supplies. When space permits, portable treatment units can be housed and operated in the airlock. The secondary containment is rectangular in shape, approximately 40 ft × 39 ft. The sloped floor space allowed for staging and storage is about 800 ft^2.

Waste is transported to the B695 Segment in waste containers ranging from small cans to 1,000-gal portable containers. In addition, liquid wastes (such as rainwater) from 5000-gal tank trailers may be transferred directly to the Tank Farm or sanitary sewer via flexible hoses attached to the quick-disconnect systems provided in the airlock. Transfer lines run in parallel along the western wall of B695 between the Tank Farm and airlock. Four quick-disconnect stations are located strategically to facilitate the transfer operations. The airlock in B696S is used for staging, storing, loading, and unloading of containerized waste, materials, and supplies.

Facility and Equipment Maintenance Activities

Maintenance activities are performed in a manner similar to those found in general industry using the graded approach. Maintenance activities are typically performed by RHWM maintenance personnel, Plant Engineering, and Hazard Control. The schedule and type of maintenance for facilities and process equipment is tailored to the facility and to the type of equipment, frequency of use, age, and performance requirements. Maintenance includes, but is not limited to, modifications to lighting, equipment calibration, lubrication, welding, cutting, and replacement or repair of instruments and components. Applicable containment components, such as HEPA filters, are included in the maintenance program.

B695 Segment Processes (Unit Operations)

Table 2-1 summarizes the unit operations performed in the B695 Segment .

Table 2-1. Unit operations at the B695 Segment[a]

Processes conducted at B695	Processes conducted at B696S
Waste Water Treatment Tank Farm Operations	Nondestructive Assay Box
Bulking Station[b]	Drum Crushing
Waste Blending Station	B696S Glove Box Operations
Chemical Reagent System	Waste Packaging Unit Operations
Evaporators[b]	Labpacking and Passivation
Centrifuge[b]	
Wastewater Filtration Module[b]	
Chopper	
Debris Washer	
Reactive Waste Processing	
Solidification System	
Small-scale Treatment	
Instrument Lab Operations	
Fume Hood Operations	
Reaction Vessel Operations	
Glove Box Operations	

[a] Pollution abatement equipment, e.g. Process Off-Gas System (POGS), is addressed in the PrHA as a separate process node, but is discussed as part of the pertinent processes described below.

[b] These are mobile units and can be placed in various areas within the LWPA and airlock.

Waste Water Treatment Tank Farm Operations

The Tank Farm is a storage and treatment system that consists of tanks, mixers, pumps, piping, valves, utility interfaces, support system interfaces, instruments, and controls. Utility interfaces include process water, shop air, instrument air, and electric power. Support system interfaces include the Programmable Logic Controller (PLC) System, Chemical Reagent System, Process Off-Gas System (POGS), and Building Transfer System. The Tank Farm is located in the southwest corner of B695 in the LWPA. Its purpose is to store and treat liquid wastewater.

Major components of the Tank Farm are the tanks, mixers, pumps, and piping. Other components include chemical reagent feed inlets, instrumentation, and local control and monitoring boxes. The nine 5000-gal tanks, nominally 8 ft diameter × 20 ft high, fabricated from fiberglass-reinforced vinyl ester resin, are cylindrical in shape with conical bottoms and dome tops. The top of each tank is accessible from the mezzanine floor. Installed at the top of each tank are a mixer, an access hatch, several feed inlets, an off-gas vent, and various sensors. Reagents (inlets are located at the top of each tank) are used to treat the wastewater. The bottom of each tank is accessible from the building’s ground floor. Each tank is seismically secured, meeting PC-2 seismic criteria.

Each tank has several measuring and monitoring instruments on the mezzanine floor (tops of the tanks) and on the ground floor (bottoms of the tanks). Some of the instruments have field-mounted gauges that display the measured values in real time. Some instruments are also connected to a central PLC data highway that can display information in multiple locations and convert or manipulate the data.

The central PLC system allows technicians to monitor activities in the Tank Farm and other process systems in B695. It receives signals directly from process equipment and instruments, sends remote-control commands to equipment, and displays information about the process instruments and equipment. The central PLC also communicates with other equipment-specific PLCs (i.e., equipment that is controlled with its own built-in, on-board PLC) and with tank farm status annunciator panels located in the Supervisory Station and in the LWPA. The PLC is accessed at the Supervisory Station computer or at several identical PLC control panels located throughout the building.

To fill any one of the tanks, a container of wastewater may be connected by flexible hose to one of the quick-disconnect stations. One of these stations is located in the Airlock (Room 1027), three are located along the west wall in the LWPA (room 1028), and three stations are located on the suction side of the three waste transfer pumps. Normal tank fill-up operations make use of any combination of the quick-disconnect stations and waste transfer pumps. When waste containers of 85 gal and less are used for adding waste to the Tank Farm, the waste will most likely be dumped into the bulking station first, and then the bulking station drain will be connected to one of the quick-disconnect stations to transfer the waste. Wastes may also be added to the tank directly through the access hatch at the top of the tank. This is accomplished by using a pump and hose. Wastes may be directly poured into the tank if the container can be carried or forklifted up to the mezzanine (e.g., partially empty drum or 5-gal carboy).

To use a portable pump to fill one of the nine tanks from the top, it is connected by flexible hose to a quick-disconnect station located on the discharge side of the waste transfer pump. To fill a tank from the bottom, a portable pump is connected to the suction side quick-disconnect station only. None of the other stations can be used for either of these two portable pump operations because check valves prevent reverse flow in some of the lines.

In all tank fill-up operations, the appropriate valves are opened and closed to fill the desired tank. The appropriate waste transfer pump is used, and pumping rate, line pressure, and tank level are monitored during the fill-up operation. When the desired volume has been pumped, the flexible hose is drained as much as possible, the pump is turned off, and valves are closed. The wastewater container may then be rinsed at the bulking station, where rinsate is collected and analyzed to determine the appropriate treatment option, if required. Loss of signal or motive device would cause valves to fail closed, e.g. fail safe.

Off-gas from stored wastewater is treated automatically in the POGS. If necessary, the off-gas can be pre-treated in the methanol scrubber prior to treatment in the POGS if monitoring reveals methanol or other volatile organic compounds are present. Stored wastewater may be treated first and then stored, or stored and then treated.

Discharge operations present four possible choices for waste removal: (1) discharge directly to the sanitary sewer, (2) discharge to another Tank Farm tank, (3) discharge to a quick-disconnect station where the wastewater can be added to another treatment unit, or (4) discharge to a quick-disconnect station where wastewater can be added to a different waste container. During the discharge of the tanks, and as a process of emptying the tanks, they are thoroughly rinsed to reduce build-up of waste residues.

All wastewater discharged from the Tank Farm to the sewer enters the LLNL-wide sewer system and mixes with other wastewater (including domestic wastewater). The LLNL sewer system joins with the

City of Livermore sewer system to transport wastewater to the public Livermore Treatment Plant, where it is treated prior to final discharge to the environment.

The second discharge option is a tank-to-tank transfer, whereby wastewater from one tank is transferred to another Tank Farm tank. The appropriate discharge tank outlet valves and fill tank inlet valves are opened, and the selected waste transfer pump is turned on. Pump pressure, flow rate, and tank levels are monitored during a tank transfer operation. The tank transfer operation is complete when the discharge tank and associated piping are rinsed into the destination tank.

The third discharge option is to a quick-disconnect station, to which a skid-mounted treatment system can be connected. A waste transfer pump and a flexible hose are used for this operation. The flexible hose is connected to a quick-disconnect station that is selected on the basis of which tank is to be emptied and where the contents are to be discharged. From the quick-disconnect station, a hose is extended to a skid-mounted treatment unit (such as the filtration unit, centrifuge, evaporators, or the waste blending station).

The appropriate waste transfer pump is identified, hose connections are made, and the necessary valves are opened. All quick-disconnect stations have valves that are normally closed, and are opened by hand before operation can occur. The selected waste transfer pump is turned on, and contents of the tank are transferred via the quick-disconnect station. In some cases, such as when feeding the evaporators, a waste transfer pump might not be used because the tanks will drain by gravity. The tank transfer operation is complete when the discharge tank and associated piping are rinsed into the destination tank.

The fourth discharge option is to a separate waste container through any of the quick-disconnect stations. Such transfer is conducted in much the same way as a transfer to a different treatment unit.

Treatment in the Tank Farm occurs in a sequence of batches (also called campaigns) rather than in continuous operation. Treatment processes that normally may be conducted in the Tank Farm include oxidation, precipitation, reduction, chlorination, cyanide destruction, detoxification, ion exchange, neutralization, clarification, coagulation, decanting, flocculation, activated carbon, and blending/bulking. Once the treatment objective is met, the waste may be stored temporarily in the Tank Farm, or it may be discharged immediately to an appropriate location.

Bulking Station

The Bulking Station is part of the Tank Farm's ancillary equipment, and as such can be used to treat waste (e.g., blending, bulking, neutralization). It is used to dump the contents of containers whose volumes are 85 gal or less, to rinse empty containers, and to decontaminate equipment. The station consists of a 700-gal, stainless-steel reservoir (approximate volume); two hot-water, high-pressure washers; and two drum dumpers.

Drums containing waste are placed into the dumper where they are lifted and tilted so that their contents are poured into the reservoir. The reservoir is long and rectangular to prevent the escape of splashing liquid (e.g., spill), thus providing some contamination control. In addition, pipe can be screwed onto bung holes to further reduce splashing effects. Containers can also be poured in by hand (or with suitable devices). The contents can then be pumped to the Tank Farm, to a container, or to another waste management unit in B695. The containers might be rinsed and the rinse water collected with the initial contents and then pumped to the waste management unit, or the rinse water might be collected separately and pumped to a different tank or management unit. Alternatively, empty containers can be rinsed using this waste management unit. Rinse water then can be pumped to the selected waste management unit.

Contaminated equipment can also be washed with this station. Equipment can be placed inside the pan and then pressure washed with the pressure washers. The rinsate will then be collected in the pan and sampled to determine if treatment is required.

Waste-Blending Station

The waste blending station is used to process liquid wastes and solid wastes amenable to making them a flowing slurry with water. The waste treated is typically aqueous and is laden with organic or metal constituents. Wastes processed through the waste blending station are similar to those that are processed in the Tank Farm, but often they are more concentrated and require targeted treatment under a more controlled process. This process allows for handling smaller batches, which reduces dilution effect by treating before introduction into larger batches. The processes performed are numerous, and are characterized generically by technologies associated with standard industrial wastewater treatment. Examples include chemical oxidation of organic constituent using Fenton's reagent (a combination of sulfuric acid and iron ion), reduction of hexavalent chromium, physical separation using settling and decanting, sparging volatile compounds with air, and precipitation.

Processing in this unit is conducted primarily in a container of up to 1,000 gal, or in a 100-gal attached fiberglass vessel. The fiberglass vessel is equipped with a line to discharge the product (e.g., processed waste), and with feed lines for waste and various reagents. When the container is used, a lid with feed lines is attached. As with many water-based processing operations in RHWM, hoses with disconnects are used to introduce liquid wastes and reagents into the vessel or container. The fluid motive devices are typical of those found throughout the industry and include such devices as diaphragm pumps. Delivery pressures and flow rates are low to moderate, and provide just enough capacity to introduce waste and reagent at acceptable rates. Reagents are normally supplied as industrial-grade chemicals and most often include concentrated caustic soda, sulfuric acid, hydrogen peroxide, and ferric sulfate. These reagents can be supplied by commercially delivered drums or by the reagent system. Other, less-hazardous chemicals can be added by dumping small containers into the process container or vessel, or they can be delivered by flushed-out reagent lines; examples are powdered carbon and calcium hydroxide.

All waste processes are considered batch or semi-batch, depending on where the process border is defined. As with other processes, a waste feed delivery container or tank and an after-process storage container or tank are used when the 100-gal fiberglass vessel is used. In general, when treatment is conducted in a container, that container is the feed and after-process container. Sensors are available to monitor parameters such as pH, level, flow, and temperature. Off-gases are collected and routed through the Process Off-Gas System (POGS), which provides pressure relief.

Chemical Reagent System

The Chemical Reagent System supplies five reagents to the Tank Farm and waste blending station, and one reagent, sodium hydroxide, to the POGS acid scrubber. Reagent tanks are located outside the west wall of B695, and their pumps are located inside the building along the west wall.

Major components of the Chemical Reagent System are the tanks, mixers, pumps, and piping that are designed for the reagents that they hold and deliver. Other components include instrumentation and controls. Two 400-gal, stainless-steel cylindrical tanks store solutions of sulfuric acid and hydrogen peroxide. Three 300-gal cylindrical tanks fabricated from fiberglass-reinforced vinyl ester resin are used to store solutions of sodium hydroxide (two tanks) and solutions of ferric sulfate. All five tanks have a reagent inlet, reagent outlet, off-gas vent, and hand-sized access port. The sodium hydroxide and ferric sulfate tanks have top-mounted, dual-impeller mixers to prevent settling. In addition, the two sodium hydroxide tanks and associated outdoor piping are wrapped in electric blankets to prevent crystallization. The sixth chemical reagent tank is a skid-mounted, stainless-steel dilution system for storing and mixing polymer. This packaged system includes an internal pump, activation chamber, 50-gal storage tank, piping, and floor stand.

The area containing the five outdoor tanks includes a roof and five secondary containment sumps, one for each tank. The polymer dilution room, which houses the polymer system, is adjacent to the outdoor tanks. Precise quantities of reagent can be pumped out of each tank by metering pumps dedicated to each reagent. The sodium hydroxide and sulfuric acid reagents each have their own air-operated, double-diaphragm pump to supply gross quantities of reagent necessary for pH adjustment.

Chemical Reagent System piping consists of individual tank fill-up lines with quick-disconnect stations, distribution lines, and drain lines for all five reagents. Individual distribution lines convey each of the five reagents from their storage tanks to their discharge locations. All five reagents are distributed to the Tank Farm (where reagents are piped directly into the tanks) and the waste blending station (where reagents are piped to five quick-disconnect stations). In addition, sodium hydroxide is distributed to the acid scrubber associated with the POGS.

Tanks normally are filled up to their high levels. During a fill-up operation, a supply truck parks near the quick-disconnect station of the appropriate tank, connects a hose and portable pump to the quick-disconnect station, opens the appropriate valves, and fills the tank.

When reagent tanks are not used for fill-up or chemical addition, they provide a continuous storage function. Chemical reagents are stored in a ready-to-use condition. Consequently, sodium hydroxide and ferric sulfate flocculent are mixed constantly to prevent settling. Sodium hydroxide tanks and outdoor-exposed piping are heated constantly to prevent crystallization and possible clogging. Clogging would only limit the flow of reagent until the clog is cleaned.

Evaporators

The evaporators are designed to remove radioactive and hazardous solids from wastewater by employing an evaporative separation process, and are operated in B695. The goal is to produce a condensate that can be discharged directly to the sanitary sewer. Evaporation generally provides cleaner effluents than conventional wastewater processes, such as precipitation, settling, or filtration; reduces the volume of hazardous and/or radioactive waste requiring disposal; and minimizes byproduct waste generation (e.g., filter media).

The units are typically operated on a batch basis, with the Tank Farm or portable tanks normally used as the source of waste feed. Because the evaporation chamber pressure is lower than ambient, waste is drawn into the evaporator pot from the feed source.

Heat transfer is achieved through the use of refrigerant and/or low-conductivity water. The closed-loop refrigeration system is powered by compressors. The evaporator columns operate under vacuum. At this condition, water boils at lower temperatures than from evaporators that do not rely on vacuum. Evaporator settings can be adjusted to accommodate the waste feed vapor pressure and in response to changes in ambient conditions. Compounds that have vapor pressures less than the operating pressure at the operating temperature will vaporize. Properties, such as boiling point, temperature, pressure, and heat transfer, are evaluated to predict treatment effectiveness, condensate and concentrate waste stream composition, as well as the distillate stream.

Water vapor and other compounds are condensed and accumulated in the condensate collection tanks. The condensers operate at low temperature to ensure the water vapor condenses. However, temperature can fluctuate with changes in ambient temperatures and condensate flow rate.

The evaporation process provides clean condensate that is transferred by means of flexible hoses from the condensate collection tank to a receiving waste container, a portable tank, or the Tank Farm. Only condensate that meets LLNL internal limits is discharged to the sanitary sewer system.

The concentrate (evaporator bottoms), consisting of nonvolatile constituents (e.g., salts and low-vapor-pressure organic matter), precipitates, and suspended solids, are normally transferred from the evaporator pot to a waste container or portable tank. If necessary, the concentrate is subjected to additional onsite treatment, such as solidification, prior to being offsite disposal. Samples of concentrate are collected and analyzed to characterize the waste and to provide information for a waste management determination and subsequent treatment.

Centrifuge

The centrifuge is a skid-mounted piece of equipment. It is capable of separating multiphase, immiscible liquids and heterogeneous liquid/solid solutions into three distinct phases based on differences in their respective densities. By attaining separated phases that are more homogeneous than the original waste stream, subsequent treatment operations that might be required are more effective.

The centrifuge can be used to separate oils and solids from water. One specific waste stream that has great potential to be processed by the centrifuge is an aqueous coolant waste consisting of an oily phase, a solvent/water emulsion phase, machined metal turnings, and other solids. The centrifuge also can be used to treat wash water and other waste streams consisting of multiphase liquids/solids that are amenable to this separation process.

The waste feed inlet is located at the top of the centrifuge, and while the centrifuge bowl spins at high speed, the waste is fed automatically into the centrifuge. Immiscible liquid phases separate inside the bowl and form an interface between the phases. The separated liquids flow in an upward progression to the top of the rotating bowl, where two outlets are provided to remove the heavy and light separated phases.

Paring disc pumps are mounted internally on the rack of the bowl to transfer the separated phases into their respective receiving containers. The paring disc converts the centrifugal force generated by the rotating bowl into a pumping action. Some of the phases (e.g., solids and heavy liquid) may be discharged to the same container, depending on the waste characteristics and final disposition of the phases.

The highest-density materials (solids) are pushed to the outer edge of the centrifuge, where they are discharged intermittently to either a sludge basin at the bottom of the centrifuge, or to a separate discharge container. A sludge pump is provided to transfer sludge from the basin into a waste container. Alternatively, a drain at the bottom of the sludge basin can be used to empty sludge out of the basin. The drain has a quick-disconnect to accommodate a bypass pumping circuit.

The Tank Farm and waste containers can be used interchangeably to hold the waste feed and effluent streams. Flexible hoses are used to make the connections.

Each batch of waste normally will be fed to the centrifuge on a continuous campaign basis under fully automatic operations. The degree of separation of liquid phases can be controlled by either adjusting the feed and discharge flow rates or by using different gravity disc configurations. Greater or lesser amounts of light- and heavy-phase liquids can be separated from each other using these methods.

Wastewater Filtration Module

The wastewater filtration module consists of off-the-shelf filtration housings that support bags, cartridges, or loose media, such as diatomaceous earth or sand. Several housings have been purchased to remove solids primarily in aqueous waste streams or that are created through precipitation and flocculation in other unit operations. The rotary drum vacuum filter used in the former A514, or a similar unit, is also used in the B695 Segment. In addition to off-the-shelf housings, RHWM uses equipment such as furnace filters in 55-gal drums to strain out large particles of glass and rock normally found in dilute, extremely low-level waste to prevent damage to other process units, such as evaporators.

The filtration module housings can be configured in several ways. The three most prevalent are vacuum filtration, pressure filtration, and cross-flow filtration. All configurations are operated at low to moderate pressures, and fluid motive devices are similar in characteristics to the ones mentioned in other unit descriptions. Bags and cartridges are selected to optimize sludge removal and reduce or limit clogging and change-out. This process is also considered batch or semi-batch, and often is placed in tandem with other unit operations. Thus, the filtration module can be placed in front of a unit operation without having to discharge directly into an effluent container or tank. This approach reduces a sludge load for a subsequent process and often augments an inline strainer already attached to the process.

Often, this unit operation is operated as part of another operation, but it can be evaluated as its own treatment process when, for example, it is used to remove precipitate from waste treated in the blending station or in Tank Farm operations. When filter housings are used, they are hooked up to feed and discharge hoses through quick disconnects. When the filtration module consists of a furnace filter and drum-type arrangement, feed and discharge lines can be taped or otherwise secured. Often in this type of operation, waste is gravity fed and controlled by a manual valve.

Chopper

The chopper is equipped with hydraulic lifts to raise and dump drum contents into their hoppers. Once inside the hopper, debris is directed down the hopper chute to the cutting teeth, where it is physically reduced in size. A HEPA-filtered exhaust system captures airborne particulates generated during size reduction operations, and exhaust from the filter is vented to the B695 ventilation system (which also is HEPA filtered) prior to being discharged to the atmosphere. Flow indication in the ventilation system is achieved through differential pressure monitoring with an alarm indicating inadequate air flow. Debris from the chopper is collected in a container placed below the chute.

The chopper normally is operated manually. A current relay is installed in the drive motor circuitry to reverse the motor automatically when a current overload condition is detected. After a short interval of reverse-operation, the chopper resumes its forward cutting operation. If an object that cannot be reduced in size causes an overload, the chopper will shut down after a preset number of consecutive reversals.

Debris Washer

The debris washer is used primarily for compliance with Debris Rule treatment under RCRA regulations, to reduce chemical and radiological concentrations in subsequent handling operations. The present description of debris is that it consists primarily of waste, of which 50 percent by volume (using visual inspection) is greater than about 2.5 inches in one dimension. It includes all types of material and combinations of material that are extremely heterogeneous in nature. For example, a brick, plastic bags, broken glass, personnel protective equipment (PPE), paper, construction materials, and any combination can be considered debris if it meets the stated dimensional criteria. Debris can be treated using many different methods, including extraction, destruction, and immobilization.

The debris washer consists of a steel box similar in dimensions to a waste storage box. An off-the-shelf, heated pressure washers modified to deliver water and reagents into the box through nozzles provides the physical extraction. A duct, which may be heated, connected to building ventilation, provides drying. A container (nominally up to 625 gal) catches the spent wash solution.

The debris waste may be size reduced, if needed, through the chopper system to create a greater surface area to be washed. The debris washer box is placed underneath the chopper chute to accept size-reduced material. Then the box lid that contains the spray manifolds is attached to the box. The debris washer box is then placed into the bucket of a box dumper, and raised approximately 62-in above the floor. Pressure washers are turned on to spray the debris with the spent washing fluid draining into the container located underneath the box dumper. The contents are dried for extended periods of time. The point of drying is to remove free liquids to below approximately 5 percent by volume but not to create a dusty environment. Once the contents are dry, the box is rotated, and contents are dumped into an appropriate container.

Solidification System

Solidification is primarily used for three purposes: (1) to remove or solidify water in a waste to reduce or eliminate free liquids, (2) to meet commercial and DOE waste acceptance criteria, and (3) to meet RCRA Land Disposal Restrictions. Other purposes not necessarily as prevalent include performing chemical reactions for pretreatment, such as oxidation to remove organic material, mixing to make a waste more homogeneous, and breaking up soft materials to change their shape.

Solidification operations consist of using hand-held or small agitation devices, a resin delivery system, and a modified “change-can” type double planetary mixer designed to mix waste material with stabilization media prior to disposal in 55-gal drums. Wastes normally will be pumped or scooped from containers or tanks, or will already be supplied in the container to be used for stabilization.

Dry powders will be the primary solidification agents used, including cement and clays (natural or substituted). Other reagents are added in smaller quantities to augment stabilization or perform pretreatment. These include chemicals such as oxidizers and pH-insensitive precipitation chemicals. The chemicals are hand delivered to the waste or media or are pumped with small portable pumps.

The double planetary mixer, located in R1038, has a steel shroud mounted on the stabilizer that rests on the rim of the waste drum. Solidification media normally are added to the drum prior to being placed under the solidification unit's shroud/mixer assembly. Feed ports are also provided in the shroud to allow additional waste and solidification agents to be added to the drum after the shroud/mixer assembly is lowered into place**.** Once mixing is complete, blades removed from the container can be cleaned by hand with hand tools, cleaners, towels, and scrapers. The drum of stabilized waste is placed in storage.

Solidification also can be achieved through hand mixing or mixing with smaller devices and conventional agitation. This usually is done with smaller quantities of waste and is performed in similar fashion as described above.

HEPA filters also can be stabilized using a resin delivery system. The filters are encapsulated by using a slow-cure resin and filling them using gravity augmented by vacuum. This prevents radionuclides and hazardous constituents from leaching into the environment, and provides a disposal option and safer storage. The process uses a premixed container of resin that is gravity and/or vacuum fed through the HEPA filter by piping and valves.

Reactive Waste Processing Area

The reactive waste processing area (RWPA) consists of Rooms 1023 and 1025. Essentially any treatment processes that can be done in B695 can be done in the RWPA. In addition to the many processes described in other sections of this DSA, RWPA treatment also includes controlled water reaction, pressure reactions, uranium bleaching, and mercury amalgamation. The RWPA has ample floor space and bench-top space to place support equipment, in-process waste, and waste processing appurtenances such as ultraviolet lamps, ozone generators, oxygen purifiers, flow-through tubes, in-line mixers, heat exchangers, data acquisition equipment, and labware and reaction vessels. Two chemical fume hoods, one inert atmosphere glove box, one radioisotope glove box, and one combination glove box are available in the RWPA, and a removable walk-in fume hood is available in the reactive materials cell. This walk-in fume hood can be removed when needed and the ventilation customized to the process to be conducted.

Treatment operations conducted in these areas are numerous. RHWM intends to use several types of equipment in the operations, but most are typical of laboratory or bench-scale operations.

Small-Scale Treatment Laboratory

The small-scale treatment laboratory, located in Room 1017, is generally used for sample preparation and waste treatment feasibility studies. However, the operations performed in the RWPA can also be performed in the small-scale treatment laboratory. The small-scale treatment laboratory is equipped with two fume hoods and standard bench top labware (e.g., rotary evaporator, bench top centrifuge, etc.).

Instrument Laboratory Operations

The instrument lab located within the B695 Segment provides real-time radiological and almost-real-time metals and VOCs analyses to aid in treating mixed and radioactive wastes and developing improved treatment processes. Typical instruments used in the lab include a flash point tester; gas-chromatograph/mass spectrometer (GC/MS); a gas chromatograph (GC) with flame ionization detector (FID), photoionization detector (PID), and a dry electrolytic conductivity detector (DELCD); a liquid scintillation counter (LSC); an X-ray fluorescence (XRF) spectrometer; a gamma spectrometer; and an alpha spectrometer. Most of the analytical results are for screening and verification purposes, not for regulatory compliance. This equipment may be removed from the lab for use elsewhere or for maintenance. New instruments may be procured and used in the lab to support operations.

The closed-cup flashpoint tester is a manual unit used to determine the flashpoint of VOC- and SVOC-containing waste. The flashpoint tester is electrically heated. Natural gas is used for the pilot flame.

The GC/MS consists of a gas chromatograph coupled directly to a mass spectrometer. This instrument is used to analyze organics either by direct injection or by an automatic sampler, which can analyze samples without human intervention. Samples are prepared in vials using standard analysis methodologies. The analysis is done using pre-programmed protocols. The GC/MS can be used to measure volatile compounds and semi-volatile compounds, and to analyze carbon adsorption efficiency.

An additional GC uses the purge-and-trap method to analyze VOCs. Three detectors are used in the analysis, depending on the sample's unknown organic constituents. These detectors are the FID, DELCD, and PID. The gas chromatograph can be expanded to seven detectors and can temperature ramp in a size compact enough to fit on a cart for use. This instrument is used for analyzing liquid samples that might be too dirty for analysis in GC/MS. The instrument has an automatic sampler that can analyze 16 samples at a time.

The LSC is designed for determining radioactivity on a wide variety of samples such as filters, membranes, solutions, and swipes. The instrument uses the patented time-resolved liquid scintillation counting method. It is equipped with a special detector, has very low background, and is ideal for analyzing environmental samples that have very low levels of radioactivity. Example sample preparation involves pipetting 1 ml of liquid sample into a scintillation vial containing 10 ml of scintillation cocktail.

The XRF is designed for elemental analysis of samples. It can detect and measure the elements in a wide variety of samples, metals/alloys, fused beads, pressed powders, and liquids. The elements that can be detected range from sodium to uranium. Samples can be prepared by scooping 5 g of solid samples into an XRF vial or pipetting 5 ml of liquid sample into an XRF vial. The vials are placed in the XRF sample tray and analyzed for 30 seconds using pre-programmed protocols.

The portable Multichannel Analyzer is used to identify gamma-emitting nuclides in environmental samples. It uses a coaxial germanium detector, and can be used to analyze different sample matrices and geometry. As an example, both Marinelli beakers and squat jars are used with small samples typically less than a liter. The samples can be placed in squat jars and run directly on top of the detector. The gamma spectrometer can be used to identify the radionuclides present in the waste once it has been established through liquid scintillation counting that the sample is radioactive.

The alpha spectrometer is used to detect alpha-emitting nuclides in waste samples. It uses a passivated implanted planar silicon detector and is applicable to samples that are prepared in disks. Sample preparation requires a series of filtration, extraction, and electrolytic deposition procedures. This protocol requires reagents in extremely small quantities. The final result is deposition of a precipitate on a disk.

Other instruments typical of analytical laboratories might be used; all require only small samples of material, and many need to be diluted to read them. Gases are used for carriers only and as fuel for the flame ionization detection. These gases normally are stored outside the facility on the gas pad. Hydrogen, helium, and nitrogen are typically used in this laboratory. Liquid nitrogen is used with the gamma spectrometer.

Fume Hood Operations

There are two fume hoods in the RWPA of B695, one in the reactive materials cell in Room 1025, and two in the small-scale treatment laboratory. Compatible wastes from two or more containers can be consolidated in the fume hoods to maximize onsite storage space and/or to reduce offsite transportation costs or onsite treatment costs. Other fume hood uses include various treatability studies, sample preparation, small-scale treatment, and chemical preparation.

The fume hoods are fabricated from corrosive-resistant materials. The exhaust ports are connected to B695 ventilation ducts that feed off-gases into the B695 POGS. Thus, a negative pressure is maintained in each fume hood with respect to pressure in their respective rooms. The fume hoods are fitted with connection points for several utilities, such as electric lighting, vacuum line, compressed air, inert gas (argon or nitrogen), natural gas, and water.

The B695 fume hood operations are typical of fume hood operations in other industrial settings. A container of waste is staged in or around the fume hood by an operator for a specific treatment process, such as acid neutralization, stabilization, chemical oxidation, or repackaging. When treatment is complete, the operator removes treated waste from the fume hood and transfers it to an appropriate receiving container. As part of the process, an operator can initiate a vacuum or open gas-supply valves to affect or control the process.

A fume hood and ventilated workstations in B696S, Room 1001, are used to provide ventilation for labpacking and passivation activities. The ventilated workstations pull air horizontally away from the worker, and are used for labpacking containers too large to fit in the fume hood, such as a 55-gal drum.

Reaction Vessel Operations

Small-scale treatment operations sometimes employ reaction vessels. Vessels include off-the-shelf pressure vessels, vessels fabricated in-house (both plastic and stainless steel), and purchased labware metal, plastic, and glass nonpressurized vessels (e.g., glass beaker).

Treatment operations primarily take place in the small-scale treatment laboratory, reactive waste processing area, or the reactive material cell. Pressure vessels can stand alone when placed on a cart, or they can be removed from the cart and placed in a glove box or fume hood when additional containment is needed. Other vessels can be used on a benchtop or placed in a fume hood or glove box, depending on the type of work to be conducted.

The pressure reaction vessels support a batch process in which the vessel is charged with waste and chemical reagents are introduced at a controlled rate. The vessel is charged either by removing the vessel head and filling the vessel with waste directly, or by introducing waste through one of the fittings mounted on the vessel head.

The vessel temperature and pressure may be monitored continuously. Liquid and gas samples can be removed via the other sample valves also located on the vessel head. After treatment, material is extracted directly or by pumping or pouring it out through sampling valves mounted to the vessel head.

Pressure vessels can be used for catalytic hydrogenation, routine catalytic reactions, organic reactions, polymerizations, and inorganic reactions. Such reactions typically generate heat and/or pressure from other processes.

Some vessels are amenable to water reaction activities. The objective is to deactivate water-reactive waste to comply with land disposal restriction treatment requirements. The vessel is used to control reaction rate, to dissipate exothermic reaction heat, and to manage product off-gases. The process of reacting a water-reactive waste with humid, inert gas or a limited amount of water generates hydrogen gas and a metal hydroxide.

The water reactor system consists of a reaction vessel, water feed system to introduce water into the vessel, and an effluent receptacle. The treatment operation is conducted in an inert atmosphere glove box or the combination glove box (in inert atmosphere mode) in the B695 RWPA. To control reactions during the treatment process, the amount of humid, inert gas, or water introduced into the reactor is limited.

The temperature and pressure of the reaction vessel may be monitored continuously during a reaction. When gas is no longer produced and the reaction temperature stabilizes, the reaction is considered complete. After treatment, waste products are removed from the vessel by pumping or pouring effluent into an appropriate receptacle.

The mercury amalgamation process is used to treat small quantities of mercury waste. Operations are conducted in the small-scale treatment laboratory, RWPA, or the reactive materials cell. The purpose of the process is to meet the best-demonstrated available technology treatment standards for specific mercury wastes. For treating mixed, radioactive, and hazardous waste containing mercury, the Environmental Protection Agency (EPA) has identified amalgamation as a technology that provides significant treatment in terms of air emissions and potentially reduces leachability. LLNL’s treatment system is designed to ensure that the amalgamation process is controlled and complete, and that product off-gases are managed safely.

The amalgamator is a small reaction vessel of approximately 1-liter capacity mounted on a stand or a small skid. The vessel is made of stainless steel and is heated electrically. It is equipped with a stirrer, viewing port, and instrumentation.

Examples of reaction vessels made of stainless steel in-house include a nominal 65-liter vessel capable of operating at about 100°C and 250 psig that is used to hydrolyze, then oxidize, volatile compounds. This reactor is used primarily in processing solvents, such as in destroying methylchloroform by hydrolyzing under pressure at elevated temperatures then oxidizing at essentially ambient pressure just below boiling.

Uranium deactivation is performed in reaction vessels. The primary purpose is to remove the pyrophoricity of uranium chips and turnings. This is a simple process employing agitation and introducing acid solutions to dissolve and/or form salt compounds of uranium that are not pyrophoric and can be further processed for disposal. This process deals with oxidation of natural and depleted uranium. The reaction vessels are for oxidation of natural or depleted uranium, which has enrichments less than 0.72% U-235 by weight. Criticality is not physically possible for uranium in water with enrichments less than 0.93% U-235 by weight in ANSI/ANS-8.1-1998. Therefore, criticality is not credible regardless of the quantity of uranium in the process.

Other reaction vessels made of plastic or glass, fabricated in-house or obtained commercially, may be used to treat various waste streams to perform treatability studies and laboratory experiments. Most studies are performed in liquid phase, but they may include solid material. The studies are normally conducted at temperatures below the boiling point and near ambient pressures. Studies include, but are not limited to, chemical oxidation, neutralization, flocculation, and stabilization. Typical vessel capacities are less than 10 gal. It is anticipated that all reaction vessel types will be used to process hazardous, low-level, and mixed waste streams.

B695 Glove Box Operations

The double-wide radioisotope glove box will be used primarily as a contamination-controlled environment. Small-scale chemical treatment along with stabilization can take place in the glove box. Compatible wastes from two or more containers can be consolidated in the radioisotope glove box to maximize onsite storage space or to reduce offsite transportation costs or onsite treatment costs. Wastes managed in this glove box typically present a high airborne-contamination hazard (e.g., from asbestos, carcinogens, and radioisotopes).

Air is pulled from the RWPA into the glove box through the inlet HEPA filter, where it then passes through the glove box and is discharged to an outlet HEPA filter before being routed to the ventilation duct that leads to the B695 POGS. The glove box pressure can be adjusted by varying the valve associated with the ventilation duct, the inlet damper, the vacuum pump, or glove box blower.

The inert atmosphere glove box is a double-wide glove box that will be used for handling, treating, and repackaging pyrophoric and reactive materials. An inert atmosphere will be provided using nitrogen and/or argon gases. The inert atmosphere is maintained by means of a regenerative drying train. Pressure inside the glove box is controlled by adding inert gas to increase the pressure or by using a vacuum pump to decrease the pressure. A pressure-relief bubbler connected to the glove box ensures that pressure is maintained within about 10 in. of water gauge (vacuum or pressure). The glove box is also connected to the facility’s ventilation ducts that feed off-gases into the B695 POGS.

The water reaction vessel can be operated in the inert atmosphere glove box, as can the pressure reactor or any other process that requires a controlled inert atmosphere. Compatible wastes from two or more containers can be consolidated in the inert atmosphere glove box to maximize onsite storage space or to reduce offsite transportation costs or onsite treatment costs.

The combination hazards glove box is a single-wide glove box that can provide either an inert atmosphere when managing pyrophoric and reactive materials, or a contamination-controlled environment when managing high airborne-contamination hazard materials. Compatible wastes from two or more containers can be consolidated in the combination glove box to maximize onsite storage space or to reduce offsite transportation costs or onsite treatment costs. When in radioisotope mode, the outlet valve will be opened to the facility's ventilation ducts that feed off-gases into the B695 POGS. The pressure of the glove box can be adjusted by varying either valve associated with the ventilation duct, the inlet damper, the outlet valve, the vacuum pump, or glove box blower. When in inert atmosphere mode, the inlet and outlet valves will be closed, and an inert atmosphere will be provided using nitrogen and/or argon gases. The inert atmosphere is maintained by means of a regenerative drying train. Pressure inside this glove box is controlled by adding inert gas to increase the pressure or by using a vacuum pump to decrease the pressure. A pressure-relief bubbler connected to the glove box ensures the pressure within this glove box is maintained within ±10 inches of water.

All three glove boxes have electrical receptacles located internally for use with electrical hand tools and/or various process equipment. Several feed-through ports are used for transferring process chemicals, wastes, and/or off-gases into or out of a glove box. The feed-throughs can also be used for electrical signals associated with process equipment, such as pH probes and thermocouples.

Nondestructive Assay (NDA) Box

The NDA box is used for gamma and neutron assays of HEPA filters and other items potentially containing radioactive materials. The NDA box is located in B696S on the East wall of room 1009. The NDA box is a passive (i.e., noninvasive, nondestructive) surveying system that utilizes multiple sodium iodide (NaI) crystals to detect gamma radiation. A large carbon steel box surrounds the NaI crystals and serves to contain the items during the analysis. The assay chamber does not have a radiation-generating device. Neutron and gamma sealed sources with known nuclides and activities are used periodically to calibrate the counting system.

HEPA filters, meeting 10 CFR 835 removable surface contamination values, can have openings capped, may be wrapped in plastic, or may be in a container. If the container is too large to fit within the assay box, the HEPA filter is removed for assay. Non-containerized HEPA filters to be assayed are examined to ensure that the sealed openings or outer plastic wrapping has not deteriorated, creating the potential for loose contamination to be spread when it is moved into the NDA box. HEPA filters with deteriorated openings or wrapping are sealed or rewrapped and surveyed in accordance with existing waste management procedures prior to assay.

B696S Drum Crushers

There are two drum crusher units on the East wall of B696S room 1009. One is designated for non-radioactive crushing operations and the other for radioactive drum crushing. Radioactive waste containers and drums that are empty or contain non-RCRA hazardous or radioactive waste solids are compacted in a drum crusher to facilitate packaging and to reduce the volume of waste shipped off site for disposal or placed into long-term onsite storage. The drum crushers are used intermittently and have the capacity of an 85-gal drum or less.

Each drum crusher consists of a completely enclosed, reinforced-steel plate. Location blocks or brackets keep the drum centered in the chamber. The compacting head is a thick, reinforced-steel plate mounted on a vertical shaft. Electronic controls provide for up-and-down movement of the compacting head.

A 10-hp, totally enclosed, fan-cooled, hydraulic pump motor provides the drum crusher with a maximum compaction force of 85,000 lb. 408-V power to the units are stepped down internally to 120 V. Steel hydraulic tubing rated at 5,000 psi handles the 3,000-psi hydraulic line pressure safely. The units are seismically designed to a peak ground acceleration of 0.57 g.

Each drum crushers ventilation exhaust port is connected to the facility ventilation system, which is HEPA filtered. Because the crushing process is strictly a mechanical operation (no chemical processing occurs), hazardous constituents including VOCs are not expected to be emitted.

B696S Glove Box Operation

Note: The B696S glove box in Room 1008 has not been used and is not currently operated.

The B696S glove box is used to sort, sample, segregate, and repackage waste other than TRU waste. Decontamination of tools used in the repackaging and inspection activities, and of lids to containers may also take place inside the glove box. The glove box is constructed of stainless steel and is approximately 180 in. long by 46 in. wide by 166 in. tall. It is fitted with five 24-in × 30-in × 0.5-in safety glass viewing windows, two maintenance glove ports, and ten working glove ports along each side of its length. The glove box is supported on a stand approximately 58 in. high to allow two 55-gal drums to be positioned underneath. The floor of the glove box is fitted with two specially designed sealable ports where the 55-gal drums are positioned to receive waste. A working platform surrounds the glove box to provide worker access to glove ports. At one end of the glove box, there is a 34-in horizontal drum port with a hydraulic drum lift to seismically hold and position the drum to be processed in the glove box. At this end, the drum lift is straddled by two scissor lift work platforms for performing drum bag-in–bag-out operations. The opposite end of the glove box contains a 12-in port for adding or removing samples or other small items. A ½-ton electric hoist is located inside the glove box to assist in moving heavy objects. The glove box is equipped with lights, video cameras, tool racks, and HEPA ventilation system. The glove box is seismically secured, and meets PC-2 seismic criteria.

Waste is well characterized prior to processing in this glove box. Analysis was performed on most legacy waste drums in inventory prior to May 1998, using active and passive neutron and gamma scanning. The vast majority of the legacy waste drums have had real-time radiography performed, up until March 1999, to look at container contents. Characterization of drums since that time has been improved through the development of more stringent certification processes.

In preparation for waste processing, a container is placed on the drum lift that is stationed at the 34-inch drum port end of the glove box. The container is positioned so that its top (with the lid still on) is parallel to and in line with this glove box opening. The top of the container is then sealed to the 34-in drum port using a large bag secured to the top area of the drum and the 34-in drum port flange. Containers may also be vertically bagged in using the same process described for a receiving drum.

To secure a new receiving drum to the glove box, a receiving bag connected to a special rigid poly flange is first installed into the drum. A receiver drum 90-mil drum liner is placed inside the bag to keep items from puncturing the bag during drum loading. The cart, loaded with the drum and flange/bag assembly, is then wheeled underneath the glove box and onto the lift table. When the lift table is raised, the old poly flange and bag (currently in the receiving flange on the port on the glove box’s floor) is forced back into the glove box, and the new poly flange and bag seats into the receiving flange. The drum is now sealed to the glove box.

When all drums are in position and glove box seals are in place, the lid from the drum containing waste to be processed can be removed. From outside the glove box, the drum lid is removed using the installed gloves, and material is removed for examination, processing, or sampling. Items are subsequently placed into one of two designated receiving drums at the other end of the glove box or bagged out through the 12-inch port. When a drum (which once contained waste) becomes empty, the lid is reinstalled, and it is moved back from the glove box. The bag-out bag is then sealed, the joint is cut to separate drum from glove box, the freshly cut exposed surfaces taped over, and surveys done for contamination control. The old drum is removed, and the next waste drum can be loaded onto the drum lift. A bag-over-bag connection technique positions it for processing its contents inside the glove box. After work is completed, the process to remove the receiving drums is similar to the one described above for the 34-in horizontal drum port.

Waste Packaging Unit

The Waste Packaging Unit is located in Room 1009, of B696 SWPA. The Waste Packaging Unit is comprised of a floor level walk-in booth equipped with a ventilation system that exhausts to a HEPA filtration system, fire sprinklers, and a personnel airlock. The Unit is constructed of stainless steel or other noncombustible durable materials that are easily decontaminated. The booth, where treatment and handling activities are performed, has approximate dimensions of 20 ft by 30 ft. Differential pressure gauges with alarm points are provided for the ventilation system. The booth has equipment access doors to facilitate movement of equipment into and out of the Unit. Personnel enter the booth through a personnel door located between the booth and the airlock. The airlock allows personnel to don, change, or remove personal protective equipment. The airlock provides an area to control the spread of contamination from personnel exiting from the Unit.

Labpacking and Passivation

Labpacking is primarily performed in B696S Room 1001 in the fume hood and ventilated workstations, and is standard practice to prepare small containers of chemicals for waste shipment. Labpacking is a term used by personnel to refer to packaging small waste containers into larger ones in accordance with Department of Transportation (DOT) regulations and California Department of Toxic Substances Control (DTSC) regulations. Labpacks are also prepared in compliance with the waste acceptance criteria of receiving offsite TSD facilities. Wastes are categorized using technical literature, e.g. Material Safety Data Sheets, chemical reference materials, DOT hazardous materials tables, and waste disposal requisitions (WDR). Once categorized, wastes are packaged into approved containers and shipped to the appropriate offsite facility.

Chemical passivation involves the introduction of certain species to an “inerting” medium (e.g. hydrating nitro-organics, stabilizing peroxides, or oil immersing elemental metal substances). Passivation is primarily performed in the B696S fume hood and B695 glove boxes.

2.6 Confinement Systems

This section describes the set of structures, systems, and components (SSCs) that perform confinement functions within the B695 Segment. Many SSCs throughout this segment perform confinement functions as a secondary purpose. For example, the tanks associated with the Tank Farm were designed to process hazardous and radioactive waste as their primary function, but the tanks also confine a hazard and are not discussed. SSCs whose primary function is to confine a hazard are discussed below.

Glove Boxes

In general, glove boxes in the B695 Segment provide confinement only for normal operating conditions and are not protective for accident conditions. The B696S glove box serves as the primary barrier between the worker and the waste material. Waste treated in glove boxes typically presents an airborne contamination hazard or requires an inert atmosphere to control undesired chemical reactions. Glove boxes also provide confinement and ventilation controls for treating small quantities of waste. The glove boxes identified in **Table 2-2** are used in the B695 Segment.

Table 2-2. Glove box locations

Glove Box	Location
Radioisotope	B695 RWPA (Room 1023)
Inert atmosphere	B695 RWPA (Room 1023)
Combination hazards	B695 RWPA (Room 1023)
B696S	B696S repackaging room (Room 1008)

The radioisotope glove box serves primarily as a contamination-controlled environment for small quantities of radioactive material. The inert atmosphere glove box is used to handle, treat, and repackage small quantities of pyrophoric and reactive materials. The combination hazards glove box can be used as either a radioisotope or inert atmosphere glove box, depending on the configuration needed.

The main discharge for the radioisotope glove box, and the combination hazards glove box when in radioisotope mode, passes through dedicated HEPA filters before being added to the building's ventilation system. These are non-testable filters, and their efficiency will depend on the service demands and size of particles. Filters are replaced periodically depending on use. Off-gases from these three glove boxes pass through the B695 POGS and HEPA filter banks before being vented to the atmosphere.

The B696S glove box serves as the primary barrier between the worker and the waste material during sorting, sampling, segregating, and repackaging activities requiring a Type III workplace. Materials and work pieces are viewed through sealed windows and handled by protective gloves. An exhaust fan pulls air from Room 1008 into the glove box through a dedicated inlet HEPA filter. The air then passes through the glove box and an exhaust HEPA filter before being routed to another HEPA filter and then to the building ventilation system.

The repackaging room in which the B696S glove box is located (room 1008) serves as a secondary confinement barrier. The repackaging room is connected to the building ventilation system, which maintains a room pressure that is higher relative to the glove box pressure and lower relative to the building pressure. Both glove box and room ventilation are considered contamination control because they are only designed to maintain slight negative pressures with low room volume changes. The pressure differential creates a secondary confinement space within the repackaging room. The repackaging room atmosphere is exhausted through a dedicated HEPA filter prior to connecting to the building ventilation system ductwork. The repackaging room is designed and constructed per the same standards and building codes as B696.

The pressure differentials described for the B696S glove box room are maintained in the same way that the other ventilation zones are maintained throughout the buildings, and as described below.

Facility Ventilation

The airflow-control system is designed with electronic components and some pneumatic devices. A high-quality, industrial-grade control system is used for differential airflow control to ensure proper room pressurization is maintained. The airflow-tracking method is used to control pressure and airflow in the different rooms or zones.

The process areas in the B695 Segment are heated and cooled to maintain the required indoor temperature and are provided with an airflow control system. For temperature and pressure control, process areas are divided into several zones. These areas are supplied with conditioned and filtered, once-through 100-percent outside air by two 50-percent air-handling units consisting of pre-filter and high efficiency filters, preheat coil, chilled-water-cooling coil, and a variable-speed supply fan. The air-handling units are sized to accommodate an additional 25-percent capacity and are located in the mechanical equipment room. The supply duct serving each zone has an air-flow-control valve with a hot-water-reheat coil for pressure and temperature control. Supply air comes from ceiling diffusers and is exhausted through wall registers near the floor. All supply ducts are constructed of galvanized steel and insulated.

Exhaust air from B695 consists of general exhaust air from the rooms and individual exhaust from processes. All exhaust air, including exhaust air from the SWPB, is collected by means of ductwork and conveyed to three stainless-steel, parallel filter units (each designed to support approximately one-third of total facility capacity), located on the northeast side of the mezzanine of B695. On each side of each filter bank, shut-off dampers are designed to close upon detection of smoke, loss of exhaust airflow, or high duct static pressure. These conditions cause the facility management system (FMS) to generate a conventional digital signal that drives the actuator and closes the damper. Loss of pneumatic control pressure (to damper actuators) or FMS control signal causes exhaust dampers to fail open. In addition, all variable adjustment valves fail open. Each filter unit has a bank of side-access pre-filters, HEPA filters, filter efficiency test sections, and a variable-speed exhaust fan. Exhaust air from all filter units is combined and discharged to the exhaust stack. Filters are sized to accommodate an additional 25-percent capacity. HEPA filters not used for housekeeping (e.g., main building ventilation HEPA filters and chopper HEPA filters) have pre-filters to take the same airflow and protect buildup of the HEPAs prematurely. The ventilation system is equipped with Magnehelic differential pressure gauges.

The ventilation system is designed to provide air movement from cleaner (exterior and storage) areas to potentially contaminated processing areas. To ensure airflow in the proper direction, pressure differentials are maintained between confinement zones by airflow tracking. Airflow tracking can maintain a negative pressurization level by ensuring that more air is always exhausted than supplied. Although the quantities of supply and exhaust air vary as the needs of a process vary, the air flow difference between supply air and exhaust air is maintained to ensure the required negative pressure while maintaining the zone's required minimum ventilation-air-change rate. The total supply and exhaust airflows are varied, depending on the requirements of all zones, by adjusting the speed of the associated fans via a controller.

Liquid Run-Off Collection Systems

The concrete floor of B695 slopes from east to west. A continuous concrete curb along the west, north, and south perimeters will contain any leaks or spills inside the building. The curb is flush with the high point of the floor at the northeast and southeast corners of the building. The top of the curb along the western edge is approximately 4-in tall, and curb height varies along the northern and southern edges. The curbing and sloped floor ensure the entire area inside B695 has adequate secondary containment, except for the reactive waste storage rooms.

The reactive waste storage rooms (rooms 1019, 1020, 1021, and 1022) in B695 have individual trenches with drains that flow to the 20,000-gal underground tank. The rooms have sloping concrete floors and internal concrete curbing. Primary containment is the trench and underground tank; secondary containment is the double wall for the underground tank.

All B695 construction joints (between slab sections and between the curb and floor) are sealed with polyamide epoxy or an equivalent coating material. Sealant is applied to the finished floor and curb surfaces to prevent liquids from penetrating into the concrete and to facilitate decontamination in the event of a spill. The top layer of the coating contains sand to provide a rough, durable surface for traction. Floors are sloped toward grated collection trenches.

The B696S truck bay has a single trench with a drain that flows to the 20,000-gal underground tank. The bay has a sloping concrete slab. Primary containment is the trench and underground tank; secondary containment is the double wall for the underground tank

B695 is divided into separate containment zones. The divisions are achieved by sloping the concrete floor and providing internal concrete curbs. The primary liquid containment for each zone is its trench and associated sump; secondary containment is the concrete curbing. B696S consists of only one containment zone as the receiving/classification room (Room 1001) and the remaining rooms in B696S (Rooms 1007, 1008, and 1009) are connected by a common floor that would allow run-off to flow to the open trench running the length of the north wall of R1009.

Locations of containment zones for B695 are as follows:

- LWPA (Rooms 1028 and 1029).
- Instrument lab (Room 1015).
- Small-scale treatment lab (Room 1017).
- Reactive waste processing (Room 1023).
- Reactive materials cell (Room 1025).
- Air lock (Room 1027).
- Debris washer (Room 1036).

- Air lock and chopper (Rooms 1037 and 1038).
- Chopper (Room 1039).
- Hydraulic room (Room 1040, 2 sumps).
- Reactive waste storage rooms (Rooms 1019, 1020, 1021, and 1022).

In B696S, all construction joints (between slab sections and between the curb and floor) in the waste management boundary are sealed with polyamide epoxy or an equivalent coating material. Sealant is applied to the finished floor and curb surfaces to prevent liquids from penetrating into the concrete and to facilitate decontamination in the event of a spill. The top layer of the floor coating contains sand to provide a rough, durable surface for traction. Floors are sloped toward grated collection trenches to facilitate removing spills and washdown water.

Periodic inspections include observing the trenches and sumps to detect any accumulated liquids. Liquids are removed with a portable pump or vacuum tanker. Liquids from sumps may be treated through processes identified in Table 2-1, or they may be released directly to the sanitary sewer after characterization. Characterization is done by sampling and analysis and/or generator knowledge. Each of the five chemical reagent tanks has a dedicated sump, which acts as the secondary containment to the tanks.

2.7 Safety Support Systems

Safety support systems in the B695 Segment include off-gas treatment and ventilation systems, the ability to use passive air sampling systems, fire sprinkler systems and alarms, and an automatic shutoff valve on the natural gas line. Off-gases from the process units in the segment are treated before discharge to the atmosphere. The type and size of treatment systems will depend on the nature and amount of waste to be processed.

Fire sprinkler systems in the B695 Segment were tailored for the anticipated risk in each operational area. Fire sprinkler systems are protected from freezing by building temperature control, and sprinkler water will be collected in the secondary containment. The alarm system is connected to the fire dispatcher on site. The automatic shutoff valve on the natural gas line is designed to close the valve in the event of an earthquake.

Process Off-Gas System (POGS)

The off-gas treatment system is mandated by RCRA and serves as an air-pollution-abatement device for the Tank Farm, blending units, centrifuge, evaporators, small-scale treatment units and fume hoods, glove boxes, debris washer, and solidification unit in the LWPA. The equipment is connected in the following order: acid gas scrubber, heater, HEPA filter, blower, and two carbon columns. A methanol vapor scrubber is located prior to the acid gas scrubber for treatment of Tank Farm off-gases, if required.

The methanol gas scrubber consists of a packed-bed tower and reservoir. The methanol scrubber is used when large concentrations of methanol are expected in the off-gas from the Tank Farm. Water is used as the scrubber medium. A pump recirculates scrubber solution through spray nozzles. Exhaust from the methanol scrubber passes through a mist eliminator and is discharged to the POGS. When the methanol scrubber is not needed, it is not operated.

The acid gas scrubber is primarily used to remove acid gases and secondarily used to remove other organics soluble in the scrubber liquid. The scrubber assembly is a vertical fume scrubber designed as a packed bed and capable of operating at 10,000 actual cubic feet per minute. The scrubber is equipped with a built-in mist eliminator. A pump recirculates scrubber solution, water, or hydroxide solution from a reservoir. The scrubber makeup system is controlled to maintain adequate flow of scrubber solution and to maintain an adequate pH range. pH probes are installed at the scrubber inlet, and are used in conjunction with a magnehelic gauge to monitor the pressure drop in the scrubber.

A heater is installed to reduce the relative humidity of process off-gas. The heater is sized to prevent condensation onto the HEPA filters and to reduce the relative humidity of the gas below 50 percent to optimize the absorptive properties of the carbon beds.

A HEPA filter between the heater and carbon columns traps particulates and prevents them from depositing on active sites on the carbon. The system is a self-contained unit that was designed and manufactured in a manner similar to the building HEPA system.

The carbon columns are designed to remove organics that might be present in the off-gas. The two carbon columns can be connected in series or in parallel; typically, they are connected in series. A PID between the two columns detects trichloroethylene breakthrough from the lead column. When the PID indicates breakthrough from the lead column, valves are adjusted so that the column that was originally the lag column now becomes the lead column. When the new lead column has breakthrough, all of the carbon is changed out and replaced at the same time. This assures that pollution abatement requirements are maintained.

HVAC

Exhaust air from B695 and B696S consists of general exhaust air from the rooms, process exhaust air from the process units, and process off-gas exhaust air from the process off-gas treatment systems and glove boxes. All exhaust air, including exhaust air from the B696 SWPA, is collected by means of ductwork and conveyed to three stainless-steel, in-parallel filter units, each designed to support one-third of total facility capacity. Each filter unit has a bank of side-access pre-filters, HEPA filters, test sections to determine HEPA efficiency, and a variable-speed exhaust fan. Exhaust air from all filter units is combined and discharged to the exhaust stack. The exhaust stack is 60 ft above ground and 18 ft above roof.

Passive Air Sampler/Continuous Air Monitor

RHWM places portable continuous-air monitors (CAMs) and/or passive air samplers (PASs) in areas where individuals are performing operations involving opened radioactive-waste containers. CAMs and PASs will be installed and used in accordance with 10 CFR 835.403, Area Monitoring. In addition, posting that an area contains radioactive materials or contains radioactive contamination is done in accordance with the LLNL *ES&H Manual*. PASs are collection devices that are used to characterize subsequent radioactivity and chemical exposures for subsequent or similar pending operations. CAMs are used for the same purpose, and are generally not responsive quickly enough to be credited with providing mitigation for the potential accidents within this facility.

Fire Sprinkler System

There are ten distinct building areas [seven sprinkler risers/zones] of wet pipe sprinkler protection in B695. Sprinkler shop drawings and hydraulic calculations indicate eight building areas [five zones] hydraulically designed to an Extra Hazard, Group 1 density of 0.3 gpm/ft^2 over the most remote 2500 ft^2, with upright, 200ºF intermediate temperature sprinklers. Five of the buildings areas [two zones] use 17/32-in orifice sprinklers, and three building areas [three zones] use 1/2-in orifice sprinklers. The remaining two building areas [two zones] are Ordinary Hazard pipe schedule systems with 1/2-in orifice, upright, 200ºF intermediate temperature sprinklers.

Sprinkler contractor submittals indicate that the sprinkler systems in B695 are seismically designed in accordance with NFPA 13.

The B696S is protected by a wet-pipe sprinkler system, and the B696 truck bay is protected by a dry-pipe sprinkler system. Both are designed and installed in compliance with NFPA 13. One underground connection protects the entire building and the truck bay. The wet pipe sprinkler system is designed for an Ordinary Hazard Occupancy Group 2 and hydraulically calculated to provide a density of 0.20 gpm/ft^2 over the most remote 1600 ft^2. The sprinkler area of coverage does not exceed 130 ft^2 per sprinkler. All sprinkler heads are new, upright, 165°F temperature-rated, 1/2-in pipe thread, have 1/2-in orifices, and corrosion-resistant brass. The truck bay is a dry pipe sprinkler system hydraulically designed to an Ordinary Hazard Occupancy Group 2 density of 0.2 gpm/ft^2 over the most remote 2080 ft^2, using 1/2-in orifice, upright, 200ºF intermediate temperature sprinklers. All piping is supported per requirements of NFPA 13. All devices and equipment are UL-listed or Factory Mutual-approved. Pipe and fittings are black steel, Schedule 40, conforming to ASTM A53, with black, malleable iron fittings. Each riser has an indicating shut-off valve with tamper switch, and flow switch.

For more details about zones and fire protection, refer to Chapter 11, Section 11.4.4, Fire Fighting Capabilities.

If all sprinklers within the discharge design area activate at once, for a single fire incident, the retention time for water from fire sprinkler systems for B695 is 29 minutes, and for B696S is 32 minutes. Secondary containment is provided for water from fire sprinkler systems and a leak from the largest container that would be stored in B695. Discharges are collected in trenches and sumps. Discharges from the reactive storage rooms collect in trenches and drain by gravity to a 20,000-gal, fiberglass underground storage tank. The tank has a connection for removing contents via an extraction truck.

Trenches and sumps that can contain 20-minutes worth of discharge of water from fire sprinkler systems provide secondary containment for the SWPA. In the B696 truck bay, additional provision for secondary containment is made to contain leaks from the largest tanker truck. Such discharges are collected in trenches and drain by gravity to the 20,000-gal fiberglass underground storage tank.

Fire Alarm Manual-Pull Stations

The UBC-required egress routes have manual-pull stations, which are positioned 48 in. above the finished floor. Manual-pull stations are connected to a fire-control panel in accordance with NFPA 72.

Emergency Voice/Alarm System

The fire alarm system sends a signal to the fire dispatcher. Depending on the nature of the emergency, the dispatcher sends out the appropriate message to building speakers. If an evacuation is warranted, the dispatcher also activates strobe lights in the building.

Automatic Natural Gas Line Isolation System

An earthquake-activated, automatic, gas shutoff valve is installed on the natural gas supply line to B695. The valve is designed to meet California standards for earthquake-actuated, automatic gas shutoff systems, Standard No. 12-23 and ANSI Z21.70 1981. The valve consists of a check valve and an acceleration-sensitive triggering mechanism. The body is located on a stationary post that has a seat formed of certain angularity to horizontal acceleration. Per manufacturing specifications, the valve will close within five seconds when subjected to a horizontal sinusoidal oscillation of 0.3 g for 0.4 seconds.

2.8 Utility Distribution Systems

Table 2-3 summarizes the utility distribution systems provided to the B695 Segment, and gives key line sizes and locations.

Electrical Service

Electrical power is provided to the B695 Segment facilities from the LLNL-furnished electrical power distribution system. The power supplies facility process equipment, lighting, ventilation and exhaust systems, and instrumentation. Primary electrical service is provided to the B695 Segment facilities via a substation that contains two transformers rated at 13.8 kV, 480/277 V, 3ϕ, 60 Hz with a standby diesel generator.

Differential pressure monitoring to ensure ventilation flow exists in the B696S glove box and the B695 chopper, is backed up so that their operability is maintained during a power outage.

Natural Gas

Natural gas is supplied to B695 via a high-pressure gas line with a seismic shutoff valve that transitions to a low-pressure gas line outside the southwest corner of B695. The B696S gas line has been terminated at B695, near the gas line source. Small bore tubing runs through B695 and distributes natural gas to the laboratories and reactive waste processing area, and meets PC-2 criteria through compliance with the LLNL Seismic Safety Program.

Water Service

Water is supplied to LLNL as part of the site-wide utility infrastructure under the administration of the LLNL Plant Engineering Department. Water from the Hetch Hetchy system is delivered under gravity flow via a 6.1-mile-long pipeline to three water storage tanks located on a hill at the south end of the Sandia National Laboratories Livermore site. If for some reason the water supply is cut off from the Hetch Hetchy source (i.e., pipeline rupture or earthquake), water supply to the storage tanks can be restored through a backup tie-in to the Zone 7 Water District. The storage tanks have a combined capacity of 1,280,000 gal. Water is delivered from these tanks to the piping grid underneath LLNL sites via a 10-in pipeline and a 16-in pipeline. Water pressure in the piping grid varies from 90 lb/in^2 in the south to 105 lb/in^2 in the north.

Domestic water for process water and fire sprinkler systems is drawn from an 8-in supply line. This line is further reduced to supply services to individual buildings as either process water or fire sprinkler water. Low conductivity water (LCW) supply and return are also part of the site-wide utility infrastructure administered by Plant Engineering. LCW is used for heat-exchange purposes (e.g., water bath temperature control).

Compressed Air

Compressed air services, at approximately 100 lb/in^2, are provided at B695 and B696S and consist of both shop air and instrument air. Shop air is used to drive pumps, valves (e.g., building ventilation valves) and various pneumatic tools, such as an impact wrench. Instrument air is essentially filtered shop air, and is used when cleaner air is required, such as for analytical instruments. The compressed air services either comes from the site-wide air system or the air compressor located in the boiler room. Instrument air is also the backup for the shop air system during times when the air compressor is down. The two accumulators for the compressed air system are located on the Tank Farm mezzanine.

Table 2-3. Utility distribution systems

Other Utilities	B695	B696 SWPA
Main Power Supply	2 pad-mounted transformers 13.8 kV, 480/277 V, 3ϕ, 60 Hz	Fed from same transformers as B695
Natural Gas Supply	4-in high-pressure natural gas supply with seismic shutoff valve	Fed from B695 1.5-in low-pressure natural gas blanked off in B695 near source
	Mezzanine (Room 2002) 1.5-in low-pressure natural gas for domestic hot water heater	
	Small-scale treatment lab (Room 1017) 1/8-in low-pressure natural gas for cabinets and acid fume hoods	
	Reactive waste processing (Room 1023) 1/8-in low-pressure natural gas for acid fume hoods	
Domestic Water and Fire Sprinkler Systems Supply	8-in CW/F	6-in CW/F
Domestic Water Supply (Process Water Supply)	LWPA (Room 1028 and 1029) – 1-in PW	Truck bay (Room 1012) 1-in PW
	Airlock (Room 1027) – 1-in PW	
	Reactive materials cell (Room 1025) – 1-in PW	Receiving/classification (Room 1001) 1-in PW
	Reactive waste processing (Room 1023) 1-in PW general use with 1/4-in PW for acid fume hoods	
	Small-scale treatment lab (Room 1017) – 1-in PW general use with 1/4-in PW for cabinets	B696 Glove box room (Room 1008) 1-in PW
	Boiler (Room 1033) – 1-in PW	
	Mezzanine (Room 2002) 1-in PW	Solid waste processing (Room 1009) 1-in PW
	Chiller (Room 1032) – 1-in PW	
Low-Conductivity Cooling Water Supply and Return	12-in source (Room 1033)	None
	Reactive waste area (Room 1023 and 1025) 2-in LCWS	

Other Utilities	B695	B696 SWPA
	Small-scale treatment lab (Room 1017) 1/4-in LCWS, cabinets	
	LWPA (Room 1028 and 1029) 4-in LCWS, future connections	
Demineralized Water	2-in DW blanked off in Room 1033	None
Hot Water Supply and Return	Boiler (Room 1033) 2.5-in HWS & R	Supplied from B695
Chilled Water Supply and Return	Chiller (Room 1032) 6-in CWS & R	Supplied from B695
Compressed Air	Boiler (Room 1033) 3-in SA	Supplied from B695 3-in SA

2.9 Auxiliary Systems and Support Facilities

The following information summarizes the auxiliary systems and support facilities for the B695 Segment.

Standby Power

Standby power system for the B695 Segment consists of a 350-kW diesel engine/generator and its associated 800-A automatic transfer switch and distribution panels. The diesel generator is rated 480/277 V, 3ϕ, 60 Hz. The generator skid and automatic transfer switch are located adjacent to the double-ended substation. Standby power is available for maintaining the HEPA exhaust fans at 50-percent airflow. Standby 208/120-V power is available for the process-monitoring systems, controls, and instrument panels. The diesel generator fuel tank is double-walled. Gas-powered, portable generators and floodlights are available for use during nonroutine waste management operations or emergency situations.

Storm-Sewer Lines and B695 Segment Site-Wide Drainage

The maximum grade for all pavement inside the B695 Segment is 3 percent, except for pavement from the truck scale to Avenue T, which has a 5-percent grade. Paved areas are graded at a minimum 1.5-percent slope for storm water drainage. Concentrated flow at paved swales is graded at a minimum 1-percent slope. Concrete curb and gutter or valley gutter will be used if the concentrated drainage flow is sloped at less than 1 percent. The minimum slope of concrete gutters is 0.5-percent. All surface drainage in landscaped areas has a minimum slope of 2 percent. An underground drainage system is provided where proper surface slopes cannot be established for drainage. 18-in and 12-in storm sewer lines are located in the B695 Segment. B695 Segment facilities are connected to the 6-in sanitary sewer line.

Specialty Gases

Specialty gases in the form of compressed gas cylinders are used for various processes. The primary gases used are argon, nitrogen, hydrogen, a hydrogen/nitrogen mixture, and compressed air, but other gases may also be used. Liquid nitrogen is also used for laboratory and testing purposes. Gases used for welding (e.g., oxygen, acetylene) will be brought into the facility when needed. Compressed air used for breathing air are self-contained breathing apparatuses. Small compressed gas cylinders (e.g., lecture bottles) of various organic compounds may be used for calibration purposes.

Two covered compressed gas cylinder storage pads are located along the east wall of B695. These two pads provide gas distribution to various areas within B695. Various compressed gas cylinders will be used throughout the facility when activities require their use (e.g., welding).

2.10 References

22CCR 66264.1080. California Code of Regulations, Title 22, Part 66264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” State of California, Sacramento, CA (22CCR 66264).

49CFR 173.465. Code of Federal Regulations, Title 49, Transportation, Part 173.465, “Type A Packaging Tests.” Office of the Federal Register, Washington, DC (49 CFR 173.465).

ASCE-7-93, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers, 1993.

Cal EPA (latest version), California Environmental Protection Agency, Department of Toxic Substances Control (2001), *Livermore Site Hazardous Waste Facility Permit*, Permit No. 99-NC-006, EPA ID: CA 2890012584 (latest version).

DOE (1994), DOE-STD-1020-94, Change 1, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, U.S. Department of Energy, Washington, DC (DOE 1994).

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CHAPTER 3
HAZARD AND ACCIDENT ANALYSES

3.1 Introduction

Chapter 3 describes the hazard and accident analysis performed for the Lawrence Livermore National Laboratory (LLNL) Building 695 Segment (B695 Segment) based on 10 CFR 830, Subpart B and guidance in DOE-STD-3009-94, Change Notice No. 3 (DOE 2006). The hazard analysis was performed using the Nuclear Safety Risk Ranking and Control Selection Guidelines provided by the DOE Safety Basis Special Project Team (Nelson 2003). The hazards and bounding accidents postulated to occur from waste storage and treatment activities at the B695 Segment are identified and analyzed. General facility hazards, such as those associated with machinery and heavy equipment—when not associated with standard industrial hazards—are considered in the hazard analysis.

Results of the hazard analysis allow potential bounding accident scenarios; associated hazard controls (preventive and mitigative); and safety-significant (SS) structures, systems, and components (SSCs) and Specific Administrative Controls (SACs) to be identified. The methodology used to identify and evaluate hazards and accidents is documented in Sections 3.3.1.1 and 3.3.1.2.

The hazard analysis uses a graded approach, per Figure 4.1 of DOE-STD-1027, Change Notice No. 1 (DOE 1997), to determine the level of analysis applied to each hazard identified. The graded approach requires the level of analysis and documentation for each facility to be commensurate with the magnitude of hazard being addressed, the stages of the facility's life cycle for which DOE approval is sought, and complexity of the facility and systems being relied on to maintain an acceptable level of risk. A discussion of these issues is found in Section 4.0 of DOE-STD-1027, Change Notice No. 1.

DOE-STD-3009-94, Change Notice No. 3, also provides guidance for grading the hazard and accident analyses. Because grading is a function of both hazard potential and complexity, a graded approach generally dictates that assessments of complex, higher-hazard facilities be more rigorous and more thoroughly documented than assessments of simple, lower-hazard facilities. The more significant a threat a hazard poses for worker or public safety, the more detailed the analysis required. The present analysis was prepared in accordance with DOE-STD-3009-94, Change Notice No. 3 (DOE 2006), with the primary objective of obtaining a better understanding of hazards and risks associated with operating the B695 Segment.

The B695 Segment has operations similar to those found in industries that handle solid waste (e.g., process liquids or trash) and industrial wastewater, except that these operations involve management of wastes that contain radioactivity. In addition, glove boxes not commonly found in industry are used. A glove box and a waste packaging unit are used for repackaging of containers containing hazardous and radioactive material in B696S. In B695, glove boxes are used for packaging and treating small quantities of toxic, radioactive, and/or reactive materials. Such operations are not complex and are typical operations for treatment, storage, and disposal sites throughout the country.

Many operations in the B695 Segment are performed under a Resource Conservation and Recovery Act (RCRA) Hazardous Waste Facility Permit and Operation Plan, similar to commercial treatment operations with “best demonstrated available technologies.” The buildings were designed and built considering such operations, using proven building systems, keeping them as simple as possible while complying with industry standards and institutional requirements. No operations performed in the B695 Segment or building system are considered complex.

The B695 Segment hazard evaluation herein includes identification and assessment of hazards, a facility hazard categorization based both on radiological and chemical hazards, and analysis of potential hazard events that could impact workers, the public, and the environment. In the first sections of Chapter 3, the purpose of the analyses is discussed, and hazard identification and evaluation methodologies are presented. The first sections are followed by identification of hazards and development of such hazards into hazardous events, assessment of preventive and mitigative features, and the hazard categorization analysis. Postulated hazardous events (see Appendix A, Process Hazard Analysis) were evaluated in a qualitative risk assessment to identify important or high-consequence events. When so identified, such events were further analyzed. In performing the analyses, LLNL used the graded approach, which prescribes that an analysis technique be no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility (DOE 2006). Therefore, the analyses presented here were conducted only to the level necessary to provide a cogent argument that the facility can be operated safely and with minimal risk to workers, the public, and the environment. Consequently, the presentation largely takes the form of a qualitative analysis. The following references support this approach:

- “Analytical effort can be limited to a simple, resource efficient hazard analysis geared to facility needs, unless events are noted that are of sufficient complexity to require more detailed, quantitative evaluations to understand the basis for safety assurance. Implicit in this methodology is the statement of DOE-STD-1027 that the largely qualitative level of effort in hazard analysis is appropriate and sufficient for accident analysis of Hazard Category 3 facilities.” (DOE-STD-3009-94, Change Notice No. 3, Introduction, p. 12)
- “Additionally, in accordance with DOE-STD-1027, the hazard analysis as described in Section 3.3, “Hazard Analysis,” of this Standard is sufficient to meet the 10 CFR 830 requirements of accident analysis for Hazard Category 3 facilities.” (DOE-STD-3009-94, Change Notice No. 3, Chapter 3, p. 27.)
- “Hazard Category 3 facilities are not required to perform formal, quantitative accident analysis.” (DOE-STD-3009-94, Change Notice No. 3, Chapter 3, p. 28.)
- “Since the hazard analysis activity is considered sufficient for Hazard Category 3 facilities, DSAs for these facilities need simply summarize the maximum consequences expected from facility operation and state that detailed accident quantification is not necessary because potential consequences are well below the Evaluation Guideline. A possible exception to this case, as previously noted, is a facility with Hazard Category 3 quantities of radionuclides but possessing large amounts of toxic chemicals. Such facilities need to summarize the maximum radiological consequences expected and identify the chemical accidents selected for accident analysis.” (DOE-STD-3009-94, Change Notice No. 3, Chapter 3, p. 48)

- "A qualitative determination of consequences from the identified accidents is required" for Nuclear Hazard Category 3 Facilities. (DOE-STD-1027-92, Change Notice No. 1, Section 4.1.2.a, Nuclear Hazard Category 3 Facilities, p. 18.)

Based on the analyses reported herein, the B695 Segment was determined to be a Hazard Category 3 nuclear facility for the radionuclide inventory. In addition, the B695 Segment is classified as a low-hazard chemical facility on the basis of modeling addressed in Appendix B. It was demonstrated that the design and operation of the B695 Segment does not adversely impact the health and safety of workers and the public.

3.2 Requirements

Requirements for the safety basis for the B695 Segment are established through 10 CFR 830, Subpart B. This chapter follows the format and content guide in DOE-STD-3009-94, Change Notice No. 3. As part of the safety analysis procedure set forth by the DOE, a hazard analysis is performed to characterize the level of intrinsic potential hazards and associated consequences resulting from potential accidents.

3.3 Hazard Analysis

This chapter describes the hazard identification and evaluation performed for the B695 Segment. The purpose of the information is to present a comprehensive evaluation of potential process-related hazards, natural phenomena, and external hazards that can affect the public, workers, and the environment arising from single or multiple failures. Consideration is given to all modes of operation, including startup, shutdown, and abnormal testing or maintenance configurations. Per standard industrial practice, examination of all modes of operation considers the potential for both equipment failure and human error.

3.3.1 Methodology

The Process Hazard Analysis (PrHA) methodology was devised to identify and characterize hazards and to perform a systematic evaluation of hazardous events at the B695 Segment. This concept is used to develop—based on the hazard analysis team's knowledge and experience with the segment's systems and operations—hazard event scenarios on the basis of identified hazards. Application of the methodology does not require detailed system information or exhaustive development of hazard event sequences. Instead, facility equipment, material, environmental factors, and support are considered on a macroscopic level, and hazard events that have occurred in the past are more easily researched. The PrHA is applicable for relatively simple systems and procedures and for identifying potential hazard events.

In general, low-level waste is managed in this segment much more frequently than TRU waste. Waste sometimes contains transuranic isotopes, but typically at levels significantly lower than 100 nCi per gram. Isotopes that are primarily beta or gamma emitters are prevalent and contribute to the radionuclide inventory in this segment at appreciable levels. The radioisotope material at risk (MAR) given in the PrHA is expressed in plutonium equivalent curies (PE-Ci). This is the method used by LLNL's Radioactive and Hazardous Waste Management (RHWM) Division to normalize dose equivalent calculations. The concept of ^{239}Pu equivalent activity, or PE-Ci, is intended to eliminate the dependency of radiological analyses on specific knowledge of the radionuclide composition of a waste stream. By normalizing all radionuclides to a common radiotoxic hazard index, radiological analyses that are essentially independent of these variations can be conducted for the RHWM nuclear facilities. The isotope ^{239}Pu is a common component of most defense TRU wastes and was selected as the radionuclide of choice for equivalency because there is a significant inventory of TRU waste in the RHWM Storage facilities, and because it generally provides the highest dose consequences per curie to which the radiotoxic hazard of other radionuclides could be indexed. Appendix C discusses the methodology in more detail.

3.3.1.1 Hazard Identification

The hazard-identification process involved identifying and inventorying hazardous materials, their hazards, and any factors that affect hazards (e.g., quantity, form, or location). Energy sources associated with B695 Segment of DWTF operations were also determined. The following conditions, which could impact the radioactive material inventory and potentially lead to a release, were investigated:

- Operational events (e.g., spills, fires, pressure, asphyxiation, and explosions).
- Natural phenomena (e.g., flooding, extreme winds, earthquakes, and lightning).
- External events (e.g., hazard events at nearby facilities and aircraft hazard events).

A hazard was considered to be anything that could adversely affect workers, property, the public, or the environment. Hazard sources anticipated for the B695 Segment were determined through discussions with design-team and operations personnel, review of planned and actual operations, design criteria, structural-design drawings, equipment specifications, and previous hazard analyses from similar RHWM operations. To facilitate the hazard-identification process, the following seven, specific categories of energy sources were investigated:

- Special nuclear material.
- Radiation sources.
- Toxic, corrosive, or reactive materials.
- Chemical energy (in the form of flammable, explosive, or pyrophoric materials).
- Electrical energy.
- Kinetic energy.
- Potential energy.

Common industrial hazards that make up a large portion of basic Occupational Safety and Health Administration (OSHA) regulatory compliance were evaluated only to the extent of determining their ability to initiate or contribute to hazard events. Otherwise, such hazards are adequately covered by 29 CFR 1910 implementation programs.

A coarse screening of events was performed during the hazard-identification process. A physical-possibility screen was applied to identify those operational events, natural phenomena, and external events not physically possible as a function of site location or characteristics of the facility. All screened events were eliminated from further analysis. For example, events such as avalanches were eliminated.

Included as part of the hazard-identification process was a facility hazard classification and categorization conducted in accordance with Hildum (2000) and DOE-STD-1027-92, Change Notice No. 1. The classification and categorization was based on comparison of the facility inventory with threshold quantities of chemicals and radionuclides.

3.3.1.2 Hazard Evaluation

The methodology used to support the hazard evaluation is a modification of the hazard analysis method described in the American Institute of Chemical Engineers, Guidelines for Hazard Evaluation Procedures, and is consistent with DOE-STD-3009-94, Change Notice No. 3. This methodology allows for consideration of potential effects on workers and the public.

The hazard evaluation was conducted to ensure that possible hazards were represented and considered. The hazard evaluation, documented in Appendix A, is called the Process Hazard Analysis, or PrHA. To reiterate, it is not the purpose of this DSA to cover safety as it relates to common industrial hazards that make up a large portion of basic OSHA regulatory compliance. The focus of the hazard evaluation is on potential hazard event conditions involving hazards associated with the B695 Segment. In general, the hazard evaluation consisted of a three-step process to:

1. Systematically evaluate hazards, develop hazard event sequences, and identify administrative and engineered controls.

2. Qualitatively assess frequencies and consequences, both unmitigated and with controls.

3. Use the results to identify which controls should be preserved in the TSRs and the appropriate safety programs to effectively reduce the potential impact on health and safety of the public and workers.

On the basis of information acquired through the hazard-identification process, operations and systems in the B695 Segment were evaluated to develop scenarios in the following categories: (1) waste treatment and processing; (2) waste storage, staging, and handling; (3) external events; and (4) natural phenomenon hazards.

The following information is provided for each scenario:

- **ID No**. Identifier to facilitate tracking of scenarios.
- **Hazard**. Includes a description of the hazard event type.
- **Scenario**. Description of scenario, or family of scenarios, including identification of potential initiators.
- **Material at risk**. Estimate of the inventory involved in the postulated scenario.
- **Unmitigated**. For a worker and the public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk to determine the scenario risk profile before controls are credited.
- **Control Type and Controls**. Appropriate safety features for eliminating, controlling, or mitigating the hazardous conditions. The controls identified fall within three groups:
    - Initial conditions used to develop a physically meaningful scenario per DOE-STD-3009-94, Change Notice No. 3, Appendix A.

  - Controls credited to reduce the frequency or consequence of the scenario.
  - Controls not specifically credited to reduce the frequency or consequence of the scenario, but that serve as defense-in-depth.

- **Mitigated**. For a worker and the public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk to determine the scenario risk profile after controls are credited.
- **Comments**. Statements provided to clarify scenario development, hazard-evaluation assumptions, or other issues.

The hazard evaluation focused specifically on workers (both site facility workers and co-located workers) because this segment will be operated with a Category 3 nuclear facility inventory. This category of facilities and hazards, by definition, cannot release the quantities of radioactive materials (see DOE-STD-1027-92, Change Notice No. 1, 4.1.2.A) that should pose a significant threat to the public. The hazard classification mechanism used in DOE-STD-1027-92, Change Notice No. 1, does not consider potential hazardous chemical releases. Results of the hazard analysis will show that with controls this facility does not contain significant chemical hazards that could threaten workers at adjacent facilities, the public, or the environment.

As part of the hazards analysis, Appendix B presents information regarding chemicals used in processing wastes and chemical constituents typically found in wastes that will be processed. Appendix B provides:

- A general discussion of waste characteristics by unit operations and by inventory evaluations.
- Information regarding bounding scenarios based on worst-case inventory hazards evaluation.
- A general discussion of expected reagent use and type, which essentially provides bounding material at risk.
- A modeling discussion that provides methodology justification.
- A summary of modeling results demonstrates the low risk.

Mixtures of waste chemicals have been evaluated and are not considered further for the following reasons:

- In general, waste constituents are diluted to orders of magnitude less than concentrations that would produce measurable offsite concentrations.
- Bounding cases can be developed quite clearly from pure component or aqueous solution reagents stored and used in larger quantities.
- Operations in former Area 514 demonstrate that only sulfuric acid exceeds the TPQ. Appendix B of this DSA addresses the hazards associated with sulfuric acid.
- The RCRA Hazardous Waste Facility Permit and Operations Plan provide the control set for waste beyond the scope of this DSA, and has been deemed adequate to protect the public.

The PrHA does evaluate chemical hazards—where pertinent, augmented by discussions in Appendix B—with the primary emphasis on bounding risks primarily through fire hazards. The consequence and frequency ranking is combined to determine the risk ranking of each event. This process results in a relative risk ranking for each analyzed hazard event-family in the B695 Segment, based on its risk to workers and the public. More information on risk matrix development is presented subsequently.

Frequency Estimates

Each hazard event was assigned a frequency or frequency class on the basis of information in **Table 3-1**.

Table 3-1. Qualitative mitigated frequency of occurrence of postulated events

Frequency level	Acronym	Frequency	Qualitative description
Anticipated	A	$10^{-2} \leq f$	Events that might occur several times during the lifetime of the facility (excluding normal operations)
Unlikely	U	$10^{-4} \leq f < 10^{-2}$/yr	Events not anticipated during the lifetime of the facility
Extremely unlikely	EU	$10^{-6} \leq f < 10^{-4}$/yr	Events that will probably not occur during the lifetime of the facility
Beyond extremely unlikely	BEU	$f < 10^{-6}$/yr	All other events

Frequency estimation considered facility or industry data, if well known and readily available, estimates, or analyst's judgment. For all instances, the best information available was used. Making estimates consisted of:

1. Identifying a rough initial estimate of scenario frequency.
2. Identifying:
   - Initiating-event frequency per year.
   - Independent or dependent probabilities for other failures (e.g., hardware, human error, conditional probability of fire).
   - Number of repetitive operations over time.
   - Period or percentage of time material is present.
3. Combining all information to obtain the final estimated scenario frequency.

Frequency of occurrence is not meant to be an absolute number but, rather, to express an expected frequency range. Frequencies are assigned to both unmitigated hazard events (before controls are applied) and mitigated hazard events (after controls are applied).

The estimate for unmitigated frequency of occurrence for each hazard event scenario is based on the assumption that no controls are in place to lower the frequency. Such estimates are based on an interpretation of “unmitigated” to be no special controls implemented above and beyond standard industrial practices, waste packaging, and assumed initial conditions.

The frequency of an hazard event scenario is a function of the frequency of the initiating event and the frequency of enabling events. Enabling events are those that must occur following the initiating event to result in the postulated hazard event. For example, for a transportation hazard event that initiates a fire in a storage area, if the initiating event is vehicle equipment failure (e.g., brakes), the enabling event could be a fuel leak that is ignited and starts a fire.

Frequency estimates for mitigated hazard event scenarios take into account controls that lower the frequency of occurrence of both the initiating event and enabling events. For the example scenario, inspection and maintenance programs can reduce the relative frequency of a postulated brake failure. The same program can also lower the frequency estimate for the enabling event, thus minimizing the overall scenario frequency. Mitigated frequencies, along with consequences, are used for selecting safety-related (safety-significant) and defense-in-depth controls. It is important to realize that the frequencies of occurrence used in the Process Hazard Analysis are not implied to be absolute numbers, but rather to express an expected frequency range of the postulated scenario.

Consequence Category Estimates

Qualitative consequence severity categories are assigned to each of the postulated hazard event scenarios. For radiological materials, the categories consider inventory, material form, and energy of release. For toxic materials the categories consider toxicity, inventory, and volatility. **Table 3-2** identifies the consequence severity levels, criteria used to establish them, and their impact. Offsite public refers to the maximally exposed offsite individual (MOI). The distance of the B695 Segment of DWTF to the fence line is approximately 170 meters. The dose to the co-located worker for an event involving an elevated release or involving plume-lofting uses the dose at 100 meters or the touch down point, which ever gives the highest dose. The site facility worker refers to the worker involved within the facility boundary, for whom safety programs, including training, typically provide assurances for operational safety. Worker consequence refers to a worker closest to the hazard, and within 100 ft for all hazard event scenarios.

Table 3-2. Consequence Levels and Risk Evaluation Guidelines

Consequence Level	Offsite Public	Worker	Site Facility Worker
High	**Considerable off-site impacts on people or the environs.** Rad exposure: >25 rem[1] TEDE or Chemical exposure: >ERPG-2/TEEL-2	**Considerable on-site impacts on people or the environs.** Rad exposure: >100 rem TEDE or Chemical exposure: >ERPG-3/TEEL-3	[2] **Facility worker hazards are typically protected with SMPs. For Safety Significant designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, should be considered.**
Moderate	**Only minor off-site impact on people or the environs.** Rad exposure: ≥1 rem TEDE or Chemical exposure: >ERPG-1/TEEL-1	**Considerable on-site impact on people or the environs.** Rad exposure: ≥25 rem TEDE or Chemical exposure: >ERPG-2/TEEL-2	
Low	**Negligible off-site impact on people or the environs.** Rad exposure: <1 rem or Chemical exposure: <ERPG-1/TEEL-1	**Minor on-site impact on people or the environs.** Rad exposure: <25 rem or Chemical exposure: <ERPG-2/TEEL-2	

Notes:

[1] Offsite consequences that challenge 25 rem from operational hazard events are protected with Safety Class SSCs independent of frequency.

[2] Occupational Radiation Protection; unintended (incidental) releases of sufficiently high frequency are considered a part of normal operations governed by 10 CFR 835.

For the site facility worker, high consequence is interpreted as prompt worker fatality or an acute injury that is immediately life threatening or permanently disabling, or significant radiological or chemical exposures to workers. This would typically result from a radiological exposure to a large prompt dose (e.g., criticality level) or from a chemical exposure to sustained Immediately Dangerous to Life or Health (IDLH) levels (i.e., life-threatening or permanently disabling, as opposed to a brief peak exposure over ERPG-3 for a few minutes), where permanent effects may occur.

For the site facility worker, moderate consequence is interpreted as serious injury with hospitalization required, but no immediate loss of life and no permanent disabilities. This would typically result from a radiological exposure to a very energetic release to an occupied area (for alpha emitters); essentially a major hazard event destroying barriers as opposed to a confinement leak. A chemical exposure with moderate consequence would result in the worker being hospitalized with evident distress; with lingering physical effects in the hospital, though none permanent.

For the site facility worker, low consequence is interpreted as minor injuries, no loss of consciousness, with no hospitalization, to negligible impacts. This would generally result from a radiological exposure to a glove box leak or small-scale confinement failure; and reflects the typical DOE complex occupational worker contamination or uptake. A chemical exposure with low consequence would result in short-term effects that dissipate quickly upon egress (e.g., eyes watering, cough) or no effects beyond irritation.

Unmitigated and mitigated public and worker consequences are estimated for each scenario in a semi-quantitative manner based on the material at risk impacted, form and energy. Mitigated consequences qualitatively estimate how effective the controls would be in reducing the consequences from a release. The analysis identifies effective controls as candidates for Technical Safety Requirements (TSRs).

Site facility worker consequence estimates are based on judgment rather than calculated exposures. If a worker is close to the release, a higher severity level is estimated, in general, than if the worker is further away from the release location. Some initiating events themselves have the potential to produce major worker consequences directly, independent of a radioactive material release. The worker consequences for such cases are based on the resulting release of radioactive or hazardous material. Mitigated worker consequence estimates are based on qualitative judgment regarding the effectiveness of applicable controls.

Risk Rankings

The frequency and consequence estimates, and the risk-ranking matrix in **Table 3-3**, are used to assign a risk rank to each hazard event scenario for workers and the public. The risk ranking is defined as: I – High, II – Moderate, III – Low, IV – Negligible.

Risk ranking I events must be protected with safety structures, systems, and components (SSC) and Technical Safety Requirements (TSR). For offsite public protection, Safety Class SSCs and TSRs are required for radiological events > 25 rem TEDE in accordance with Appendix A of DOE-STD-3009. Events which challenge but do not exceed 25 rem TEDE should be considered in selection of Safety SSCs and/or TSRs. Operational events resulting in high offsite radiological consequences must be moved forward into accident analysis for determination of safety classification, without consideration of frequency.

Risk ranking II events must be considered for protection with TSRs and safety SSCs. The consideration of control(s) shall be based on the effectiveness and feasibility of the considered controls along with the identified features and layers of defense in depth (DID). Operational events resulting in high offsite radiological consequences must be moved forward into accident analysis for determination of safety classification, without consideration of frequency.

Risk ranking III events are generally protected by the safety management programs (SMPs). These events may be considered for defense in depth SSCs in unique cases.

Risk ranking IV events do not require additional measures.

Table 3-3. Qualitative Risk Ranking Bins

Frequency → Consequence ↓	Beyond Extremely Unlikely $f < 10^{-6}$/yr	Extremely Unlikely $10^{-6} \le f < 10^{-4}$/yr	Unlikely $10^{-4} \le f < 10^{-2}$/yr	Anticipated $10^{-2} \le f$
High	III	II	I	I
Moderate	IV	III	II	I
Low	IV	IV	III	III

Scenario Development

It is not practical to develop every possible scenario for this Category 3 nuclear facility segment. Instead, the PrHAs focused on key scenarios for each operation. This approach only addressed the highest unmitigated worker consequences and the highest unmitigated public consequences. The intent is to ensure that an adequate review of controls can be developed for mitigated risks. A graded approach for this Category 3 nuclear facility reduces the amount of superfluous information in the PrHA, yet still adequately evaluates risk commensurate with the segment's category and complexity.

Control Description

Preventive and mitigative controls that apply to the subject scenarios are listed in the PrHA in Appendix A. The process involved identifying existing controls for B695 Segment of DWTF activities and proposing new controls as necessary. The total list of controls for a scenario gives an indication of the defense-in-depth that is provided. In the PrHA, controls that are initial conditions, and controls credited for reducing risk, are identified with single asterisks and double asterisks, respectively.

Once draft PrHA tables were completed, the results were evaluated to determine if the controls identified were adequate. Risks considered medium (II) or high (I) after mitigation by controls stated in the PrHA were evaluated further. New controls were identified if possible to reduce scenario risk to low (III) or negligible (IV). In the event that no controls could be identified to reduce risk to low or negligible, then specific justification were provided to explain why no controls were considered available or feasible.

3.3.2 Hazard Analysis Results

This section presents the results of the hazard identification, classification, and evaluation for the B695 Segment. Significant aspects of defense-in-depth and identification of any safety-significant SSCs and other items potentially requiring TSR coverage are summarized.

3.3.2.1 Hazard Identification

This subsection presents the results of the hazard-identification activity. Attributes of the hazards identified here are the basis for subsequent hazard evaluation. The principal hazards in the B695 Segment are in the form of chemical and radioactive material. Appendix B discusses chemical hazards specific to unit operations and modeling to determine the hazard classification. **Table 3-4** summarizes the principal radioactive hazards, including estimates of their form, type, location, and total quantity.

Table 3-4. Representative radionuclides expected in the B695 Segment

Radionuclide	Hazard Category 2 TQ, Ci
^{60}Co	1.9×10^5
^{90}Sr	2.2×10^4
^{137}Cs	8.9×10^4
^{152}Eu	1.3×10^5
^{154}Eu	1.1×10^5
^{155}Eu	7.3×10^5
^{228}Th	92
^{230}Th	89
^{232}Th	18
^{234}U	220
^{235}U	240
^{238}U	240
^{237}Np	58
^{238}Pu	62
^{239}Pu	56
^{240}Pu	55
^{241}Am	55
^{3}H	3.0×10^5

Other hazards associated with the B695 Segment (see Table 3-5) were identified through use of a checklist and discussions with program personnel. Such hazards do not necessarily have a quantity or type associated with them, and they can exist in all locations throughout the segment. The one exception would be staging of TRU waste containers in the yard, which is limited to 36 hours. The hazards identified in **Table 3-5** were considered in addition to those shown in **Table 3-4** to develop the PrHA.

Table 3-5. B695 Segment hazard source list

Source Category	Hazards List
Motion/mechanical	Vehicles, mass in motion, belts, gears, chains, sharp edges, pinch points, push carts, forklifts, crane, manlifts
Gravity–mass	Falling, falling objects, roll-up doors, lifting, hoists, tripping, slipping, earthquakes
Static	Container rupture, overpressurization, negative-pressure effects
Natural phenomena	Earthquake, wind, flood, lightning
Cold	Ice, snow, wind, rain, cold surfaces, compressed gases
Heat	Electrical equipment, hot surfaces, electricity, friction, solar, fire
Flammable materials and fires	Presence of fuel: solid, liquid, gas Presence of ignition source: engines, sparks, welding
Pressure	Confined or compressed gases, pressurized liquids, objects propelled by pressure, noise
Electrical	Static electricity, power supplies, power cables, transformers, wiring, batteries, exposed conductors, other high-voltage sources, lightning
Radiant	Intense light (electric arc welding), RF fields, infrared radiation (welding), solar, ionizing radiation, electromagnetic radiation, neutrons
Chemical (present, combustion product, or reaction product)	Flammable or combustible materials (e.g., hydrogen from radiolytic decomposition of materials), asphyxiants, carcinogenic materials, toxic materials, reproductive hazards

Source Category	Hazards List
Chemical reaction (nonfire)	Corrosion, rust, and related hazards (e.g., heat and pressure)
Criticality	Although treatment and storage operations, on average, contain much less fissionable material than would cause any criticality concern, the total fissionable material inventory in this segment exceeds the minimum critical mass.

Low-level waste consists of β- and γ-emitting radionuclides. Representative radionuclides and their corresponding Category 2 threshold limits are shown in Table 3-4. An inventory-control program has been established to limit radionuclides to below the Category 2 threshold limits.

Waste treated is typically represented by alpha, beta, and gamma emitters. However, the B695 Segment is expected to rarely treat waste streams that are considered transuranic (i.e., greater than 100 nCi/g of transuranic isotopes with half-lives greater than 20 years).

The radionuclide inventory in the B695 Segment will be controlled by the "sum of the ratio" method outlined in DOE-STD-1027-92, Change Notice No. 1.

3.3.2.2 Hazard Classification

This subsection presents the segmentation and classification of the B695 Segment from the remainder of the DWTF facilities, and the results of the B695 Segment final hazard classification activity outlined in DOE-STD-1027-92, Change Notice No. 1.

Analyses of the chemical hazards of the B695 Segment were performed using LLNL *ES&H Manual* Document 3.1, "Safety Analysis Program," revision April 2001 (LLNL 2001) and Hildum (2000) that showed these facilities met the criteria for Low Hazard facilities as discussed below. The path forward regarding the revision of *ES&H Manual* Document 3.1 was submitted to NNSA, which was subsequently approved (NNSA 2008).

The B695 Segment involves treatment, storage, staging, and handling of radioactive and hazardous waste. Hazardous materials are contained in wastes and reagents processed and used in the B695 Segment. Furthermore, the total quantity of chemicals (reagents) in the facility is maintained below the individual TPQs established in 29 CFR 1910.119 and in 40 CFR 355, except sulfuric acid which was evaluated in Appendix B. Because the quantity of sulfuric acid exceeded the TPQ value, the initial classification for the B695 Segment of DWTF was a moderate hazard chemical facility. However, modeling discussed in Appendix B illustrates that this segment is below the applicable TEEL values for the worker and public. In addition, hydrogen peroxide was modeled in Appendix B even though the concentration in use in the B695 Segment (52%) is less than the concentration for which the TPQ is established. Modeling for hydrogen peroxide resulted in concentrations that were below the applicable TEEL values for the worker and public. Therefore, the B695 Segment is classified as a low-hazard chemical facility.

Segmentation of the B695 Segment, with respect to the remainder of the RHWM facilities, was performed by considering future operations in the DWTF as well as existing operating facilities (see **Figure 2-1**). Many areas in and around the DWTF RHWM facilities include areas with little or no radionuclides, or are other nuclear segments. Such areas are as follows:

- DWTF Storage Area. This is a Category 2 nuclear facility that consists of B693, the radioactive waste storage area (RWSA) in B696 (referred to as B696R), and associated yard areas and storage areas within the yard. The DWTF Storage Area is separated from the B695 Segment by a fire-resistive partition in B696 and a minimum distance of 20 ft elsewhere.
- T6951 Maintenance Area. This area is separated from the nuclear facility by fences and gates. It contains only small amounts of solvents and lubricants for maintenance purposes and fueled vehicles and does not contain radionuclides. This area is also used for office space.
- DWTF Rain Water Management Area. This area is a sloped pad to the west of B696S that is used to store tankers containing dilute concentrations of radioactive and hazardous materials, e.g., rainwater.
- DWTF Electrical Utility Yard. This area is separated from the nuclear facility by fences. It contains only fuel for the generator and does not contain radionuclides.
- Existing Trees North of B696. This area does not contain hazardous chemicals or radionuclides and is separated from the B695 Segment by a minimum distance of 20 ft.

The B695 Segment includes all areas west of the DWTF Storage Area within the DWTF fence line that have not been mentioned above. The areas mentioned above, which are not considered part of the B695 Segment, are covered under separate DSAs, HARs, or appropriate screening documents. The minimum distance of 20 ft discussed above is controlled by not allowing storage or staging of combustible materials and hazardous or radioactive materials, and is used for emergency response vehicles and for infrequent transient movement of materials to and from other locations. The partition between B696R and B696S was also augmented with an expanded fire lane to prevent combustible material from being close enough to the segment interface to cause a fire to spread between both segments.

In this DSA, the justification for segmenting the B695 Segment from other segments is presented. Aircraft hazard event, fire, and earthquake are the worst common-cause event conditions identified in this DSA by which one radioactive materials inventory could conceivably interact with another. To justify the proposed segmentation plan, it is shown in the segmentation justification (Appendix E) that the B695 Segment is sufficiently separated physically from other segments or that passive barriers exist if separation distance is not adequate. In addition, independence of pertinent systems precludes the interaction of its MAR with that of another segment via aircraft hazard event, fire, or earthquake.

All DWTF buildings (except B695 and B696, which are approximately 48 ft apart and have the B696 truck bay between them) are at least 50 ft apart, and the area between them is covered with asphalt. The separation, in conjunction with each building’s noncombustible, PC-2 construction, amply serves as a passive barrier in the form of a firebreak. In addition, RHWM has established a 20-ft firebreak marked appropriately between the B695 Segment and the DWTF Storage Area (except for B696R/B696S as discussed above). In B696, the combination of the B696S/B696R partition and the TSR combustible loading limits precludes a fire from propagating from one side of the partition to the other. Examination of building separation distances and container stacking practices demonstrates that these distances provided adequate separation (NFPA 80A).

Interactions between B695 and B696 through the truck bay during an earthquake are not anticipated to be significant because the truck bay is part of B696 and is essentially structurally independent from B695. A flexible joint exists between the B696 truck bay roof and the B695 interface. Penetrations through both buildings from duct and pipe are also not anticipated to have significant interactions.

Some common utilities are shared between segments, including electrical systems, communication systems, hot and cold water supply, and fire sprinkler system. However, their failure would not result in bringing material together nor would safety controls be compromised. The fire sprinkler system is considered defense-in-depth. No common utilities are considered safety-significant or safety-class SSCs. The ventilation system is not shared between the B695 Segment and B696R in the DWTF Storage Area.

The B695 Segment will not exceed the HC-2 threshold quantities identified in Table A-1 of DOE-STD-1027-92, Change Notice No. 1, Attachment 1, Threshold Quantities for a HC-2 nuclear facility. In addition, fissile material inventory controls preclude the possibility of criticality in the B695 Segment. Therefore, the facility is categorized as a Hazard Category 3 nuclear facility.

3.3.2.3 Hazard Evaluation

This section provides the analysis of B695 Segment operations. LLNL used the graded-approach concept, which prescribes that an analysis technique be no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility (DOE 2000). The analysis performed in this evaluation verifies that the B695 Segment is operated at low risk to workers, the public, and the environment.

The generic hazards from energy sources, materials, and natural phenomena associated with the B695 Segment were identified in **Tables 3-4 and 3-5**. These generic hazards were developed into hazard scenarios as documented in the PrHA in Appendix A using the methodology in Section 3.3.1.2.

The focus of the hazard evaluation is on potential hazard event conditions involving generic hazards associated with the B695 Segment. Normal and abnormal conditions can also present hazards to a worker. However, such hazards are likely to involve minor exposures and other occupational hazards. Such hazards are addressed by the safety management programs (e.g., Radiation Protection Program) in Chapters 7 through 17 of this DSA. Hazard event-initiation events for the hazards listed above are presented in the following sections.

Human Error

Vehicle (e.g., truck, forklift, manlift) and crane hazard events that result in damage to equipment and significant loss of waste to the surrounding environment are considered to be in the “anticipated” to “unlikely” frequency range. An example of such an hazard event would be a forklift colliding with the waste blending station, resulting in the loss of 1000 gal of wastewater to the facility floor. It is anticipated that vehicle and crane hazard events will happen, but most hazard events will not expose the chemical or nuclear inventory to any risk (e.g., a forklift collides with wall of facility while backing up, resulting in minor damage to the wall and negligible damage to forklift). Within the “unlikely” frequency range, a variety of scenarios can originate from the same initiator. For instance, a vehicle or crane hazard event involving a single waste package could be in the “anticipated” to “unlikely” range, and a vehicle or crane hazard event involving a process unit could also be in the “unlikely” range.

When an event is initiated by human error and requires concurrent enabling events then the unmitigated frequencies are reduced by 1 bin. For instance, a vehicle crash that causes a spill is considered unlikely.

However, a vehicle rash that causes a spill and a fire is considered extremely unlikely. Frequency estimates for some mitigated hazard event scenarios would remain the same as the unmitigated frequency category, but the estimate for other scenarios could be reduced to the next-lower frequency category, depending on controls that are implemented.

Process Equipment Failures and Gas Generation

For unmitigated frequency estimates, equipment failures that lead to a significant release are generally considered to be in the "anticipated" frequency category (once every 1 to 100 years) or "unlikely" category (once every 100 to 10,000 years), depending on the particular equipment. Frequency of occurrence estimates for mitigated hazard event scenarios initiated by equipment failures could be lowered by one frequency category if controls are identified to improve the item's reliability significantly.

Gas generation and release to the atmosphere from treatment of wastes is considered to be in the "unlikely" frequency category. Process chemicals used to treat the waste stream react with the waste, producing many byproducts, including various types of gases.

Waste Container Failure from Gas Buildup

Gas buildup during handling or storage that can cause harm is considered to have an unmitigated frequency of "unlikely" (once every 100 to 10,000 years) for unvented containers or systems and "extremely unlikely" (once every 10,000 to 1,000,000 years) for vented containers or systems.

It was concluded in an analysis (HC/AB-B696-0202, "Radiolytic Hydrogen Deflagration," June 2002) that only a partial failure of a drum with partial release of radioactivity was physically plausible. The analysis was based on the maximum drum inventory consisting of 8 Ci of ^{239}Pu emitting 5.24 MeV alpha-particles in a hermetically sealed drum. This analysis remains valid with the increased maximum inventory of 50 PE-Ci since the χ/Q relationship can be linearly extrapolated for source term. Given a large portion of the waste is expected to contain low level waste with radionuclides of lower decay energies, the conclusion of the analysis is bounding for operations in the B695 Segment.

Criticality

The unmitigated frequency of a criticality event in the B695 Segment is considered "beyond extremely unlikely" (less than once every 1,000,000 years). A criticality safety program further mitigates a potential criticality event.

External Toxic Events, Fires, and Explosions

Hazard events occurring at nearby LLNL facilities or offsite industrial facilities might have an impact on the B695 Segment. Nearby facilities considered in the B695 Segment safety analysis include the National Ignition Facility (NIF), located approximately 800 ft to the south; B691, located 600 ft to the southeast; and B697. In addition, the DWTF Storage Area is within the DWTF complex. External hazards are evaluated in the PrHA.

Toxic events, fires, and explosions that could affect the B695 Segment but originate external to that segment are considered to be "extremely unlikely" (once every 10,000 to 1,000,000 years). Such events include fires and explosions involving either vehicles or other flammable gas or liquid sources on nearby roadways or facilities on the DWTF site, but not involved in the affected operation, or originating in other nearby facilities.

Airplane Crash

The probability of an aircraft crash into the B695 Segment must be evaluated to bound the risk presented by surrounding airports and types of aircraft and operations in those airports. The probability of an aircraft crashing into the B695 Segment was evaluated using the method described in DOE-STD-3014-96 (DOE 1996). The operations of general aviation aircraft at the Livermore Municipal Airport (LVK) dominate the risk of an aircraft crash to facilities at the LLNL. An assessment for Building 332 showed that general aviation associated with the LVK accounted for approximately 90% of the aircraft crash probability. Hence, the scope of the analysis is limited to quantification of the risk from general aviation at LVK.

As shown in Appendix E, the calculated annual probability of an aircraft crash into the Building 695 Segment is 2.5×10^{-5}. For the purposes of this DSA, an airplane crash leading to the release of radioactive and/or hazardous material is considered credible in the “extremely unlikely” range (once every 10,000 to 1,000,000 years).

Seismic Events

The design basis earthquake (DBE) for a PC-2 facility at LLNL is 0.57 g with a 1000-year return period (“unlikely” frequency class) (DOE 1994b). Facility structures designed to withstand effects of the DBE are considered mitigative features that reduce the consequences of the hazard event scenario. A structural collapse of the B695 segment significant structures caused by a PC-2 earthquake is not credible because the B695 Segment significant structures have been designed to withstand such an earthquake with only minor damage that is easily repaired. The most likely occurrence in a seismic event is the toppling of stacked containers or minor leaks from process equipment.

Another hazard event scenario initiated by an earthquake is a fire that puts the inventory at risk (e.g., natural gas line ruptures as a result of the earthquake). A significant post-seismic fire is considered to have a frequency less than the seismic event itself.

Lightning

Although B695 Segment facilities are not protected by lightning arrestors, the facilities are constructed primarily of metal and are grounded. The Livermore Valley rarely experiences severe weather. Thunderstorms occur fewer than 10 days per year and are not intense. Over the past 10 years, only four lightning strikes have been recorded within a 2-mile radius of the LLNL site. There are no recorded instances of lightning strikes within the boundaries of the Livermore site during the past 10 years. For the purposes of this analysis, lightning strikes on the B695 Segment are considered “extremely unlikely” (once every 10,000 to 1,000,000 years).

High Winds

The extreme-wind analysis included an evaluation of all winds with speeds less than and equal to that of the DBW. The design basis wind (DBW) for a PC-2 facility at LLNL is 72 mph (fastest-mile wind) with a 1.07 importance factor added at 10 m above the ground (DOE 1994b). Neither tornadoes nor wind-generated missiles need be considered in the design of PC-2 SSCs. Accordingly, buildings within the B695 Segment were designed and constructed to withstand a DBW event. The frequency of a tornado or other storm generating beyond design basis wind (greater than 72 mph) in the Livermore valley is extremely unlikely.

The unmitigated frequency of a high wind event impacting waste containers and causing a spill of radioactive or hazardous material is estimated to be “unlikely.” Spills can be caused by debris from loose components and materials near a facility impacting the waste containers, and such impacts could also be generated from building components (such as a door) that are blown free by high wind.

Floods

The design-basis flood (DBFl) for a PC-2 facility at LLNL has a return period of 2000 years, and is “unlikely” (DOE 1994b). The B695 Segment is located at an elevation of approximately 611 ft, National Geodetic Vertical Datum. Whereas flooding can occur at the site, the facility is located above the 100-yr flood plain and is not affected by floods of this magnitude (Lin 1998). Although no probabilistic flood hazard evaluation has been performed for the LLNL site, a study conducted for Sandia National Laboratory (SNL), Livermore, California, concluded that minor flooding in SNL and LLNL could occur from local precipitation and the resulting arroyo overflow (Savy and Murray 1988). The study also indicated that SNL was not threatened by failure of the Del Valle Dam nor significantly impacted by failure of the South Bay Aqueduct. It is reasonable to conclude that both sites are subject to similar conditions; thus, some minor flooding of the LLNL site is expected to occur during a DBFl. A recent flood study done for the DWTF supports these conclusions (Lin 1998).

In general, the LLNL site slopes downward from east to west and south to north. Two arroyos are located near the LLNL site. The Arroyo Seco approaches the LLNL from the south and crosses its southwest corner. The Arroyo Las Positas approaches the LLNL from the east and travels around the site along the eastern and northern borders. Because the B695 Segment is located in the northeast corner of the LLNL site, it is estimated that the primary threat from flooding at the B695 Segment would arise from overflow of Arroyo Las Positas from excessive precipitation.

It was concluded in the DWTF flood analysis that the worst-case flooding scenario is the overflow of the Arroyo Las Positas during a 2,000-year and a 5,000-year event. Both events would cause flooding with an average depth of 9 and 12 inches, respectively, into the B695 Segment.

Loss of Utilities

Total loss of utilities (e.g., electrical, natural gas, water and compressed air) is possible and is covered by several scenarios discussed in the PrHA tables (e.g., external and natural phenomenon hazards). Hazard events occurring at nearby LLNL facilities or offsite industrial facilities may cause a loss of one or more utilities; however, waste material would still be contained within the facility or unit. Cranes, valves, and other devices, fail safe (e.g., loss of power to cranes does not cause the load to be released and fall to the ground). Loss of utilities can also be caused by human error. Secondary events from loss of utilities, such as a subsequent fire, are also covered in various PrHA scenarios, and are considered “anticipated” (WH-8) to “extremely unlikely” (EX-1, NPH-1).

Evaluation of Waste Storage, Handling, Treatment, and Processing Operations

Scenarios identified in the PrHA generally involve liquid spills, solid spills, fires, and deflagrations caused by vehicle hazard events, equipment malfunction, and chemical reactions, some of which may involve human error.

Vehicle or Crane Hazard Events

Scenarios involving vehicle (e.g., truck, forklift, manlift) or crane hazard events could result in the release of radioactive material due to a spill and/or fire. Credible initiators for such scenarios include personnel error in misjudging speed, container mishandling, and vehicle fires near stored containers. In addition to spills, spills followed by fires are postulated.

The unmitigated frequency of a spill following a vehicle or crane hazard event is estimated as “anticipated” to “unlikely” in accordance with the general guidelines described previously. Therefore, crediting a rigorous forklift, manlift, or crane operator training program that includes classroom training and on-the-job training would lower the mitigated frequency to the “unlikely” or “extremely unlikely” range.

For scenarios involving spill and fire following a vehicle or crane hazard event, the unmitigated frequencies are lowered by 1 bin (e.g., “unlikely” to “extremely unlikely”) to account for the conditional probability of a fuel spill and ignition in a vehicle hazard event. In general, because of the limited inventory, unmitigated consequences for spills and fires are considered “low” for the public and the worker. Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological or chemical consequence. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. Movement of waste requires a minimum of two personnel (if self-rescue cannot be performed), which further supports a reasonable detection and emergency response to any event. All scenarios involving vehicle or crane hazard events are at “low” risk and below for the public and workers.

While scenarios in this group of hazard events generally have “low” consequences and “low” or “negligible” risks to the worker, some scenarios (i.e., RS-1, RS-2, TF-1, TF-2, and UD-2) have higher unmitigated consequences and risks to the worker. Once controls such as training and personnel evacuation are credited, the risks from these scenarios to the worker are all at “low” or “negligible.”

WH-13 addresses a spill during payload assembly or transport. Because of the limited inventory, consequences for spills are considered “low” for the public and the worker.

Equipment Malfunctions

Equipment malfunction scenarios result in a slow release of material through leaks in equipment, and are considered “anticipated” (e.g., FM-2). Through our experience with equipment, instantaneous catastrophic releases of material from equipment malfunctions do not happen and were not analyzed.

Co-located worker consequences vary based on unit operations and scenario development, but are generally “low.” Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location; they are qualitatively judged to have a minimal impact on potential consequences because the amount, type, and form of material typically results in minimal consequences. Worker and public consequences vary based on unit operations and scenario development, but are generally “low” to the worker and the public due to the inventory controls (e.g., less than the DOE-STD-1027-92, Change Notice No. 1, Hazard Category 3 thresholds) in place for most unit operations.

While scenarios in this group of hazard events generally have “low” consequences and “low” risks to the worker, some scenarios have higher unmitigated consequences and risks to the worker.

After controls are credited, all scenarios involving equipment malfunctions are at “low” risk and below for the public and workers.

Glove Box Hazard Events

The B696S glove box will be used for handling LLW. Hazard event scenarios involving spills associated with the B696S glove box are considered “anticipated” (e.g., GB-1, GB-3). Fire scenarios associated with the B696S glove box are considered “unlikely” (e.g., GB-2). A glove box breach due to a missile strike from a cylinder is considered “unlikely” (e.g., GB-4). Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively estimated as “low” because of the limitations on the amount and type of waste to be handled in the glove box. A minimum of two persons are required for B696S glove box work to be conducted, which supports a reasonable detection and emergency response to any event. The consequences to the worker and public in these scenarios (GB-1, GB-2, GB-3, and GB-4) are considered “low.” All scenarios involving the B696S glove box are at “low” risk or below for the public and workers.

Glove boxes found in B695 (inert atmosphere glove box, combination glove box, and radioisotope glove box) are considered in hazard event scenarios for reactive waste processing area (RWPA) treatment (e.g., RW-1 through RW-3). Spills in these glove boxes are “anticipated” and fires are “unlikely.” Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences; they are qualitatively judged to have a similar potential for injury because a worker would have to remain in the vicinity and receive a sustained exposure rather than a brief peak exposure in order to result in significant consequences. It is reasonable to assume that the workers will observe a significant glove box breach and leave the scene in a timely manner. A minimum of two persons are required when waste treatment processes are being conducted, which further supports a reasonable detection and emergency response to the event. The consequences to the worker and public are considered “low.” RWPA treatment glove boxes are at “low” risk for the public and workers. Respirators for the worker are required whenever a process batch in the RWPA exceeds 0.52 PE-Ci.

Chemical Reactions

Accidental chemical reactions may cause equipment failure through incompatibility or gas evolution due to inadvertent mixing, resulting in a catastrophic release of material. Such reactions occur less frequently ("unlikely" or "extremely unlikely") than those that cause leaks or small releases ("anticipated").

RHWM generally processes low-level radioactive waste consisting of alpha, beta and gamma emitting nuclides, e.g., Sr-90. Radioactive waste typically contains no or extremely low concentrations of transuranic radionuclides, e.g., much less than 100 nCi/g, and often contains depleted uranium.

In those rare instances when transuranic radionuclides are treated, the potential for pyrophoric reactions exists. Pyrophoric reactions are primarily a concern for dry materials with large surface areas. Even for plutonium, the ignition temperature exceeds 150°C for particle sizes less than 100 micron AED (see Figure 3-1, NUREG/CR-6410). The ignition temperature for uranium of similar sizes is even higher (see Figure 4-8, DOE-HDBK-3010-94), i.e., uranium is less reactive. In addition, most transuranic radionuclides are expected to be in sludges or oxides. Hence, pyrophoric reactions do not pose a significant impact on the health and safety of the public or the workers.

Consequences of accidental chemical reactions vary as a function of unit operations and scenario development, but are generally "low" to the co-located worker for most unit operations. For these scenarios, site facility worker consequences are consistent with the co-located worker consequences. Although workers closer to the point of release could receive a higher exposure as compared to the exposures evaluated at the onsite receptor location, they are qualitatively judged to have a similar potential for injury because a worker would have to remain in the vicinity and receive a sustained exposure rather than a brief peak exposure in order to result in significant consequences. It is reasonable to assume that the workers will observe the event and leave the scene in a timely manner. A minimum of two persons are required when waste treatment processes are being conducted, which further supports a reasonable detection and emergency response to the event. Worker and public consequences vary as a function of unit operations and scenario development, but are generally "low" to the worker and the public for most unit operations.

While scenarios in this group of hazard events generally have "low" consequences and "low" risks to the worker and public, some scenarios (i.e., BS-5b, RW-4b, and TF-4b) have higher unmitigated consequences and risks to the worker and the public.

After controls are credited, all scenarios involving accidental chemical reactions are at "low" risk and below for the public and workers.

Electrical Failure or Welding Hazard Event Fire

Initiation of a fire involving electrical cables or equipment can occur only from an electrical short or exposure fire and combustion of damaged or worn insulation. A fire will be sustained only if a significant decomposition of insulating materials occurs, i.e., the 1% thermal decomposition is not sufficient for a large fire. The 1% thermal decomposition temperature of polyvinyl chloride, a typical insulation material, is 457°K (363°F) (The SFPE Handbook of Fire Protection Engineering, 2nd ed., Society of Fire Protection Engineers, Boston, Massachusetts). Other energy sources in the vicinity of the electrical cables and equipment necessary to maintain high temperatures and cause significant thermal degradation are limited in the B695 Segment.

In addition, the limiting oxygen index (LOI)—a measure of the tendency for a material, once ignited, to continue burning after the ignition source is removed—is typically very high for the insulating materials. For polyvinyl chloride, the LOI is 47 compared to 20 for cotton (SFPE Handbook). A high LOI indicates that wire insulation requires a relatively large exposure fire to become self-propagating; rather, it will stop burning once the ignition source is removed. Quantities of combustibles in proximity to the electrical cables and equipment are not sufficient for a large exposure fire. Hence, initiation and propagation of an electrical fire is not likely in the B695 Segment.

For conservatism, a fire initiated by an electrical failure (e.g., WH-8) or welding hazard event (e.g., WH-9) is considered an “anticipated” event. A combustible control program is an available control to lower the consequences of such events. Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be related to elevated temperature and smoke rather than the result of radioactive/chemical uptake. Although workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological/chemical consequence. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. An observer is required during operations involving hot work, which further supports a reasonable detection and emergency response to any event. For these scenarios, the unmitigated consequences to the worker and public are “low.” Electrical failure and welding hazard event fires are at “low” risk for the public and workers.

Container Deflagration

The B695 Segment does not store TRU waste for long periods of time. Therefore, the untmitigated frequency of a deflagration scenario for both vented and unvented containers (WH-6) is considered “extremely un likely.”

The unmitigated and mitigated consequences to the worker, the co-located worker, and the public are estimated to be “moderate.” The resulting radioactive uptake to a worker may result in serious injury, but is not expected to be life threatening or permanently disabling. During transport of unvented TRU waste containers, the drums are either fitted with a drum lid restraining device or overpacked into a larger drum.

Inadvertent Firearm Discharge

The PrHA hazard event frequencies that result from an inadvertent discharge of security personnel firearms that cause an uncontrolled release of hazardous material range from “unlikely” to “beyond extremely unlikely.” These frequencies are one frequency bin lower than comparable events initiated by a small breach in a container or system because armed security personnel are not assigned to the B695 Segment and rarely visit the facility. For conservatism, the consequences for all uncontrolled releases of hazardous material resulting from the inadvertent discharge of a firearm are the same as those for other events initiated by a small breach in a container or system. Security controls identified in the PrHA table, although not credited with reduction in risk, include preventive engineering controls such as bolt locks, centerfire cartridges, holsters, loading stations, MILES equipment, safety on firearm, and trigger guards, and preventive administrative controls such as procedures and training.

Evaluation of External Events Hazards

External event scenarios were deemed appropriate for analysis in this report. Among them are external toxic-chemical release, external fire, projectiles, and aircraft hazard event. Other external events (e.g., nuclear test activity, strong radio transmissions, and structural interaction) were removed during the coarse screening because of site characteristics.

External Toxic-Chemical Release

In the PrHA, the frequency of an external event occurring at a nearby facility that could impact the B695 Segment is considered "extremely unlikely." Co-located worker consequences are considered "low." Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. The nature of a hazard event at a nearby facility provides indication of the event, which further supports a reasonable detection and emergency response to any event. The consequences to a worker and the public are considered "low." External events at nearby facilities impacting the B695 Segment present "negligible" risk to the public and workers.

External Fire (Flammable Gas, Generator, Office Fire, Lab Chemical)

The B695 Segment is separated from other nuclear facilities in the DWTF complex. Physical separation consists of the partition between B696 SWPA and B696 RWSA, which is attached to B696 SWPA, and a clear zone with the minimum width of 20 ft adjacent to the segment to prevent fire propagation between segments. In the PrHA, however, external fires were conservatively considered "extremely unlikely." The consequences are estimated as "low" for the co-located worker. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure and a worker would have to remain in the plume for an extended period of time (hours) in order to receive a significant exposure. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. The nature of an external fire provides indication of the event, which further supports a reasonable detection and emergency response to any event. The consequences to workers and the public are considered "low."

External fires at nearby facilities impacting the B695 Segment present "negligible" risk to the public and workers.

Projectiles and Other External Events

In the PrHA, hazard events as a result of projectiles (e.g., gas cylinder ruptures) that cause uncontrolled release of hazardous materials are considered "extremely unlikely." Co-located worker consequences are considered "low." Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) to receive a significant exposure. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. The nature of an hazard event at a nearby facility provides indication of the event, which further supports a reasonable detection and emergency response to any event. The consequences to workers and the public are considered “low.” External events at nearby facilities impacting the B695 Segment are a “negligible” risk for the public and workers.

Aircraft Hazard Event

In the PrHA, an aircraft hazard event with subsequent fire is considered “extremely unlikely.” Worker injuries would primarily be related to heat, smoke, and physical trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location. However, this is qualitatively judged to have minimal impact on potential consequences because the thermal input would tend to loft the plume, reducing the potential exposure. Therefore, consequences to the site facility worker were estimated as “moderate.” The unmitigated aircraft crash represents a “low” risk to the public and the worker.

Facility worker consequences were not estimated I the immediate proximity of the rash as the event itself and the subsequent fire would yield worker fatalities independent of any radiological release. The physical impacts and subsequent fire from the crash itself could result in non-radiological consequences that are life threatening or cause permanently disabling injuries for the ite facility worker. However, this potential derives from an externally imposed initiator that is immune to any intervention by either facility management or DOE. It is thus outside the envelope of consequences ranking in an analysis performed to define facility controls.

Evaluation of Natural Phenomena Hazards

Seven natural phenomena hazard (NPH) events were deemed appropriate for the analysis in this DSA: a DBE and a DBE leading to a fire, extreme winds impacting inventories in the building or in the yard, a flood, and a lightning strike impacting inventories in the building or in the yard. Other NPH events (e.g., snow and hurricane) were removed in the coarse screening because of site characteristics.

Earthquake

Earthquakes without fire are judged to be in the “unlikely” frequency range. Earthquakes with fire are judged to be “extremely unlikely” frequency range due to a conditional probability of a fire given an earthquake.

Unmitigated consequences for an earthquake spill or fire are considered “low” to the co-located worker. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological/chemical consequence. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. An earthquake provides an indication of the event, which further supports a reasonable detection and emergency response to any event. Unmitigated consequences to the worker and public for a spill or a fire are estimated to be "low." These consequence estimates account for potential interactions between building utilities and other attachments with containerized TRU waste inventories.

TRU waste has higher concentrations and dose equivalent levels (e.g., greater than100 nCi/g with 510 rem/µCi for ^{239}Pu) than low-level waste, but is only occasionally managed (e.g., when transferred from B696R) in the B695 Segment. Mitigative features for this NPH event include the following:

- A SAC ensures that: TRU waste stored in TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.

After controls are credited, NPH seismic hazard events are at "low" risk or below for the public and workers.

Extreme Winds

Design basis wind events impacting inventories in the building or yard are considered in the "unlikely" frequency range for the purposes of the PrHA. The consequences to the co-located worker are considered "low." Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but the estimated consequences to the worker are minimalized because significant winds would enhance dispersion and significantly lower the potential exposure. A worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological/chemical consequence. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. A significant wind that results in the release of radioactive/chemical material provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The consequences from a design basis wind hazard event are considered "low" for the worker and public.

Flood

The flood analysis included a graded-approach evaluation of all floods with water levels as great as, and including, that of the DBFl. The DBFl for a PC-2 facility at LLNL has a return period of 2000 yrs, and is "unlikely." It is concluded that some degree of failure to drums would occur from a 2,000 year flooding event at the facility, resulting in the leaking of a portion of the drums' radioactive contents. The consequences to the co-located worker are considered "low." Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be the result of consequences from a flood rather than the result of radioactive/chemical uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because flooding conditions significantly limit the potential for the release of airborne particles. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. A significant flood provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The consequences to the worker and the public are considered "low." The resulting risk to the worker and public is "low."

Lightning Strike

For the purposes of this analysis, lightning strikes are considered “extremely unlikely.” The consequences are considered “low” to the co-located worker. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be the result of electrical trauma rather than the result of radioactive/chemical uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure. A worker would have to remain in the plume for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological/chemical consequence. It is reasonable to assume that the workers will observe the hazard event and leave the scene in a timely manner. A lightning strike in a nuclear segment provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The unmitigated consequences are considered “low” to the worker and public. The NPH lightning strike hazard events are at “negligible” risk for the public and worker.

Evaluation of Criticality Events

Criticality events are considered to be “beyond extremely unlikely.” Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are not consistent with the co-located worker consequences. Workers closer to the point of release could receive a prompt radiation dose that would have significantly higher consequences than exposure to the fission products generated. This could result in consequences that are life threatening or result in permanently disabling injuries for the site facility worker. For the unmitigated case, consequences to the worker are considered “high,” and consequences to the public are considered “low.” The criticality hazard event is at “low” risk or below to the public and worker.

3.3.2.3.1 Planned Design and Operational Safety Improvements

As the result of the Hazard Evaluation, no specific design or operational safety improvement changes were identified.

3.3.2.3.2 Defense in Depth

This section summarizes significant aspects of the defense-in-depth philosophy as implemented to provide safety at the B695 Segment. This section does not provide a comprehensive list of defense-in-depth items listed in the PrHA, but consists of both design and safety management programs. Defense-in-depth includes safety-significant SSCs and ensures that the health and safety of the public and workers are not adversely impacted by design and operation of the B695 Segment.

Defense-in-depth controls are engineered and administrative provisions, and they serve either a mitigative or preventive function. The control types given in the PrHA constitute initial conditions of scenario development, controls credited for reducing frequency or consequence, and other defense-in-depth controls that contribute to best management practices.

The B695 and B696S glove boxes, B695 glove box inerting system, fume hoods, and bench tops enclosures (including the inert atmospheres design attribute) are considered defense-in-depth features to provide for enhanced worker protection. The diesel generator supports these SSCs and is also considered defense-in-depth.

Electrical paneling is also considered defense-in-depth. Fire suppression systems are installed in the B695 Segment to control fire growth and, thus, to prevent fire propagation in the event of a fire. Although facility fire suppression in TRU storage areas systems are not specifically credited to reduce the risk for any potential fires in the PrHA, the facility fire suppression systems in TRU storage areas are considered important defense in depth features providing enhanced worker protection. The B696S crane restraints are considered important defense in depth. The drum lid restraining device used during transport of pressurized unvented TRU waste drums are considered important defense in depth.

Safety-Significant Structures, Systems, and Components (SSC)

On the basis of the PrHA, the following three passive SSCs have been designated as safety-significant.

1. Approved TRU waste containers. The various types of storage containers represent the innermost design defense-in-depth measure. All TRU waste is stored in approved TRU waste containers as described in Section 4.4.1.3. Approved TRU waste containers meet the free drop test performance criteria outlined in 49 CFR 173.465(c)(1). Buildup of explosive gases within the containers is mitigated by the presence of vents on most TRU waste drums. TRU Oversize Boxes and LLW/TRU conversions (see Section 4.4.1.3) are not required to be vented.

2. B695 Segment building structural systems. The facility structures are designed and constructed to withstand PC-2 earthquake and wind.

3. B696S/B696R partition. The partition between B696R and B696S is included for segmentation purposes.

Chapter 4 discusses the safety function for each of these safety-significant SSCs.

Technical Safety Requirements (TSRs)

TSR coverage is required for design features and administrative controls that support the safety-significant concept. The design features are the PC-2 structural systems of the buildings, the B696S/B696R partition, and containers meeting the free drop test performance criteria for Type A packaging (49 CFR 173.465(c)(1)) for storage of TRU waste.

The following are specific administrative controls at the B695 Segment:

- The total radioactive material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalents (FGE).

- The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 FGE based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the National Environmental Policy Act (NEPA) limits.

- All TRU waste shall be stored in approved TRU waste containers.

- TRU waste stored in TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.

- TRU waste shall not be staged outside the building for more than 36 hours.

The following are programmatic controls at the B695 Segment:

- A criticality safety program, further described in Chapter 6, Prevention of Inadvertent Criticality, includes fissile material inventory controls to reduce the likelihood of a criticality event.
- A requirement for an inspection program and a maintenance program for safety-significant SSCs is invoked through an in-service inspection and test and maintenance programs, further described in Chapter 10, Initial Testing, In-Service Surveillance, and Maintenance.
- Personnel evacuation in hazard event conditions will take place under guidelines established in the Emergency Preparedness Program, further described in Chapter 15, to limit potential consequences to site facility workers.
- A fire protection program, further described in Chapter 11, Operational Safety, includes 20-ft separation between segments and an average combustible loading limit of 7 lbs/ft^2 of equivalent ordinary combustibles in fire areas storing TRU waste and in B696S Room 1009 for segmentation, excluding waste in metal containers.
- A traffic control program to provide protection from vehicular traffic for TRU waste in the yard. This program is intended to limit the speed of vehicles while in the yard and includes speed limits posted in the yard and vehicles required to stop at the yard gate before entering.

Further TSR derivation information is provided in Chapter 5 of this report.

3.3.2.3.3 Worker Safety

The major features protecting workers from hazards associated with hazard events occurring during facility operation are similar to those documented in the defense-in-depth section, Section 3.3.2.3.2. They include the description of safety-significant SSCs and administrative controls requiring TSRs.

The hazards to B695 Segment workers, associated with normal and abnormal conditions, include potential exposure to radionuclides, hazardous materials, and safety and health hazards. Radiation exposure can occur with radioactive materials within TRU waste containers or from exposure to contamination that may exist on the surfaces of waste containers or waste-handling equipment. The hazardous component of hazardous, mixed (radioactive waste with RCRA hazardous waste constituents), and combined (radioactive wastes with non-RCRA, California-hazardous constituents) wastes include solid corrosives, metals, and organics. The sources of safety and health hazards include electrical hazards, motion hazards, gravity-mass hazards, and pressure, heat, and noise hazards.

RHWM implements and maintains a full set of safety management programs that are described further in Chapters 6 through 17. As stated previously, the focus of the hazards analysis is on potential hazard event conditions. From the list of safety management programs, the following were considered to be the most significant for worker safety. They are included in the TSRs and are described in later chapters of this DSA.

- Emergency Preparedness Program (DSA Chapter 15). Ensures that workers are aware of the proper response actions in the event of an emergency.
- Training Program (DSA Chapter 12). Ensures that operators are qualified to perform their specified duties and thereby minimize exposure to hazardous conditions.
- Hazardous Material Protection Program (DSA Chapter 8). Ensures that workers are provided adequate protection from hazardous materials, including training.
- Radiation Protection Program (DSA Chapter 7). Ensures that workers are provided adequate protection from radiological hazards, including training and monitoring.
- Fire Protection Program (DSA Chapter 11). Ensures that the facility has provisions in place for combustible loading control and adequate fire fighting capabilities.
- Configuration Management Program (DSA Chapter 17). Ensures protection of workers by establishing the mechanisms for consistency between design requirements, physical configuration, and documentation of configuration items.
- In-service Inspection & Test Program (DSA Chapter 10). Ensures the integrity of the safety-significant SSCs. Inspections are performed by qualified personnel using documented procedures.
- Traffic Control Program (DSA Chapter 11). Provides protection from vehicular traffic for TRU waste in the yard by limiting the speed of vehicles in the B695 Segment.
- Criticality Safety Program (DSA Chapter 6). Ensures that the potential for an inadvertent criticality event is precluded.

Procedures were identified in the hazard evaluation and are an intrinsic part of the above programs.

3.3.2.3.4 Environment Protection

Protection of the environment is the result of design and operational features that reduce the potential for large releases of hazardous materials to the environment. Impacts to the environment from the scenarios discussed in this chapter are considered to be less than impacts to the public. Controls identified in the PrHA are considered to be sufficient to address impacts to the environment.

3.3.2.3.5 Accident Selection

Because the hazard analysis activity is considered sufficient for Hazard Category 3 nuclear facilities, no accidents were selected for further analysis. Further accident quantification is not necessary because potential consequences are well below Evaluation Guidelines.

3.4 Accident Analysis

This section is not applicable for a Hazard Category 3 nuclear facility.

3.5 References

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CHAPTER 4
SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

This chapter provides details on those segment structures, systems, and components (SSCs) classified as safety-significant (SS) as a result of the hazard analyses in Chapter 3. Material is organized to follow the outline for Chapter 4 specified in DOE-STD-3009-94, Change Notice No. 3 (DOE 2006). The adequacy of controls is established by describing for each SSC its safety function(s) and the functional requirements to support the safety function(s), by evaluating its functional requirements, and by describing the associated technical safety requirements (TSRs).

The following SS SSCs were identified in Section 3.3.2.3.2 as the most important to safety in terms of their specific preventive or mitigative function:

- Transuranic (TRU) waste containers.
- B696 Solid Waste Processing Area (SWPA) PC-2 structural system and B696S/B696R partition.
- B695 PC-2 structural system.

The safety functions that these SS SSCs perform contribute substantially to preventing or mitigating the event scenarios evaluated in the process hazard analysis (PrHA), or they provide defense in depth, or they provide for worker safety in potentially life-threatening or disabling situations.

This chapter also provides the safety function(s), functional requirements, evaluation with respect to functional requirements, and a brief description of the assumptions requiring control by TSR for each of the Specific Administrative Controls (SACs).

4.2 Requirements

From the types of safety SSCs covered in this chapter, the following codes, standards, and DOE orders are applicable:

DOE Order 420.1A	*Facility Safety* (§4.4 through 4.4.6 only).
DOE-STD-1020-2002	*Natural Phenomena Hazard Design and Evaluation Criteria for Department of Energy Facilities.*
DOE-STD-1186-2004	*Specific Administrative Controls*
DOE-STD-3009-94, Change Notice No. 3	*Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis.*

4.3 Safety-Class Structures, Systems, and Components

Hazard Category 3 nuclear facilities do not have safety-class SSCs because of the reduced magnitude of hazards. No safety-class SSCs were identified in the hazard analysis in Chapter 3 for the B695 Segment for chemical hazards or radiological hazards.

4.4 Safety-Significant Structures, Systems, and Components

Safety-significant (SS) SSCs protect workers against potentially life-threatening or disabling conditions. This section discusses each of the SS SSCs identified in Chapter 3, and it describes their safety functions, functional requirements, SSC evaluation, and relevant TSR controls. Inspection criteria are invoked as part of the in-service inspection and test program in Chapter 10, Initial Testing, In-Service Surveillance, and Maintenance.

4.4.1 TRU Waste Containers

4.4.1.1 Safety Function

The TRU waste containers provide primary confinement for TRU waste material being handled or stored at the B695 Segment. The safety functions of TRU waste containers are to provide a barrier to significant releases and to mitigate releases in the event of mechanical impacts or thermal stresses.

Approved TRU waste containers are designed to retain integrity under normal handling and transport conditions, to resist breach after a fall from common conveyances and other mishaps, to be noncombustible to prevent fires from spreading and limit release, and to provide some protection in NPH events, e.g., earthquake, high wind, and flood.

TRU waste containers will be vented, except for TRU oversize boxes and LLW/TRU conversions (i.e., LLW containers that have been converted to TRU waste after assay). The vent allows flammable gases that may be generated inside the container from radiolytic decomposition of waste material and other reactions to vent to the atmosphere and not build up to a flammable concentration.

4.4.1.2 System Description

Standard 55-gal drums, standard waste boxes (SWBs), TRU oversize boxes, and other steel containers meeting the definition of an approved TRU waste container (see Section 4.4.1.3) are used as packages for TRU waste in the B695 Segment. TRU oversize boxes are used primarily for large items that will not fit into standard containers.

The containers prevent loss of primary confinement for radioactive material being stored, staged, or handled, thus preventing a significant release of radioactive material.

Vents in metal containers are of two basic designs. Standard carbon-media filter vents are installed in a hole in the lid of most drums. The filter itself serves a contamination control function and not a safety function for the purposes of this chapter. The hole in the drum boundary is the safety element. The second vent design is the vent clip, a metal strap installed over the lip of the drum that compresses the lid gasket and provides a vent opening.

4.4.1.3 Functional Requirements

Containers must provide a level of protection that supports the bases of the hazard and accident analyses. The functional requirements for approved TRU waste containers are as follows:

1. Containers must be vented (except for TRU oversize boxes and LLW/TRU conversions), and the vents must be designed to allow flammable gases that may be generated inside the waste container to be relieved.

2. Containers must meet the free drop test performance criteria for Type A packaging. Requirements for these containers can be found in 49 CFR 173.465(c)(1). The primary performance criterion is that the container can withstand a 4-ft drop, without any leakage.

Following is a description of the approved TRU waste containers used to store TRU waste in the B695 Segment:

- DOT 17C, 17H, or UN1A2 steel drums with vents (except for LLW/TRU conversions – see note).
- Standard waste boxes (SWBs) refers to oval shaped steel containers with vents, roughly 3-ft high by 6-ft long by 4.5-ft wide, designed for efficient loading into TRUPACT II Type B shipping containers.
- TRU Oversize Boxes refers to unvented steel containers, rectangular in shape. Built to contain large pieces of contaminated equipment, the dimensions of each TRU oversize box are unique. Heights vary from approximately 53-in to 101-in, widths vary from approximately 47-in to 70-in, and lengths vary from approximately 78-in to 138-in.
- Other steel containers with vents satisfying the free drop test performance criteria for Type A packaging (e.g., ten drum overpacks, 85-gal drums).

Note: LLW/TRU conversions are waste containers that have been assayed after acceptance, based on acceptable knowledge, and found to have greater than 100 nCi/g of alpha-emitting transuranium radionuclides (elements above uranium in the periodic table) with half-lives greater than 20 years, thereby meeting the definition of TRU waste. These containers have very low levels of TRU isotopes, on the order of 0.02 Ci total. These drums are steel containers that meet the Type A free drop test performance criteria specified in 49 CFR 173.465(c)(1), but are not required to be vented.

4.4.1.4 System Evaluation

The approved steel containers used to package TRU waste meet the above functional requirements. The performance criteria for these containers are that they protect the waste from mechanical stresses and the elements of weather and provide confinement for the waste. To ensure that containers meet these criteria, weekly inspections will be performed.

4.4.1.5 TSR Controls

The steel containers including vents (where applicable) are passive design features. As part of the TRU Waste Container Maintenance Program, weekly inspections of waste container integrity will be conducted.

4.4.2 PC-2 Structural Capability of DWTF Structures

The B695 Segment consists of the following two main functional buildings or areas:

- Building 695 (B695), Liquid Waste Processing Building (LWPB).
- Building 696S (B696S), Solid Waste Processing Area (SWPA).

4.4.2.1 Safety Function

The safety function of the structural systems of the B695 Segment buildings is to not collapse in a PC-2 NPH event. Structural collapse could result in unacceptable damage to waste containers.

4.4.2.2 System Description

The building structural system consists of the foundations, columns, beams directly connected to the columns, lateral bracing, and the roof deck. Design codes, standards, regulations, and orders that establish the requirements applicable to the engineering design for B695 Segment operations are listed in Section 2.2. An overview of current B695 Segment building and equipment configurations is presented in Section 2.3. The layout and construction of B695 Segment buildings and process equipment are described in detail in Section 2.4.

4.4.2.3 Functional Requirements

The functional requirements necessary to fulfill the safety functions stated above are as follows:

- Maintain structural integrity (not collapse) during a seismic event up to a PC-2 earthquake.
- Maintain structural integrity (not collapse) during a PC-2 wind event.

4.4.2.4 System Evaluation

The buildings are designed and constructed to meet PC-2 criteria. Every five years or less, the building and significant appurtenances (i.e., crane restraints) will be assessed for its continued conformance with as-built structural design and for any conditions (e.g., damage or degradation) which may compromise its safety function. The inspection is conducted in addition to Condition Assessment Surveys and other inspections by support organizations (e.g., Plant Engineering).

4.4.2.5 TSR Controls

The B695 and B696S structural systems are passive design features. A building structure inspection program is established, implemented, and maintained to ensure that B695, B696S, and significant appurtenances (i.e., crane restraints) meet their DOE PC-2 requirements. This program includes inspections every five years or less by a qualified engineer (e.g., structural or civil) to verify that significant physical deterioration of or damage to the structures has not occurred.

4.4.3 B696S/B696R Partition

The partition between B696R and B696S has been identified as a safety-significant SSC as it serves to support segmentation between the Waste Storage Facilities and the B695 Segment.

4.4.3.1 Safety Function

The safety function of the partition between B696R and B696S is to reduce the likelihood of fire propagation. The partition between B696R and B696S serves to support segmentation.

4.4.3.2 System Description

The B696S/B696R partition is the wall assembly separating the low B696R and high bay B696S. The partition extends from true wall to true wall (inside of the exterior skin) in the north south direction and from the floor to the underside of the roof decks.

The cross-section of the partition between B696R and B696S consists of three layers of 5/8-in. Type X sheet rock, on 4-in. 20 gage metal studs, R-13 insulation, an approximately 5.75-in. air gap, 4-in. 20 gage metal studs, and three layers of 5/8-in. Type X sheet rock.

4.4.3.3 Functional Requirements

The functional requirement necessary to fulfill the safety function stated above is to maintain a continuous vertical and horizontal construction assembly between B696R and B696S designed to limit the spread of heat and fire. Any modifications (e.g., penetrations) to the partition must be consistent with at least 2-hr fire-resistive rating.

4.4.3.4 System Evaluation

The partition continues to meet its safety function as long as the integrity of the continuous vertical and horizontal construction assembly remains uncompromised, even though minor damage to the partition may exist.

4.4.3.5 TSR Controls

The B696S/B696R partition is a passive design feature. The partition between B696R and B696S is inspected monthly and also inspected every five years or less to verify that significant physical deterioration or damage to the partition has not occurred.

4.5 Specific Administrative Controls

The specific administrative controls (SACs) in this section are judged to require TSR coverage beyond that required for programmatic Administrative Controls (ACs). These controls are designated as SACs to provide assurance of the effectiveness and dependability beyond that which might be required if they were simply to be implemented under the auspices of a Safety Management Program.

The SACs listed in Table 4-1 are identified as initial condition assumptions used in the unmitigated and mitigated frequency and consequence evaluation in the hazard evaluation (Section 3.3). Relevant information is provided in this Section for each SAC with descriptions sufficiently detailed to provide an understanding of the safety function of the SAC.

Table 4-1 Specific Administrative Controls

Section	Specific Administrative Control
	Facility Nuclear Inventory Limits
4.5.1	• The total radioactive material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalent (FGE).
4.5.2	• The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 FGE based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the National Environmental Policy Act (NEPA) limits.
	Facility Nuclear Storage and Handling Limits
4.5.3	• All TRU waste shall be stored in approved TRU waste containers.
4.5.4	• TRU waste stored in approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.
4.5.5	• TRU waste shall not be staged outside the building for more than 36 hours.

4.5.1 Facility Inventory Limit

4.5.1.1 Safety Function

The safety function of the SAC is to limit the amount of nuclear material in the facility to no more than that assumed in the hazard analysis.

4.5.1.2 SAC Description

This SAC ensures the following facility limits assumed in the hazard analysis are maintained.

- The total radioactive material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalent (FGE).

To maintain the facility as a HC-3 nuclear facility, as defined by DOE-STD-1027-92, the radionuclide inventory in the facility must never exceed the quantity of any one of those specified in Attachment 1 of the DOE standard, nor shall the inventory exceed a combination of radionuclides such that the sum of ratios methodology described in the standard exceeds unity. The facility inventory limit is based on the limit specified in the standard for Pu-239 (i.e., 56 curies). Pu-239 equivalency for each non-Pu-239 radionuclide entering the facility is established by a comparison of its inhalation dose hazard relative to that of Pu-239. This process is described in the B695 Segment DSA, Appendix C.

The threshold value for fissile material is specified in DOE-STD-1027-92 and described as the minimum theoretical mass necessary for a nuclear criticality to occur with moderation and reflection. The value for an aqueous solution of Pu-239 is approximately 450 grams and is the most limiting of the fissile nuclides listed. By limiting the fissile mass allowed in the B695 Segment to less than 450 FGE, inadvertent criticality is not credible and is precluded.

4.5.1.3 Functional Requirements

This SAC shall ensure that the amount of nuclear material allowed in the facility is no more than that assumed in the hazard analysis.

There are no SSCs or unique functional requirements associated with this SAC. The limits must be consistently implemented in documents (e.g., FSPs, OSPs) to which qualified workers are trained.

4.5.1.4 SAC Evaluation

There are no SSCs or unique performance criteria associated with this SAC. Specification of these controls in procedures and other applicable documents are verified in DSA implementation and maintained by the USQ process.

The requirement imposed on this SAC is that RHWM operations personnel will complete the tasks needed to assure the amount of nuclear material allowed in the facility is no more than that assumed in the hazard analysis.

4.5.1.5 TSR Controls

The following Directive Action SACs shall be established:

- The total radioactive material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalent (FGE).

4.5.2 TRU Waste Container Inventory Limit

4.5.2.1 Safety Function

The safety function of the SAC is to limit the amount of nuclear material in each approved TRU waste container to no more than that assumed in the hazard analysis.

4.5.2.2 SAC Description

This SAC ensures the following limit assumed in the hazard analysis is maintained.

- The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 FGE based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the National Environmental Policy Act (NEPA) limits.

4.5.2.3 Functional Requirements

This SAC shall ensure that the amount of nuclear material allowed in any TRU waste container is no more than that assumed in the hazard analysis.

There are no SSCs or unique functional requirements associated with this SAC. The limits must be consistently implemented in documents (e.g., FSPs, OSPs) to which qualified workers are trained.

4.5.2.4 SAC Evaluation

The container limit of 50 PE-Ci was an initial condition for containerized radioactive material accident scenarios in the hazard analysis presented in the B695 Segment DSA. 50 PE-Ci per TRU waste container was analyzed in the hazard analysis to provide bounding consequences and is established as the inventory limit. The current LLNL Environmental Impact Statement (DOE 2005-b; FR 2005) assumes an inventory of 12 PE-Ci per approved TRU waste container in the DWTF. Therefore, inventory is controlled at lower limits for consistency with the current NEPA container limits. The NEPA limits are not derived from the requirements, assumptions, or conditions of the facility safety basis. The limit of 200 FGE ensures that a criticality event involving a container is not credible.

There are no SSCs or unique performance criteria associated with this SAC. Specification of these controls in procedures and other applicable documents are verified in DSA implementation and maintained by the USQ process.

The requirement imposed on this SAC is that RHWM operations personnel will complete the tasks needed to assure each approved TRU waste container is at or below the established inventory limits for B696S and B695 prior to the storage of the TRU waste container in B696S or B695 as assumed in the safety basis.

4.5.2.5 TSR Control

The following Directive Action SACs shall be established:

- The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 FGE based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the National Environmental Policy Act (NEPA) limits.

4.5.3 TRU Waste Container

4.5.3.1 Safety Function

The safety function of the SAC is ensure that all TRU waste is stored in approved TRU waste containers as assumed in the hazard analysis.

4.5.3.2 SAC Description

This SAC ensures the following assumption from the hazard analysis is maintained.

- All TRU waste shall be stored in approved TRU waste containers.

4.5.3.3 Functional Requirements

This SAC shall ensure that all TRU waste shall be stored in approved TRU waste containers as assumed in the hazard analysis.

There are no SSCs or unique functional requirements associated with this SAC. The limits must be consistently implemented in documents (e.g., FSPs, OSPs) to which qualified workers are trained.

4.5.3.4 SAC Evaluation

Approved TRU waste containers satisfy the free drop test performance criteria for Type A packaging [see 49 CFR 173.465(c)(1) for the applicable package mass]. These containers are vented, with the exception of TRU Oversize Boxes and LLW/TRU conversions. Venting drums minimizes the potential for hydrogen gas buildup. Regarding TRU Oversize Boxes, tests have demonstrated that hydrogen buildup in the boxes is well below the lower flammability limit. The unvented containers are inspected regularly.

There are no SSCs or unique performance criteria associated with this SAC. Specification of these controls in procedures and other applicable documents are verified in DSA implementation and maintained by the USQ process.

The requirement imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that TRU waste is stored in approved TRU waste containers as assumed in the safety basis.

Prior to acceptance, Radiological Characterization Analysts (RCAs) review all waste packages to ensure they meet the RHWM waste acceptance criteria. As part of this process, the RCAs verify that all TRU waste is packaged in approved TRU waste containers.

4.5.3.5 TSR Controls

The following Directive Action SACs shall be established:

- All TRU waste shall be stored in approved TRU waste containers.

4.5.4 Stacking Heights

4.5.4.1 Safety Function

The safety function of the SAC is to limit the height from which containers could fall to no more than that assumed in the hazard analysis.

4.5.4.2 SAC Description

This SAC ensures the following facility limit assumed in the hazard analysis is maintained.

- TRU waste stored in approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.

4.5.4.3 Functional Requirements

This SAC shall ensure that TRU waste stored in approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked as assumed in the hazard analysis.

There are no SSCs or unique functional requirements associated with this SAC. The limits must be consistently implemented in documents (e.g., FSPs, OSPs) to which qualified workers are trained.

4.5.4.4 SAC Evaluation

This was identified in seismic scenarios as a mitigative control. Containers satisfying the free drop test performance criteria for Type A packaging [see 49 CFR 173.465(c)(1)] are used to store TRU waste. Such containers are designed to survive at least a 4-ft drop consistent with their Type A packaging performance criteria. Ten drum overpacks are approximately 6-ft in height and therefore, are not stacked.

There are no SSCs or unique performance criteria associated with this SAC. Specification of these controls in procedures and other applicable documents are verified in DSA implementation and maintained by the USQ process.

The requirement imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that stacking of approved TRU waste containers is within the assumptions made in the safety basis. The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that TRU waste containers are not stacked more than two high and that TRU waste containers exceeding a nominal height of 4-ft are not stacked.

4.5.4.5 TSR Controls

The following Directive Action SACs shall be established:

- TRU waste stored in approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-feet shall not be stacked.

4.5.5 TRU WASTE Staging

4.5.5.1 Safety Function

The safety function of the SAC is to limit the amount of time that TRU waste containers may be staged outside the building to no more than that assumed in the hazard analysis.

4.5.5.2 SAC Description

This SAC ensures the following facility limit assumed in the hazard analysis is maintained.

- TRU waste shall not be staged outside the building for more than 36 hours

4.5.5.3 Functional Requirements

This SAC shall ensure that the time that TRU waste may be staged outside the building shall be limited to 36 hours as assumed in the hazard analysis.

There are no SSCs or unique functional requirements associated with this SAC. The limits must be consistently implemented in documents (e.g., FSPs, OSPs) to which qualified workers are trained.

4.5.5.4 SAC Evaluation

The probability of a vehicle collision with staged waste increases with the amount of time the waste remains outside the building. It is assumed that limiting the time TRU waste is allowed to be staged outside to 36 hours will reduce the probability of such a collision.

There are no SSCs or unique performance criteria associated with this SAC. Specification of these controls in procedures and other applicable documents are verified in DSA implementation and maintained by the USQ process.

The requirement imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to meet the 36 hour staging time limit as assumed in the safety basis.

The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that TRU waste is staged for no more than 36 hours. There are no time restraints associated with performing the required operations other than ensuring the 36 hour limit is met.

4.5.5.5 TSR Controls

The following Directive Action SACs shall be established:

- TRU waste shall not be staged outside the building for more than 36 hours

4.6 References

DEO (1996), *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Change Notice 1, DOE-STD-1020-94, U.S. Department of Energy (1996).

DOE (2002b), *Facility Safety*. DOE Order 420.1A, U.S. Department of Energy, Washington D.C. (May 2002).

DOE (2002c), *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-2002, U.S. Department of Energy (January 2002).

DOE (2004), *Specific Administrative Controls*, DOE-STD-1186-2004, U.S. Department of Energy (August 2004).

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, DC (DOE-STD-3009-94, Change Notice No. 3).

DOE/RL-96-57, Test and Evaluation Document for DOT Specification 7A Type-A Packaging; Volume 1 and 2 (see http://www.hanford.gov/pss/t&p/dot7a/pdot7a.htm), 1996, U.S. Department of Energy.

U.S. Department of Transportation, Research and Special Programs Administration, 49 CFR 178.350 (b).

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CHAPTER 5
DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

5.1 Introduction

The Technical Safety Requirements (TSRs) constitute an agreement between the Department of Energy (DOE) and the LLNL Radioactive and Hazardous Waste Management (RHWM) Division regarding safe operation of the B695 Segment. The TSRs were developed using criteria derived from this Documented Safety Analysis (DSA). Development criteria ensure adequate protection for the off-site and on-site population in the event of an uncontrolled release of hazardous materials.

Based on the information in DOE-STD-1027-92, Change Notice 1 (DOE 1997), it was determined that the B695 Segment is a Hazard Category 3 nuclear facility. As such, the TSRs consist primarily of inventory limits to maintain Hazard Category 3 classification, preserving the assumptions made pertaining to segmentation, and those controls necessary to prevent uncontrolled releases of hazardous material to workers and the public. Appropriate commitments to safety programs are presented in the administrative controls (ACs) sections of this chapter.

5.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

10 CFR 830	Nuclear Safety Management.
DOE-STD-3009-94, Change Notice No. 3	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports.

5.3 TSR Coverage

This section provides assurance of comprehensive coverage of all identified safety-significant structures, systems, and components (SS SSCs); design features (DFs); specific administrative controls (ACs); and programmatic administrative controls (programmatic ACs) to be covered by the TSRs. In addition to the identified SS SSCs, operator training, inventory controls, and facility-wide programs to reduce fire, radiation, and hazards are part of the B695 Segment's principal management mechanisms for limiting the probability and consequences of initiating events that can lead to recognized accidents. Passive and active systems have been integrated into the B695 Segment design, and inventory controls have been established to manage the segment as a Hazard Category 3 nuclear facility. **Table 5-1** summarizes the TSR safety controls organized by relevant hazard. Given that TSRs will be provided as a separate document, the discussion of TSR coverage in this DSA only refers generically to the type of TSR coverage to be implemented for each control, instead of addressing specific TSR section numbers.

Table 5-1. Technical safety requirements by hazard event type

Relevant Hazard	Major Features Relied On	Control Type
Natural phenomena event • Seismic • Flood • Extreme winds • Lightning strike	Safety-significant SSCs - Building structural systems (seismic and wind rating) - TRU waste containers Administrative Controls - Radiological Inventory Control Program of 56 PE-Ci - Personnel evacuation as part of Emergency Preparedness Program - Limiting Stacking of TRU waste containers - Outside Staging Limit - In-service Inspection and Test and Maintenance Programs	 DF DF SAC Programmatic AC SAC SAC SAC
Operational event • Vehicle hazard event • Equipment malfunctions • Chemical reactions • Electronic failure or welding hazard event fire • Container deflagration • Glove box hazard events • Crane hazard event	Safety-significant SSCs - TRU waste containers Administrative Controls - Radiological Inventory Control Program of 56 PE-Ci - Container Limit of 50 PE-Ci; administratively controlled consistent with the NEPA limits - Outside Staging Limit - Radiation Protection Program - Personnel evacuation as part of Emergency Preparedness Program - In-service Inspection and Test and Maintenance Programs - Configuration Management Program - Fire Protection Program - Traffic Control Program - Training Program	 DF SAC SAC SAC Programmatic AC Programmatic AC Programmatic AC Programmatic AC Programmatic AC Programmatic AC Programmatic AC
External event • Toxic chemical release • Fire • Projectiles and other external events • Aircraft hazard event	Safety-significant SSCs - TRU waste containers Administrative Controls - Radiological Inventory Control Program of 56 PE-Ci - Outside Staging Limit - Personnel evacuation as part of Emergency Preparedness Program	 DF SAC SAC Programmatic AC
Criticality	Administrative Controls - Fissile gram equivalents (FGE) - Criticality Safety Program	 SAC Programmatic AC
Segmentation	Safety-significant SSCs - B696S/B696R partition Administrative Control - Fire Protection Program • In-service Inspection and Test and Maintenance Programs	 DF Programmatic AC Programmatic AC

5.4 Derivation of Modes

Facility modes are not required because there are no LCOs. The facilities will be in performing their mission throughout the operational life of the facility. No TSRs were specifically identified on the basis of a difference between an operation mode, a standby mode, and a shutdown mode. During the development of the PrHAs, there was no perceived difference in the frequency of an hazard event or consequences between different modes.

5.5 TSR Derivation

Based on the hazard analysis, there are no Safety Limits (SL), Limiting Control Settings (LCS), Limiting Conditions of Operation (LCO), or Surveillance Requirements (SR). TSR coverage will be required for three design features and ACs that provide defense-in-depth. The design features are the Performance Category 2 (PC-2) building structural systems, B696S/B696R partition, and using approved TRU waste containers. The ACs are provided in **Table 5-1**. Programmatic ACs are discussed in further detail in the programmatic chapters. Specific ACs are described below. There will be no sections that further describe SLs, LCSs, LCOs, and SRs.

5.5.1 Specific Inventory Limits

1. The total radionuclide material inventory shall be no greater than 56 PE-Ci and the fissile material inventory shall be no greater than 450 Pu-239 fissile gram equivalent (FGE).

   Safety Function: 56 PE-Ci is the limit on radioactive inventory in the B695 Segment to ensure the segment remains below the threshold for HC-2 facilities as established in DOE-STD-1027, Change Notice No. 1. 450 Pu-239 FGE ensures that an inadvertent criticality event is not credible and is precluded.

   Basis: <u>56 PE-Ci:</u> To maintain the facility as a HC-3 nuclear facility, as defined by DOE-STD-1027-92, the radionuclide inventory in the facility must never exceed the quantity of any one of those specified in Attachment 1 of the DOE standard, nor shall the inventory exceed a combination of radionuclides such that the sum of ratios methodology described in the standard exceeds unity. The facility inventory limit is based on the limit specified in the standard for Pu-239 (i.e., 56 curies). Pu-239 equivalency for each non-Pu-239 radionuclide entering the facility is established by a comparison of its inhalation dose hazard relative to that of Pu-239. This process is described in the B695 Segment DSA, Appendix C.

   <u>450 Pu-239 FGE:</u> The threshold value for fissile material is specified in DOE-STD-1027-92 and described as the minimum theoretical mass necessary for a nuclear criticality to occur with moderation and reflection. The value for an aqueous solution of Pu-239 is approximately 450 grams and is the most limiting of the fissile nuclides listed. By limiting the fissile mass allowed in the B695 Segment to less than 450 FGE, inadvertent criticality is not credible and is precluded.

2. The radioactive content of waste material in each approved TRU waste container shall be no greater than 50 PE-Ci and the fissile material inventory shall be no greater than 200 Pu-239 fissile gram equivalent (FGE) based on Acceptable Knowledge. The amount of radioactive material shall be administratively controlled consistent with the NEPA limits.

Safety Function: Radioactive and fissile material container inventory limits are assumed conditions for the hazard analysis performed in the B695 Segment DSA for scenarios involving TRU waste containers, and serve to limit the radioactive material that can be impacted in hazard event scenarios. Inventory limits protect these assumptions and ensure that the consequences determined in the process hazards analysis remain bounding.

Basis: The container limit of 50 PE-Ci was an initial condition for containerized radioactive material hazard event scenarios in the hazard analysis presented in the B695 Segment DSA. 50 PE-Ci per TRU waste container was analyzed in the hazard analysis to provide bounding consequences and is established as the inventory limit. The current LLNL Environmental Impact Statement (DOE 2005; FR 2005) assumes an inventory of 12 PE-Ci per approved TRU waste container in the DWTF. Therefore, inventory is controlled at lower limits for consistency with the current NEPA container limits. The NEPA limits are not derived from the requirements, assumptions, or conditions of the facility safety basis. The limit of 200 FGE ensures that a criticality event involving a container is not credible.

5.5.2 Specific Container Handling and Storage Provisions

The following requirements are specified as individual controls:

1. All TRU waste shall be stored in approved TRU waste containers (i.e., steel containers that satisfy the criteria provided in Section 4.4.1).

   Safety Function: Approved TRU waste containers provide a confinement function limiting worker exposures and radioactive waste vulnerability in hazard event scenarios involving containerized TRU waste.

   Basis: Approved TRU waste containers satisfy the free drop test performance criteria for Type A packaging [see 49 CFR 173.465(c)(1) for the applicable package mass]. These containers are vented, with the exception of TRU Oversize Boxes and LLW/TRU conversions. Venting drums minimizes the potential for hydrogen gas buildup. Regarding TRU Oversize Boxes, tests have demonstrated that hydrogen buildup in the boxes is well below the lower flammability limit. The unvented containers are inspected regularly.

2. Approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-ft shall not be stacked.

   Safety Function: Stacking height limitations prevent loss of confinement of TRU waste stored in approved TRU waste containers due to containers falling from heights in excess of design specifications.

   Basis: This was identified in seismic scenarios as a credited control. Containers meeting Type A packaging free drop test performance criteria (49 CFR 173.465(c)(1)) are used to store TRU waste. These containers are designed to survive at least a 4-ft drop consistent with the free drop test performance criteria for Type A packaging (49 CFR 173.465(c)(1)). Ten drum overpacks are approximately 6-ft in height and therefore, are not stacked.

3. **AC Statement:** TRU waste staged outside the building will be limited to 36 hours.

   Safety Function: Staging time limitations minimize the potential for a vehicle collision with staged TRU waste containers.

   Basis: The probability of a vehicle collision with staged waste increases with the amount of time the waste remains outside the building. It is assumed that limiting the time TRU waste is allowed to be staged outside to 36 hours will reduce the probability of such a collision.

Table 5-2. Representative radionuclides expected in the B695 Segment

Radionuclide	Hazard Category 2 Threshold Quantities, Ci
^{60}Co	1.9×10^5
^{90}Sr	2.2×10^4
^{137}Cs	8.9×10^4
^{152}Eu	1.3×10^5
^{154}Eu	1.1×10^5
^{155}Eu	7.3×10^5
^{228}Th	92
^{230}Th	89
^{232}Th	18
^{234}U	220
^{235}U	240 (9.8×10^{-4})*
^{238}U	240
^{237}Np	58
^{238}Pu	62
^{239}Pu	56 (28)*
^{240}Pu	55
^{241}Am	55
^{3}H	3.0×10^5

*Values in parentheses reflect the fissile material inventory limit of 450 g for either U-235 or Pu-239.

5.5.3 Configuration Management Program

A configuration management program shall be established, implemented, and maintained to ensure consistency between the appropriate design requirements, physical configuration, and documentation of SSCs necessary to protect workers and the public as described in Document 41.2, "Configuration Management Program Description," in the *ES&H Manual*. This program includes designated system engineers. The USQ process is performed in accordance with the LLNL Unreviewed Safety Question process as described in Document 51.3, "LLNL Unreviewed Safety Question (USQ) Procedure," in the *ES&H Manual*.

5.5.4 In-service Inspection & Test and Maintenance Programs

A in-service inspection and test program including initial testing, and a maintenance program are established, implemented, and maintained to ensure the integrity of the Design Features in Section 6. Inspections, tests, and maintenance are performed by qualified personnel. Inspections, tests, and maintenance are described in Chapter 10.

5.5.5 Emergency Preparedness Program

Personnel evacuation is a programmatic administrative control within the Emergency Preparedness Program for operational hazard events, external events, and NPH events. *LLNL's Emergency Plan* addresses the necessary long-term response activities and offsite actions. The FSP and RHWM's Contingency Plan (LLNL latest revision) address the short-term response actions that are RHWM's responsibility. The Emergency Preparedness Program is discussed in detail in Chapter 15.

5.5.6 Hazardous Material Protection Program

LLNL's Hazardous Material Protection Program is a part of the overall Health and Safety Program. The Health and Safety Program is devoted to the identification, evaluation, and control of environmental factors and stresses found in the workplace as they apply to all facilities, including the B695 Segment. The facility-specific program identifies applicable aspects of the LLNL Hazardous Materials Protection Program as they apply to the B695 Segment, and shows how they protect against facility hazards and contribute to facility safety. The Hazardous Materials Protection Program is discussed in detail in Chapter 9.

5.5.7 Radiation Protection Program

A radiation protection program, consistent with the requirements of 10 CFR 835, is described in Chapter 7. This program helps to ensure that radiation doses are kept as low as reasonably achievable (ALARA) at the B695 Segment. The Facility Safety Plan contains process administrative limits that are derived in accordance with the Radiation Protection Program. Facility specific requirements of the Radiation Protection Program are: differential pressure when operating the chopper and respirators for the worker are required whenever a process batch exceeds 0.52 PE-Ci. The Radiation Protection Program is discussed in detail in Chapter 7.

5.5.8 Fire Protection Program

A program is in place to maintain in effect all contractor-applicable provisions of DOE Order 420.1A (DOE 2002b). The B695 Segment is maintained as a low fire-loading area, by minimizing combustibles in waste storage and processing areas (combustible loading is limited to an average of 7 pounds of equivalent ordinary combustibles per square foot in fire areas storing TRU waste and in B696S Room 1009 for segmentation, excluding waste containerized in metal packaging). A 20-ft exclusion zone is maintained between nuclear segments, except between B696S and B696R, which are separated by a fire-resistive partition. In addition, the separation is expanded between adjacent roll-up doors in B696 near the segment boundary. The separation prevents fire from impacting both segments through adjacent roll-up doors. The Fire Protection Program is discussed in detail in Chapter 11.

5.5.9 Traffic Control Program

A traffic control program is established, implemented, and maintained to provide protection from vehicular traffic for TRU waste in the yard. The traffic control program is intended to limit the speed of vehicles while in the yard and includes speed limits posted in the yard and vehicles required to stop at the yard gate before entering. This program is implemented through the FSPs and discussed in Chapter 11.

5.5.10 Training Program

The training program provides appropriate instructional support to enable B695 Segment workers to develop and maintain competencies for successfully executing work assignments. *ES&H Manual* Document 40.1, "LLNL Training Program Manual," provides guidance for developing and managing individual directorate training programs. The Training Program is discussed in detail in Chapter 12.

5.5.11 Criticality Safety Program

The Criticality Safety Program is established, implemented, and maintained in accordance with *ES&H Manual* Document 20.6, "Criticality Safety" and is consistent with the requirements of contractor-applicable portions of DOE Order 420.1A (DOE 2002b). The B695 Segment has a low radiological inventory threshold of 56 PE-Ci and 450 Pu-239 FGE and a container limit of 50 PE-Ci and 200 Pu-239 FGE. The Criticality Safety Program is discussed in Chapter 6.

5.6 Design Features

The following SSCs will be identified as design features: TRU waste containers; the B695 and B696S structures; and the B696S/B696R partition.

Descriptions of the passive design features not specifically required to have TSRs are provided in Chapter 2.

The following are Equipment Important To Safety:

- B695 Structural System (Safety-Significant SSC)
- B695 Fire Suppression System (Important Defense-in-Depth)
- B696S Structural System (Safety-Significant SSC)
- B696S/B696R Partition (Safety-Significant SSC)
- B696S Fire Suppression System (Important Defense-in-Depth)
    - Wet Pipe Fire Suppression System
    - Dry Pipe Fire Suppression System
- TRU Waste Containers (Safety-Significant SSC)

5.7 Interface with TSRs from Other Facilities

The Waste Storage Facilities have their own, established TSRs. No TSRs from facilities located near the B695 Segment directly affect this segment's safety basis. Personnel transferring TRU waste containers into the B695 Segment due to onsite transportation activities verify that the received material does not exceed the Segment limit of 56 PE-Ci.

The partition between B696 SWPA and the B696 RWSA Segment is considered an interface because it is shared by both nuclear facilities. This wall will be inspected on a 5 year cycle, as discussed in Section 5.5.4, in accordance with the building inspection interval specified in the Waste Storage Facilities DSA.

5.8 References

10 CFR 830, Nuclear Safety Management.

DOE (1997), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. DOE-STD-1027-92, Change Notice 1. U.S. Department of Energy, Washington, DC (September 1997).

DOE (2005), *Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management*, March 2005 (DOE/EIS-0348, DOE/EIS-0236-S3).

DOE (2002b), *Facility Safety*, DOE Order 420.1A, U.S. Department of Energy, Washington, DC (May 2002).

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, DC (DOE-STD-3009-94, Change Notice No. 3).

FR (2006), *Record of Decision of the Final Site-Wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement*, November 29, 2005 (Federal Register/ Vol. 70, No. 228).

LLNL (latest revision), *Contingency Plan for Radioactive and Hazardous Waste Management Facilities: Area 612, Area 514, Building 233 CSU, and the Decontamination and Waste Treatment Facility*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-127066)

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

CHAPTER 6
PREVENTION OF INADVERTENT CRITICALITY

6.1 Introduction

The B695 Segment at LLNL includes B695, B696S, and associated yard area. It is a Hazard Category 3 (HC-3) nuclear facility used for the treatment and storage of hazardous waste, which may contain fissionable materials. The B695 Segment has a low radiological inventory threshold of 56 PE-Ci and 450 Pu-239 fissile gram equivalent (FGE). This precludes the potential for inadvertent criticality.

A criticality safety program is established, implemented, and maintained in accordance with *ES&H Manual* Document 20.6, “Criticality Safety” to ensure that all B695 Segment operations and activities are reviewed, evaluated, and documented by the LLNL Nuclear Criticality Safety Section in accordance with contractor-applicable portions of DOE Order 420.1A (DOE 2002). Criticality safety controls are implemented in the FSPs.

6.2 References

DOE (2002), *Facility Safety*. DOE Order 420.1A, U.S. Department of Energy, Washington D.C., May 2002.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

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CHAPTER 7
RADIATION PROTECTION

7.1 Introduction

This chapter defines the B695 Segment (B695, B696S, and the associated yard area), Radiation Protection Program (RPP), as referred to in other parts of this DSA and the B695 Segment TSRs. This chapter augments the LLNL site-wide RPP, as defined by Appendix A of *ES&H Manual* Document 20.5, Occupational Radiation Protection: Implementation of 10 CFR 835. Specific controls, identified in the PrHA (Appendix A) or in Chapter 3 of this DSA, that fall within the scope of radiation protection are identified in this chapter.

7.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy (DOE)

DOE Order 435.1	Radioactive Waste Management
DOE Order 420.1A	Facility Safety
DOE Order 5400.5, Change 2	Radiation Protection of the Public and the Environment

Code of Federal Regulations

10 CFR 820	Procedural Rules for DOE Nuclear Activities
10 CFR 835	Occupational Radiation Protection
10 CFR 830, Subpart A	Nuclear Safety Management
40 CFR 61, Subpart H	National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

California Code of Regulations

22 CCR 66262	Standards Applicable to Generators of Hazardous Waste
22 CCR 66264	Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities

Other Requirements

DTSC Permit #99-NC-006	Livermore Site Hazardous Waste Facility Permit

7.3 Radiation Protection Program and Organization

The B695 Segment shall be operated in compliance with the DOE-approved LLNL-RPP. The requirements in the LLNL RPP have been incorporated into the *ES&H Manual* (Documents 20.1-20.4) and apply to activities and operations in this nuclear facility. These requirements are implemented at B695 Segment through the FSP and facility procedures. Additionally, B695 Segment shall utilize the services provided by the Hazard Control Radiation Safety Section (RSS) and the ES&H Team such that workers and areas are properly monitored and radiation doses are maintained ALARA. The RSS provides calibrated radiation detectors, personnel dosimetry (TLDs and direct-reading dosimeters), bioassay analysis, and swipe and air filter analysis. The ES&H Team 1 shall develop and implement a radiation monitoring program that is appropriate for the operations conducted. RHWM management shall meet with the ES&H Team 1 on a periodic basis (typically, annually) to verify changes in operations and personnel are reflected in the monitoring program.

Additional facility specific radiation protection requirements, resulting from the PrHA and hazard evaluation are encompassed by the RPP. These requirements are documented in the Administrative Limits section of this chapter. They are carried forward to the TSRs as elements of the RPP and implemented through the B695 Segment FSPs and procedures conducted by RHWM personnel.

Additional organizational summary material is provided in Chapter 17, *Management, Organization, and Institutional Safety Provisions.*

7.4 ALARA Policy and Program

It is the policy of the DOE and LLNL that exposure of personnel to ionizing radiation associated with LLNL operations is to be maintained as low as reasonably achievable below regulatory limits. The ALARA objective is achieved by integrating the following factors:

- Management involvement.
- Education and training.
- Facility designs.
- Safety procedures.
- Radiation dosimetry.
- Workplace monitoring.
- Environmental monitoring.
- Emergency preparedness.
- Program evaluations.
- ALARA goal-setting.
- Benefit versus risk analyses.

LLNL's detailed ALARA program is provided in *ES&H Manual* Document 20.4, "LLNL Occupational Radiation Protection ALARA Program." The ALARA program is applicable to B695 Segment activities.

7.5 Radiological Protection Training

Radiological protection training is required for all personnel, appropriate to individual job assignments. General employees receive general radiation safety training prior to potential exposure. Allowance may be made for previous DOE training on generic radiation-safety topics (i.e., those not specific to a site or facility), provided the training had been received at another DOE site or facility within the past two years. General employees are instructed in radiation safety during new-employee orientation. Retraining is provided when there is a significant change to the radiological protection policies and procedures that affects general employees. Retraining is conducted at intervals not to exceed two years. Retraining is accomplished by means of a self-study booklet that is sent to employees.

Radiological-worker training and retraining programs are in place for employees at LLNL who work on, with, or near ionizing-radiation-producing equipment or radioactive materials. Training and retraining requirements for unescorted access into radiological areas or radiological buffer areas are specified in *ES&H Manual* Document 20.1, "Occupational Radiation Protection.". Initial training is offered by the Hazard Control Department. Training includes both classroom and applied training and must be refreshed every two years. Supervisors are required to identify workers who require training and ensure they attend the training. The Hazard Control Department provides the requisite training. In addition, on-the-job training (OJT) is provided by qualified instructors to customize the concepts of classroom training to a worker's actual work assignment.

Training programs for health and safety technicians are conducted at intervals not exceeding two years. The training familiarizes technicians with the fundamentals of radiation protection and procedures for maintaining exposures ALARA. The program includes classroom and applied training. The level of facility-specific training is commensurate with a technician's assignment.

Specialized radiological control courses are also available from the Hazard Control Department. The need for other courses is at the discretion of the supervisor or according to advice given by the health physicist responsible for the area. Direct supervisors are required to complete training as specified in the *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (see Chapter 9).

7.6 Radiation Exposure Control

This section summarizes the plans and procedures for controlling external and internal occupational exposure to radiation.

7.6.1 Administrative Limits

The principal occupational radiation safety consideration in the RHWM facilities, including the B695 Segment, is to minimize radiation exposure and assimilation of radioactive materials by employees. Activities in the B695 Segment comply with the intent of applicable DOE requirements by implementing, through the B695 Segment FSPs and facility procedures, the following site policies and programs specified in the *ES&H Manual*: Document 20.1, "Occupational Radiation Protection;" Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials;" Document 20.4, "LLNL Occupational Radiation Protection ALARA Program;" and Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835."

The B695 Segment Facility Safety Plans (FSPs) and the *ES&H Manual* provide information on isotope source handling and use, radiation safety systems, and safety procedures that provide administrative controls to prevent excessive radiation exposure. The Facility Safety Plan shall contain administrative limits on processes that are derived in accordance with the Radiation Protection Program to ensure that worker doses from normal operations and potential accidents remain ALARA. These limits include:

It is LLNL policy to comply with radiation protection standards given in 10 CFR 835, which specifies an annual radiation dose limit of 5 rem to the whole body, 50 rem to the skin and to the extremities, and 15 rem for the lens of the eye. When individual whole-body doses can exceed 100 mrem/yr, the facility must establish individual ALARA goals.

7.6.2 Radiological Practices

To prevent personnel contamination, LLNL provides protective apparel for individuals working with radioactive materials. Anyone working with dispersible radioactive materials is required to wear, at a minimum, a laboratory coat and water-resistant gloves. Additional clothing and shoes may be specified, as needed. Radioactive contamination of surfaces outside work enclosures is maintained ALARA. Articles or equipment to be used in nonradioactive work areas or outside LLNL are decontaminated to levels that allow for unrestricted use.

Radiological areas will be identified and maintained in accordance with 10 CFR 835. Engineering controls for radiological areas will be developed under the supervision of the ES&H Team 1 health physicist. Waste treatment storage areas where radioactive materials are to be present will be posted with warning signs containing applicable safety instructions and information for the radioactive materials present.

Access control to the B695 Segment will be enforced. Only those personnel approved by the appropriate supervisors will be authorized to work in this facility. Such individuals are required to complete radiation worker training prior to working in an area where radioactive materials and waste are handled as appropriate for the work activity. Personnel not regularly assigned to the B695 Segment will be required to prearrange access and be escorted while in the operational zones.

7.6.3 Dosimetry

Personnel entering the B695 Segment will be required to wear a dosimeter designed to measure radiation exposure to beta and gamma and neutron radiation as applicable. Dosimeter readings will be obtained and recorded, and statements of accumulated external occupational radiation doses will be provided annually to all employees. If dosimeter analysis reveals unexpected results, the cause will be investigated.

The health physicist supporting the RHWM Division will determine the appropriate type of dosimeters, including personal alarming dosimeters, as needed for various types of radioactive-material-handling activities in accordance with the requirements of *ES&H Manual* Document 20.1, “Occupational Radiation Protection.” Additionally, the health physicist supporting the RHWM Division will determine if internal dose monitoring is to be performed in accordance with the requirements of *ES&H Manual* Document 20.2, “LLNL Radiological Safety Program for Radioactive Materials.”

As stated in Chapter 6 of this report, a criticality accident is not a credible event in the B695 Segment. Thus, there are no criticality alarm systems, and nuclear accident dosimeters are not required.

7.6.4 Respiratory Protection

Respiratory protection devices will be available for emergency response by trained personnel or for operations that the industrial hygienist and/or health physicist determine that respiratory protection is necessary. The devices will be used when engineering controls (e.g., safety enclosures or proper ventilation) are not feasible or when emergency conditions develop.

7.7 Radiological Monitoring

The Hazard Control Department administers the program that meets 10 CFR 835 and *ES&H Manual* Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," requirements. The radiological monitoring requirements are documented in the facility specific HP-DAP. For the B695 Segment, this program includes:

- Measuring ambient radiation fields.
- Monitoring for airborne contamination.
- Surveying for surface contamination.

The Hazard Control Department also selects, obtains, calibrates, distributes, and maintains radiation-monitoring instruments, as needed. Radiation air monitoring devices will be brought in, as required, for emergency situations. Health physicists will evaluate on a case-by-case basis the use of CAMs and PASs, which will be used when operations requiring them are conducted in B695 Segment facilities.

7.8 Radiological Protection Instrumentation

The health physicist supporting the RHWM Division will prescribe a radiation monitoring program that meets 10 CFR 835 requirements. This program includes the type of monitoring (e.g., air, contamination surveys), the type of instrumentation needed, the type of detectors, sensitivities of instruments, and other information.

7.9 Radiological Protection Record-Keeping

Dosimeter readings will be obtained and recorded, and statements of accumulated external occupational radiation doses will be provided annually to all employees, as required by 10 CFR 835, Occupational Radiation Protection, per NNSA/LLNS Contract DE-AC52-07NA27344. Under existing programs, employees are notified of any positive radiation dose. Any radiation dose that exceeds the limits, as stated in *ES&H Manual* Document 20.4, "LLNL Occupational Radiation Protection ALARA Program," is reported to the supervisor and to the person involved as soon as the information is available. The Hazard Control Department investigates the cause of such doses and maintains and stores all occupational radiation dose records for LLNL. Radiological records are maintained per 10 CFR 835 as described in *ES&H Manual* Document 20.1, "Occupational Radiation Protection." Document 20.1 provides the responsibilities for radiological record generation and maintenance. Records that are generated as a result of the requirements of 10 CFR 835 are retained until DOE authorizes their disposition.

7.10 Occupational Radiation Exposures

The collective total effective dose equivalent (TEDE) for all RHWM workers between 2000 and 2005 ranged from 0.071 person-rem (2001) to 1.794 person-rem (2004) (Le 2005). Per 10 CFR 835, the maximum allowable exposure limit (TEDE) is 5 rem/yr. The annual collective TEDE for all RHWM personnel based on historical data is less that the individual maximum allowable dose limit of 5 rem.

7.11 References

Le (2005), Email from Quang Le to Heather Larson, LLNL, December 2, 2005.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

CHAPTER 8
HAZARDOUS MATERIAL PROTECTION

8.1 Introduction

This chapter includes information on LLNL's Hazardous Material Protection Program, which is a part of the overall Health and Safety Program. The Health and Safety Program is devoted to identification, evaluation, and control of environmental factors and stresses found in the workplace as they apply to all facilities, including the B695 Segment.

The objectives are to identify applicable aspects of the Hazardous Material Protection Program as they apply to this facility and to show how they protect against facility hazards and contribute to facility safety. The process for reducing occupational chemical exposures is also described in Section 8.11.

8.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE Order 440.1A	Worker Protection Management for DOE Federal and Contractor Employees

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
10 CFR 850	Chronic Beryllium Disease Prevention Program
10 CFR 851	Worker Safety and Health Program
29 CFR 1910.1200	Occupational Safety and Health Standards

8.3 Hazardous Material Protection Program and Organization

The LLNL Health and Safety Policy, which includes requirements for radioactive and hazardous material protection, is defined in the *ES&H Manual* (LLNL latest revision). The policy is implemented through use of engineering and administrative controls and personal protective equipment (PPE). Procedures provide detailed requirements and responsibilities for implementing each part of the LLNL Health and Safety Policy. It is the policy of LLNL to implement DOE health and safety orders and to comply with prescribed standards and local, state, federal regulations, and Lawrence Livermore National Security policies.

All management levels are responsible for developing and implementing procedures to protect workers against hazards in the workplace. LLNL also has the Hazard Control Department as one of its environment, safety, and health (ES&H) organizations. By providing information on the radioactive and hazardous properties of materials and on relevant regulations, by recommending methods for control of hazardous materials, and by monitoring the work environment, this department, through its ES&H teams, assists supervisors and employees in maintaining safe work areas. The head of the Hazard Control ES&H Team 1 assigned to the Radioactive and Hazardous Waste Management (RHWM) Division interacts directly with the Facility Manager.

The ES&H Team 1 consists of multidisciplinary specialists, including at least one industrial hygienist. Most LLNL industrial hygienists are certified by the American Board of Industrial Hygiene and/or have graduate degrees in industrial hygiene or a closely related field. The industrial hygienists interface with facility staff and other ES&H team members, including health and safety technicians, safety engineers, health physicists, fire protection engineers, safety analysis specialists, safety and health trainers, nuclear criticality safety specialists, Environmental Analysts, and Health Services Department personnel.

8.4 ALARA Policy and Program

The Health and Safety Program, documented in *ES&H Manual* Document 20.4, "LLNL Occupational Radiation Protection ALARA Program," serves to maintain employee exposures to hazardous substances at levels below those of regulatory guidelines. This document provides guidance and identifies responsibilities for maintaining all exposures to hazardous materials well within DOE limits and federal and state regulations. All management levels of LLNL are responsible for developing and implementing procedures to protect workers against hazards in the workplace. The facility safety plan (FSP) is the basic safety and health procedure that must be followed by all personnel present within the building or area. Safety and health requirements specific to a hazardous waste operation are presented in the FSP or an Integration Work Sheet with a Safety Plan addendum (IWS/SP).

8.5 Hazardous Material Training

The LLNL RHWM Training Program provides LLNL personnel with the necessary knowledge and skills to perform their duties safely and in an environmentally sound manner. RHWM personnel manage the B695 Segment. They are responsible for processing LLNL-generated wastes and for storing, packaging, and preparing shipments of LLNL's radioactive (TRU and low-level), hazardous, mixed, and combined wastes for offsite treatment and/or disposal. Training is provided for RHWM personnel as described in *ES&H Manual* Document 40.1, "LLNL Training Program Manual." The ES&H Team 1 support for RHWM receive either general or occasional site worker training as described in 29 CFR 1910.120(e). The ES&H Team 1 members also receive emergency response training that meets First Response Awareness or First Response Operational levels per 29 CFR 1910.120(q). Emergency response services beyond these training levels are provided by the LLNL/Alameda County Fire Department.

8.6 Hazardous Material Exposure Control

8.6.1 Hazardous Material Identification Program

All regulated waste received at the B695 Segment will have been properly identified, prior to delivery, on a waste disposal requisition (WDR) form. Appropriate labels are affixed to waste containers in the waste accumulation area. The label is cross-referenced to the accompanying WDR form by its unique number. Potential radioactive (TRU and low-level), hazardous, mixed, and combined wastes are identified and documented through the following:

- Knowledge and assessment of the operations.
- Periodic walk-through surveys.

- Review of proposed projects and facilities.
- Maintenance of a hazardous material tracking system.

To assess potential hazards, all programs, facilities, and buildings are subject to review and evaluation by Hazard Control Department personnel. Results of the reviews are forwarded to the appropriate department so that any deficiencies can be corrected. Records of reviews are maintained by the Hazard Control Department. The program and activities that identify, analyze, and control potential hazardous material are described in the *ES&H Manual* Document 14.1, "LLNL Chemical Safety Management Program," and the FSP.

8.6.2 Administrative Limits

Exposures must be kept below the limits specified in DOE orders [i.e., the lower of the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs), or the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs)].

8.6.3 Occupational Medical Programs

LLNL's Medical Monitoring Program, which is implemented by the Health Services Department, is described in *ES&H Manual* Document 10.1, "Occupational Medical Program." This monitoring program includes physical examinations, medical evaluations, and record-keeping of hazardous material exposures. Based on a hazard assessment of specific substances described in work control documents, the ES&H Team industrial hygienist in consultation with supervisors and the Health Services Department determine the appropriate medical surveillance programs. Tailored medical surveillance programs for Hazardous Waste Workers, Beryllium Workers, and Respirator Users are common for hazardous waste technicians.

8.6.4 Respiratory Protection

LLNL's respiratory protection program is described in *ES&H Manual* Document 11.1, "Personal Protective Equipment," and in Section 7.6.4 of this document. The process for reducing occupational chemical exposures is also described in Section 8.11.

8.7 Hazardous Material Monitoring

ES&H Manual Document 14.1, "LLNL Chemical Safety Management Program" describes exposure monitoring for chemical hazards. Other sections of the ES&H Manual for specific substances as well as procedures within the Hazard Control Department further detail how hazards are evaluated, monitored, and controlled.

ES&H Manual Document 12.2, "Ventilation," and Document 12.3, "Evaluation and Control of Facility Airborne Effluents," provide the ventilation requirements and acceptance criteria for all new and modified facilities. This document provides all surveillance, maintenance, and systems-failure procedures for all existing facilities. Area ES&H teams conduct regular performance checks on all ventilation systems used for hazardous materials.

Exposures must be kept below the limits specified in DOE orders (i.e., the lower of the OSHA PELs or the ACGIH TLVs). Monitoring for air and surface contamination is appropriate for initial evaluation of new waste handling procedures or after working conditions have been changed. Results will help determine if a regular surveillance program is necessary.

The LLNL Site Annual Environmental Report (LLNL-a latest revision) provides information on the environmental monitoring activities conducted by the Environmental Protection Department. Activities include sampling and reporting results for air, sewage effluent, groundwater, surface water, soil, vegetation, and foodstuffs.

LLNL's environmental activities include radiological and nonradiological surveillance, effluent- and compliance-monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

8.8 Hazardous Material Protection Instrumentation

The Hazard Control Department ES&H Team 1 assists supervisors and employees in maintaining safe work areas by providing information on the hazardous properties of materials and relevant regulations, recommending methods for control, and monitoring the work environment. Instrumentation used for monitoring, sampling, and surveying is selected and placement determined by the appropriately qualified and trained member of the ES&H team (e.g., IH, HP, IS). Information on the inventory and technical specifications of monitoring instruments are available in the Industrial Hygiene Instrument Laboratory.

8.9 Hazardous Material Protection Record-Keeping

Results of hazardous material monitoring performed by the Hazard Control Department are documented in a report and provided to RHWM and the Health Services Department. Copies are maintained by Hazard Control according to department policies for authorized release only. Occupational exposure records are maintained per regulatory requirements.

8.10 Hazard Communication Program

In compliance with Title 29 Code of Federal Regulations Part 1910.1200 (29 CFR 1910), the Hazard Control Department has a written Health Hazard Communication Program (*ES&H Manual* Document 10.2, "LLNL Health Hazard Communication Program"). The purpose of the program is to ensure that hazardous materials have been evaluated and that this information is communicated to affected employers and employees. Other provisions of the Health Hazard Communication Program include:

- Identification and labeling of hazardous materials.
- Hazardous materials evaluation.
- Information and training.

RHWM implements the Health Hazard Communication Program for operations in the B695 Segment and other RHWM facilities. Implementation of these provisions is discussed in *ES&H Manual* Document 10.2, "LLNL Health Hazard Communication Program" and in the RHWM FSPs.

8.11 Occupational Chemical Exposures

Potential for detectable levels of hazardous materials exists in the B695 Segment operations. Routine industrial hygiene surveillance of current RHWM operations in the B695 Segment have not shown exposures above LLNL adopted Occupational Exposure Limits (OELs). Occasionally, low-levels of surface contamination have been found and are managed in consultation with the ES&H team 1 Industrial Hygienist. Although there have been previous operations with legacy waste materials that have exceeded OELs, none of those operations on legacy waste are currently performed. Controls (e.g., ventilation, respiratory protection) commensurate to the potential hazard shall be evaluated and recommended by the ES&H Team 1. A hazard assessment and analysis shall occur prior to the start of an operation. When operational parameters change (e.g., frequency, quantity, location), operations shall be reviewed to ensure adequacy of current control methodologies. Records of exposure assessments are available through the Industrial Hygiene Section.

8.12 References

CFR (29 CFR 1910), *Occupational Safety and Health Standards*, U.S. Department of Labor, Code of Federal Regulations, Title 29. Office of the Federal Register, Washington, DC

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-a (latest edition), *Environmental Report*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-50027-96).

LLNL-b (latest revision), LLNL Chronic Beryllium Disease Prevention Program (CBDPP) Implementation of 10 CFR 850 (UCRL-AR-144636).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 9
RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 Introduction

This chapter describes the overall radioactive and hazardous waste management program and organization. The B695 Segment is a Hazard Category 3 nonreactor nuclear facility. Operations in B695 and 696S will include transuranic (TRU) waste, low-level waste (LLW), mixed LLW, hazardous waste, non-hazardous waste, and California combined waste. In addition to receipt, inspection, handling, sampling, and characterization, wastes will be stored in B696S and B695.

RHWM generally processes low-level radioactive waste with no, or extremely low, concentrations of transuranics (e.g., much less than 100 nCi/g). Wastes processed often contain only depleted uranium and beta- and gamma-emitting nuclides, e.g., ^{90}Sr, ^{137}Cs, and ^{3}H.

9.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy (DOE)

DOE Order 435.1	Radioactive Waste Management
DOE Order 420.1A	Facility Safety
DOE Order 5400.5 Change 2	Radiation Protection of the Public and the Environment

Code of Federal Regulations

10 CFR 820	Procedural Rules for DOE Nuclear Activities
10 CFR 835	Occupational Radiation Protection
10 CFR 830, Subpart A	Nuclear Safety Management
10 CFR 850	Chronic Beryllium Disease Prevention Program
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

California Code of Regulations

22 CCR 66262	Standards Applicable to Generators of Hazardous Waste
22 CCR 66264	Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities

LLNL Manuals and Reports

UCRL-AM-148488, Rev 3	*LLNL Radioactive Waste Program Certification and Quality Assurance Plan* (LLNL 2008)

Other Requirements

DTSC Permit #99-NC-006	Livermore Site Hazardous Waste Facility Permit
Operations Plan	Part A and Part B Permit Application For Hazardous Waste Treatment and Storage Facilities Livermore Site, UCAR-10275

LLNL implements most DOE environment, safety, and health (ES&H) policies and programs through site policies and programs specified in LLNL's *ES&H Manual* (LLNL latest revision). The primary guidelines for safe acceptance of radioactive and hazardous waste are covered in the Radioactive and Hazardous Waste Management (RHWM) Division's Waste Acceptance Criteria (LLNL-a latest revision). The requirements include operational safety requirements.

9.3 Radioactive and Hazardous Waste Management Program and Organization

This section summarizes the radioactive and hazardous waste management program and organization for the B695 Segment. Included in the discussion is an overview of safety management policies and philosophies used as the basis of the program.

B695 is a permitted waste treatment and storage facility. The permit was issued by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC). LLNL manages hazardous and mixed waste generated on site in accordance with the conditions of this permit. B696S is a RCRA-permitted facility and is authorized to store hazardous waste for up to one year and conduct authorized treatment activities.

LLNL implements DOE's ES&H policies and programs through site policies and programs specified in the LLNL *ES&H Manual*. The B695 Segment Safety Management Policy, as with all RHWM operations, is conducted in accordance with the LLNL *ES&H Manual* Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials." Guidelines for safe management of waste are also covered in *ES&H Manual* Document 36.1, "Hazardous, Radioactive, and Biological Waste Management Requirements," Document 36.2, "Managing Office and Shop Supplies for Disposal," Document 36.3, "Management of Satellite and Waste Accumulation Areas for Hazardous and Mixed Waste," and Document 14.4, "Working Safely with Beryllium."

In addition, to efficiently and safely perform operations within the B695 Segment, management has determined that controls specified within the Facility Safety Plan (FSP) must also be followed. All work in the B695 Segment beyond activities commonly performed by the public must be authorized with an IWS. Depending on the level of hazards associated with the activity, an SP may also be required.

In the area of radioactive waste management, LLNL's primary objective is to minimize impacts to the public and the environment, keeping all impacts ALARA, and below allowable limits. Waste management operations at the B695 Segment are also conducted in a manner that minimizes impact to workers.

The Hazard Control Department provides assistance to B695 Segment supervisors and workers for both radiological and nonradiological occupational safety. The Environmental Protection Department is responsible for assisting B695 Segment personnel in protecting the environment from operations at the facility. In addition, the management and certification program of LLW is described in the Radioactive Waste Program Certification and Quality Assurance Plan (LLNL 2008).

The RHWM Division Leader is responsible for overall facility operation and delegates, in writing, the succession of responsibility during any absence. The RHWM Division Leader is responsible for safe operation within the B695 Segment. Safe operation includes, as necessary, interface requirements with other site organizations and facilities to ensure the availability of fire protection, electric power, utilities, and other items.

RHWM is responsible for operations at the B695 Segment. The group leaders are responsible for overall site safety and have control over those activities necessary for safe operation and maintenance. Individuals who carry out health physics and quality-assurance functions have organizational independence.

Waste management, procedures, and training are provided in the *Training Implementation Matrix (TIM) for the Hazardous Waste Management Division* (LLNL-c latest revision), which addresses the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*.

The B695 Segment must also comply with facility-specific FSPs. FSPs implement policies and programs specified in the *ES&H Manual*. An Integration Work Sheet with a Safety Plan addendum (IWS/SP) is written as required for activities not described in the FSP.

Each LLNL employee assigned to the B695 Segment is required to read and understand the applicable SOPs, FSPs, and/or IWS/SPs for those activities with which the employee is involved. These procedures and plans are maintained as part of the operating record. FSPs, SOPs, and IWS/SPs are available for inspection and review from RHWM. Trained personnel perform all waste management activities and respond to emergency incidents at the B695 Segment. Training includes annual and refresher training as well as on-the-job training in special skills or knowledge areas. RHWM workers handling radioactive materials also receive training through the EP0006 series of courses.

9.4 Radioactive and Hazardous Waste Streams or Sources

The waste types associated with the B695 Segment complex and the safety analyses of these materials are presented in Chapter 3, “Hazard and Accident Analysis,” and in Chapter 2, “Facility Description.” RHWM wastes were identified from the 2005 LLNL EIS (DOE 2005). Appendices A and B of the EIS quantify waste generation for LLNL, and the reader is referred there for further detail. Specific information on the types of hazardous and/or mixed wastes managed in B695 (and B696S when permitted) can be found in the DTSC Hazardous Waste Facility permit and associated Operation Plan.

9.4.1 Waste Management Process

This section summarizes the overall waste management plan, including the management policy or philosophy, at the B695 Segment. Included in the discussion is a summary of administrative and operational practices important to effective management of each of the waste types (e.g., waste segregation).

B695 Segment Management Policy and Philosophy

Waste generated at the B695 Segment will go through the same general process of identification, characterization, and labeling as wastes entering the B695 Segment from other facilities at LLNL. Waste is segregated into separate containers according to compatibility and opportunities for recycling. The waste name, identifying constituents, characteristics, and any radionuclides in the waste in each container are recorded on a waste label attached to that container.

B695 Segment workers will complete a waste disposal requisition (WDR) for waste generated at the B695 Segment. The WDR is used to document information about the waste in a specific waste container. The WDR information is entered into a database management system that is maintained by RHWM for record keeping and retrieval. Each WDR is uniquely numbered to facilitate tracking through the computerized database. Subsequent management and treatment information is appended to the database information to provide a complete disposition record of the waste stream. Once the waste is accepted, RHWM personnel determine whether the waste is appropriate for onsite treatment, storage, or offsite disposition.

Administrative and Operational Practices

Operations in the B695 Segment comply with the FSPs. FSPs implement policies and programs specified in LLNL's *ES&H Manual*. An Integration Work Sheet with a Safety Plan addendum (IWS/SP) is written as required for special activities.

Operation of B695 (and B696S when permitted) must also comply with the DTSC Hazardous Waste Facility permit for storage, handling, and treatment of hazardous wastes.

9.4.2 Waste Sources and Characteristics

Wastes may be generated at the B695 Segment as a result of treatment, characterization, handling containers, maintenance, cleanup of spills, and other operations. Chapters 2 and 3 of this report include discussions of all B695 Segment operations. These chapters describe waste sources, storage, and appropriate waste handling at the B695 Segment.

9.4.3 Waste Handling or Treatment Systems

Chapters 2 and 3 of this report include discussions of all B695 Segment operations. In particular, these chapters describe waste handling and treatment systems at the B695 Segment.

9.5 References

DOE (2005). Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement, DOE/EIS-0348, DOE/EIS-0236-S3, March 2005.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-a (latest revision), *Waste Acceptance Criteria*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL-c (latest revision), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-116655).

LLNL (2008), *LLNL Radioactive Waste Program Certification and Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AM-148488, Rev 3, (February 2008).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 10
INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

10.1 Introduction

This chapter discusses initial testing or inspection that will be done at startup of the B695 Segment. Essential features of the in-service surveillance and maintenance programs are also addressed.

10.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements. The B695 Segment was designed and is operated in accordance with the following applicable regulations for startup testing, in-service surveillance, and maintenance:

U.S. Department of Energy

DOE 440.1A	Worker Protection Management for DOE Federal and Contractor Employees
DOE O 433.1	Maintenance Management Program for DOE Nuclear Facilities

Codes

Uniform Building Code (UBC) (ICBO 1994)	International Conference of Building Officials (ICBO)
Industrial Ventilation (ACGIH 1995)	American Conference of Governmental Industrial Hygienists (ACGIH)

10.3 Initial Testing

Initial testing or inspection on major repairs or modifications is preformed under the In-service Inspection and Test Program. For the B695 Segment, initial testing consists of acceptance testing per design specifications and walkthroughs. See Section 10.5 for additional information on the Maintenance program.

10.4 In-Service Inspection & Test Program

An in-service inspection and test program is established, implemented, and maintained to ensure the integrity of the Design Features described in Section 5.6 and other Defense in Depth SSCs. Inspections and tests are performed by qualified personnel. The in-service inspection and testing of safety-significant SSCs (i.e., TRU waste containers, B695 and B696S structural systems, and B696S/B696R partition) is discussed in Chapter 4.

Fire alarms, fire sprinkler system, and fire extinguishers will be inspected and tested periodically for operational readiness. Hazard Control fire protection professionals and Emergency Management Division also conduct periodic surveillances of fire sprinkler systems in accordance with applicable NFPA requirements.

10.5 Maintenance Program

LLNL has a maintenance program in effect that is described in the *ES&H Manual* (LLNL-a latest revision). The program incorporates applicable regulations and information from DOE Order 433.1, *Maintenance Management Programs for DOE Nuclear Facilities* (DOE 2001), as well as self-assessments of LLNL maintenance organizations and previous audits. DOE Order 433.1A, *Maintenance Management Program for DOE Nuclear Facilities* (DOE 2007), is replacing DOE O 433.1, and with the implementation of the new order by LLNL, the RHWM maintenance program will be updated as applicable.

B695 Segment operations incorporate the Laboratory-wide plan into its maintenance plan. *ES&H Manual* Document 52.1, “LLNL Maintenance Implementation Plan for Nonreactor Nuclear Facilities.” Specific implementing details are found in RHWM-specific documents, such as the RHWM Maintenance Manual (LLNL-b latest revision). RHWM is responsible for maintaining SS SSCs and delineating requirements, including frequency of maintenance, calibration, and performance. The maintenance plan addresses the implementation of facility safety and operability and ensures that the capital investment in building and equipment is protected.

The graded approach to maintenance takes into account the potential for equipment failure on the following items, in order of importance: the public, laboratory workers, the environment, security and safeguards, and the Laboratory mission. A scale is used to rate anticipated results of the worst credible failure. Each structure, system, or component is assigned a risk rating. Areas and/or treatment units in the facility are assigned a category that corresponds to the highest risk rating for any structure, system, or component inside the area. The graded approach matches the category with level of maintenance.

Category 1 is the most rigorous maintenance program, designed to emphasize reliability and minimize the probability of failure. The lowest category addresses maintenance limited to fixing broken items. Safety-related systems in the B695 Segment have assigned risk categories, and the maintenance program is in accordance with the LLNL Maintenance Implementation Plan. Safety significant design features have been assigned a minimum of category 2 significance.

LLNL’s overall real property and installed equipment maintenance plan is referred to as the Critical Facilities Maintenance Program. This program is administered by the central maintenance organization. The RHWM Division administers the personal property and programmatic equipment maintenance program. Other LLNL organizations that assist RHWM in maintenance are Maintenance and Utilities Services Department (MUSD), Mechanical Engineering, Motor Pool, Alarms Division, and Hazard Control. RHWM maintenance procedures incorporate the B695 Segment design and operations.

The FAC provides the personnel for maintenance of the sprinklers. Journeyman plumbers are trained in sprinkler piping and operations. Journeyman electricians are trained in alarm system operation and maintenance.

10.6 References

DOE (2001), *Maintenance Management Program for DOE Nuclear Facilities*, DOE Order 433.1, U.S. Department of Energy, Washington, DC, June 1, 2001.

DOE (2007) *Maintenance Management Program for DOE Nuclear Facilities*, DOE O 433.1A, U.S. Department of Energy, Washington, DC, February 13, 2007.

LLNL-a (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-b (latest revision), *Radioactive and Hazardous Waste Management (RHWM) Maintenance Manual*, Lawrence Livermore National Laboratory, Livermore, CA.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 11
OPERATIONAL SAFETY

11.1 Introduction

This chapter describes the essential features of the operational safety and fire protection programs as they relate to the B695 Segment. Provisions in this information will satisfy the requirements of DOE STD 3009-94, Change Notice 3. LLNL's operational safety and fire protection programs demonstrate that the B695 Segment can be operated without posing undue risk to the health and safety of facility workers, other onsite employees, or individuals at the site boundary. The general aspects of operational safety that are applicable to the facility are presented in Section 11.3, "Conduct of Operations." Conduct of operations for the B695 Segment follows the guidance specified by DOE Order 5480.19, Change 2 (DOE 2001), *Conduct of Operations Requirements for DOE Facilities.* Chapter 11 includes the basis for the conduct of operations program and the fire protection program.

11.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

DOE STD 3009-94, CN 3	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports.
DOE Order 5480.19, Change 2	Conduct of Operations Requirements for DOE Facilities

The B695 Segment shall also comply with 29 CFR 1926 and 29 CFR 1910 requirements.

This section includes the design codes, standards, regulations, and DOE orders required for establishing the safety basis of the B695 Segment. The safety program for the Radioactive and Hazardous Waste Management (RHWM) Division facilities is administered through a series of hierarchical documents that promulgate responsibilities and give direction for safe operations. The LLNL *ES&H Manual* (LLNL latest revision) is the chief administrative safety document, and it serves as the basis for LLNL's general safety policy. The B695 Segment and all programs at LLNL are subject to requirements specified in the *ES&H Manual*.

The next level of administrative safety documentation is the RHWM Facility Safety Plans (FSPs) and Integration Work Sheet with a Safety Plan addendum (IWS/SP), followed by standard operating procedures (SOPs). To ensure that document contents are appropriate for current operations, FSPs, IWS/SPs, and standard operating procedures are periodically reviewed in accordance with the *ES&H Manual*.

11.3 Conduct of Operations

To ensure compliance with Chapter 1 of DOE Order 5480.19, Change 2 (DOE 2001), the B695 Segment facilities operate in accordance with *ES&H Manual* Document 3.5, "Conduct of Operations for LLNL Facilities." Document 3.5 provides requirements and guidelines for the departmental elements to be used in developing directives, plans, and procedures relating to the conduct of operations at the B695 Segment. The practices and implementation of the programs described in this document provide consistent and auditable requirements, standards, and responsibilities for B695 Segment operations. Specific conduct-of-operation (ConOPs) topic areas from DOE 5480.19 that are considered in the B695 Segment are as follows:

- **Operations Organization Administration**. The RHWM facility manager, line manager, supervisors, and project leaders operating within the B695 Segment are responsible for ensuring the safety of operations and that an acceptable level of performance is achieved. The RHWM project leaders and group leaders are responsible for accomplishing division waste handling, processing and shipping goals, and the RHWM supervisors are responsible for directing day-to-day activities of employees and keeping management informed of operating problems and achievements.
- **Shift Routines and Operating Practices.** Operations personnel adhere to the safety practices in the facility safety plans, conduct routine facility and equipment inspections, and promptly notify supervisors of any unexpected situations. Personnel protection practices are followed to maintain personnel exposure as low as reasonable achievable to radiation, chemicals, toxic materials, or other personnel hazards. Through line management, the Waste Storage Facilities operations supervisor directs overall operations of the facility and ensures that only trained personnel are working in the facility.
- **Communications.** The B695 Segment provides adequate and reliable communication capability during routine and emergency conditions. The B695 Segment communication systems include telephones, evacuation voice/alarm (EV/A) systems, personnel beepers, radios, and audible and visual alarms. Employees will be instructed in the proper use of facility-specific communication devices. In addition, communications include fire pull stations that alert the onsite Alameda County Fire Department Emergency Dispatch. In the event of a communications system failure, the Fire Department is notified upon a total loss of power. A description of emergency equipment and engineering control systems is provided in Chapter 2.
- **Control of On-the-Job Training (On-shift)**. B695 Segment employees who are new to an area may have a thorough technical background and a theoretical understanding of an operation, but on-the-job training (OJT) may still be required to ensure they understand specific details of an operation. Work conducted by personnel under instruction will be carefully supervised to avoid errors that could have significant impact on safety or operations. OJT will be conducted so that the trainee satisfactorily completes all of the required training objectives and receives maximum learning benefit from the experience. The training of workers meets the requirements of 29 CFR 1910.120 HAZWOPER. A description of training for workers is provided in Chapter 12, “Procedures and Training.”
- **Investigation of Abnormal Events**. Using the guidance provided in the *ES&H Manual* Part 4, “Feedback and Improvement,” the RHWM facility manager is responsible for identifying abnormal events that require analysis. This document provides guidance for investigating abnormal events.
- **Notifications.** Employees or project leaders notify their line management of events that could affect the health and safety of the public or endanger the health and safety of employees. Line management is then responsible for notifying appropriate LLNL and DOE personnel, and other

agencies, of these events. *ES&H Manual* Document 4.5, “Incidents--Notification, Analysis, and Reporting,” ensures the uniformity, efficiency, and thoroughness of such notifications, consistent with DOE Order 231.1A.

- **Controlling Equipment and System Status**. The status of B695 Segment equipment is monitored. Systems or operations are controlled so that operations proceed according to specifications. For example, weight capacities are not exceeded for equipment used for lifting, glove box loading, and container storage. A description of B695 Segment equipment is provided in Chapter 2, “Facility Description.” Containers are stored in a stable configuration.
- **Lockouts and Tagouts.** Lockout and tagout is a proven procedure for ensuring that employees do not cause harm (e.g., shock) to themselves or others when working on or around equipment capable of causing harm. It is imperative that individuals working on or around potential stored energy sources at the B695 Segment observe LLNL’s lockout and tagout policies and procedures. The B695 Segment facility and operations operate in accordance with *ES&H Manual* Document 12.6, “LLNL Lockout/Tagout Program,” which provides guidance on this subject.
- **Independent Verification.** Independent verification is the act of checking to ensure that essential components such as valves, switches, circuit breakers, and other items are positioned to ensure proper functionality as established. Such verification recognizes the human element of component operation, that is, that any employee, no matter how proficient, can make a mistake and misposition valves, switches, circuit breakers, or other items. The concept of independent verification is incorporated into written procedures for the B695 Segment, which are in place at RHWM or with Hazard Control (as applicable).
- **Logkeeping**. Formal records or logbooks are maintained for those operations that can have significant impact on health, safety, or the environment, or significant impact to programs. The records contain enough information so they can be used to track the history of various situations or pieces of equipment, or to document occurrences within the facility.
- **Operations Turnover.** Shift personnel should be aware of the current conditions in the B695 Segment facility so that they can perform their duties in a safe manner. Therefore, it is important that employees report changes and other relevant information that occur during their shift. However, B695 Segment operations are typically operated only during the normal 8- to 10-hour day shift. Off-shift work is occasionally conducted and may include the performance of inspections as required under RCRA regulations.
- **Operations Aspects of Facility Chemistry and Unique Processes**. The RHWM facility manager or group leaders are responsible for identifying and monitoring those operating parameters that, if out of range, could impact health, safety, or the environment. There are no operating parameters in the B695 Segment that require indirect monitoring.
- **Required Reading.** LLNL’s safety policies and procedures are documented in a variety of manuals, including the *ES&H Manual*, FSPs, Documented Safety Analyses, Technical Safety Requirements, and IWS/SPs. The RHWM Division has a required reading program, which is specified in the *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL-b latest revision);
- **Timely Orders and Instructions to Operators/Workers.** Instructions that are important to health, safety, or the environment are communicated to B695 Segment employees. Instructions

are provided in safety and operating procedures, employee instruction aids, request forms, and LLNL notices.

- **Operating Procedures for Equipment And Systems**. B695 Segment procedures are written instructions that give employees directions on how to conduct specific operations or operate specific systems or pieces of equipment during normal, postulated off-normal, and emergency conditions. The procedures are written for operations that could significantly impact health, safety, the environment, or the program. The procedures are outlined in Chapter 12, “Procedures and Training.”
- **Operator-Aid Postings**. “Operator aids” are technical postings, other than formal procedures, rules, instructions, or the like, that assist employees in accomplishing specific tasks. Required postings (those that are not operator aids) include radiation area signs, material balance sheets, and evacuation assembly point postings. Operator aids provide an important function in the safe operation of a facility. Postings in the B695 Segment reflect the most current information available.
- **Equipment and Piping Labeling**. Equipment labeling is required by Occupational Safety and Health Administration (OSHA) regulations. Equipment and piping are consistently labeled in the B695 Segment so that maintenance and modifications can be safely conducted.

11.4 Fire Protection

11.4.1 Fire Hazards

This section provides an overview of the B695 Segment facility fire hazards in terms of overall combustible loading proximal to hazardous materials being stored or processed at B695 Segment facilities. Explosive materials (e.g., those materials used in the fabrication of an explosive device) are not stored in the B695 Segment; thus, explosion criteria are not applicable. Fire hazards at the B695 Segment consist of fuel sources and ignition sources. The Fire Hazard Analysis (LLNL 2007 and LLNL 2008) provides more information on fire protection issues at the B695 Segment.

The primary fuel sources identified within the facility and proximal to the radioactive material inventory are as follows:

- **Combustible Contents of Waste Containers.** Combustible waste within the waste inventory primarily consists of paper, cloth, plastic, and other ordinary combustible materials. Some of the combustible materials may also be co-contaminated with organic solvents or Class 1 oxidizers, e.g., nitrate salts or cellulose materials. Class 1 oxidizers slightly increase the burning rate but do not cause spontaneous ignition when they come in contact with combustible materials according to NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*. Unprocessed wastes may include flammable liquids stored in compatible closed containers and combustible wastes in cardboard and wood packaging, but the most common packaging is steel drums.
- **Combustible Packaging and Pallets**. All TRU waste is packaged in closed steel containers on steel pallets. LLW and hazardous waste may be stored in a variety of containers including metal containers or combustible packaging such as plastic drums and bags, plastic tanks, wood crates, and fiber boxes. These containers are closed. Waste other than TRU waste may be stored on combustible pallets. Combustible materials in the B695 Segment facilities that store TRU waste

and B696S Room 1009 are limited by the combustible loading controls described in Section 11.4.3.

- **Natural Gas**. A 4-in natural gas line, with a seismic shutoff valve, services B695. A second seismic shutoff valve is located at the hot water boiler in B695. Smaller branch lines serve other operations in B695 (e.g., the Process Control Laboratory). A 1-1/2-in natural gas branch line runs to B696S and is capped off in the North West corner of Room 1009.
- **Propane.** Forklifts used to convey waste containers inside and outside the facility are powered by liquefied propane gas (LPG). Propane forklifts with 15- to 35-lb fuel tanks represent a significant source of flammable gases. The fuel system on these vehicles satisfies applicable Department of Transportation (DOT) requirements. Refueling is performed by changing out the forklift LPG tank and is conducted in a designated location outside and away from any building. LPG will flash to vapor if released to the atmosphere, and, therefore, it represents a flammable gas hazard.
- **Liquid Fuels**. The most common, significant fuel source is a flammable/combustible liquid spill from a vehicle (i.e., fuel or hydraulic fluid). Vehicles include cars, forklifts, manlifts, and various sizes of trucks, ranging from small utility vehicles with 10 to 20 gal of gasoline or diesel fuel, up through trucks with supplemental fuel supplies or an occasional large tractor-trailer truck with up to 80 gal of fuel.
- **Hydraulic Fluid.** The fluid used to power the hydraulic system of forklifts and manlifts has a flash point greater than 200°C (390°F) with a limited volume of less than 90 liters (20 gal).
- **Cleaning solvents.** Small amounts of cleaning solvents may be present, which must be properly stored, according to *ES&H Manual* Document 14.1, "LLNL Chemical Safety Management Program."
- **Chemicals**. Common process chemicals used are sodium hydroxide, sulfuric acid, hydrogen peroxide, and ferric sulfate, none of which are combustible or flammable. Other chemicals may be present and, like all chemicals, are properly stored, according to *ES&H Manual* Document 14.1, "LLNL Chemical Safety Management Program."

Table 11-1 identifies where flammable and combustible materials are located in the B695 Segment by type of material.

Table 11-1. B695 Segment combustible or flammable materials by types and locations

Combustibles/Flammables	Location	
	B695	B696S
Fuels–fixed[1]	yes	no
Fuels–transient[2]	yes	yes
Containerized waste	yes	yes
Other chemicals[3]	yes	yes
Miscellaneous combustibles[4]	yes	yes

1 Fuels–fixed include flammable fuel that resides in permanently installed facility components, such as natural gas supply lines.

2 Fuels–transient include flammable fuel that exists in vehicles that transit in and out of, or between, facilities.

3 Other chemicals include nonfuel, flammable chemicals, such as acetone, in liquid waste at sufficient concentration to generate flammable vapors.

4 Miscellaneous combustibles include trash, packaging material, or other debris items not included as containerized waste.

The following potential ignition sources that may exist inside or outside the B695 Segment facility were evaluated in the process hazard analysis (PrHA) and were found to be adequately controlled. The means to minimize or control these sources are discussed, as appropriate.

- **Vehicles**. Engine heat from trucks and vehicles operating near the B695 Segment presents a potential ignition source for the fuel sources described above. The PrHA considered several vehicle accidents, including forklift and manlift accidents, that result in a fire and waste burning.
- **Forklifts and Manlifts**. Engine heat from forklifts and manlifts used during waste container handling and maintenance operations presents a potential ignition source for the combustible waste being conveyed or located nearby. When using a forklift, waste containers are placed away from the forklift engine; when manlifts are used, waste containers are moved away from the area in which the manlift is to be maneuvered. For these reasons and because TRU waste is packaged within metal waste containers, engine heat is a highly unlikely ignition source for the combustible contents of TRU waste containers.
- **Electrical Fault.** All facility electrical systems were designed in accordance with NFPA 70, *National Electric Code*. Electrical wiring and devices in the vicinity of operations where flammable gases or vapors can exist under normal conditions, or could exist in case of accidental rupture or breakdown, are rated as suitable in accordance with Chapter 5 of NFPA 70. All electrical wiring within the waste process and storage areas is routed within conduit. In addition, major electrical equipment is installed according to PC-2 seismic criteria.
- **Lightning**. The Livermore Valley rarely experiences severe weather. Thunderstorms occur fewer than 10 days per year and are not intense. Thus, the B695 Segment facility is not equipped with lightning protection air terminals. The buildings, however, are grounded.
- **Airplane Crash.** There is a possibility of a small aircraft crash in the B695 Segment. The onsite Alameda County Fire Department will respond to such an event. The B695 Segment has sprinklers that would activate, where the system is not damaged. Supplemental water can be provided from nearby hydrants (see Section 11.4.4).
- **Welding and Other Hot Work**. Occasional welding, using either electrical arc or hot flame (oxyacetylene or MAPP gas), may be required to maintain important building systems. LLNL uses a permit system described in *ES&H Manual* Document 2.2, “Managing ES&H for LLNL Work.” Before welding could be performed, a Hot Work Permit must be issued by the Emergency Management Departmentto ensure personnel who perform welding, soldering, and other hot-work operations with a high fire potential are aware of and protected from hazards.
- **Wildfire.** The area north of B696S is asphalt paving for about 20 feet. On the north side of the asphalt is a row of small trees, about 20 feet tall, beyond which is an open field buffer zone, owned by LLNL, and kept from accumulating weeds by seasonal mowing. Although wildfire could occur in open grassy areas near facilities or in forested areas further away, the area north of B696S is maintained free of excess weeds and grass. The exposure threat of a wildfire is minimal. Areas adjacent to all other DWTF facilities are paved or lawn. Trees north of B696 are periodically trimmed and maintained to reduce fire exposure to storage areas/buildings.

The estimated combustible loading in the various B695 Segment waste process and storage areas is low. Combustible materials are limited to the quantity required for current needs (less than 7 lbs/ft^2 average calculated annually in fire areas storing TRU waste and in B696S Room 1009, excluding containerized waste in metal containers) and are separated from ignition sources. Protection of the facilities is provided by automatic sprinkler systems, portable fire extinguishers, and non-combustible construction. The hazard analyses documented in Chapter 3 addresses fire hazards particular to B695 Segment facilities.

Potential fires from Chapter 3 fall into two groups: fires outside buildings and fires inside buildings. Fires outside buildings are postulated to involve staged waste impacted by vehicles. Inventory controls are in place to limit the MAR available. Fires inside buildings are postulated to occur due to electrical faults, welding accidents, chemical reactions, and other mechanical faults. The inventory involved varies depending on the initiator, but ranges from single containers and individual process limits to the entire segment inventory limit.

Fire Hazard Analyses

The Fire Hazard Analysis (LLNL 2007) for B696 addresses hazards in both B696R and B696S. The FHA for B695 (LLNL 2008) examined the staging and treatment of solid and liquid radioactive, mixed and hazardous wastes.

The B696 FHA (LLNL 2007) identifies the Maximum Credible Fire Loss as resulting in the operation of twelve sprinklers, minor damage to the structure, possible contamination of the area and minor equipment losses, which is consistent with the DSA accident analysis.

The conclusion of the B696 FHA (LLNL 2007), is as follows: Based in this analysis, this facility meets the fire protection objectives and criteria outlined in Section 4 of DOE Order 420.1A, qualifying it as an Improved Risk facility.

The conclusion of the B695 FHA (LLNL 2008), is as follows: This facility meets the fire protection objectives and criteria outlined in Section 4 of DOE Order 420.1A, qualifying it as an Improved Risk facility.

11.4.2 Fire Protection Program and Organization

In conformance with DOE Order 420.1A (DOE 2002) and the LLNL *ES&H Manual*, the fire safety program at the B695 Segment includes provisions for:

- Minimizing the potential for occurrence of a fire or related event in B695 Segment facilities.
- Ensuring that fire does not cause an unacceptable onsite or offsite release of hazardous or radioactive material that will threaten the health and safety of employees, the public, or the environment.
- Providing an acceptable degree of life safety to LLNL and contractor personnel and the public from fire in B695 Segment facilities.
- Ensuring that B695 Segment operations will not suffer unacceptable delays as a result of fire and related hazards.
- Ensuring that property damage to B695 Segment facilities from fire and related events does not exceed defined limits in *ES&H Manual* Document 22.5, “Fire.”

Response to fire, medical, and hazardous materials incidents on LLNL property is provided by the Alameda County Fire Department under contract to LLNL. The Alameda County Fire Department staffs LLNL fire Stations with cleared, trained fire fighters and fire fighter/paramedics. Memoranda of Understanding (MOUs) and mutual-aid agreements exist among specific functional LLNL organizations and departments and also with external agencies and organizations. The Safeguards and Security Organization develops and signs security and law enforcement-related MOUs for LLNL. The EMD develops and signs MOUs related to fire, emergency medical services, and HAZMAT issues. The Hazard Control Department and the Health Services Department develop and sign MOUs associated with local medical facilities.

In addition, a communications system is maintained specifically for emergency control purposes. Fire alarms at the B695 Segment annunciate at the LLNL Fire Dispatch Center (B313), where personnel, in turn, transmit alarms over emergency evacuation alarms within the affected building.

The LLNL fire protection program is implemented through three organizations: Emergency Management Department, Maintenance Utilities Services Division (MUSD), and ES&H Teams. Emergency Management Department—through the onsite Alameda County Fire Department—is responsible for initial response to and investigation of all life-threatening and property-loss emergencies on or adjacent to LLNL property. The Emergency Management Department inspects and tests selected fire protection equipment. The Emergency Management Department also provides fire protection engineering support to ES&H Team members. The Emergency Management Department Fire Marshal manages Fire Protection Engineering Services to the ES&H Teams and is the Fire Protection Subject Matter Expert. ES&H Teams 1 and 2 provide environment, safety, and health support to the various LLNL programs. Each ES&H team has at least one assigned, qualified fire protection engineer who provides fire protection engineering support. Plans for new or revised fire protection systems and features must be reviewed and approved by the Fire Protection Engineer prior to start of work. Fire extinguishing system acceptance tests and inspections must be witnessed by the Fire Protection Engineer prior to occupancy.

MUSD and the Emergency Management Department have the primary responsibility for testing and maintaining LLNL's fire protection and detection systems and utilities. They also have primary responsibility for portable fire extinguisher testing and maintenance.

The RHWM Self-Help Plan (LLNL-c latest revision) and B695 Segment FSPs outline the emergency program and actions to be taken by RHWM personnel responding to fires and other potential accidents at the B695 Segment facility.

11.4.3 Combustible-Loading Control

Combustible loading in B695 Segment facilities is controlled as a function of the LLNL fire protection program. RHWM implements measures to minimize and control the use of combustible materials at the B695 Segment and to prevent the accumulation of unnecessary combustibles. Implementation of these measures includes, but is not limited to, the following activities:

- Housekeeping is inspected at least monthly by a trained staff member to ensure that equipment, materials, and stored wastes are orderly.

- Combustible materials are limited to an average of 7 pounds of equivalent ordinary combustibles per square foot in fire areas storing TRU waste and in B696S Room 1009, excluding containerized waste in metal containers.
- Noncombustible or fire-retardant materials are used whenever practical.
- TRU waste is stored on non-combustible pallets.
- Combustible waste is collected in covered metal containers.
- Significant storage of flammable or combustible liquids shall be avoided in B696S.
- Grass and brush are clear-cut and removed from the vicinity of buildings and waste storage areas.
- A 20-ft exclusion zone is maintained between nuclear segments, except between B696S and B696R, which are separated by a fire-resistive partition. In addition, the exclusion zone is expanded between adjacent roll-up doors in B696 near the segment boundary. This prevents fire from impacting both segments through adjacent roll-up doors.

11.4.4 Fire Fighting Capabilities

A detailed discussion of fire fighting capabilities at LLNL is provided in the LLNL *Emergency Plan* (LLNL-d latest revision). The onsite Alameda County Fire Department response schedule to emergencies is described in Emergency Management policy number 100, *Response Schedule*. The onsite Alameda County Fire Department response drive time for the main Livermore site is expected to be within four minutes 90% of the time to any facility. Normal response to an automatic alarm is one engine with a crew of four. Additional fire fighting support is available through mutual aid from outside fire agencies.

A detailed description of available fire fighting equipment, fire response procedures, basic training, personnel qualifications for firefighters, and special precautions taken for fire fighting in radiological and hazardous chemical environments is also provided in the LLNL *Fire Protection Program* (LLNL-e latest revision).

The Contingency Plan developed for the B695 Segment (LLNL-f latest revision) provides an overview of the fire protection available at B695 Segment facilities to detect fires, alert personnel to fire emergencies, suppress fire, and minimize fire spread. Portable fire extinguishers and fire hydrants are available at all B695 Segment facilities.

Automatic Fire-Suppression Systems

All significant B695 Segment facilities except contractor owned units, are fully protected by automatic fire sprinkler systems designed and installed in accordance with requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, or other automatic fixed fire extinguishing systems, and in conformance with the B695 Segment fire safety program discussed above. Sprinkler water flows are monitored to automatically initiate a fire alarm at the Emergency Dispatch Center (B313). **Table 11-2** summarizes information about the sprinkler systems in the B695 Segment .

Table 11-2. B695 Segment automatic sprinkler protection

Facility	Auto sprinkler protection	Wet/ dry	Hazard class	Design (gpm @ sq ft)	Temperature rating	Orifice size (in.)
B695						
Zone 1	Yes	Wet	EH1	0.30 @ 2500	Intermediate	$^{17}/_{32}$
Zone 2	Yes	Wet	OH	pipe schedule	Intermediate	1/2
Zone 3	Yes	Wet	OH	pipe schedule	Intermediate	1/2
Zone 4	Yes	Wet	EH1	0.30 @ 2500	Intermediate	$^{17}/_{32}$
Zone 5	Yes	Wet	EH1	0.30 @ 2500	Intermediate	1/2
Zone 6	Yes	Wet	EH1	0.30 @ 2500	Intermediate	1/2
Zone 7	Yes	Wet	EH1	0.30 @ 2500	Intermediate	1/2
B696						
Zone 1	Yes	Wet	OH2	0.20 @ 1600	Intermediate	1/2
Zone 4	Yes	Dry	OH2	0.20 @ 2080	Intermediate	1/2

Most B695 Segment facilities are designed to retain fire water discharged from automatic sprinkler systems. NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, requires the retention of fire water for a duration of 30 minutes. However, the code of record, Uniform Fire Code (UFC) only requires 20 minutes, and the State of California Code of Regulations (CCR) requires compliance with the UFC. If all sprinklers within the discharge design area should activate at once, for a single fire incident, the fire water retention time for B695 is 29.5 minutes, and for B696S is 32 minutes. This satisfies the intent of both NFPA 801 and the Uniform Fire Code.

Some areas of the B695 Segment drain into an underground, fiberglass-reinforced plastic tank. The tank is nominally 20,000 gal and is maintained by removing water from the tank each time fire sprinkler water is discharged and collected in the tank. Overflow on secondary containments provides connection to the underground tank, and liquid in sufficient quantity overflows and gravity-feeds into the tank.

The B695 FHA contains the location of each fire zone for the facility.

Most fires are expected to activate only a few fire sprinklers, and the onsite Alameda County Fire Department can be expected to respond within four minutes 90% of the time, and to shut down the sprinklers after they confirm the fire is extinguished.

A general LLNL requirement mandates that contaminated liquid runoff from fire fighting operations should be prevented from leaving the site. Alameda County Fire Department firefighters are aware of the requirement, and, when possible, they prevent fire fighting water from entering storm drains. The Laboratory’s sewer diversion facility (B193) is designed to prevent hazardous materials from being carried offsite from the Laboratory's sewer system, including fire fighting water entering the waste stream from a building's sewer system or floor drains.

Fire Detection and Alarms

B695 Segment facilities are protected by fire alarm systems. The building fire alarm control unit (FACU) is activated whenever water discharges from a fused sprinkler or a manual fire alarm pull station (located at most egress doors), or when a fire detector (in selected locations) is activated. The FACU transmits the alarm to the Emergency Dispatch Center (B313), automatically summoning the onsite Alameda County Fire Department. The panel does not automatically initiate audible and visual building evacuation signals. The emergency dispatcher must manually initiate building evacuation signals.

Fire Extinguishers

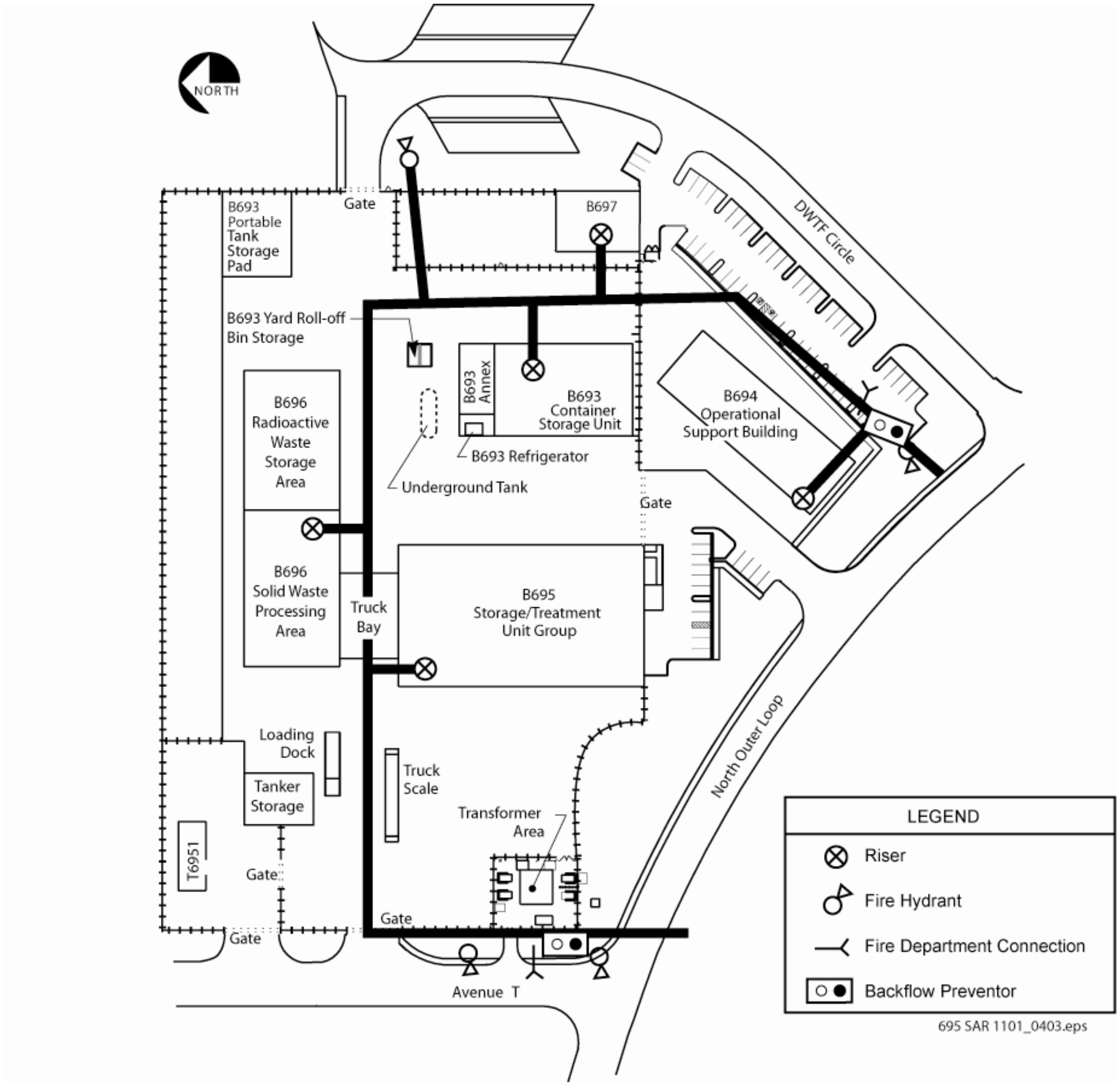
Appropriate types and sizes of fire extinguishers (e.g., fire extinguishers for water-reactive materials stored in B695 reactive materials cells) are placed throughout B695 Segment facilities and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. Additional fire extinguishers are located where specific fire hazards are present.

Water Supply and Fire Hydrants

Water is supplied to the main Livermore site from three, elevated, 500,000-gallon (each), steel tanks located on the Sandia National Laboratories Livermore site, approximately one mile south of the Laboratory. Fire protection and domestic water is supplied to the grid system at LLNL through one 14-in and one 16-in water main connected into a 14-in water main on the south side of the LLNL grid. The LLNL grid consists of mains of varying size, and the minimum main size is 8 in. In addition to primary supply reservoirs, secondary connections are provided to local municipal water mains on both the west and north sides of the Laboratory. An additional connection to the 27-in, Zone *7* water main on the Laboratory's north side is pumped into the Laboratory's water distribution system through approved fire pumps, as needed. With all available water supplies considered, the total available water flow (to depletion) at LLNL is 8,900 gpm for 5 hours, and 7,476 gpm for 7 hours. The water supply is adequate for the sprinkler system and fire department hose stream demand.

An adequate number of fire hydrants are located in the vicinity of all B695 Segment facilities. Hydrant numbers 694, 695, 696, and 697 surround the B695 Segment facilities. **Figure 11-1** shows the approximate location of the B695 Segment fire water main distribution system.

Figure 11-1. DWTF fire protection water main distribution system



Hydrant flow tests are conducted by the onsite Alameda County Fire Department. Records of the tests and water flow information are available at the Emergency Management Department office. The flow capabilities of the hydrants protecting B695 Segment facilities are adequate to fight expected fires as detailed in the individual building Fire Hazard Analyses. Outage of fire protection water for non-routine maintenance complies with NFPA 25.

Other Fire Controls

The inert atmosphere and combination hazards glove boxes located in B695 are equipped with an inert gas system that is used to create an atmosphere in the glove boxes that prevents ignition of combustible materials from the potentially reactive materials processed in the glove boxes. Small quantities of water-reactive materials may be stored in Building 695 reactive materials storages cells. These materials include wastes, such as alkali and earth alkali metals and metal salts. The materials are stored in quantities on the order of 50 pounds or less. Materials are stored in sealed containers to reduce the chance of fire sprinkler water reacting with material. In addition, fire extinguishing media specific to water-reactive materials can be available in nearby storage areas.

NFPA 704, Standard System for the Identification of the Hazards of Materials for Emergency Response, diamond-shaped placards are provided throughout B695 Segment facilities. The placards indicate the maximum hazard in each category (health, fire, reactivity, and special warnings) associated with the types of material in the facility and indicate the worst-case condition that an emergency responder can expect to encounter at the facility.

A variety of heavy equipment is available from Plant Engineering to assist in a fire emergency. The equipment includes compressors, cranes, cutting torches, forklifts, manlifts, generators, pumps, scrapers, and bulldozers. All emergency equipment is maintained regularly to ensure that it is operational at all times. Preventative maintenance checks are performed by the automotive fleet maintenance crew according to the recommended factory schedule.

Fire Response

The RHWM Self-Help Plan and B695 Segment FSPs identify personnel responsibilities, emergency equipment, and required actions necessary to mitigate fires within B695 Segment facilities. These plans also specifically define the types of emergencies that must be mitigated by the onsite Alameda County Fire Department and those that may be remedied by RHWM personnel. The types of emergencies and responses are outlined in Chapter 15, “Emergency Preparedness Plan” Of this DSA. B695 Segment personnel may respond to a small incident without notifying the LLNL Fire Department.

Basic Training and Personnel Qualifications

B695 Segment personnel are trained to respond to potential emergencies, such as fires. The training is outlined in B695 Segment facilities FSPs and in *ES&H Manual* Document 40.1, “LLNL Training Program Manual.” Training information may be found in “Statement of Work Between LLNL and Alameda County Fire Department, Section 6.

DOE Order 5480.19 requires that training procedures be developed for operating systems and equipment during normal, abnormal, and emergency conditions. Such procedures developed for B695 Segment facilities are in accordance with RHWM SOPs.

The training requirements of 29 CFR 1910.120 for emergency responders, including the onsite Alameda County Fire Department, to a fire or explosion at B695 Segment facilities are implemented through *ES&H Manual* Document 40.1, “LLNL Training Program Manual.”

Special Precautions

Special precautions are needed for fighting fires in radiological and hazardous chemical environments. Protection of firefighters at LLNL in radiological environments is outlined in *ES&H Manual* Document 22.6, “Exposure to Radiation in an Emergency.” Special precautions are also described in documents and procedures provided in Policy 1130, “Minimum Professional Standards for Fire Fighters, Fire Officers, and Chief Officers,” of the onsite Alameda County Fire Department Policies and Procedures Manual.

11.4.5 Fire-Fighting-Readiness Assurance

The onsite Fire Protection Department conducts periodic fire protection inspections of LLNL, including the B695 Segment. In addition, the RHWM Division has a combustible-loading program that includes inspections of B695 Segment facilities to keep it free from unnecessary combustibles.

RHWM personnel participate in LLNL site-wide Self Help drills annually. LLNL conducts a coordinated program of these drills and exercises to provide emergency-response training and to establish a method for evaluating the response capability and readiness. Drills are designed to develop and maintain personnel emergency-response skills. They are conducted separately by each emergency response organization (ERO) and reflect the organization’s specific training needs, which have been discovered during prior drills.

The Emergency Management Exercise Program is an annual, full-participation exercise based on rotating scenarios, such as a natural disaster, a security incident, or hazardous material incidents. The scenarios are designed to test the operational capability of individual organizations. The drills are evaluated for each exercise, and lessons learned are incorporated into subsequent exercises. Drills and exercises are discussed in *LLNL Emergency Plan* (LLNL-d latest version).

Classification and notification of accidents at the B695 Segment are outlined in Chapters IV and V, respectively, of the *LLNL Emergency Plan*, Volume 1. Internal reporting at the B695 Segment will require employees to notify the Waste Treatment Group Leader, or designee, of all release incidents (large or small), and the Fire Department of all large incident releases (exceeding Level 1), fires, or other emergencies. The Waste Treatment Group Leader, or designee, gathers preliminary information and then must immediately notify the facility manager and the Hazard Control ES&H Team. Records of fire protection system testing, inspection, and maintenance shall be prepared and retained in accordance with the requirements of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

11.5 Traffic Control Program

A traffic control program is established, implemented, and maintained to provide protection from vehicular traffic for TRU waste in the yard. The traffic control program is intended to limit the speed of vehicles while in the yard and includes speed limits posted in the yard and the requirement that vehicles stop at the yard gate before entering. This program is implemented through the FSPs.

11.6 References

DOE (2001), *Conduct of Operations Requirements for DOE Facilities*, DOE Order 5480.19, Change 2, U.S. Department of Energy, Washington D.C., October 23, 2001.

DOE (2002), *Facility Safety*, DOE Order 420.1A, U.S. Department of Energy, Washington D.C., May 2002.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-b (latest revision), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Waste Management Division, Livermore, CA (UCRL-AR-116655).

LLNL-c (latest revision), *Self-Help Plan Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL-d (latest revision) *LLNL Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-113311).

LLNL-e (2001b), *LLNL Fire Protection Program*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-116646).

LLNL-f (latest revision), *Contingency Plan for Radioactive and Hazardous Waste Management Facilities: Area 612, Area 514, Building 233 CSU, and the Decontamination and Waste Treatment Facility*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-TR-127066-04).

LLNL (2007), Fire Hazard Analysis, Building 696, Lawrence Livermore National Laboratory, Livermore, CA, February 22, 2007.

LLNL (2008), *Fire Hazards Analysis Building 695*, Lawrence Livermore National Laboratory, Livermore, CA, April 2008.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 12
PROCEDURES AND TRAINING

12.1 Introduction

This chapter addresses the processes by which the content of procedures and the training program are developed, verified, and validated at the B695 Segment.

12.2 Requirements

Key requirements include applicable requirements that are derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other necessary requirements.

DOE Order 5480.19, Change 2 (DOE 2001b), requires that procedures be developed to provide specific direction for the operation of systems and equipment during normal, abnormal, and emergency conditions. The order includes technical-content development, verification, and validation requirements for procedures. The requirements of this order are implemented at the B695 Segment through the use of *ES&H Manual* Document 3.5, "Conduct of Operations for LLNL Facilities." This document requires that facility safety plans (FSPs) and, if necessary, integration work sheets with safety plans (IWS/SPs) and standard operating procedures (SOPs) be developed for activities that do not conform to existing codes, standards, and guidelines in the *ES&H Manual*.

DOE Order 5480.20A Change 1 (DOE 2001a), requires that nuclear facilities develop and maintain a training program that provides the process and policies so that personnel receive both on-the-job training (OJT) and classroom training to ensure they are familiar with all aspects of their positions. Training programs in nuclear facilities at LLNL are implemented through *ES&H Manual* Document 50.1, "Personnel Selection, Qualification, and Training Requirements for Nuclear Facilities." The training requirements of 29 CFR 1910.120, paragraph P and 22 CCR 66264.16 related to hazardous waste operations are implemented through the RCRA Part B permit. 40 CFR 264 requires training of the personnel who operate the hazardous waste facility.

12.3 Procedure Program

The Radioactive and Hazardous Waste Management (RHWM) Division implements its programs and controls through procedures. Procedures are developed by RHWM to ensure that waste is managed in a manner that will protect human health and the environment and that the procedures will comply with all applicable regulatory requirements.

ES&H Manual Document 3.3, "Facility Safety Plans and Integration Work Sheets with Safety Plans," governs the development of FSPs and IWS/SPs. Each FSP provides general facility safety policies and rules, identifies hazards and environmental concerns, and specifies the ES&H controls for long-term experiments, operations, and work performed in the facilities.

RHWM has a procedure that governs the development of RHWM administrative procedures (ADMs) and SOPs. This procedure meets the requirements of *ES&H Manual* Document 3.4, "Preparation and Use of

Work Procedures," and Document 3.5, "Conduct of Operations for LLNL Facilities," and the *Hazardous Waste Management Division Quality Assurance Plan* (QAP) (LLNL-a latest revision).

12.3.1 Development of Procedures

Risk is the fundamental consideration in determining that procedures be developed for activities. Supervisors are responsible for making this determination and for directing the development of a procedure to ensure correct performance of an activity and to address safety concerns.

A technical subject-matter expert (or experts) is assigned to work with the technical writer/safety professional to provide input to the procedure. Procedures are written according to a standard format to ensure uniformity across the division.

The FSPs specify the responsibilities, hazards, policies, and controls for operations within the facility. IWS/SPs contain the basic controls needed for safe operation beyond those contained in the *ES&H Manual* and applicable FSPs, and IWS/SPs are used to document new and short-lived activities. The RHWM procedures cover specific administrative and technical activities at a more detailed level. These documents contain safety advice for a given activity, preoperational requirements, the assignment of responsibilities, instructional steps on how to perform the activity in a safe manner, specific record-keeping requirements, and other miscellaneous information associated with the operation. Chapter 10 provides more information on maintenance and surveillance testing.

All procedures are formally reviewed, verified, and validated. Draft procedures are submitted for formal review to management, various subject-matter experts, and ES&H safety professionals. All comments are resolved, and the documents are submitted for final signature review.

12.3.2 Maintenance of Procedures

Supervisors are responsible for ensuring that their staff is familiar with the latest FSPs and procedures pertinent to their operation. This responsibility is implemented through the RHWM reading program, OJT, classroom training, and general supervisory oversight. The RHWM FSPs procedures are available on RHWM's controlled document server.

The FSPs and IWS/SPs are controlled as outlined in *ES&H Manual* Document 3.3, "Facility Safety Plans and Integration Work Sheets with Safety Plans." RHWM's ADMs and SOPs procedures are controlled in accordance with a RHWM document control procedure and are distributed by being posted on the controlled document server. Authorized versions of the RHWM's procedures are available only from the controlled document server or the RHWM Document Control Offices files.

Finalized procedures undergo periodic review to ensure that their contents still reflect current operations and comply with any ES&H regulations that may have been issued since the last review. FSPs are reviewed and updated triennially. If no changes are required, a memo to that effect is prepared and signed by the responsible individual. The memo is controlled and disseminated according to *ES&H Manual* Document 3.3, "Facility Safety Plans and Integration Work Sheets with Safety Plans." ADMs are reviewed and updated triennially, and SOPs are reviewed and updated annually or triennially depending on the scope. If changes occur to an operation prior to the standard review time, it is the responsibility of the area supervisor to initiate the update of the procedure. The update may take place in the form of an addendum to the original FSP, as an "immediate change implementation" to a procedure, or it may involve update and re-issuance of the actual document. Review, approval, and distribution requirements for issuing addenda and supplements are the same as those for the original procedure. During the next regular revision, addenda or supplements are incorporated, as necessary, into the original safety procedure.

12.4 Training Program

RHWM follows requirements in DOE Order 5480.20A Change 1 (DOE 2001a), which specifies selection, qualification, and training requirements for personnel involved in the operation, maintenance, and technical support of DOE nuclear facilities. The training requirements of 29 CFR 1910.120, paragraph P, are implemented at B695 through *ES&H Manual* Document 50.1, “Personnel Selection, Qualification, and Training Requirements for Nuclear Facilities.” The training of personnel in hazardous waste management procedures is also required by 22 CCR 66264.16 and is implemented through *ES&H Manual* Document 36.1, “Hazardous, Radioactive, and Biological Waste Management Requirements.”

The purpose of the RHWM training program is to provide appropriate instructional support that will enable B695 Segment workers to develop and maintain competencies for successfully executing work assignments. *ES&H Manual* Document 50.1, “Personnel Selection, Qualification, and Training Requirements for Nuclear Facilities” and Document 40.1, “LLNL Training Program Manual,” provides guidance for developing and managing training programs. Guidance includes the following:

- Determining job categories, specific qualification requirements, and training requirements and responsibilities.
- Documenting training information.
- Qualifying course materials and instructors.
- Evaluating the training program.

The RHWM training program provides RHWM personnel with:

- Basic knowledge of regulatory requirements, hazards, and facility emergency response activities.
- Waste handling activities, including transportation of materials, tie-down methods, sampling activities, and general container handling.
- Instruction on specific duties and responsibilities relative to an individual’s hazardous, radioactive, or mixed waste activities.
- Waste management unit-specific instruction for hazardous waste treatment, storage, and offsite shipment for those RHWM personnel who perform hands-on hazardous waste management facility operations.

RHWM personnel receive both broad and specific training in hazardous and mixed waste regulations relative to their job duties and responsibilities, including emergency response activities, to reduce the risk from accidents. Training is provided by several different methods depending on the type of information and skills required for performing the task. The first type is classroom instruction, provided by an instructor in a lecture and discussion format. The second type is training and evaluation implemented through On-the Job Training (OJT) for specific operations. A third type is self paced reading and review of safety and procedural documents. A fourth type is E-learning which is delivered through computers and other multi-media technologies. In some cases a combination of these methods will be used to convey the information and then provide the trainee practical experience in performing the activity.

The goal of the LLNL training program is to ensure that all employees have the skills and knowledge to carry out their work assignments safely and effectively. The objectives of the LLNL training program are to determine and document training requirements, to document and make available appropriate training-related information, to ensure that the program is structured to permit adequate review and analysis of its effectiveness, and to maintain documentation that provides guidance for implementing the program.

The format and content requirements for training program development, verification, and validation are provided in DOE Order 5480.20A. The requirements are implemented for B695 Segment facilities through the following *ES&H Manual* Documents:

- 40.1, "LLNL Training Program Manual."
- 40.2, "Environmental, Safety & Health Training and Education."
- 50.1, "Personnel Selection, Qualification, Training, and Staffing at LLNL Nuclear Facilities."

Training consists of OJT and classroom training, as necessary. Training program content requirements for specific facilities generally are identified in the FSPs.

12.4.1 Development of Training

The RHWM Division's *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL-b latest revision); *ES&H Manual* Document 40.2, "Environmental, Safety & Health Training and Education," and *ES&H Manual* Document 40.1, "LLNL Training Program Manual," require that training content be such that employees can perform their responsibilities and apply their skills and knowledge to provide maximum protection for themselves, fellow employees, LLNL facilities, the public, and the environment. Detailed information on the technical content development of training program requirements is contained in Appendix A of *ES&H Manual* Document 40.1, "LLNL Training Program Manual." In general, training program content requirements are identified in the FSPs for the facilities. The training program representative meets with RHWM management and subject-matter experts for input to course lesson plans. The draft course material is reviewed by management and subject-matter experts for accuracy before being finalized.

The RHWM Training Team maintains Training Plans for each RHWM job assignment. The training plans are maintained online to allow for easy access to the most up-to-date version.

12.4.2 Maintenance of Training

To keep RHWM training materials current, the RHWM training program representative reviews all RHWM procedures and changes to procedures and has access to the RHWM server that contains the latest procedures. The training representative meets periodically with the B695 Segment area supervisors to stay current on their operations and to determine any new training needs, or changes to existing courses, within their areas of responsibility. The training representative holds a monthly training meeting with RHWM management personnel. This enables the training program representative to stay current on changes occurring within RHWM facilities so training materials can be updated or new training materials developed, as needed.

Training records for RHWM facility workers are maintained on a computer database. The LLNL database is used by LLNL personnel, managers and training organizations throughout the Laboratory as a tool to monitor training and as the repository for course-completion information. The database is regularly updated as training is completed. Original records are maintained by the training organization.

Presently, licenses are issued to forklift drivers and crane operators.

12.4.3 Modification of Training Materials

Procedures for identifying and correcting training program deficiencies are contained in Section 7.2 of *ES&H Manual* Document 40.1, "LLNL Training Program Manual." Students are also asked to submit comments on their training via course evaluation forms. Supervisors and subject matter experts are asked to alert the training program representatives whenever operations or regulatory requirements change. Course material is periodically reviewed to determine if changes are necessary. Course lesson plans and materials are then updated accordingly.

12.5 References

DOE (2001a), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, DOE Order 5480.20A Change 1, Department of Energy, Washington, DC, July 12, 2001.

DOE (2001b), *Conduct of Operations Requirements for DOE Facilities*, DOE Order 5480.19, Change 2, U.S. Department of Energy, Washington D.C., October 23, 2001.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-a (latest revision), *Radioactive and Hazardous Waste Management Division Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA (M-078-92).

LLNL-b (latest revision), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-116655).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 13
HUMAN FACTORS

13.1 Introduction

This chapter discusses the human factors engineering that helped shape the design of the DWTF. Per DOE-STD-3009-94, Change Notice No. 3 (DOE 2006), the discussion of human factors is limited to human factors engineering. Human factors engineering focuses on designing facilities, systems, equipment, and tools so they are sensitive to the capabilities, limitations, and needs of humans. Human factors engineering supports, and is supported by, the hazard analyses described in Chapter 3.

13.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

Codes

Uniform Building Code (ICBO 1994)

Emergency Eyewash and Shower Equipment (ANSI 1990)

LLNL Manuals

Design Safety Standards (LLNL-b latest revision)

13.3 Human Factors Process

The human factors process considers the involvement of humans in potential operational accidents at the facility and identifies the important human–machine interfaces for safety SSCs. Involvement may be with respect to prevention (e.g., inspection, analytic, and surveillance activities, or container handling or moving) and mitigation (e.g., shutdown of operations during off-normal or emergency situations) activities.

13.4 Identification of Human–Machine Interfaces

Three safety-significant SSCs were identified as a function of the process hazard analysis: the PC-2 structural systems of B695 and B696S, B696S/B696R partition, and approved TRU waste containers. The Process Hazard Analysis (PrHA), found in Appendix A, describes the accidents that are likely to involve workers.

By focusing on worker aspects of the hazard analysis, the most important human–machine interfaces with the safety SSCs can be identified. The following human factors related controls are identified in the PrHA as defense-in-depth:

Training

- The human–machine interface is operators driving vehicles to transport waste and operate cranes, and workers operating the various waste processing units.

- The human–machine interface is operation of the forklift used in stacking.

Maintenance, testing, and inspection (MT&I)

- The human–machine interface is the maintenance and operation of test equipment to assure the integrity of the waste container safety-significant SSCs.
- The human–machine interface is the maintenance and inspection of equipment used to transport or process waste.

13.5 Optimization of Human–Machine Interfaces

The B695 Segment was designed in accordance with regulations listed in Section 13.2, including "General Design Criteria for DOE Facilities," of DOE Order 6430.1A. This order dictates human factors elements in the facility, including allowances for spacing of TRU waste containers.

Adequate lighting is supplied to ensure that operators can see when they are operating equipment (e.g., cranes) and vehicles. The facility is also equipped with emergency lighting to guide a worker to safety.

All work in the B695 Segment will be performed by personnel trained for that task or supervised by trained personnel. As part of their training, personnel will be cognizant of major pieces of equipment. A more detailed discussion of worker training is presented in Chapter 12.

Operating personnel will wear protective equipment as required. When required, respirators and other specific personnel protection devices will be used. The facility is designed with eyewashes and showers available to workers in accordance with applicable codes. The eyewash is composed of two soft-spray outlet heads equipped with float-off dust covers to keep out contaminants. The shower is a high-visibility, ABS, plastic showerhead with an IPS stay-open ball valve.

Radioactive and Hazardous Waste Management (RHWM) Division personnel use standard operating procedures (SOPs) in their daily work. These procedures list the appropriate personnel protective equipment required for each operation. In addition, LLNL's Hazard Control Department assigns safety professionals to support RHWM operations. Personnel include industrial hygienists and industrial safety and health physicists. These professionals prepare hazard assessment forms for each operation. The hazard assessments specify the safety equipment that must be in place and/or worn by RHWM personnel when performing an operation. The RHWM Division maintains these forms on file.

Vehicles used in the B695 Segment will be purchased from forklift manufacturers and are designed with consideration given to human safety, comfort, and operational ease. Forklift operators will be trained in the use of such equipment and will generally be experienced in transporting waste containers at LLNL. Operators will be licensed within the LLNL training system to operate forklifts.

The B696S glove box has been evaluated for ergonomics through the use of a mock-up model box used to determine personnel comfort and to minimize distractions. In addition, the glove box was manufactured by personnel who are experienced in the design of radiation protection devices, and who have built glove boxes for other DOE sites.

At a minimum, two persons are required for movement of waste if self-rescue cannot be performed, or when waste treatment processes are being conducted. Only one person is required for inspections and maintenance. However, no person shall perform an operation that might render them incapable of self-rescue without being in contact with another person.

13.6 References

ANSI (1990), Emergency Eyewash and Shower Equipment, American National Standard Institute, New York, NY (ANSI-Z-358.1-1990).

DOE (1994), *General Design Criteria,* DOE Order 6430.1A, U.S. Department of Energy, Washington, DC.

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, DC (DOE-STD-3009-94 Change Notice No. 3).

ICBO (1994), *Uniform Building Code*, International Conference of Building Officials (Western Fire Chiefs Association), Whittier, CA (1994 edition).

LLNL-b (latest revision), *Design Safety Standards*, Lawrence Livermore National Laboratory, Livermore, CA.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 14
QUALITY ASSURANCE

14.1 Introduction

This chapter outlines the Quality Assurance (QA) Program and Organization, which integrates quality management with the appropriate requirements of environmental regulations and guidance documents. This chapter provides information regarding the management and assurance of quality in those activities that are applicable to the Radioactive and Hazardous Waste Management (RHWM) Division, specifically to the B695 Segment .

14.2 Requirements

The primary QA directive is 10 CFR 830, Subpart A, Quality Assurance Requirements. This key requirement is included in the NNSA/LLNS Contract (NNSA/LLNS 2007).

14.3 Quality Assurance Program and Organization

LLNL endorses the application of quality management and recognizes the role of a coordinated quality assurance management program. The B695 Segment is a nonreactor nuclear facility that comes under the jurisdiction of the *LLNL Quality Assurance Plan* (LLNL-b latest revision) and 10 CFR 830, Subpart A. RHWM addresses all requirements of 10 CFR 830, Subpart A, in the *Radioactive and Hazardous Waste Management Division Quality Assurance Plan* (RHWM QAP) (LLNL-c latest revision).

The purpose of the RHWM QAP is to ensure that RHWM management provides planning, organization, direction, control, and support to achieve the organization's objectives; that the line organizations achieve quality; and that overall performance is reviewed and evaluated using a thorough assessment process.

The RHWM QAP serves as the primary QA reference for personnel assigned to, or assisting in, performing work activities within the B695 Segment. This QAP also serves as the basis for audits and reviews; identifies formal controls and documentation requirements; and provides a means of feedback to verify the effectiveness of controls and achievement of quality goals. The QAP is implemented through procedures, instructions, and procurement documents established by the RHWM Division. Operations and maintenance in the B695 Segment will be subject to the LLNL RHWM QAP.

The RHWM QAP defines QA requirements for activities in the B695 Segment, including interfaces with the "TRU Waste Certification and QA Plan" and the "Low-Level Waste Program Certification and QA Plan." The Packaging and Transportation Safety (PATS) Quality Assurance Plan interface requirements are also defined in the RHWM QAP.

The structure of RHWM and the relation of the line organization to the QA group is outlined in the RHWM QAP. The RHWM QA Manager is responsible for direction of the RHWM QA program and for developing, maintaining, and verifying the RHWM QA program that includes the B695 Segment. RHWM line management is responsible for ensuring that appropriate procedures and controls are developed and implemented for assigned tasks, that applicable standards have been identified, and that compliance with the standards is verified. All vendors, contractors, subcontractors, or other LLNL organizations must comply with applicable LLNL/RHWM QA program element requirements. Additional organizational summary material is provided in Chapter 17, *Management, Organization, and Institutional Safety Provisions.*

14.4 Quality Improvement

The RHWM QAP describes control of nonconformances through the nonconformance and corrective action process. The process includes initiation of a nonconformance and corrective action report (NCAR). Implementing procedures, developed at the division level, further define the process for reporting on tracking, issuing, dispositioning, evaluating, and closing nonconformance reports. The LLNL Lessons Learned program also provides information to improve the quality and safety of operations and facilities.

14.5 Documents and Records

Documents that specify QA requirements or prescribe quality-affecting activities are prepared, reviewed, and released for issuance and distribution in accordance with written procedures. Document control and records management requirements are identified in the RHWM QAP.

14.6 Quality Assurance Performance

14.6.1 Work Processes

Work processes are performed to established technical standards and administrative controls. Work is performed under controlled conditions using approved instructions, procedures, or other appropriate means.

14.6.2 Design

The B695 Segment was designed and constructed under the DWTF QAPP (LLNL 1996). Operations and modifications to the B695 Segment will be undertaken within the RHWM QAP requirements that include requirements for controlling design inputs, outputs, verification, technical review, alternate calculations and analyses, peer reviews, design-change control, interface control, and QA records.

14.6.3 Procurement

The requestor and RHWM Cost Account Manager are responsible for ensuring that procurement documents include appropriate technical, regulatory, LLNL Supply Chain Management, and QA requirements. The RHWM QA Manager reviews quality-affecting procurement documents. These requirements are met through both internal RHWM procurement procedures and LLNL procurement department procedures. RHWM procedures ensure that procurement documents and their changes are reviewed and approved. Procurement activities are planned and documented.

Selection of vendors is based on an evaluation of the capability to provide items, services, and other products in accordance with requirements of the procurement documents. Qualified vendor performance is verified periodically through inspection, surveillance, audit, or test.

Containers that are used for packaging hazardous material or hazardous waste, including TRU waste containers that meet the free drop test performance criteria for Type A packaging (49 CFR 173.465(c)(1)), are procured through PATS in accordance with the PATS Quality Assurance Plan.

14.6.4 Inspecting and Testing for Acceptance

When it is necessary to ensure that required inspections and tests are performed, the status of inspection and test is identified either on the items or in documents traceable to the items. This approach ensures that items that have not passed the required inspections and tests are not inadvertently installed, used, or operated. All inspections and acceptance tests for construction of the B695 Segment were subject to the DWTF QAPP. After facility acceptance, inspections will be performed subject to the RHWM QAP.

14.6.5 Independent Assessment

Audits, completed by LLNL staff, are the primary method for independent assessment and focus on improving items and processes. The emphasis is on achieving quality by department-line organizations. Audits and surveillance are performed in accordance with written procedures or checklists. Activities are evaluated against specific criteria and objectives. Quality verification reports, where appropriate, detail corrective actions, identification of root causes, actions to prevent recurrence, lessons learned, and actions to be taken for improvement.

14.7 References

10 CFR 830 ,Subpart A, “Quality Assurance Requirements,” Nuclear Safety Management, U.S. Department of Energy, Code of Federal Regulations, Title 10, Office of the Federal Register, Washington, DC (10 CFR 830 Subpart A).

LLNL-b (latest revision), LLNL Quality Assurance Program, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-c (latest revision), Hazardous Waste Management Division Quality Assurance Plan, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL (1996), Decontamination and Waste Treatment Facility (DWTF) Quality Assurance Project Plan (QAPP), Lawrence Livermore National Laboratory, Livermore, CA (May 1996, Rev. 0).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

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CHAPTER 15
EMERGENCY PREPAREDNESS PROGRAM

15.1 Introduction

This chapter provides an overview of the emergency preparedness program for Radioactive and Hazardous Waste Management (RHWM) Division personnel at the B695 Segment .

15.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

DOE

DOE Order 151.1 C, "Comprehensive Emergency Management System."

DOE Order 231.1A, "Environment, Safety, And Health Reporting."

15.3 Scope of Emergency Preparedness

ES&H Manual Document 22.1, "Emergency Preparedness and Response," describes the emergency management system and provides emergency planning procedures for operational emergencies. The *LLNL Emergency Plan* (LLNL-a latest revision) provides additional information.

As a research facility, LLNL employs many energy sources, ranging from chemicals and explosives to radiation and microwaves, high-powered lasers, and high-voltage electricity, which have the potential to pose serious hazards. The scope and extent of emergency planning and preparedness at LLNL address these hazards as well as hazards that have the potential for larger, more serious injuries, such as fires, earthquakes, or security-related incidents. LLNL uses an emergency management system (known as the Incident Command System) for response to and mitigation of potential consequences of onsite and significant nearby emergencies that could threaten LLNL workers, the public, or the environment.

The degree of emergency planning and preparedness for a particular facility corresponds to the type and scope of hazards and consequence potential for harm. B695 is used to store and treat liquid radioactive, mixed, and hazardous waste. B695 also contains treatment equipment used with liquid-waste processing operations to treat various solid waste, such as debris. B696S primarily manages solid radioactive waste, including TRU waste, uranium waste, tritium-bearing waste, and other solid low-level waste (LLW). Emergency response for radioactive materials is covered in *ES&H Manual* Document 22.1, "Emergency Preparedness and Response," and Document 22.6, "Exposure to Radiation in an Emergency."

Facility hazards discerned in the hazard analysis include vehicle accidents (spills and fires), electrical accidents (fire), deflagration, airplane crash, high winds (spills and fires), lightning (fire), flood (contaminated runoff), and earthquakes (spills and fires). In general, emergencies at the Laboratory can be divided into three categories:

- Local emergencies that only involve a few people or a single location.
- Local emergencies with a potential to spread and become a large-scale incident.
- Large-scale or wide-spread emergencies that can affect multiple locations or facilities.

There are no accidents involving the B695 Segment that have the potential for significant offsite consequences, as discussed in Chapter 3. Emergency preparedness planning for large accidents is described in Section 15.4 and can involve offsite support organizations and hospitals. Smaller, local accidents could often be responded to by the onsite Alameda County Fire Department and support organizations.

Because the facility may experience some flooding in the 2,000-year design basis flood, leading to water 9 inches above floor, the following emergency provisions are established:

- Move waste to another part of the facility or another facility if enough notice of a flood is provided and if there is capacity.
- Sandbag the entrance to B696S and B695 if there is enough notice. However, sandbags can be breached, and it may not be possible to maintain them during a flood. If sand bags are breached, especially during a severe flood, water rushing past the bags will likely carry dirt and other solids into the facility. Sand bags may be a reasonable option if only low flooding is expected.
- Sandbag the entrance to B696S and B695 with the intent of flooding the room with clean water to reduce the amount of solids that are potentially swept into the facility. Solids create a disposal problem. This may be a reasonable option if the weather forecasts high flood conditions and there is time to react.

In any emergency, the Laboratory's onsite Alameda County Fire Department and Protective Force Division can be supported by specialists in Hazard Control, the Environmental Protection Department, RHWM, and Health Services, if necessary. Fire protection at the B695 Segment is described in Chapter 11.4.

The *Self-Help Plan* (LLNL-b latest revision) and the B695 Segment Facility Safety Plans (FSP) are designed to be used with the *LLNL Emergency Plan*. Self-help organizations are needed because a large-scale emergency, such as an earthquake, may overburden the onsite emergency response organization (ERO), and there may be significant delays to some requests for assistance because responses may have to be prioritized. Under such conditions, departments, divisions, or facilities will need to react locally to an emergency by using the self-help organizations for periods of eight hours or longer. The Self-Help Plan defines roles and responsibilities for facility personnel during emergency conditions. Responsibilities center on accounting for personnel, responding to injuries, and search-and-rescue operations, as follows:

- Ensuring that all personnel who should be in an assigned area are accounted for.
- Providing care and protection to personnel.
- Providing first aid.
- Transporting injured personnel.

- Assessing and reporting emergency situations.
- Protecting facilities.

Following events that could significantly affect the building structure, an assessment will be performed prior to bringing personnel back into the building.

15.4 Emergency Preparedness Planning

The *LLNL Emergency Plan* describes the system's organizational elements, interfaces, authorities, responsibilities, resources, and actions to be taken in response to emergencies.

15.4.1 Emergency Response Organization

The RHWM Division handles small incidents with the RHWM Waste Treatment Group Leader or alternate as

For a release to be determined a small incident, as described in the RHWM Contingency Plan (RHWM 2008), all of the following criteria must be met:

- The nature and potential hazards are known.
- The release presents no actual or potential threat to human health or the environment.
- Incident results in either no injury or injury requiring first aid only and no loss of work time due to injury. Note: For purposes of this plan, first aid is defined as care that can be provided by a nonmedically trained person to treat minor injuries using typical first-aid kit supplies such as adhesive bandages and antiseptic.

For large incidents, personnel are to evacuate the immediate area to maintain their own safety, and the onsite Alameda County Fire Department is contacted. The first or senior Fire Department officer dispatched to or present at the incident site becomes the incident commander (IC) until relieved by the Duty Chief; the Duty Chief then becomes the IC. The IC is responsible for assessing the emergency conditions, making the initial emergency level classification, initiating onsite response activities, and requesting support from offsite organizations.

The Fire Department Duty Chief is responsible for notifying the Laboratory Emergency Duty Officer (LEDO) and initiating notification of the DOE and other offsite agencies. The LEDO may direct activation of the Emergency Operations Center (EOC) and notification of the Emergency Management Team at which time the LEDO assumes the role of Emergency Director. The Emergency Director also directs the efforts of the Emergency Response Organization (ERO) to identify the material released and to assess potential or actual health consequences.

The primary means of activating the Emergency Response Organization is through the Communicator, a digital call/paging system. For Operational Emergencies, the IC classifies the incident and makes the initial notification. Follow-up notification comes from the Emergency Operations Center under the direction of the Emergency Director.

Agreements with offsite emergency response organizations are discussed in the *LLNL Emergency Plan*. Response to fire, medical, and hazardous materials incidents on LLNL property is provided by the

Alameda County Fire Department under contract to LLNL. The Alameda County Fire Department staffs both LLNL fire stations with security-cleared, trained fire fighters and fire fighter/paramedics. Both LLNL and the Alameda County Fire Department have ongoing contacts with local response agencies, mutual-aid agreements, and the response lead per California requirements. The State of California provides additional emergency assistance as described in the California Disaster and Civil Defense Master Mutual Aid Agreement. State agencies provide assistance at the direction of the Governor's Office of Emergency Services (OES). The Alameda County Sheriff's OES is the lead offsite response coordination agency for major emergency and disaster situations at or affecting the Livermore site. In addition, the Alameda County Fire Department is signatory to the State of California Master Mutual Aid Agreement for fire services and the Alameda County Mutual Aid Response Plan. Upon request, associated fire services will respond with personnel and equipment to support LLNL emergencies. The Livermore/Pleasanton Fire Department coordinates its activities with the Alameda County OES. If LLNL's primary communication links become unavailable, the ERO assists in activating the Amateur Radio Emergency Services (ARES). LLNL has a Memorandum of Understanding (MOU) in place with Valley Care Medical Center and Eden Medical Center to provide medical support for LLNL contaminated patients.

15.4.2 Assessment Actions

The RHWM Waste Treatment Group Leader or alternate decides the level of an emergency (small or large incident) and may consult with the Hazard Control Department ES&H Team for help with this assessment. In case of a radioactive release, the Hazard Control Department ES&H Team is called to monitor radioactivity levels. If personnel have any doubt about their ability to clean up a release properly and safely, or if the incident is determined to be a large incident, the onsite Alameda County Fire Department is notified immediately.

The *LLNL Emergency Plan* defines and describes Operational Emergency classifications (i.e., "Not Requiring Further Classification," "Alert," "Site Area Emergency," and "General Emergency"). Upon arrival at the scene, the IC determines if the incident is an Operational Emergency. The classification is made using the applicable Emergency Action Levels (EALs), which provide guidance to classify under conditions of limited real-time availability of event-specific data, such as distance to the site boundary, and applicable Protective Action Guides (PAGs) criteria.

An Alert would be declared for:

- An actual or potential substantial degradation in the level of control over hazardous materials (radiological and nonradiological) such that the radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material is expected to exceed the applicable Protective Action Guide (PAG) value beyond 30 meters, but not greater than the facility boundary (i.e., 100 meters).
- An actual or potential substantial degradation in the level of safety of a facility or process that could, with further degradation, produce a Site Area Emergency or General Emergency.

A Site Area Emergency would be declared for:

- An actual or potential major failure of functions necessary for the protection of workers or the public. The radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material is expected to exceed the applicable Protective Action

Guide (PAG) or Acute Exposure Guideline Level (AEGL) or equivalent values beyond the facility boundary or exclusion zone boundary. The PAG or AEGL value is not expected to be exceeded at or beyond the site boundary.

- Actual or potential major degradation in the level of safety of a facility or process that could, with further degradation, produce a General Emergency.

A General Emergency would be declared for:

- Actual or imminent catastrophic reduction of facility safety systems with potential for the release of large quantities of hazardous materials (radiological or nonradiological) to the environment.
- The radiation dose from any release of radioactive material or a concentration in air from any release of other hazardous material is expected to exceed the applicable PAG or AEGL value at or beyond the site boundary.

In the event of an accidental release to the environment, release response would be implemented and, if the incident were declared a large incident, the National Atmospheric Release Advisory Capability (NARAC) Center may be requested to enhance the Emergency Management Team’s plume release modeling capability with commensurate implications of toxic or radiological releases. The NARAC center can estimate the effects and atmospheric dispersion of hazardous and radioactive waste releases within the immediate area surrounding a release or within Northern California. The NARAC center is equipped to perform detailed atmospheric dispersion calculations, allowing an accurate tracing of hazardous and radioactive waste dispersion. The capability of this system allows the various response teams to have information on any hazardous and mixed waste (radioactive material) concentrations resulting from an accidental release. Additional near-event dispersion calculations are available from the LLNL ERO’s Consequence Assessment Team (CQT) or the Hazard Control Industrial Hygiene Group.

15.4.3 Notification

Communications systems are in place for the prompt, initial notification of Laboratory emergency response personnel, onsite personnel, and emergency response personnel/organizations offsite, including NNSA-LSO/OAK, DOE Headquarters, and other federal, state, and local organizations. Communication systems are also in place to provide for continuing, effective communication among the emergency response organizations, both offsite and onsite, throughout an Operational Emergency.

Notification of emergency response personnel is done through the Communicator®. DOE and offsite agency notifications shall commence within 15 minutes of the actual declaration of an Alert, Site Area Emergency, or General Emergency, or within 30 minutes of the actual declaration of an Operational Emergency not requiring further classification.

Follow-up notifications are provided on an hourly basis or whenever classification of the emergency event changes. The Alameda County Office of Emergency Services notifies other appropriate State of California entities and can use the State of California’s Emergency Broadcast System.

External Relations and Communications is responsible for providing timely and accurate information to the community, news media, and Laboratory workforce on matters concerning health, safety, and operations during and following an Operational Emergency. During an emergency, External Relations and Communications acts as the single point of contact for the news media, and as a principal source of information for Lab employees and community officials. It is also possible to coordinate the dissemination of information with outside agencies through the Joint Information Center.

LLNL employees are notified via the dedicated Evacuation Voice/Alarm (EVA). Alternative emergency communication systems include Radio 1610, the Emergency Radio Paging System, the LLNL telephone system, emergency signals/alarms, and the emergency vehicle public address system.

15.4.4 Emergency Facilities and Equipment

This section briefly describes emergency equipment available to the B695 Segment. Such equipment includes emergency communication equipment, fire detection and suppression equipment, water supplies, emergency-response and spill-control equipment, and decontamination equipment.

Emergency Communication Equipment

Numerous methods for communicating emergency information are available, including:

- LLNL sitewide emergency paging system.
- Area emergency paging systems.
- Telephones.
- Radio pagers and radio transceivers.
- Horns, sirens, and klaxons.
- Portable loudspeakers and megaphones.

Fire Detection and Suppression Equipment

The *Self-Help Plan* specifies locations of fire extinguishers throughout the facility. Fire extinguishers are typically located in areas of specific fire hazards.

The B695 Segment has an installed wet-pipe automatic fire sprinkler system. Discharge of water through fire sprinkler(s) sends a signal to the fire alarm control unit (FACU), and the FACU will forward the signal to the onsite Alameda County Fire Department.

Fire alarm pull stations are provided at emergency egress points. Speakers and strobe lights of the EV/A system are strategically located to warn people to evacuate the buildings.

Water Supplies

Water supplies for all purposes, including emergency responses, are provided to the B695 Segment facilities as part of the site-wide utility infrastructure.

Emergency-Response and Spill-Control Equipment

Several categories of emergency-response equipment will be available to the B695 Segment facilities, including spill-control equipment, response vehicles and heavy equipment, site safety equipment, personal protective equipment, and emergency assembly-point kits. The FSPs provide details on location, control, testing, and maintenance of emergency equipment and supplies. The *LLNL Fire Protection*

Program (LLNL-b latest revision) describes emergency equipment available for larger incidences that require mitigation by the onsite Alameda County Fire Department.

15.4.5 Protective Actions

Protective action criteria are levels of hazardous material that indicate action is needed to prevent or limit exposure to the hazard. The IC will direct protective actions of affected onsite personnel based on the initial assessment. If initial projections indicate that a hazardous material plume may extend beyond the site boundary, or that protective action criteria may be exceeded offsite, the IC will make protective action recommendations to offsite agencies.

The onsite Alameda County Fire Department has available Protective Action Guides for hazardous materials. Protective actions include standby for further information, shelter, and evacuate. Criteria for determining the best protective action for onsite personnel and the public are described in the *LLNL Emergency Plan*.

Onsite protective actions will be modified or lifted at the direction of the IC, with concurrence of the Emergency Director. Shutdown of operations is the responsibility of operations personnel in the affected building or facility. Emergency response information and follow-up health and hygiene surveys are documented.

LLNL's Health Services Department is a professional medical staff that is responsible for maintaining a detailed medical emergency response plan for providing medical care, using both LLNL and offsite facilities, during emergencies. In addition, the Emergency Management employs paramedics. The onsite medical facility includes a decontamination area that is designed for treatment of injured or noninjured radiologically or chemically contaminated personnel.

As described above under "Notifications," state and local response personnel and organizations are notified within 15 minutes of declaring an "Alert," "Site Area Emergency," or "General Emergency". Follow-up notifications are provided on an hourly basis or whenever classification of the emergency event changes. The External Relations and Communications provides information to the public and news media during an Operational Emergency. The Alameda Office of Emergency Services notifies other appropriate State of California entities and can use the State of California's Emergency Broadcast System. The offsite agencies alert the public and provide guidance on what action to take.

15.4.6 Training and Exercises

Personnel at the RHWM facilities, including the B695 Segment, participate in LLNL sitewide emergency drills and exercises. The *LLNL Emergency Plan* describes how emergency preparedness is maintained through use of training and exercises. LLNL conducts a coordinated program of drills and exercises to provide emergency-response training and to establish a method for evaluating response capability and readiness.

Drills are designed to develop and maintain personnel emergency-response skills. They are conducted separately by each ERO and reflect the organization's specific training needs, which have been discovered during prior drills. An integrated exercise is conducted annually to test communication and notification among organizations.

The Emergency Preparedness Section's Exercise Program includes an annual, full-participation exercise based on rotating scenarios, such as a natural disaster, security incident, or hazardous material incidents. The scenarios are designed to test the operational capability of individual organizations.

A Self Help drill is conducted annually. The Self Help program serves as a vehicle for training employees to help themselves during a catastrophic event, such as an earthquake, where professional first responders may be overwhelmed by calls for assistance. Personnel are trained to evacuate in accidents (e.g., large spill or fire) through an established training program described in Chapter 12, Section 12.4, Training Program.

15.4.7 Recovery and Reentry

Recovery includes incident assessments and investigation, recovery planning, scheduling, repair, restoration, and return or relocation. The *LLNL Emergency Plan* describes the provisions made for recovery from an Operational Emergency and reentry into the affected facility. The Emergency Director is responsible for terminating an operational emergency when applicable criteria are met. Such termination constitutes entry into the recover phase.

Prior to emergency termination, a recovery organization will be established. The Emergency Director will appoint a Recovery Manager who designates a Recovery Team. The Team may include advisors from the Environmental Protection Department, Hazard Control Department, and Maintenance and Utility Services Department. The Recovery Manager will continue communications and coordination with offsite federal, state, and local officials, as needed.

The Recovery Plan indicates that emergency response personnel will be deployed to evaluate an emergency situation and determine when it is safe to return the facility to normal operations. Following such determination, the Recovery Manager notifies the Hazard Control Department ES&H Team leader and transfers responsibility for the facility to the facility manager.

15.5 References

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-a (latest revision), *LLNL Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-113311).

LLNL-b (latest revision), *Self-Help Plan, Hazardous Waste Management Division*, Environmental Protection Department, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL-c (2001, or latest revision), *LLNL Fire Protection Program*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-116646).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

RHWM (2008), *Contingency Plan for Radioactive and Hazardous Waste Management Facilities: Area 612, Area 514, Building 233 CSU, and the Decontamination and Waste Treatment Facility*, Lawrence Livermore National Laboratory, Livermore CA, UCRL-AR-127066-REV-3, (January 2008).

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CHAPTER 16
PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

16.1 Introduction

This chapter provides a discussion of future decontamination and decommissioning (D&D) activities, and it also provides a conceptual D&D plan. Because of the similarity of Resource Conservation and Recovery Act (RCRA) requirements to those found in the DOE orders and guides pertaining to D&D operations, this chapter summarizes information contained in the RCRA Closure Plan for the DWTF. The DWTF will be closed according to requirements of RCRA and the California Hazardous Waste Control Law (HWCL).

The good-practice guides (surveillance and maintenance, deactivation, and decommissioning) associated with DOE O 430.1A will be used as guidance for the disposition of this facility, following principles in the appropriate chapters of LLNL's *ES&H Manual*. The integrated safety management concepts in DOE P 450.4 and DOE G 450.4-1B are reflected in the RCRA-required health and safety plan, which is an integral part of the RCRA Closure Plan. This plan also incorporates the ideas found in DOE-STD-1120-98, including work planning and identification, integrated hazard analysis, hazard controls and ES&H documentation, and work performance.

16.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

DOE-STD-1027-92, Change Notice No. 1	Hazard Categorization and Accident Analysis Techniques (1992).
DOE-STD-1120-98	Integration Of Environment, Safety, And Health Into Facility Disposition Activities (1998).
DOE Order 5400.5, Change Notice No. 2	Radiation Protection of the Public and the Environment (1993).
DOE Order 430.1	Real Property Asset Management, (2003)
DOE Policy 450.4	Safety Management System Policy (1996).
DOE Guide 450.4-1B	Vol 1, Integrated Safety Management Guide (2001).
10 CFR 835	Occupational Radiation Protection
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 261.24	Identification and Listing of Hazardous Waste
22 CCR 66264.112	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.
22 CCR 66261.24	Identification and Listing of Hazardous Waste

16.3 Description of Conceptual Plan

Prior to the start of D&D activities, an Implementation Plan that describes the actual work to be performed in the facility and methods for complying with DOE orders and the *ES&H Manual* will be developed. This plan will be based on an evaluation of all contamination sources identified within the facility. It will also include data from contamination files and detailed budgets and schedules. It is anticipated that the Implementation Plan will resemble the RCRA Closure Plan.

The waste inventory of the DWTF will be decreased significantly before D&D activities begin. This means that the radioactive inventory will also decrease to well below Nuclear Hazard Category 3 limits stated in DOE-STD-1027-92, Change Notice No. 1, and likely be at radiological facility levels.

Before decontamination, a pre-sampling survey will be conducted to determine where contamination exists within each unit or structure. Following the survey, sampling will be conducted, analytical results will be compared to the respective regulatory limits, and the appropriate decontamination activities will then be undertaken. If analytical results are equal to, or exceed, regulatory limits for any RCRA, HWCL, or DOE components, the item will be decontaminated until analytical results are below regulatory levels. If it is determined that further decontamination will not remove the identified contamination, decontamination activities will cease, and the item will be disposed of according to the level and type of contamination.

Sampling and analysis will be done with waste minimization as a goal, and with special emphasis on mixed-waste minimization. Therefore, the first attempt to decontaminate equipment or a structure will be by washing the surface using pre-developed techniques. The walls and floors of the B695 Segment are epoxy-coated to simplify decontamination activities.

Any waste is a hazardous waste if it contains a substance at a concentration that exceeds its listed STLC, TTLC, or TCLP value pursuant to 22 CCR, Section 66261.24, or 40 CFR 261.24. All swipes that require radiological analysis will be evaluated for radioactive release levels according to DOE Order 5400.5 and 10 CFR 835. TCLP testing will be performed to address the hazardous material aspects of issues regarding mixed-waste.

The RCRA Closure Plan includes, but is not limited to, discussions of the following topics that will enable final closure certification at the end of the facility's operating life:

- General Facility Description: a general discussion of LLNL, its location, operations, and associated hazardous waste management activities.
- Waste Management Unit Information: an overview description of the specific waste-management units, including dimensions, location, construction materials, historical uses, potential historical contaminants, and containers and equipment used to manage waste at the unit.
- Maximum Waste Inventory: a description of the maximum inventory of waste that could be in storage or treatment at any time during the operating life of the unit.
- Closure Performance Standards: a discussion of several topics, including the sampling and analysis methodology, removal and disposal of contaminated equipment and structural components, and evaluation of wastes to regulatory definitions.

- Schedule for Closure: a discussion of the expected year of closure and a milestone chart showing the closure activities. The closure schedule provides a mechanism for tracking the progress of closure activities.
- Inventory Removal Procedures: a discussion of disposal options for waste generated during D&D activities.
- Disposition of Equipment and Associated Structures: a discussion of disposal of noncontaminated equipment; decontamination of equipment and structures, debris waste, and equipment used for treatment of listed waste (if appropriate); and demolition and/or removal of contaminated structures for onsite treatment or offsite treatment or disposal.
- Closure Certification: a discussion of certification and analyses to be performed to verify clean closure and to certify closure.
- Site Safety and Health Plan: a discussion of site hazards and controls for LLNL or contractor personnel to perform assigned tasks safely.

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CHAPTER 17
MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 Introduction

This chapter provides an overview of management, organization, and institutional safety provisions at the B695 Segment. Information in this section is presented in accordance with the LLNL ES&H Manual Document 51.1, “Documented Safety Analysis Program Plan.” LLNL has incorporated Integrated Safety Management (ISM) into all aspects of operations. The NNSA/LLNS Contract Appendix G (NNSA/LLNS 2007) has been used to select the most appropriate national consensus standards, along with appropriate LLNL-developed standards. Organizations and personnel with responsibilities for safety, and interfaces among the organizations, are described in this chapter. In addition, descriptions are provided of safety consciousness, safety culture, performance assessment, configuration and document control, occurrence reporting, and staffing and qualification for the B695 Segment.

17.2 Requirements

The safety program for the Radioactive and Hazardous Waste Management (RHWM) Division facilities is administered through a series of hierarchical documents that state responsibilities and give direction for safe operations. Key requirements are described below. The *ES&H Manual* is a compilation of ES&H-related requirements and policy. Requirements in the *ES&H Manual* are based on NNSA/LLNS Contract Appendix G standards (NNSA/LLNS 2007) identified for the specific work and associated hazards, and LLNL best practices that management has determined are requirements. The Appendix G standards set was derived from statutes, regulations, DOE Orders, and national and internally developed consensus standards. The Appendix G standards set is found in Contract No. DE-AC5207NA2733 agreement between Lawrence Livermore National Security, LLC and NNSA (NNSA/LLNS 2007). The *ES&H Manual* also describes implementation of the ES&H management commitments made in the Laboratory's *Integrated Safety Management System Description* (LLNL-a latest revision). Adherence to the requirements and processes described in the *ES&H Manual* ensures that safety documents across the Laboratory are developed in a consistent manner.

The next level of administrative safety documentation is the RHWM facility safety plans (FSPs) and integration work sheets with safety plans (IWS/SPs), followed by standard operating procedures (SOPs). The FSPs include not only safety requirements specific to the facility as derived from the *ES&H Manual* (LLNL latest revision), but also from the Technical Safety Requirements. To ensure that document contents are appropriate for current operations, FSPs, IWS/SPs, and procedures are reviewed on an established schedule in accordance with the *ES&H Manual*. *ES&H Manual* Document 2.2, “Managing ES&H for LLNL Work,” discusses these documents in more detail.

When any new activity or a change to an existing activity is planned, an Integration Work Sheet (IWS) is developed following *ES&H Manual*, Document 2.2, “Managing ES&H for LLNL Work.” The IWS process ensures that a careful review is performed both by ES&H subject-matter experts and RHWM management. All applicable parts of the Occupational, Safety and Health rules found in 29 CFR 1910 are identified as standards that RHWM will use to provide workers at the B695 Segment with a safe and healthful working environment.

17.3 Organizational Structure, Responsibilities, and Interfaces

The overall RHWM organizational structure, including that for the B695 Segment, is presented in this section. Included are safety provisions in the RHWM organizational structure that help ensure and enhance facility safety.

17.3.1 Organizational Structure

LLNL is a multi-program laboratory operated for the DOE by the Lawrence Livermore National Security, LLC. To accomplish its mission, LLNL operates through a matrix system, with each major organization headed by a programmatic associate director or program leader. The management structure is summarized in **Figure 17-1**. The nuclear facility managers are matrixed from Nuclear Operations into Weapons and Complex Integration (WCI) principal directorate.

17.3.2 Organizational Responsibilities

Operational and management personnel responsibilities are outlined in this section. Included in the discussion are interfaces with other organizations, line operating organizations, and safety organizations.

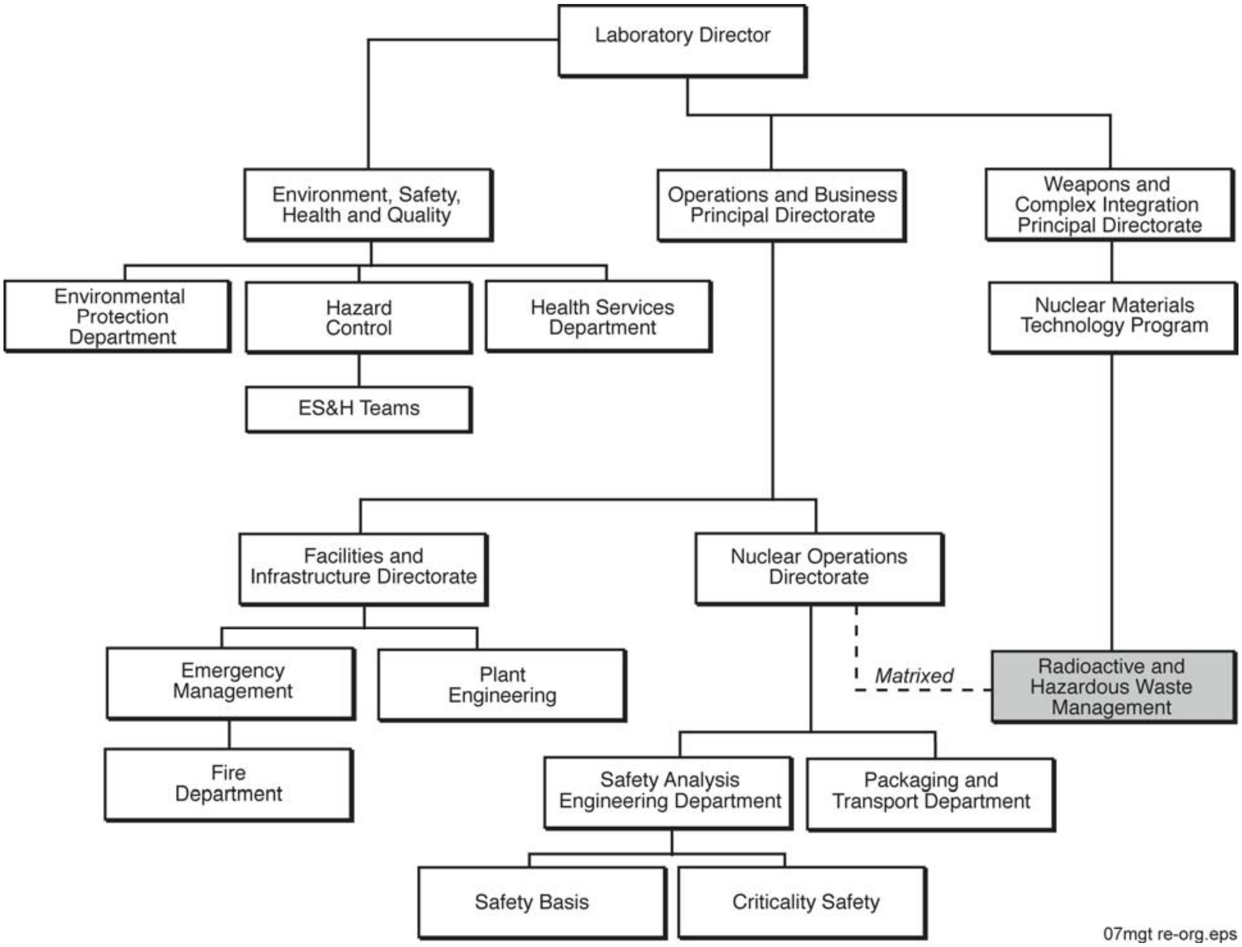
Operational and Management Personnel

ES&H Manual Document 2.1, "General Worker Responsibilities and Integrated Safety Management," provides specific roles for personnel based on their position. RHWM personnel of the EPD will manage the B695 Segment. They will be responsible for storing and treating liquid and solid radioactive, mixed, and hazardous waste in B695. Because B695 contains treatment equipment, RHWM personnel will also be responsible for using the equipment in conjunction with liquid-waste processing operations to treat various solid waste, such as debris. In addition, RHWM personnel will be responsible for operating the B696 SWPA, which will be used primarily to manage solid radioactive waste, including TRU waste, uranium waste, tritium-bearing waste, and other solid low-level waste (LLW). RHWM generally processes low-level radioactive waste with no, or extremely low, concentrations of transuranics (e.g., much less than 100 nCi/g). Wastes processed often contain only depleted uranium and beta- and gamma-emitting nuclides, e.g., ^{90} Sr, ^{137}Cs, ^{3}H. Lines of authority, responsibility, and communications are established and defined for the highest, down to intermediate management levels, including all safety and operating organization positions.

WCI has line responsibility. They execute the scope, manage the budget and schedule, and provide day to day direction of the facility managers assigned to Nuclear Operations. The nuclear facility managers are matrixed from Nuclear Operations into the WCI principal directorate. In this role, they are accountable to the Nuclear Material Technology Deputy Principal Associate Director for the safe and compliant operation of the facility.

The RHWM Division Leader/Deputy Division Leader is responsible for overall facility operation and shall delegate, in writing, the succession to this responsibility during any absence. Delegation shall be to a qualified individual. The RHWM Division Leader is responsible for safe operation within the B695 Segment. Safe operation includes interface requirements with other site organizations and facilities to ensure the availability of Hazard Control Department subject matter experts, fire protection, electric power, utilities, and related needs.

Figure 17-1. Management organization chart



The RHWM Storage and Disposal Group and Waste Treatment Group Leaders are the Facility Managers of the B695 and B696S facility and are responsible for the operational functions. The group leaders are responsible for overall site safety and have control over those activities necessary for safe operation and maintenance of the B695 Segment.

The Facility Point of Contact (FPOC) for B695 is the Waste Treatment Nuclear Operations Supervisor, and the FPOC for B696S is the RHWM Storage and Disposal Nuclear Operations Supervisor. Some of the FPOC responsibilities include concurring that work can be performed within the safety envelope of the facility, identifying hazards associated with the work location and communicating them to the responsible work management chain, participating in pre-start review of work (when one is conducted), evaluating proposed operational or activity changes against the facility's existing ES&H documentation (e.g., the authorization basis), and concurring that work may proceed in the building, prior to the onset of work.

Individuals who carry out health physics and QA functions, have independent safety review, audit, and compliance oversight. A health and safety technician, whose qualifications meet DOE Order 5480.20A (DOE 1994) requirements, shall be on call when radioactive material is present in the B695 Segment.

Interfaces with Other Organizations

Members of the Hazard Control ES&H Team 1 may be called in to advise on planned and ongoing operations, conduct hazard assessments, and support RHWM at the B695 Segment during emergency incidents. The team consists of specialists in industrial hygiene, industrial safety, health physics, environmental protection, explosives safety, fire-protection engineering, and criticality safety. An environmental analyst of the EPD serves on the Hazard Control ES&H Team.

The LLNL Emergency Management Division is called in to handle major incidents. Details of emergency management at LLNL are found in the *LLNL Emergency Plan* (LLNL-b latest revision).

Technical and Engineering Support, Maintenance, and Modifications

Most large-scale design, construction, and maintenance efforts at LLNL are coordinated through Plant Engineering. Within the RHWM Division, the Waste Treatment Group Leader provides facility coordinators, fabrication technicians, and maintenance technicians to support smaller projects.

Safety Issue Discovery, Communication, Management, and Resolution

Safety issue discovery takes place in a variety of ways, ranging from a worker's concern to a formal audit. Safety concerns from workers are transmitted to their supervisor who can act on them directly, often with input from the ES&H Team, or they can be passed on to the group leader for action. Employees are aware that a variety of additional options are in place to raise safety issues. Audit results are typically forwarded to the division leader and corrective action plans developed by the appropriate group leader. For some issues, a nonconformance report can be issued in accordance with the RHWM *Quality Assurance Plan* (LLNL-c latest revision).

For safety issues that meet requirements found in the LLNL implementation of the Occurrence Reporting process, the institutional procedure is found in the *ES&H Manual* Document 4.5, "Incidents—Notification, Analysis, and Reporting." Corrective actions from occurrence reports are tracked to closure in the LLNL ES&H Issues Tracking System database (*ES&H Manual* Document 4.2, "ES&H Issues and Deficiencies Management"). Corrective actions and closure of findings are described in the *Safety and Environmental Protection Directorate Integrated ES&H Management Program*.

LLNL has an active Lessons Learned program run by the Hazard Control Department. The RHWM Division submits issues of general usefulness to this program.

Independent Safety Review, Audit, and Compliance Determination

RHWM has a variety of external (to LLNL) and internal audits. In addition to DOE audits, external audits include DNFSB, California Highway Patrol, Department of Transportation (DOT), and Department of Toxic Substance Control (DTSC) audits.

In terms of independent internal audits, LLNL staff carries out a variety of audits of RHWM activities, including those in areas such as criticality, nuclear facility authorization basis, and radiation worker protection. Findings from the audits are always tracked to closure in the LLNL ES&H Issues Tracking System database.

Safety Analysis Services, Including USQ Evaluation

The Laboratory has a staff of trained safety analysts in the Safety Basis Division in the Nuclear Operations Directorate. In addition, Safety Analysts within the RHWM Division perform Unreviewed Safety Question (USQ) evaluations and develop DSAs and TSRs.

Support Services Such As Utilities and Other Offsite Support

The Plant Engineering Department provides telecommunications and utilities services. The Laboratory has backup sources for both electricity and water.

17.3.3 Staffing and Qualifications

This section summarizes the bases for staffing levels and the knowledge, skills, and abilities of personnel assigned to the B695 Segment. Included is a description of programs and provisions for monitoring safety performance of the staff.

The Training Implementation Matrix (TIM) for RHWM (LLNL-d latest revision) addresses the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*. *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” defines the LLNL training program. The FSPs discuss the safety training requirements for employees who work therein.

The program associate director (AD) is responsible for carrying out the program’s technical work and for ensuring that LLNL health and safety policies are integrated into the program’s activities and plans. The program AD has the primary responsibility for ensuring:

- The safe conduct of all activities connected with program work.
- That program training responsibilities required by *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” are carried out.
- The LLNL work force assigned is properly trained to carry out the work.
- That facilities and procedures used are appropriate for the work.

17.4 Safety Management Policies and Programs

Facility safety is maintained at the B695 Segment through safety management policies and programs as described in the following sections. The safety management program is established to ensure that any hazardous activities are defined, evaluated, planned, performed, assessed, and improved in accordance with LLNL’s Integrated Safety Management (ISM) policy and requirements.

17.4.1 Safety Review and Performance Assessment

As described in Section 17.2 above, when any new activity, or a change to an existing activity, is planned, an IWS is developed following the *ES&H Manual*, Document 2.2, "Managing ES&H for LLNL Work." This work authorization control process requires hazardous work to be controlled by procedure, instruction, permit, or other such controlling documents and ensures that a careful review is performed both by ES&H subject-matter experts and RHWM management.

The Hazard Control Department's ES&H Team 1 provides independent safety oversight and support to RHWM facility operations. The ES&H Team 1 is composed of representatives from various safety disciplines, including health physics, industrial hygiene, fire safety, environmental protection, and industrial safety. The representatives also provide independent reviews of RHWM positive USQDs along with FSPs, IWS/SPs, and selected procedures.

17.4.2 Configuration and Document Control

The configuration management program is established in accordance with *ES&H Manual* Document 41.2, "Configuration Management Program Description" including:

- Design control process
- Safety basis & implementing document control
- Safety system configuration control (e.g., engineering drawings, work authorization control documents)
- The USQ process in *ES&H Manual* Document 51.3, "LLNL Unreviewed Safety Question (USQ) Procedure."

Maintenance activities and document control are discussed in Chapters 10 and 14, respectively. Any changes to documents or maintenance activities that result in the proposed activities above, are processed through the USQ program.

17.4.3 Occurrence Reporting

ES&H Manual Document 4.5, "Incidents—Notification, Analysis, and Reporting," describes notifications to be made at LLNL following an incident, reports that must be prepared, the methodology of incident analysis, and action required to minimize the frequency of a similar incident recurring. This conforms to the requirements of DOE Order 231.1A (DOE 2003).

Staff members of the B695 Segment are responsible for initial reporting and for writing occurrence reports. In addition, occurrences with application to others are written up for the LLNL Lessons Learned program that is operated by the Hazard Control Department.

17.4.4 Safety Culture

To ensure that the B695 Segment is operated in a safe manner, LLNL has established various programs for self-assessment, monitoring, enhancing operational personnel performance, and corrective action. Periodically, several levels of LLNL management review LLNL safety procedures and operations to ensure their continued effectiveness. The safe operation of the B695 Segment will be monitored by the Hazard Control Department ES&H Team 1 to ensure that management is aware of risks and that necessary risks are minimized. Documents and procedures that help establish the safety culture at the B695 Segment are provided in the LLNL *ES&H Manual*. Other safety-related programs that will be applicable include:

- Integrated Safety Management, including the IWS process.
- Directorate and RHWM self-assessments.
- Management pre-start and operational readiness reviews.
- Responsible individual and supervisor monitoring.
- Periodic review and revision of safety procedures.
- Conduct of operations.
- QA system monitoring.
- Nonconformance and corrective action reports.
- ALARA.
- Industrial safety and hygiene.
- Safety meetings.

17.5 References

DOE (2003), *Environment, Safety and Health Reporting*, DOE Order 231.1A, U.S. Department of Energy, Washington, DC, August 19, 2003.

DOE (1994), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, DOE Order 5480.20A, Department of Energy, Washington, DC, November 15, 1994.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-133867).

LLNL-a (latest revision), *LLNL Integrated Safety Management System Description*, Livermore, CA (UCRL-AR-132791).

LLNL-b (latest revision), *LLNL Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-113311).

LLNL-c (latest revision), *Radioactive and Hazardous Waste Management Division Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL-d (latest revision), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-116655).

LLNL-e (latest revision), *RHWM Nuclear Facility Configuration Management Program*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-151576).

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, October 1, 2007.

APPENDIX A
PROCESS HAZARD ANALYSIS

A.1 Introduction

Appendix A presents the results of the Process Hazards Analysis (PrHA) performed for the B695 Segment for waste operations, natural phenomena hazards, and external events. **Tables A-1** through **A-3** contain information on the frequency of occurrence of postulated events, consequences of events, and risk group rankings, respectively. **Table A-4** provides a list of processes (activities and treatment or unit operations) described in Section 2.5 of this DSA, and the corresponding scenarios related to those processes or that bound risk. **Table A-5** is a list of acronyms followed by global notes and explanations for the PrHA table. **Table A-6** is the multi-page PrHA table.

Table A-1. Qualitative mitigated frequency of occurrence of postulated events

Frequency level	Acronym	Frequency	Qualitative description
Anticipated	A	$10^{-2} \leq f$	Events that might occur several times during the lifetime of the facility (excluding normal operations)
Unlikely	U	$10^{-4} \leq f < 10^{-2}$/yr	Events not anticipated during the lifetime of the facility
Extremely unlikely	EU	$10^{-6} \leq f < 10^{-4}$/yr	Events that will probably not occur during the lifetime of the facility
Beyond extremely unlikely	BEU	$f < 10^{-6}$/yr	All other events

Table A-2. Consequence Levels and Risk Evaluation Guidelines

Consequence Level	Offsite Public	Worker	Site Facility Worker
High	Considerable off-site impacts on people or the environs. Rad exposure: >25 rem[1] TEDE or Chemical exposure: >ERPG-2/TEEL-23	Considerable on-site impacts on people or the environs. Rad exposure: >100 rem TEDE or Chemical exposure: >ERPG-3/TEEL-3	[2,3] Facility worker hazards are typically protected with SMPs. For Safety Significant designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, should be considered.
Moderate	Only minor off-site impact on people or the environs. Rad exposure: ≥1 rem TEDE or Chemical exposure: >ERPG-1/TEEL-1	Considerable on-site impact on people or the environs. Rad exposure: ≥25 rem TEDE or Chemical exposure: >ERPG-2/TEEL-2	
Low	Negligible off-site impact on people or the environs. Rad exposure: <1 rem or Chemical exposure: <ERPG-1/TEEL-1	Minor on-site impact on people or the environs. Rad exposure: <25 rem or Chemical exposure: <ERPG-2/TEEL-2	

Notes:
[1] Offsite consequences that challenge 25 rem from operational hazard events are protected with Safety Class SSCs independent of frequency.
[2] Occupational Radiation Protection; unintended (incidental) releases of sufficiently high frequency is considered a part of normal operations governed by 10 CFR 835.
[3] See Section 3.3.1.2, Consequence Category Estimates, for discussion of qualitative criteria for site facility worker.

Table A-3. Qualitative Risk Ranking Bins

Consequence Level	Beyond Extremely Unlikely $f < 10^{-6}$/yr	Extremely Unlikely $10^{-6} \leq f < 10^{-4}$/yr	Unlikely $10^{-4} \leq f < 10^{-2}$/yr	Anticipated $10^{-2} \leq f < 10^{-1}$/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	I
Low Consequence	IV	IV	III	III

Table A-4. Process list and related scenarios

Waste treatment and processing activities	Related scenarios or those that bound risk
Bulking station	BK–1 through BK–5
Waste blending station	BS–1 through BS–6
Centrifuge	CF–1 through CF–5
Drum crusher	DC–1 through DC–2
Debris washer	DW–1 through DW–3
Evaporators	EV–1 through EV–7
Waste water filtration module	FM–1 through FM–3
B696S glove box operations	GB–1 through GB–4
Process off-gas system	PG-1
Chemical reagent system	RS–1 through RS–5
Lab packing and passivation	RW-1 through RW-9
Small-scale treatment	SS–1 through SS–2
Instrument lab operations	SS–1 through SS–2
Fume hood operations	RW–1 through RW-9
Reaction vessel operations	RW-1 through RW-9
B695 Glove box operations	RW–1 through RW-3
Solidification system	SU–1
Waste water treatment Tank Farm operations	TF–1 through TF–4
Waste storage activities	WH–1 through WH–12 and WH-15 through WH-16
Waste handling activities	WH–1 through WH–18
Facility and equipment maintenance activities	WH–1 through WH–12
Waste packaging unit	WP-1 through WP-2

Table A-5. B695 Segment PrHA table acronyms

Term	PrHA table acronyms
Preventive administrative	PA
Preventive engineering	PE
Mitigative administrative	MA
Mitigative engineering	ME
Worker	W
Public	P

A.2 Global Notes

- In the “Consequence” and “Risk” columns in the PrHA, “W” denotes consequence and risk to the site facility worker or the co-located worker, whichever has the greater potential consequence, and “P” denotes consequence and risk to the public.
- Impacts to the environment from the scenarios are considered less than impacts to the public. As such, controls identified in the PrHA are considered sufficient to address impacts to the environment. In addition, locked sewer access and secondary containment provide controls to protect the environment. The RCRA Operations Plan provides the control necessary to protect the public for managing hazardous wastes through RCRA permit approval.
- Chemicals that may be present in wastewater include methanol, chlorinated solvents, oils, and others. When the terms “waste” or “wastewater” are used as a material at risk, refer to Appendix B for an assessment of the types and quantities of chemical constituents. Accidents with reagents are assumed to represent and bound offsite consequences. Chemicals that cause fire are considered in fire scenarios.
- Waste volumes are assumed to come from various sources. When a scenario involves a Tank Farm tank spill for example, it bounds volume from smaller containers (e.g., portable tanks). Similarly, containerized waste spills may come from multiple containers, but the MAR that bounds risk would not change.
- Common cause failures and interactions were evaluated and are not an issue since single mode failures can release the entire MAR (e.g., 56 PE-Ci).
- Consistent with the Waste Storage Facilities DSA, training decreases the frequency for workers; Emergency Response decreases worker consequence; and for slow leaks, incident response (e.g., calling 911 and informing other personnel) is available, but is not credited.
- Inside-building ventilation is provided as a best management practice and for general worker comfort.
- When both an initiating event and concurrent enabling event must occur in an accident scenario, unmitigated frequencies are reduced by 1 bin. For instance, a vehicle crash that causes a spill is considered unlikely. However, a vehicle crash that causes a spill and a fire is considered extremely unlikely.
- Traffic controls are in place requiring vehicle drivers to stop at the gate prior to driving into the DWTF yard area. While this is not indicated in the individual scenarios, this control is considered an initial condition for all scenarios involving vehicles. Personnel are also trained for transport and tie-down of materials as part of the training program administrative control.
- Total loss of utilities (e.g., electrical, natural gas, water, and compressed air) could happen and would be covered by many of the scenarios discussed in the PrHA tables (e.g., external and natural phenomenon hazards). Waste material would still be contained within the facility or unit. Secondary events, such as a subsequent fire, are also covered in various PrHA scenarios.
- Vehicles include, but are not limited to, cars, trucks, forklifts, cranes, and manlifts.
- Common mode failures are considered in this PrHA. Mitigation relies on human performance (e.g., training, evacuation) rather than SSCs. Interactions are considered and evaluated.

- Higher concentrated wastes typically are generated in small volumes.

Table A-6. Process Hazard Analysis (PrHA) Table

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Waste treatment and processing activities															
Bulking Station															
BK-1	Release of waste	Forklift or other vehicle collides with drum rinse station resulting in loss of material	Approximately 700 gal of dilute mixed radiological/chemical waste water, parts cleaning solution (decon operations), or rinse water Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection (vehicles) MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1. The rinsing/bulking pan size is approximately 700 gal 2. Pan may catch rinsate from empty drums, feed from containers of waste, or decon solution from a part being washed in the pan
BK-2	Fire	Forklift or other vehicle collides with drum rinse station, waste released, fire	Approximately 700 gal of dilute mixed radiological/chemical waste water, parts cleaning solution (decon operations), or rinse water Radiological hazard is bounding concern (Cat 2 threshold)	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection (vehicles) MA – Inventory controls* MA – Personnel evacuation ME- Fire sprinkler system	EU	L	L	IV	IV	1. See BK-1

*Asterisk signifies initial condition for scenario development. **Double asterisk signifies credited control for reducing frequency or consequence.

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
BK-3	Release of waste	Operator error resulting in slow spill	Two containers of dilute mixed radiological/chemical waste water, parts cleaning solution (decon operations), or rinse water Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection (vehicles) MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 See BK-1 2 Two drum dumpers exist where operator error can involve spills
BK-4	Release of waste	Equipment malfunction due to corrosion from incompatibility resulting in leaks of sludge and / or liquid	Approximately 700 gal of dilute mixed radiological/chemical waste water, parts cleaning solution (decon operations), or rinse water Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection (unit) PA – Training PE – Equipment Design MA – Inventory controls* MA – Incident response MA – Personnel evacuation	A	L	L	III	III	1 See BK-1 2 Training could further reduce chances for leaks due to reduction in placing incompatibles
BK-5	Fire	Immiscible flammable liquids igniting by changing electrical potential	One container mixed radiological/chemical flammable liquid Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler system	U	L	L	III	III	1 See BK-1 2 Mischaracterization of waste is considered human error and may result in a fire by concurrent initiating and enabling events 3 Fires with larger quantities of liquid are analyzed in "waste handling" PrHAs

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
Blending Station															
BS-1	Container/ Pipe Rupture	Vehicle collides with container/ pipes, or appurtenances; waste released	1000 gal of mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and inspection MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator 2 Simple leaks of aqueous solution have a low radiological ARF and RF
BS-2	Container/ Pipe Rupture, Fire, Radiation, Chemical	Vehicle collides with container/ pipes, or appurtenances; waste released; and/or subsequent fire	1000 gal of mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance testing and inspection MA – Inventory Control* MA – Personnel evacuation ME- Fire sprinkler system	EU	L	L	IV	IV	1 Human error assumed as the initiator 2 Simple leaks of aqueous solution have a low radiological ARF and RF 3 A subsequent fire is less frequent and has consequences bounded by BS-1
BS-3	Inadvertent release of liquid to sewer	Operator error at Programmable Logic Control (PLC) allows slow release of waste to sewer	1000 gal of mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection MA – Incident response MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator 2 Concurrent enabling event required for release 3 Slow release allows time for incident response and reduces consequences (negligible for workers) 4 Simple leaks of aqueous solution have a low radiological ARF and RF
BS-4	Incompatible chemicals/ release of waste liquid	Operator error results in inadvertent chemical reaction causing container failure, resulting in slow leak	1000 gal of mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Training MA – Inventory controls* MA –Personnel evacuation MA – Incident response	A	L	L	III	III	1 Human error assumed as the initiator 2 Simple leaks of aqueous solution have a low radiological ARF and RF
BS-5a	Incompatible chemicals/ release of gas	Operator error causes inadvertent chemical reaction resulting in evolution of hazardous gas from chemicals not identified as extremely hazardous substance	1000 gal of mixed radiological/chemical wastewater Chemical hazard is bounding concern	U	L	L	III	III	PA – Approved procedures PA – Training MA – Emergency Response	U	L	L	III	III	1 Human error assumed as the initiator 2 Worker is aware of hazard due to obvious reaction (bubbling and heat) 3 Concurrent initiating events reduce unmitigated frequency

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
BS-5b	Incompatible chemicals/ release of gas	Operator error causes inadvertent chemical reaction resulting in evolution of hazardous gas (e.g., cyanide and/or sulfide) from chemicals identified as extremely hazardous substance	1000 gal of mixed radiological/chemical wastewater Chemical hazard is bounding concern Higher concentrated wastes typically are generated in small volumes	EU	M	L	III	IV	PA – Approved procedures PA – Training MA – Emergency Response	EU	M	L	III	IV	1 Human error assumed as the initiator 2 To produce high quantities of high concentrated incompatible chemicals requires multiple enabling conditions over significant time. There is infrequent cyanide and/or sulfide loading and infrequent use of acids on that waste type 3 Worker is aware of hazard due to obvious reaction (bubbling and heat) 4 The primary waste streams would be described as industrial hazardous waste. Several inventories showed less than 1 in 100 containers to be extremely hazardous substances, which reduces the frequency of an accident by one bin. 5 Radiological material is contained in solution; release is negligible
BS-6	Incompatible chemicals/ fire	Operator error causes inadvertent chemical reaction resulting in fire	1000 gal of mixed radiological/chemical wastewater Chemical hazard is bounding concern	U	L	L	III	III	PA – Approved procedures PA – Training MA –Emergency Response	U	L	L	III	III	1 See BS-5b

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
Centrifuge															
CF-1	Container or pipe rupture, release of waste	Forklift or other vehicle collides with centrifuge or centrifuge hose, resulting in a spill	Approximately 55 gal of mixed radiological/chemical wet sludge, 1,000 gal of light liquid, and/or 4,500 gal of dilute wastewater Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, and inspection, (vehicles) MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator 2 Volume of sludge collected or in hold-up is less than or equal to 55 gal constrained by equipment design and operational necessity. Portable tanks approximately 1,000 gal in volume may be used to accept light liquids. 3 Feed may be from Tank Farm tank
CF-2	Container or pipe rupture, fire, radiation	Forklift or other vehicle collides with centrifuge or centrifuge hose; waste released; fire results	Approximately 55 gal of mixed radiological/chemical wet sludges, 1,000 gal of light liquid, and/or 4,500 gal of dilute wastewater Radiological hazard is bounding concern (Cat 2 threshold)	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance Testing, and Inspection (vehicles) PE – Equipment Design MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler system	EU	L	L	IV	IV	1 See CF-1 2 Concurrent initiating and enabling events reduce unmitigated frequency
CF-3	Inadvertent release not associated with vehicle	Operator error resulting in slow release spill	Approximately 55 gal of mixed radiological/chemical wet sludges, 1,000 gal of light liquid, and/or 4,500 gal of dilute wastewater Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Training MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 See CF-1 2 Human error assumed as the initiator

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
CF-4	Release of waste	Equipment malfunction due to corrosion from incompatibility resulting in leaks of sludge and or liquid	Approximately 55 gal of mixed radiological/chemical wet sludges, 1,000 gal of light liquid, and/or 4,500 gal of dilute wastewater Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection (unit) PA – Training PE – Equipment Design MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 See CF-1 2 Training can reduce placement of incompatible chemicals
CF-5	Fire	Immiscible flammable liquids ignite by changing electrical potential	Mixed radiological/chemical wet sludge Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PE – Equipment Design MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler system	U	L	L	III	III	1 Mischaracterization of waste is considered human error and may result in a fire 2 Note drums or the centrifuge basin is used to catch sludge (the basin is relatively small) 3 Fires with larger quantities of liquid are analyzed in "waste handling" PrHAs

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Drum Crusher															
DC-1	Release of residual liquid in drum	During crushing absorbent was not used; containers split, resulting in slow release spill	Less than 55 gal of mixed radiological/chemical rinsate, 50 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection MA – Inventory controls* MA – Incident response	A	L	L	III	III	1 Containers are rinsed or “emptied” prior to crushing; often floor dry is employed. (“Emptied” implies contents poured out and some residual remains.) 2 Assumes multiple containers can be crushed simultaneously (smaller containers inside) 3 Both drum crushers were considered
DC-2	Fire	Crushing drum causes sparks and catches residual waste on fire	Less than 55 gal of mixed radiological/chemical liquid waste, 50 PE-Ci	U	L	L	III	III	PA – Approved procedures PA – Training PE – Equipment design MA – Personnel evacuation MA – Inventory controls* ME – Fire sprinkler system	U	L	L	III	III	1 See DC-1 2 Concurrent initiating and enabling events required for scenario to occur 3 Operators are trained to rinse drums prior to crushing

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
Debris Washer															
DW-1	Release of waste	Operator error resulting in spill	Approximately 112 cubic feet of partially wet mixed radiological/chemical solid waste and/or 625 gal of spent wash water Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance Inspection PE – Equipment Design MA – Inventory controls* MA – Personnel evacuation MA – Incident response	A	L	L	III	III	1 Human error assumed as the initiator 2 Dilute wash water contains mild concentrations of reagents and/or contaminants 3 Wet solid material allows for incident response (not credited)
DW-2	Release of waste	Equipment malfunction due to corrosion from incompatibility, resulting in leaks	Approximately 112 cubic feet of partially wet mixed radiological/chemical solid waste and/or 625 gal of spent wash water Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PA – Training PE – Equipment Design MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 Dilute wash water contains mild concentrations of reagents and/or contaminants 2 Wet solid material allows for incident response (not credited)
DW-3	Fire	Movement of waste debris causes spark, igniting combustible waste	Approximately 112 cubic feet of mixed radiological/chemical solid waste Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler System	U	L	L	III	III	1 Dilute wash water contains mild concentrations of reagents and/or contaminants 2 Wet solid material allows for incident response (not credited) 3 Fire requires concurrent events 4

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
Evaporator															
EV-1	Release of waste	Forklift or other vehicle collides with one of the evaporator pots resulting in spill	Approximately 100 gal of concentrate and/or dilute mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection (vehicles) PA – Training MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator 2 Volume of concentrate collected or in hold-up is approximately 100 gal per tower 3 Both the LLW evaporator and the MLLW evaporator are considered in the Evaporator HA events
EV-2	Release of waste	Forklift or other vehicle collides with one of the evaporator pots, Waste released, Fire	Approximately 100 gal of concentrate and/or dilute mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	EU	L	L	IV	IV	PA – Approved procedures PA – Maintenance, testing, & inspection (vehicles) PA – Training MA – Inventory controls* MA – Personnel evacuation	EU	L	L	IV	IV	1 See EV-1
EV-3	Release of waste	Operator misoperates equipment resulting in slow release spill	Approximately 100 gal of concentrate and/or dilute mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection PA – Training MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 See EV-1 2 Slow release allows for incident response (not credited)

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
EV-4	Release of waste	Equipment malfunction due to corrosion from incompatibility, resulting in leaks	Approximately 100 gal of concentrate and/or dilute mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, &inspection (unit) PA – Training PE – Equipment Design MA – Incident response MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 Volume of concentrate collected or in hold-up is approximately 100 gal per tower 2 Volume of concentrate collected or in hold-up is approximately 100 gal per tower 3 Both the LLW evaporator and the MLLW evaporator are considered in the Evaporator HA events 4 Slow release allows for incident response (not credited) 5 In this case, leaks occur under vacuum, which result in substantially reduced worker consequence. No credit taken for equipment design. 6 Training can reduce placement of incompatible materials
EV-5	Fire	Immiscible flammable liquids igniting by changing electrical potential	Approximately 100 gal concentrate and/or dilute mixed radiological/chemical wastewater Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training PE – Equipment Design MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 See EV-1 2 Mischaracterization of waste is considered human error and may result in a fire 3 Equipment operations (design) substantially reduces oxygen in the system and also rapidly removes volatiles toward cold surfaces
EV-6	Release of refrigerant	System leak due to pressure relief or incompatibility with the waste in contact with heat exchange surfaces	Approximately 1,000 lb of refrigerant (e.g., r-22, 907c, 134A)	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PE – Equipment Design MA – Inventory controls*	A	L	L	III	III	1 Evaluation was based on questions that are historically asked about refrigerant in evaporators of this magnitude. This type of incident is considered industrial in nature. Mitigative controls do reduce the frequency of leaks but not by an order of magnitude. To date, release of refrigerant has not posed worker or public consequences.

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
EV-7	Refrigerant Fire	System leaks onto hot surfaces and ignites	Approximately 1,000 lb of refrigerant	U	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PE – Equipment Design MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 See EV-6 2 Technically, refrigerants can burn but are not flammable and are so volatile as to not be able to build up enough internal heat to ignite under most circumstances

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Filtration Module															
FM-1	Release of waste	Forklift or other vehicle collides with filtration system(s), resulting in spill	Approximately 55 gal of mixed radiological/chemical wet sludges Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (vehicles) PA – Training PE – Equipment Design MA – Inventory controls* MA – Incident response MA – Personnel evacuation	U	L	L	III	III	1 Operating history shows little or no airborne release when sludge is exposed to the air, next to personnel. 2 Human error assumed as the initiator 3 Volume of sludge collected or in hold-up is less than or equal to 55 gal constrained by equipment design and operational necessity
FM-2	Release of waste	Equipment malfunction due to corrosion from incompatibility, resulting in leaks of sludge	Approximately 55 gal of mixed radiological/chemical wet sludges Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PA – Training PE – Equipment Design MA – Incident response MA – Personnel evacuation MA – Inventory controls*	A	L	L	III	III	1 See FM-1 2 Leaks happen as a matter of routine, most commonly due to the scenarios described. Consequences of these routine leaks are typically negligible for a worker; “low” was used to be conservative

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				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
FM-3	Fire	Immiscible flammable liquids igniting by changing electrical potential	Approximately 55 gal of mixed radiological/chemical wet sludges Radiological hazard is bounding concern (Cat 2 threshold)	U	L	L	III	III	PA – Approved procedures PA – Training MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler system	U	L	L	III	III	1 See FM-1 2 Mischaracterization of waste is considered human error and may result in a fire 3 Note that entire 55 gal of waste will not burn, only the small portion over the amount of sludge, but the order of magnitude in consequence would not change
Glove Box (696S)															
GB-1	Spill of waste	While loading 696S glove box, container contents completely spill to the ground (single 85-gal container)	Low-level waste	A	L	L	III	III	PA – Approved Procedures PA – Maintenance testing and inspection PA – Training PE – Equipment Design MA – Personnel evacuation MA – Radiation Protection Program MA – Inventory control* MA – Enclosed room	A	L	L	III	III	1 The 696S glove box room is closed when loading and after evacuation, and acts to mitigate radiation release and reduce public consequences (not credited)
GB-2	Fire in 696S glove box	Activities while handling waste within the 696S glove box cause waste items to catch fire (contents of one source container and 2 destination containers, about 25 cubic feet)	Low-level waste	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Glove box MA – Inventory controls* MA – Personnel evacuation MA – Radiation Protection Program ME – Fire suppression systems in glove box ME – Fire sprinkler systems in building	U	L	L	III	III	1 See GB-1 2 Fire requires initiating and enabling events
GB-3	Breach of 696S glove box	While working in 696S glove box, worker breaches glove box (contents of one source container and 2 destination containers, about 25 cubic feet)	Low-level waste	A	L	L	III	III	PA – Approved Procedures PA – Training MA – Personnel evacuation MA – Radiation Protection Program MA – Inventory controls*	A	L	L	III	III	1 See GB-1

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
GB-4	Breach of 696S glove box	Cylinder initiated missile breaching glove box (contents of one source container and 2 destination containers, about 25 cubic feet)	Low-level waste	U	L	L	III	III	PA – Approved Procedures PA – Training MA – Personnel evacuation MA – Inventory controls*	U	L	L	III	III	1 See GB-1

ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
Process Off Gas System															
PG-1	Release of acid scrubber solution	Equipment malfunction due to corrosion from incompatibility, resulting in leaks of sludge	Approximately 300 gal dilute acidic or caustic chemical solution	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PE – Equipment Design MA – Personnel evacuation	A	L	L	III	III	1 Range of scrubbing solution is typically pH 4 – 11 2 Carbon fire not considered as fire with large MAR; such fire is considered elsewhere
Reagent System															
RS-1a	Spill	Vehicle collides into single reagent tank causing slow/small spill of one reagent	400 gal of sulfuric acid, sodium hydroxide, ferric sulfate, or hydrogen peroxide	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Equipment Design MA – Emergency Response ME - Sump	EU	L	L	IV	IV	1 Accident into polymer station not considered because no toxic material is at risk 2 Reagent material is not combustible 3 Salt solutions are non-volatile, sulfuric acid less volatile than water 4 Chemical contact hazard (SIH), not inhalation hazard, is cause of injury (contact consequences are potentially negligible) 5 Personnel evacuation is a natural response 6 Vehicle provides an inherent degree of separation from breach 7 Yard configuration naturally inhibits vehicles from fast speeds

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
RS-1b	Spill	Vehicle collides into single reagent tank causing large/rapid spill of one reagent	400 gal of sulfuric acid, sodium hydroxide, ferric sulfate, or hydrogen peroxide	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Equipment Design MA – Emergency Response ME - Sump	EU	L	L	IV	IV	1 See RS-1a
RS-2	Spill	Vehicle collides into adjacent reagent tanks causing spill of reagents	800 gal total spilled of NaOH +NaOH; NaOH + $Fe_2(SO_4)3$; $Fe_2 (SO_4)3+$ H_2SO_4; $H_2SO_4+H_2O_2$	EU	M	L	III	IV	PA – Approved procedures PA – Maintenance testing and Inspection PA – Training PE – Equipment Design MA – Emergency Response ME - Sump	EU	M	L	III	IV	1 More than two simultaneous tank ruptures are considered beyond extremely unlikely 2 Chemical contact hazard (SIH), not inhalation hazard, is cause of injury. Worker may suffer minor burns but no hospitalization required 3 Reactions do not generate gas that are significantly more hazardous than reagents (See RS-1b) 4 Hydrogen peroxide that is mixed randomly without special preparation does not form an explosive material 5 Personnel evacuation is a natural response 6 Vehicle provides an inherent degree of separation from breach 7 Yard configuration naturally inhibits vehicles from fast speeds
RS-3	Release of reagent	Equipment malfunction due to corrosion, resulting in leaks	400 gal of sulfuric acid, sodium hydroxide, ferric sulfate, or hydrogen peroxide	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection PE – Equipment Design MA – Emergency Response ME - Sump	A	L	L	III	III	1 See RS-1a 2 Leaks happen as a matter of routine, and are primarily due to normal corrosion or deterioration. 3 Chemical contact hazard (SIH), not inhalation hazard, is cause of injury (contact consequences are potentially negligible) 4 Personnel evacuation is a natural response

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
RS-4	Release of reagent	Chemical delivery truck hose leaks or connection breaks while loading one of the tanks	5000 gal of sulfuric acid, sodium hydroxide, ferric sulfate, or hydrogen peroxide	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Equipment Design MA – Emergency Response	U	L	L	III	III	1 See RS-3 2 Includes a scenario in which a truck connected to the reagent tank can roll away from parked position, severing hose, which is less likely than a routine leak. 3 Chemical contact hazard (SIH), not inhalation hazard, is cause of injury (contact consequences are potentially negligible) 4 Personnel evacuation is a natural response 5 Chemical delivery truck present ~10 hours/year; last delivery truck was only 350 gal in 2005.
RS-5	Release of reagent	Inadvertant connection of chemical delivery truck hose to wrong container causing mixing of different reagents. Results in over-pressurizing tanks and release reagent (non-explosive)	400 gal of NaOH +NaOH; NaOH + $Fe_2(SO_4)3$; $Fe_2 (SO_4)3$+ H_2SO_4; H_2SO_4+H_2O_2	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection PE – Equipment Design MA – Emergency Response ME - Sump	A	L	L	III	III	1 Tanks have adequate venting, but not considered in frequency mitigation 2 Personnel evacuation is a natural response 3 Chemical contact hazard (SIH), not inhalation hazard, is cause of injury (contact consequences are potentially negligible) 4 Hydrogen peroxide that is mixed randomly without special preparation does not form an explosive material
Reactive Waste Processing Area															
RW-1	Release of waste	Operator error resulting in slow release spill	Approximately 55-gal of mixed radiological/chemical waste that has been treated Chemical hazard is bounding concern	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance and Inspections PE – Equipment design MA – Inventory controls* MA – Incident response MA – Personnel evacuation	A	L	L	III	III	1 Human error assumed as the initiator 2 Reactive Waste Processing by its very nature treats small quantities of waste. 55-gal is based on permit restrictions 3 Includes fume hood, glove box, and lab packing operations

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				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
RW-2	Release of waste	Equipment malfunction due to mechanical failure results in release	Approximately 55-gal of mixed radiological/chemical waste that has been treated Chemical is bounding concern	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PE – Equipment design MA – Incident response MA – Inventory controls* MA – Personnel evacuation MA – Radiation Protection Program	A	L	L	III	III	1 See RW-1 2 Leaks happen as a matter of routine. Consequences of the leak are low to the worker for this waste 3 Respirators for the worker are required whenever a process batch will be > 0.52 PE-Ci
RW-3	Fire	Chemical reaction (e.g., loss of glove box inerting ability) resulting in ignition of evolved gas (e.g., hydrogen or methane) or waste material	Approximately 82 kg of regulated waste	U	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PA – Training PE – Equipment design MA – Inventory controls* MA – Emergency Response MA – Radiation Protection Program ME – Fire sprinkler system	U	L	L	III	III	1 See RW-1 2 Mischaracterization of waste is considered human error and may result in a fire 3 Respirators for the worker are required whenever a process batch will be > 0.52 PE-Ci 4 Personnel evacuation is a natural response
RW-4a	Release of toxic gas	Incompatible chemicals are inadvertently mixed in the reaction system releasing toxic gases from chemicals not identified as extremely hazardous substance	Approximately 15-gal of mixed radiological/chemical waste batch in reaction vessel Chemical hazard is bounding concern	U	L	L	III	III	PA – Approved procedures PA – Training PE – Equipment design MA – Personnel evacuation	U	L	L	III	III	1 See RW-1 2 Toxic gas release happens routinely and is expected but is not released in sufficient quantities to pose a hazard. 3 This bounds passivation activities in the labpack area

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
RW-4b	Release of toxic gas	Incompatible chemicals are inadvertently mixed in the reaction system releasing toxic gases (e.g., cyanide and/or sulfide) from chemicals identified as extremely hazardous substance	Approximately 15-gal of mixed radiological/chemical waste batch in reaction vessel Chemical hazard is bounding concern	EU	M	M	III	III	PA – Approved procedures PA – Training PE – Equipment design MA – Emergency Response	EU	M	M	III	III	1 See RW-1 2 To produce high quantities of high concentrated incompatible chemicals requires multiple enabling conditions over significant time. There is infrequent cyanide and/or sulfide loading and infrequent use of acids on that waste type 3 This bounds passivation activities in the labpack area 4 The primary waste streams would be described as industrial hazardous waste. Several inventories showed less than 1 in 100 containers to be extremely hazardous substances, which reduces the frequency of an accident by one bin. 5 Personnel evacuation is a natural response 6 Worker is aware of hazard due to obvious reaction (bubbling and heat)
RW-5	Release of reagents	System leak due to mechanical failure of reaction system causes release of reagent	Approximately 55 gal of chemical reagent concentrated solutions (e.g., sodium hydroxide, or sulfuric acid)	A	L	L	III	III	PA – Approved procedures PA – Maintenance Inspection (unit) PE – Equipment design MA – Emergency Response	A	L	L	III	III	1 See RW-1 2 Personnel evacuation is a natural response 3 Small release of chemical contact hazard (SIH), not inhalation hazard, is cause of injury (contact consequences are potentially negligible)

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
RW-6	Release of waste and/or reagent	During uranium deactivation operation: Operator error resulting in spill	One container of wet sludge, primarily natural or depleted uranium and its alloys and/or a 55-gal equivalent of concentrated acid solutions	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection (vehicles) PA – Training PE – Equipment Design MA – Inventory controls*	A	L	L	III	III	1 Human error assumed as the initiator 2 Historical experience demonstrates operations involving dumping uranium waste out on a table for repackaging caused no worker consequences 3 Spills of concentrated acids have occurred in our facilities with negligible worker or off-site consequences
RW-7	Release of waste	During uranium deactivation operation: Equipment malfunction due to corrosion from incompatibility resulting in leaks of sludge	One container of wet sludge, primarily natural or depleted uranium and its alloys and/or a 55-gal equivalent of concentrated acid solutions	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, &inspection (unit) PA – Training PE – Equipment Design MA – Inventory controls*	A	L	L	III	III	1 See RW-6 2 Leaks happen as a matter of routine. Consequences of these routine leaks are negligible to the public
RW-8	Fire	During uranium deactivation operation: Rapid dissolution of uranium metal through moderate-rate reaction or exposure of finely divided bare metal to the air	82-kg uranium (as natural), 7e-3 PE-Ci wet sludge	A	L	L	III	III	PA – Approved procedures PA – Training MA – Inventory controls* MA – Emergency Response	A	L	L	III	III	1 Operations involving dumping uranium waste out on a table for repackaging showed no worker consequences 2 Uranium does not present significant threat to public; no other isotopes present in appreciable quantities 3 Personnel evacuation is a natural response; release is too small and/or slow to cause moderate worker exposure 4 Historical data from this operation demonstrates the rate to be moderately paced

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
RW-9	Release of toxic gas	During uranium deactivation operation: Incompatible chemicals are inadvertently mixed in the uranium deactivation process resulting in gas release	One container of wet sludge, primarily natural or depleted uranium and its alloys and/or a 55-gal equivalent of concentrated acid solutions Chemical hazard is bounding concern	A	L	L	III	III	PA – Approved procedures PA – PPE PA – Training PE – Equipment Design MA – Emergency Response	A	L	L	III	III	1 See RW-6 2 Toxic gas release is not expected but will be similar in consequence to the release of acid (saturated halogenated acid vapor) 3 Personnel evacuation is a natural response; release is too small and/or slow to cause moderate worker exposure
Small Scale Treatment															
SS-1	Release of chemical	Operator error resulting in small chemical spill	15-gallons waste or product chemical	A	L	L	III	III	PA – Approved procedure PA – Training PE – Equipment design MA – Emergency Response ME – Chemical Hood	A	L	L	III	III	1 Human error assumed as the initiator
SS-2	Radiation	Operator error resulting in small release of radiological waste, release of radiological standard, or breach of sealed source	0.52 PE- Ci	A	L	L	III	III	PA – Approved procedure PA – Training PE – Equipment design MA – Inventory controls* MA – Emergency Response ME – Chemical Hood	A	L	L	III	III	1 Human error assumed as the initiator 2 Small Scale Lab and Instrument Lab typically has <Cat 3 levels of radiological material (small lab)
Solidification Unit															
SU-1	Release of uncured stabilized waste	Operator error	55 gal of uncured mixed radiological/chemical stabilized waste Radiological hazard is bounding concern (Cat 2 threshold)	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, testing, & inspection MA – Inventory controls*	A	L	L	III	III	1 Human error assumed as the initiator 2 Reagents used in stabilization are in small quantities and present minimal risk to workers 3 Partially stabilized waste cannot produce ARFs near those found in solid wastes considered above

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Tank Farm															
TF-1	Tank /pipe rupture	Vehicle collides with tank, pipes, or appurtenances dispersing contents	4,500 gal of dilute mixed radiological/chemical wastewater Aqueous radiological material (56 PE-Ci) is bounding concern. Very dilute chemical material	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Tank Farm Structure MA – Inventory controls* MA – Emergency Response	U	L	L	III	III	1 Human error assumed as the initiator 2 Accident involving multiple tanks is beyond extremely unlikely 3 The Reagent System scenarios bound waste handling accidents involving chemical releases. 4 Simple leaks of aqueous solution have a low radiological ARF and RF
TF-2	Tank /pipe rupture	Vehicle collides with tank, pipes, or appurtenances; waste released; and/or subsequent fire	4,500 gal of dilute mixed radiological/chemical wastewater Aqueous radiological material (56 PE-Ci) is bounding concern. Very dilute chemical material	EU	L	L	III	IV	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Tank Farm Structure MA – Inventory controls* MA – Emergency Response	EU	L	L	III	IV	1 Human error assumed as the initiator 2 Mitigated accident involving multiple tanks is beyond extremely unlikely 3 Simple leaks of aqueous solution have a low radiological ARF and RF 4 A subsequent fire is less frequent and has consequences bounded by TF-1
TF-3	Inadvertent release	Operator error results in release of waste to facility floor	4,500 gal of dilute mixed radiological/chemical wastewater Aqueous radiological material (56 PE-Ci) is bounding concern. Very dilute chemical material	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection MA – Inventory control* MA – Emergency Response	A	L	L	III	III	1 Human error assumed as the initiator 2 Slow release allows time for incident response and reduce consequences (not credited) 3 Simple leaks of aqueous solution have a low radiological ARF and RF

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
TF-4a	Incompatible chemicals/ causes release of gas	Operator error causes evolution of hazardous gas from chemicals not identified as extremely hazardous substance	4,500 gal of dilute mixed radiological/chemical wastewater Dilute chemical hazard is bounding concern	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection MA –Emergency Response	U	L	L	III	III	1 Human error assumed as the initiator 2 Concurrent initiating and enabling events are unlikely
TF-4b	Incompatible chemicals/ causes release of gas	Operator error causes evolution of hazardous gas (e.g., cyanide and/or sulfide) from chemicals identified as extremely hazardous substance	4,500 gal of dilute radiological/chemical wastewater Dilute chemical hazard bounding concern	EU	M	L	III	IV	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection MA – Inventory controls* MA – Emergency Response	EU	M	L	III	IV	1 Human error assumed as the initiator 2 To produce high quantities of high concentrated incompatible chemicals requires multiple enabling conditions over significant time. There is infrequent cyanide and/or sulfide loading and infrequent use of acids on that waste type 3 The primary waste streams would be described as industrial hazardous waste. Several inventories showed less than 1 in 100 containers to be extremely hazardous substances, which reduces the frequency of an accident by one bin. 4 Worker is aware of hazard due to obvious reaction (bubbling and heat) 5 Radiological material is contained in solution; release is negligible

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Waste Storage/Staging/Handling															
WH-1	Vehicle accident, radiation	Vehicle collides with container causing rupture, waste spills	5000 gallons of mixed radiological/chemical wastewater, 50 PE-Ci	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator 2 5,000 gal is a tanker, which is considered the largest volume spilled 3 Tanker containment provides protection when in use. Drainage guides liquids away from workers.
WH-2	Vehicle accident, radiation	Vehicle collides with array of drums, waste water spills	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Approved container MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 Human error assumed as the initiator
WH-3	Vehicle accident, radiation, fire	Vehicle collides with array of drums, waste water spills, fire spreads to other arrays	Mixed radiological/chemical waste; 56 PE-Ci	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance testing and Inspection PE – Approved container MA – Inventory controls* MA – Personnel evacuation	EU	L	L	IV	IV	1 See WH-2 2 Accident involving multiple containers followed by a fire is considered extremely unlikely
WH-5	Vehicle accident, fire, radiation	Vehicle collides with multiple containers of solid waste; waste released, fuel leaks, fire	Mixed radiological/chemical waste; 56 PE-Ci	EU	L	L	IV	IV	PA – Approved procedures PA – Training PA – Maintenance and Inspection (vehicle) PE – Approved container MA – Inventory controls* MA – Personnel evacuation	EU	L	L	IV	IV	1 See WH-2 2 Accident involving multiple containers followed by a fire is considered extremely unlikely

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
WH-6	Deflagration, radiation	TRU waste in a vented or unvented container builds up hydrogen, gas in headspace ignites, container leaks, and deflagration	50PE-Ci	EU	M	M	III	III	PA – Approved procedures PA – Maintenance testing and Inspection PE – Approved container MA – Inventory controls* MA – Personnel evacuation ME – Fire sprinkler system	EU	M	M	III	III	1. Radiolysis occurring in low level waste drums would be considered beyond extremely unlikely 2. Oversized containers are primary sources, 3.7 PE-Ci is the historical largest single container amount, most are less than 1 PE-Ci 3. Facility does not store TRU waste for long periods of time, causing frequency EU for both vented and unvented containers
WH-8	Fire, radiation	Electrical failure initiates small fire impacting waste containers	Mixed radiological/chemical waste; 56 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – Maintenance and Inspection PE – Approved container MA – Personnel evacuation MA – Combustible Control Program MA – Inventory controls* ME – Fire sprinkler system	A	L	L	III	III	1 Electrical failure assumed as the initiator. 2 Combustible material that is not contaminated waste is limited to reduce fire spread
WH-9	Fire, radiation	Welding operation initiates small fire impacting waste container	Involves 1 container mixed radiological/chemical waste; 50 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – Maintenance, testing, & inspection PE – Approved container MA – Personnel evacuation MA – Combustible Control Program MA – Inventory controls* ME – Fire suppression system sprinkler	A	L	L	III	III	1 Welding fire assumed as the initiator. 2 Combustible material that is not contaminated waste is limited to reduce fire spread
WH-10	Radiation	Crane containing heavy load strikes and breaches waste containers	Mixed radiological/chemical waste; 56 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, Testing and Inspection MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	1 Human error assumed as the initiator 2 Seismic event may also be an initiator (frequency would be U)

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
WH-11	Fire, radiation	Crane containing heavy load strikes and breaches waste containers, fire ensues	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Approved procedures PA – Training PA – Maintenance, Testing and Inspection MA – Inventory controls* MA – Personnel evacuation	U	L	L	III	III	1 See WH-10 2 Concurrent fire reduces unmitigated frequency
WH-12	Radiation, fire	Flammable compressed gas cylinder ruptures and causes fire that impacts B695 Segment	Mixed radiological/chemical waste; 56 PE-Ci containerized waste	EU	L	L	IV	IV	PA – Approved procedures PA – Maintenance, testing, & inspection MA – Personnel evacuation MA – Combustible Control Program MA – Inventory controls* ME – Fire sprinkler system	EU	L	L	IV	IV	1 Release of flammable gas and subsequent fire is considered extremely unlikely due to infrequent welding operations and knowledge of historical industrial welding accidents
WH-13	Radiation	One or more drums fall and breach during payload assembly or payload transport; waste spills.	Mixed radiological/chemical waste; 56 PE-Ci	A	L	L	III	III	PA – Approved container PA – Training MA – Inventory controls* MA – Personnel evacuation	A	L	L	III	III	
WH-14	Spill	Waste containers fall (greater than 4 feet) while loading/unloading a vehicle (e.g., using the loading dock) or stacking containers causing a spill of waste and release of radioactive material.	Mixed radiological/chemical waste; 56 PE-Ci containerized waste	A	L	L	III	III	MA – Inventory controls* MA – Personnel evacuation PE – Approved containers PA – Training PA – Maintenance, testing and inspection	A	L	L	III	III	
WH-15	Lithium hydride fire	Fire initiated by general facility fire burns lithium hydride container	<10 lb solid lithium hydride dispersed throughout container with tritium contamination Lithium hazard bounds the tritium hazard	U	L	L	III	III	MA – Combustible Control Program ME – Fire sprinkler system PA – Maintenance, testing, & inspection MA – Emergency Response	U	L	L	III	III	1 Tritium is <100 Ci 2 Inadvertent activation of fire sprinklers is bounded by this scenario 3 Lithium hydride is stored/handled in small, discreet subunits. 4 Containers typically have <<10 lbs of LiH..

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
WH-16	Lithium hydride fire	Fire initiated by general facility fire burns lithium hydride container	Approximately 50 lb solid lithium hydride dispersed throughout container with tritium contamination Lithium hazard bounds the tritium hazard	EU	M	L	III	IV	MA – Combustible Control Program ME – Fire sprinkler system PA – Maintenance, testing, & inspection MA – Emergency Response	EU	M	L	III	IV	1 Tritium is <100 Ci 2 Inadvertent activation of fire sprinklers is bounded by this scenario
WH-17	Spill	Operator error during container handling activities (e.g., labpacking, filling/emptying container, opening/closing lid) causes drum to spill in B695, B696S, or yard area	55 gal of chemical waste	A	L	L	III	III	PA – Approved procedures PA – PPE PA – Training	A	L	L	III	III	1 Human error assumed as the initiator
WH-18	Spill	Operator error during container handling activities (e.g., labpacking, filling/emptying container, opening/closing lid) causes drum to spill in B695, B696S, or yard area	55 gal of radiological waste <56 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – PPE PA – Training MA – Inventory controls*	A	L	L	III	III	1 Human error assumed as the initiator

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Waste Packaging Unit															
WP-1	Spill	While handling waste (other than TRU) within the Waste Packaging Unit, container contents completely spill to the ground	112 cubic feet of solid mixed radiological/chemical waste, <50 PE-Ci	A	L	L	III	III	PA – Approved procedures PA – PPE PA – Training MA – Personnel evacuation MA – Inventory controls*	A	L	L	III	III	1 Human error assumed as the initiator

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
WP-2	Fire	Activities while handling waste (other than TRU) within the Waste Packaging Unit cause waste items to catch fire	112 cubic feet of solid mixed radiological/chemical waste, <50 PE-Ci	U	L	L	III	III	PA – Approved procedures PA – PPE PA – Training MA – Personnel evacuation ME – Fire sprinkler system MA – Inventory controls*	U	L	L	III	III	1 Human error assumed as the initiator

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
External Events															
EX-1	External fire	Fire from combustible and/or flammable liquids in the maintenance shop and/or backup generator	56 PE-Ci containerized mixed radiological/chemical waste	EU	L	L	IV	IV	PE – Approved containers PA – Approved procedures PE – Equipment Design MA – Personnel evacuation MA – Inventory controls* ME-Significant space between facilities	EU	L	L	IV	IV	1 Flammable liquids are stored for use in the maintenance shop 2 Diesel fuel is used to run backup generator 3 Total loss of power due to transformer and generator failure would have consequences similar to or less than indicated (waste material still contained within facility or unit)
EX-2	External fire	Chemical fire in B697, or DWTF Storage Area resulting in fire and release in B695 Segment	56 PE-Ci containerized mixed radiological/chemical waste	EU	L	L	IV	IV	PE – Approved containers PA – Approved procedures PA – Maintenance, testing, & inspection PE – Equipment design MA – Personnel evacuation MA – Inventory controls* ME-Building structure ME-Significant space between facilities ME – Fire sprinkler systems	EU	L	L	IV	IV	1 External fires are considered extremely unlikely
EX-3	Radiation	Accident at nearby facility releases material or debris to cause release in B695 Segment (e.g., projectile)	56 PE-Ci containerized mixed radiological/chemical waste	EU	L	L	IV	IV	PA – Maintenance, testing, & inspection PE – Approved containers MA – Personnel evacuation MA – Inventory controls* ME – Building structure	EU	L	L	IV	IV	1 Explosions or releases of toxic materials at nearby facilities that can affect B695/B696S segment are considered extremely unlikely 2 Material transitioning through the segment is considered in this scenario

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
EX-4	Radiation	Nonflammable compressed gas cylinder ruptures and becomes projectile(s)	56 PE-Ci containerized mixed radiological/chemical waste	EU	L	L	IV	IV	PA – Approved Procedures PA – Maintenance, testing, & inspection PE – Approved containers MA – Personnel evacuation MA – Inventory controls* ME – Building structure	EU	L	L	IV	IV	1 Nearest compressed gas cylinders are located along the east wall of B695
EX-5	Radiation, fire	Flammable compressed gas cylinder ruptures and causes fire that impacts B695 Segment	56 PE-Ci containerized mixed radiological/chemical waste	EU	L	L	IV	IV	PA – Approved Procedures PA – Maintenance, testing, & inspection PE – Approved containers MA – Personnel evacuation MA – Inventory controls* ME – Building structure ME – Fire sprinkler system	EU	L	L	IV	IV	1 See EX-3
EX-6	Fire, radiation	Airplane crashes into segment, waste released, resultant fuel leak, fire impacts B695 Segment	56 PE-Ci containerized mixed radiological/chemical waste	EU	M	M	III	III	PE – Approved containers MA – Emergency Response MA – Inventory controls*	EU	M	M	III	III	1 Personnel evacuation involves workers evacuating the area 2 Does not evaluate for workers directly impacted by airplane 3 Given the limited amount of radiological material (Cat 3) at facility, the estimated consequence for worker is Moderate

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
FA-1	Radiation, spill	Firearm carried by security personnel inadvertently discharges breaching a container or equipment containing waste releasing material	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure	U	L	L	III	III	1 LLNL security requirements forbid workers from bringing firearms into facility 2 Armed security personnel are not assigned to the facility and rarely visit facility 3 Inadvertent firearm discharge caused by operator error, equipment malfunction or failure

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				Unmitigated						Mitigated					
FA-2	Radiation, spill	Firearm carried by security personnel inadvertently discharges breaching a nonflammable compressed gas cylinder which ruptures, creating projectile(s)	Mixed radiological/chemical waste; 56 PE-Ci	BEU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure	BEU	L	L	IV	IV	1 See FA-1 2 Secondary event (projectiles breaching a radioactive material container or system) considered BEU since initiator frequency is sufficiently small compared to the current analysis.
FA-3	Radiation, fire	Firearm carried by security personnel inadvertently discharges breaching a flammable compressed gas cylinder which ruptures, creating projectile(s), and fire results	Mixed radiological/chemical waste; 56 PE-Ci	BEU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure ME – Fire sprinkler system	BEU	L	L	IV	IV	1 See FA-2
FA-4	Radiation, fire	Firearm carried by security personnel inadvertently discharges breaching a container or equipment containing waste, releasing material and fire results	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure ME – Fire sprinkler system	U	L	L	III	III	1 See FA-1

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				Unmitigated						Mitigated					
FA-5	Radiation, deflagration	Firearm carried by security personnel inadvertently discharges breaching waste container causing ignition of flammable gas resulting in deflagration and release of radioactive materials	56 PE-Ci	EU	M	L	III	IV	PA – Security controls PE – Security controls PA – TRU waste container maintenance program* MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure ME – Fire sprinkler system	EU	M	L	III	IV	1. See FA-1 2. The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program that minimizes the potential for hydrogen accumulation. 3. The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low for the worker, which is consistent with the effects of a spill event. 4. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for deflagration in the DSA
FA-6	Chemical spill	Firearm carried by security personnel inadvertently discharges breaching a container or reagent tank releasing material	Mixed radiological/chemical waste or reagent chemical; 56 PE-Ci	EU	M	M	III	III	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure	EU	M	M	III	III	1 See FA-1 2 Known reagent release maximum quantity does not result in moderate consequence. Complete inventory release for reagents in the tank at B695 has been evaluated in the DSA. (e.g., sulfuric acid, hydrogen peroxide, others) 3 Chemicals in B695 extremely dilute, or in low quantities. 4 The primary waste stream would be described as industrial hazardous waste. Chemical Health Risk Assessment demonstrates low hazard.

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ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
FA-7	Chemical fire	Firearm carried by security personnel inadvertently discharges breaching a container or reagent tank releasing material and fire results	Mixed radiological/chemical waste or reagent chemical; 56 PE-Ci	BEU	M	M	IV	IV	PA – Security controls PE – Security controls MA – Personnel evacuation MA – Inventory controls* MA – Emergency response ME – Building structure ME – Fire sprinkler system	BEU	M	M	IV	IV	1 See FA-6 2 Secondary event (resulting fire) considered BEU because initiator frequency is sufficiently small compared to the current analysis.
Natural Phenomenon Hazards															
NPH-1	Earthquake fire	Gas line breaks causing fire near source or at boiler	Mixed radiological/chemical waste; 56 PE-Ci	EU	L	L	IV	IV	PA – Maintenance, testing, & inspection PE – Approved containers MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked MA – Inventory controls* MA – Personnel evacuation ME - Building structure* ME - Fire sprinkler system	EU	L	L	IV	IV	1 B695 Segment buildings and fixtures, and gas line comply with the ES&H Manual Seismic Safety Program 2 Chillers and other appurtenances (e.g., air compressor, utility source lines, electrical distribution) would have no greater impact 3 A DBE is unlikely; concurrent fire following an earthquake affecting MAR is extremely unlikely 4 TRU waste containers are designed to withstand 4-ft drops, and will stay sealed and reduce fire consequences 5 Includes toppling and sliding of equipment.
NPH-2	Design basis wind, radiation,	High wind (up to 72 mph) impacts building and yard, wind and debris enters through open doors, waste spills in yard or building	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Maintenance, testing, & inspection PE – Approved containers MA – Inventory controls* ME - Building structure*	U	L	L	III	III	1 Building designed to PC-2 wind criteria (72 mph) 2 Approved containers for TRU reduce spill frequency 3 High winds disperse materials and make the consequences minor

*Asterisk signifies initial condition for scenario development. **Double asterisk signifies credited control for reducing frequency or consequence.

ID No.	Hazard	Scenario	Material At Risk	Unmitigated					Control Type/ Controls	Mitigated					Comments
				Freq	Consequence		Risk			Freq	Consequence		Risk		
					W	P	W	P			W	P	W	P	
NPH-3	Lightning, fire, radiation	Lightning strikes building structures, resultant fire, which impacts containers	Mixed radiological/chemical waste; 56 PE-Ci	EU	L	L	IV	IV	PE – Electrical grounding system PE – Approved containers MA – Personnel evacuation MA – Inventory controls* ME - Fire sprinkler system	EU	L	L	IV	IV	1 Lightning striking the building is considered extremely unlikely
NPH-4	Lightning, fire, radiation	Lightning strikes waste containers stored in yard areas, fire, waste released	Mixed radiological/chemical waste; 56 PE-Ci	EU	L	L	IV	IV	PE – Approved containers MA – Personnel evacuation MA – Inventory controls*	EU	L	L	IV	IV	1 Lightning striking the containers in the yard is considered extremely unlikely
NPH-5	Design basis flood, radiation	Heavy rains cause design basis flooding in buildings and yard areas, containers are knocked over by running water and spill	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PE – Approved containers MA – Inventory controls*	U	L	L	III	III	1 Waste container failures due to flood are only considered for completeness and are bounded by other NPH
NPH-6	Design basis earthquake, radiation	Design basis earthquake impacts facilities, process equipment and drums topple, waste spills	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked** PA – Maintenance, testing, & inspection PE – Approved containers MA – Inventory controls* MA – Personnel evacuation ME - Building structure*	U	L	L	III	III	1 Buildings and fixtures designed to PC-2 earthquake criteria. 2 A DBE is unlikely 3 TRU waste containers designed to withstand 4-ft drop. 4 B696S glove box built to PC-2. 5 Includes toppling and sliding of equipment.
NPH-7	Design basis earthquake fire, radiation	Design basis earthquake impacts facilities, initiates fire, drums topple, waste released	Mixed radiological/chemical waste; 56 PE-Ci	U	L	L	III	III	PA – Maintenance, testing, & inspection PE – Approved containers MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked MA – Inventory controls* MA – Personnel evacuation ME - Building structure* ME - Fire sprinkler system	U	L	L	III	III	1 See NPH-6 2 Seismic shut-off as defense-in-depth reduces frequency of fire from gas line. Not credited 3

*Asterisk signifies initial condition for scenario development. **Double asterisk signifies credited control for reducing frequency or consequence.

ID No.	Hazard	Scenario	Material At Risk	Unmitigated Freq	Unmitigated Consequence W	Unmitigated Consequence P	Unmitigated Risk W	Unmitigated Risk P	Control Type/ Controls	Mitigated Freq	Mitigated Consequence W	Mitigated Consequence P	Mitigated Risk W	Mitigated Risk P	Comments
Process Criticality															
PC-1	Criticality	Liquid waste being processed forms an ideal condition and goes critical	MAR > 200 g fissile material	BEU	H	L	III	IV	PA – Approved procedures PA – Criticality Safety Program MA – Personnel evacuation MA – Inventory Controls*	BEU	H	L	III	IV	1 The LLNL Criticality Safety Program as implemented for B695 Segment makes a criticality event incredible 2 Applies to all liquid waste processing units 3 When the worker is close by the consequence is considered high, otherwise is moderate
PC-2	Criticality	Solid waste being processed forms an ideal condition and goes critical	MAR > 200 g fissile material	BEU	H	L	III	IV	PA – Approved procedures PA – Criticality Safety Program MA – Personnel evacuation MA – Inventory Controls*	BEU	H	L	III	IV	1 The LLNL Criticality Safety Program as implemented for B695 Segment makes a criticality event incredible 2 Applies to all solid waste processing units 3 When the worker is close by the consequence is considered high, otherwise is moderate
PC-3	Criticality	Containers exceed the radionuclide fissile material limit, moderator/reflector limits and/or configuration controls and criticality occurs	MAR > 200 g fissile material	BEU	H	L	III	IV	PA – Approved procedures PA – Criticality Safety Program PA – Maintenance, Testing, and Inspection PA – Training PE – Approved container MA – Personnel evacuation MA – Inventory Controls*	BEU	H	L	III	IV	1 The LLNL Criticality Safety Program as implemented for B695 Segment makes a criticality event incredible 2 Applies to all solid and liquids in containers in storage 3 When the worker is close by the consequence is considered high, otherwise is moderate

*Asterisk signifies initial condition for scenario development. **Double asterisk signifies credited control for reducing frequency or consequence.

APPENDIX B
CHEMICAL HAZARDS ANALYSIS

B.1 Liquid Waste Treatment Facility Chemical Hazards

The Resource Conservation and Recovery Act (RCRA) permit issued by the California Department of Toxic Substance Control (DTSC) allows LLNL's Radioactive and Hazardous Waste Management (RHWM) Division to store mixed and hazardous waste material. RHWM also treats the wastes in permitted units and several additional, small-scale treatment processes. Some of the treatment options employ chemicals in amounts that merit evaluation against lists of reportable quantities for chemicals used in industrial or waste treatment settings, or sites contaminated with hazardous materials subject to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulation. The following lists are applicable:

- 40 CFR 302: Designation, Reportable Quantities, and Notification, Table 302.4, List of Hazardous Substances and Reportable Quantities.
- 40 CFR 355: Emergency Planning and Notification, The List of Extremely Hazardous Substances and Their Threshold Planning Quantities.
- 29 CFR 1910: Occupational Safety and Health Standards, Subpart H, Hazardous Materials, Section 1910.119, Process Safety Management of Highly Hazardous Chemicals.

Chemical inventories in excess of the threshold planning quantities (TPQs) in 10 CFR 1910.119 and 40 CFR 355, qualify a facility for an initial hazard classification as a moderate-hazard chemical facility. In such cases, dispersion modeling can be performed and the results compared to toxicity limits [e.g., Temporary Emergency Exposure Limits (TEELs)] to determine whether a final hazard classification as a low-hazard chemical facility is justified. Chemical inventories greater than the reportable quantity (RQ), but less than the TPQs, qualify a facility as a low-hazard chemical facility.

Chemical Hazards Specific to the B695 Segment

It is important to conservatively estimate the hazardous materials used, stored, or treated in the B695 Segment. Evaluation of process chemicals and wastes potentially subject to treatment in the B695 Segment was performed by comparing data compiled in the *Health Risk Assessment for Hazardous and Mixed Waste Management Units at Lawrence Livermore National Laboratory* (Health Risk Assessment) (EPD 1997) and *LLNL Facility Screening Report for Area 514 Facility: B514, B514A, B513, and B513A* (Facility Screening Report) (Wajda 2002 against 40 CFR 302, 40 CFR 355, and 29 CFR 1910..

It was straightforward to estimate the reagent chemical inventories because larger quantities of concentrated reagents used in Tank Farm operations and similar processes bound chemical releases from the segment. The Health Risk Assessment was used to look at chemical constituents that could be found in wastes subjected to various processes. This is an EPA, federally mandated requirement for a facility operating under a RCRA permit and is a conservative and mature methodology recognized by regulators in assessing risk to the public and environment for operating Treatment, Storage, and Disposal facilities.

The Health Risk Assessment used extensive resources and included a comprehensive review of data historically found in existing facilities (e.g., Area 514, which has been replaced by B695 and the associated yard areas within the DWTF segment). Scale-up modifications were done to match facility design and permit capacity. In many instances, waste constituents were double counted by subjecting the identified waste to multiple processes. Such doubling is possible in the B695 Segment; however, each process step would reduce or pacify chemical constituents with each treatment. The Health Risk Assessment did not assume reduction or pacification in its treatment of waste and constituent. In addition, to scale up to design and permit capacities, and the double-counting conservatism, the time frame captured in the assessment averaged over relatively high waste-generation rate years for a variety of wastes.

All processes tabulated in the Process Hazard Analysis (PrHA, see Chapter 3) were also assessed for chemical threats. It was obvious that many processes did not warrant consideration in depth because the chemical constituents involved exist in residue and would be available in quantities much less than the RQ, and far less than the TPQ. Examples of such processes are B696S glove box operations and drum crushing operations. In other words, quantities of chemicals found in waste usually occur as part of the waste or are considered to be the bulk of the waste and not merely a residue. The drum crusher, on the other hand, primarily processes containers that have been emptied, and the glove box is largely used to processes lab trash with little or no chemical constituents. Lithium hydride was the largest quantity of reactive material found in the chemical inventory of the Health Risk Assessment. Because of this, PrHA scenarios (Appendix A, WH-15 and WH-16) were considered to specifically address the bounding case of reactive materials in storage. Other unit operations involve potential chemical inventories that could exceed RQ. However, most of the chemicals do not have established TPQs (moderate hazard threshold).

The Health Risk Assessment was validated recently by looking at Area 514 inventory records when performing a screening to convert that facility into a radiological area. The Facility Screening Report (performed July, 17, 2002) demonstrated that the only chemical exceeding the TPQ was sulfuric acid. No waste constituents were greater than the TPQ.

In summary, the analysis revealed that some of the B695 Segment process chemicals and chemical constituents in the waste inventory meet or exceed RQ thresholds. Further examination determined that only one TPQ limit was reached during evaluation. Sulfuric acid stored in the B695 Segment reagent storage tank does exceed the listed TPQ amount.

To address the issue and aid in assigning a proper hazard classification to the facility, release modeling was performed. In addition to sulfuric acid, hydrogen peroxide used in the facility was also modeled. At the concentration used by the Waste Treatment Group (50%), hydrogen peroxide has no listed TPQ. However, the concentration is close enough to 52% hydrogen peroxide—the concentration at which a TPQ is established—that it was considered reasonable to perform release modeling to address any potential impacts to receptors of concern.

B.2 Reagent Chemicals

The B695 Segment Tank Farm uses several common industrial chemicals during the course of liquid waste treatment. They are:

- Sulfuric acid.

- Sodium hydroxide.
- Hydrogen peroxide.
- Ferric sulfate.
- Granulated activated carbon.
- Other chemical reagents

Sulfuric Acid

Sulfuric acid is the most common industrial chemical in the world and is used in a wide variety of industrial processes. It is an oily, nonvolatile liquid approximately twice as dense as water. The sulfuric acid used in the Tank Farm is 98% industrial-grade material and is used to lower the pH level of aqueous waste to levels acceptable for release to the local Publicly Owned Treatment Works (POTW). The B695 Segment sulfuric acid storage tank can hold approximately 400 gal (2786 kg) of material. The physical nature of sulfuric acid makes it primarily a local corrosive and contact hazard.

The amount of sulfuric acid stored in the B695 Segment exceeds the TPQ threshold (1000 lb, per 40 CFR 355, Appendix A) and initially qualifies the segment as a moderate-hazard chemical facility. Modeling was performed to determine whether a final hazard classification as a low-hazard chemical facility is warranted.

Sodium Hydroxide

Sodium hydroxide is an industrial chemical of significance and is the most prevalent alkaline chemical used commercially. B695 Segment reagent sodium hydroxide is 50% technical grade and is a moderate volatility liquid approximately 1.5 times the density of water. RHWM uses sodium hydroxide to raise the pH level of aqueous waste to levels acceptable for release to the local POTW. The B695 Segment sodium hydroxide storage tank can hold approximately 300 gal (1737 kg) of material. The physical nature of sodium hydroxide makes it primarily a local corrosive and contact hazard.

The amount of sodium hydroxide stored in the B695 Segment exceeds the RQ (1000 lb, per 40 CFR 302.4, Appendix A). There is no TPQ assigned to sodium hydroxide. Therefore, sodium hydroxide qualifies the segment as a low-hazard chemical facility, and no further modeling is required.

Hydrogen Peroxide

Hydrogen peroxide is used to treat organic waste constituents amenable to the oxidation process. The goal is to destroy organic compounds by oxidizing carbon in the waste to carbon dioxide. B695 Segment reagent hydrogen peroxide is 50% technical grade and is a moderate volatility liquid with a density slightly greater than that of water. The B695 Segment hydrogen peroxide storage tank can hold approximately 400 gal (1665 kg) of material. The physical nature of hydrogen peroxide makes it primarily a local contact hazard.

Regulatory limits for hydrogen peroxide are established for a 52% solution. Therefore, the 50% concentration of hydrogen peroxide used in the segment is below the criteria for which regulatory limits are established. Nevertheless, hydrogen peroxide was considered for further evaluation as a conservative step. The amount of hydrogen peroxide stored in the B695 Segment exceeds the TPQ for the 52%

solution (1000 lb per 40 CFR 355, Appendix A). Modeling was performed to determine if a final hazard classification as a low-hazard chemical facility is warranted.

Ferric Sulfate

Ferric sulfate is a flocculent material used to remove suspended solids from aqueous waste. RHWM uses 50% ferric sulfate solution to perform "polishing" of wastewater prior to filtration and discharge to the POTW. The B695 Segment ferric sulfate storage tank can hold approximately 300 gal (1709 kg) of material. The physical nature of ferric sulfate makes it a minor contact hazard.

The amount of ferric sulfate stored in the B695 Segment exceeds the RQ (1000 lb, per 40 CFR 302.4, Appendix A). No TPQ is assigned to ferric sulfate. Therefore, ferric sulfate qualifies the segment as a low-hazard chemical facility, and no further modeling is required.

Granulated Activated Carbon

Granulated activated carbon (GAC) is used in the Tank Farm to pull carbon-bearing wastes out of solution onto surface sites of the solid carbon. The carbon is added manually to waste and is removed from the aqueous phase by filtration. The physical nature of GAC makes it primarily a minor inhalation hazard, but this statement should be qualified because GAC is not a readily dispersible material. Inhalation hazards are of minor concern to workers, and virtually no offsite impact exists.

No RQ or TPQ levels are assigned to GAC. Therefore, GAC qualifies the segment as a general industry chemical facility, and no further modeling is required.

Other Chemical Reagents

Other chemical reagents used in very small quantities were also assessed and are discussed in the RCRA operations plan in Volume 11, Part XIV, Appendix XIV.4R. No RQs or TPQs are exceeded because such chemicals are primarily used for small-scale treatment methods, as discussed earlier.

B.3 Modeling Methods

The ALOHA^{tm} air-release modeling software package was used to analyze potential offsite impacts resulting from chemical hazards associated with B695 Segment operations. ALOHA, which stands for Areal Location of Hazardous Atmospheres, was developed for and adopted by the EPA Chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office (NOAA) of Response and Restoration. Its purpose is to assist chemical emergency planners and first responders in predicting how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release. ALOHA can predict rates of chemical release from broken gas pipes, leaking tanks, and evaporating spill puddles, and it can model the dispersion of both neutrally buoyant and heavier-than-air gases using Gaussian and heavy-gas models.

Air Release Modeling Parameters

LLNL chose to use the DOE-recommended meteorological conditions for analysis of potential chemical releases occurring at the B695 Segment. Conditions were set at Pasquill stability class F with a wind velocity of 1 meter per second (m/s). The temperature was set to the Livermore mean summer temperature of 87.5°F (30.8°C). The release scenario was modeled with locations of concern at 100 and 170 m (exposures at the LLNL fence lines) from the incident. Release heights were set appropriate to the type of incident. Both spills were modeled at a release height of 0 m. The fence-line receptor was set (where receptor height was a user-settable option) to a height of 2 m. In both ALOHA simulations, the software was allowed to self select between light- and heavy-gas dispersion options.

B.4 Release Scenarios

No specific accident scenarios are postulated for either chemical release. The development of accident scenarios with more realistic assumptions (e.g., leak before catastrophic failure) may result in more realistic results. It was assumed that any accident will cause the entire tank contents to be released. Because of the position of the retention sump directly under reagent tanks, all of the reagent release is assumed to be contained within the sump volume. A surface area of 38.75 ft^2 was used as the spill area based on sump dimensions. Additionally, a surface area of 32,083 ft^2 was used as a spill area based on a 5,000 gallon sulfuric acid delivery truck spill assuming a 0.25 inch pool thickness.

Sulfuric Acid

The amount of sulfuric acid in the building exceeds the TPQ of 1000 lb, as listed in 40 CFR 355, Appendix A. From this hazardous material inventory, the initial building classification is that of a moderate chemical hazard facility.

ALOHA Results: Sulfuric acid release from reagent storage tank

Chemical Information:

Chemical name: 98% sulfuric acid
Molecular weight: 98.07 kg/kmol
TLV-TWA: 1 mg/m^3; IDLH: 15 mg/m^3
Default LOC from library: 2 mg/m^3
Footprint level of concern: 2 mg/m^3
Boiling point: 640.0°F
Vapor pressure at ambient temperature: 0 atm
Ambient saturation concentration: 5.54×10^{-6} ppm, or 0%.

Atmospheric Information (manual input of data):

Wind: 1 m/s from W at 2 m   No inversion height
Stability Class: F   Air temperature: 87.5°F
Relative humidity: 25% Ground roughness: open country
Cloud cover: 0.3

Source Strength Information

Puddle area: 38.75 ft^2
Puddle volume: 400 gal
Soil type: concrete
Ground temperature: 87.5°F
Initial puddle temperature: ground temperature

Release duration: ALOHA limited the duration to 1 hour
Maximum computed release rate: 3.15×10^{-11} lb/min
Maximum average sustained release rate: 2.87×10^{-11} lb/min (averaged over 1 min or more)
Total amount released: 0 lb

Time-Dependent Information:

Concentration estimates were calculated at the points East: 100 and 170 m.

A concentration/dose diagram was not drawn because ALOHA modeling yielded no significant concentration/dose at the points selected.

ALOHA Results: sulfuric acid release from 5000 gallon chemical delivery tank trailer.

Chemical Information

Chemical Name: 98% SULFURIC ACID
Molecular Weight: 98.07 kg/kmol
TLV-TWA: 1 mg/(cu m)
IDLH: 15 mg/(cu m)
Default LOC from Library: 2 mg/(cu m)
Footprint Level of Concern: 2 mg/(cu m)
Boiling Point: 540.00° F
Vapor Pressure at Ambient Temperature: 1.46e-07 atm
Ambient Saturation Concentration: 0.15 ppm or 1.48e-05%

Atmospheric Information (manual input of data):

Wind: 1 meters/sec from W at 2 meters
No Inversion Height
Stability Class: F (user override)
Air Temperature: 87.5° F
Relative Humidity: 25%
Ground Roughness: open country
Cloud Cover: 3 tenths

Source Strength Information:

Puddle Area: 32083 square feet
Puddle Volume: 5000 gallons
Soil Type: Concrete
Ground Temperature: 87.5° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 0.00185 pounds/min
Max Average Sustained Release Rate: 0.00177 pounds/min
(averaged over a minute or more)
Total Amount Released: 0.079 pounds

Time-Dependent Information:

Concentration estimates at the points:

East 100 m; maximum concentration = 0.12 mg/(cu m)
East 170 m; maximum concentration = 0.0486 mg/(cu m)

Hydrogen Peroxide

The TPQ for 52% hydrogen peroxide listed in 40 CFR 355, Appendix A, is 1000 lb. Hydrogen peroxide was modeled to demonstrate that, even at the concentration used by RHWM (50%), accidental releases will result in downwind concentrations that are less than TEEL concentration levels for receptors of concern at 100 and 170 m (LLNL fence line).

ALOHA Results

Chemical Information:

Chemical name: hydrogen peroxide
Molecular weight: 34.01 kg/kmol
TLV-TWA: 1 ppm; IDLH: 75 ppm
Default LOC from library: 10 ppm
Footprint level of concern: 10 ppm
Boiling point: 302.36°F
Vapor pressure at ambient temperature: 0.0039 atm
Ambient saturation concentration: 3,926 ppm, or 0.39%.

Atmospheric Information (manual input of data):

Wind: 1 m/sec from W at 2 m   No inversion height
Stability Class: F   Air temperature: 87.5°F
Relative humidity: 25% Ground roughness: open country
Cloud cover: 0.3

Source Strength Information:

Puddle area: 38.75 ft^2
Puddle volume: 400 gal
Soil type: concrete
Ground temperature: 87.5°F
Initial puddle temperature: ground temperature
Release duration: ALOHA limited the duration to 1 hour
Maximum computed release rate: 0.0101 lb/min
Maximum average sustained release rate: 0.01 lb/min (averaged over 1 min or more)
Total amount released: 0.60 lb

Time-Dependent Information:

Concentration estimates at the points:
East 100 m; maximum concentration = 2.45 ppm
East 170 m; maximum concentration = 0.877 ppm.

Analysis of Possible Reagent Interaction

In addition to assuming that a tank breach leads to a simple spill (i.e. one with no interaction between chemicals) into the containment sump, potential interactions between reagent chemicals was examined. Considering the nature of potential RHWM operations, a number of scenarios were proposed.

The first scenario assumes that a single tank is breached by an external source (i.e. chemical delivery vehicle) with no damage to the walls of the berm. In this instance LLNL maintains that the majority of the reagent will be contained by the retention berm but acknowledges that some might escape and contact non-epoxy protected surfaces. A comparison of chemical surface area to release rate of analyzed reagents shows that exposed surface areas can be increased by a factor of 10, at a minimum, without approaching allowable TEEL limits for airborne concentrations. This scenario does not pose a hazard greater than that previously detailed in the DSA.

In the second instance two reagent vessels are forcefully breached and the retention berm remains intact. Again the majority of the reagents are contained separately in their respective retention berms but there is some interaction between reagents in this case. In order to adequately respond to this question it was decided that bench scale tests would be run in order to better understand how the reagents would behave during an event of this type.

Only reagents from adjacent reagent tanks were assumed to interact so the pairs (sulfuric acid/hydrogen peroxide, sulfuric acid/ferric sulfate solution, and sodium hydroxide/ ferric sulfate solution) of reagents were mixed under the following conditions:

- Equal portions of reagents were released simultaneously from pipettes into an Erlenmeyer flask and shaken to insure quick and complete mixing.
- Temperature changes, reaction behavior, and reaction end products were monitored during the tests.
- A Fluke model 725 Multifunction Process Calibrator with a type J thermocouple was used to measure temperature changes.

The results of these trials follows:

1) 98% Sulfuric acid – 50% Hydrogen peroxide

Initial Temperature: 60ºF

Final Temperature: 151ºF

The reaction results demonstrated that the reaction proceeded to completion and was exothermic in nature. Formal application of data kinetics was not included, but anecdotal evidence indicated that the reaction would proceed rapidly. This information was confirmed as the reaction caused a temperature rise of 90 degrees in approximately 10 seconds. The reaction was tractable and there was a small steam release. No violent bubbling or chemical spatter was detected. No unusual end products were noted and a warm clear acid solution remained following the reaction.

2) 98% Sulfuric acid – 50% Ferric sulfate solution

Initial Temperature: 60ºF

Final Temperature: 170ºF

The reaction caused a temperature rise of 110 degrees in approximately 20 seconds. Again the reaction was tractable and no unusual bubbling or chemical spatter was detected. A relatively moisture free, thick white chalky sulfate deposit remained following the reaction, fairly unremarkable with the exception of the end product.

3) Sodium hydroxide – 50% Ferric sulfate solution

Initial Temperature: 60ºF

Final Temperature: 215ºF

The reaction proceeded quickly to completion and was strongly exothermic in nature. As before, formal application of data kinetics was not included, but anecdotal evidence indicated that the reaction would proceed rapidly. This information was confirmed as the reaction caused a temperature rise of 155 degrees in approximately 10 seconds. The reaction was more vigorous than expected and there was a small steam release. Brief but vigorous bubbling occurred and some chemical spatter was detected on the interior surface of the flask. The residual product was a gooey caramelized sludge that was difficult to remove from the thermocouple surface. Flask was disposed.

The conclusion that was drawn from these three trials is that while it would be undesirable to allow these chemical to interact, the potential consequences remain only local in nature. Off gases detected during the tests were largely water vapor and only a potential hazard to the worker unable to evacuate the immediate vicinity of the spill.

B.5 Results and Comparison to TEEL Limits

The following is a description of the ramifications of achieving specific TEEL levels:

- TEEL-0. The threshold concentration below which most people will experience no appreciable risk of health effects.
- TEEL-1. The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild, transient, adverse health effects or perceiving a clearly defined objectionable odor.
- TEEL-2. The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- TEEL-3. The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

To meet the requirements for a low-hazard chemical facility, air releases cannot lead to exposures that exceed minimum TEEL-2 thresholds offsite and TEEL-3 thresholds onsite. **Table B-1** summarizes the concentrations resulting from the proposed chemical release scenarios.

Table B-1. Concentrations resulting from the proposed release scenarios

Number	Chemical	ALOHA results (100 m)	ALOHA results (170 m)	TEEL-1	TEEL-2	TEEL-3	Units
1	Sulfuric acid (400 gallons)	Nondetectable at this distance	Nondetectable at this distance	2	10	30	mg/m^3
2	Sulfuric acid (5000 gallons)	0.1	0.05	2	10	30	mg/m^3
3	Hydrogen peroxide	2 ppm	0.9 ppm	10	50	100	ppm

Results of the modeling yield concentrations that do not exceed the respective TEEL limits for offsite and onsite receptors. Because sulfuric acid reacts with other reagents and moisture in the air, modeling was also done at 100˚C to account for potential mixing of sulfuric acid spills with chemicals in adjacent reagent tanks. Airborne concentrations were still 150 times lower than the TEEL-2 concentration limit and significantly lower than the TEEL-1 concentration limit. Therefore, the B695 Segment qualifies for a final hazard classification as a low-hazard chemical facility.

One of the assumptions in the foregoing analysis concerns the surface area of the retention berm. It is acknowledged that some spillage over berm walls could potentially occur. For sulfuric acid, such a possibility is not a concern for receptors at 100 and 170 m because concentrations are low relative to TEEL guidelines. For hydrogen peroxide, the concentration at 100 m is roughly a factor of 41 (100/2.45) less than the TEEL-3 concentration. Therefore, even if some spillage were to occur over berm walls, the concentration of hydrogen peroxide at the receptors of concern would remain below applicable TEEL levels. In addition, hydrogen peroxide is a light-sensitive chemical that decomposes to oxygen and water. The conclusion is that hydrogen peroxide does not pose a hazard to receptors at 100 and 170 m.

The sensitivity analysis of air, ground and puddle temperatures indicates that puddle temperature is the dominant factor impacting sulfuric acid airborne concentration. At an air and ground temperature of 87.5ºF the sulfuric acid airborne concentration at 100 meters is 0.0156 ppm or 0.0626 mg/m^3. This is a factor of 159 times smaller than the TEEL-2 value of 10 mg/m^3 and 31 times smaller than the TEEL-1 value. At an air and ground temperature of 115ºF (highest recorded temperature in Livermore, CA history) the sulfuric acid airborne concentration at 100 meters is 0.0171 ppm or 0.0686 mg/m^3. This is a factor of 145 times smaller that the TEEL-2 value of 10 mg/m^3 and 29 times smaller than the TEEL-1 value. Comprehensive results of this analysis can be found in RHWM Calculation # WM/FS-B695-0401, *Evaluation of 400 gallon Sulfuric Acid Release at an Elevated Temperature* (Shogren 2005).

B.2 References

EPD (1997), *Health Risk Assessment for Hazardous and Mixed Waste Management Units at Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, CA, UCRL-AR-119482-97, (February 1997).

Shogren (2005), *Evaluation of 400 gallon Sulfuric Acid Release at an Elevated Temperature,* Calculation # WM/FS-B695-0401, (February 2, 2005).

Wajda (2002) *LLNL Facility Screening Report for Area 514 Facility: B514, B514A, B513, and B513A*, Lawrence Livermore National Laboratory, CA, (July 17, 2002).

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APPENDIX C
^{239}PU EQUIVALENT CURIE CALCULATIONS

C.1 Calculation Criteria and Equations

In general, low-level waste (LLW) is managed in the B695 Segment much more often than transuranic (TRU) waste. Wastes sometimes contain transuranic isotopes, but they are often much less than 100 nCi per gram. Isotopes that are primarily beta or gamma emitters are prevalent and contribute to the radionuclide inventory in this segment at appreciable levels.

Low-level waste consisting mostly of beta and gamma emitting radionuclides represents the majority of waste to be treated in the B695 Segment. Radionuclides and respective inventories in the B695 Segment is shown in **Table C-1**.

Table C-1. Representative radionuclides expected in the B695 Segment

Radionuclide	Hazard Category 2 Threshold Quantities, Ci
^{60}Co	1.9×10^5
^{90}Sr	2.2×10^4
^{137}Cs	8.9×10^4
^{152}Eu	1.3×10^5
^{154}Eu	1.1×10^5
^{155}Eu	7.3×10^5
^{228} Th	92
^{230} Th	89
^{232}Th	18
^{234}U	220
^{235}U	240 (9.8×10^{-4})*
^{238}U	240
^{237}Np	58
^{238}Pu	62
^{239}Pu	56 (28)*
^{240}Pu	55
^{241}Am	55
^{3}H	3.0×10^5

*Values in parentheses reflect the fissile material inventory limit of 450 g for either U-235 or Pu-239.

Only fractions of transuranic isotopes in Table C-1 are expected in the treatment waste stream; however, the anticipated concentrations are significantly less than 100 nCi/g, which would not be qualified as TRU waste.

The radionuclide inventory in the B695 Segment will be controlled by the “sum of the ratio” method outlined in DOE-STD-1027-92.

Dose-conversion factors for such isotopes are considered when normalizing to PE-Ci equivalents. Tritium will not be converted to PE-Ci and is compared to its own acceptance limit. The ^{239}Pu equivalent curie concept extends to LLW waste, as defined in DOE O 435.1, for each radionuclide exceeding 1 curie per container. Only those that exceed 1 curie are included, not all others present in the container. In general, LLW radionuclides have dose-conversion factors (discussed below) that are orders of magnitude less than that of ^{239}Pu. Therefore, the acceptable activity per container is orders of magnitude greater than it is for ^{239}Pu.

^{239}Pu equivalency is based on dose-conversion factors for inhalation. The methodology for calculation is provided in Appendix B of the *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE 2008). The dose-conversion factors used in the *Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* are based on DOE/EH-0071 (DOE 1988). Table A.1 in DOE-STD-1027-92 apparently used the largest value of the Inhalation Class D, W, or Y found in DOE/EH-0071 in the interest of conservatism in calculating Category 2 thresholds (LANL 1994). By adopting the above methodology, the Radioactive and Hazardous Waste Management (RHWM) Division is using a more restricted definition of ^{239}Pu equivalent activity.

The concept of ^{239}Pu equivalent activity (PE-Ci) is intended to eliminate the dependency of radiological analyses on specific knowledge of the radionuclide composition of a waste stream. By normalizing all radionuclides to a common radiotoxic hazard index, radiological analyses that are essentially independent of such variations can be conducted for the B695 Segment facility. ^{239}Pu, as a common component of most defense TRU wastes, was selected as the radionuclide to which the radiotoxic hazard of other TRU radionuclides could be indexed.

TRU radionuclides primarily present inhalation hazards. Such radionuclides allow a valid relation to be established that normalizes the inhalation hazard of a TRU radionuclide to that of ^{239}Pu for purposes of the B695 Segmentradiological analyses. They also allow for the parameter PE-Ci to be passed on as information to other segments when needed (e.g., when transferring waste from one segment to another and maintaining proper inventory control). In effect, the radiological dose consequences of an airborne release of a quantity of radioactivity with a known radionuclide distribution will provide a conservative estimate for the consequences of a release of that material expressed in terms of a quantity of ^{239}Pu. To obtain the correlation, the 50-year, effective, whole-body dose commitment or dose-conversion factor for a unit intake of each radionuclide will be used.

For a known radioactivity quantity and radionuclide distribution, the ^{239}Pu equivalent activity is determined using radionuclide-specific weighting factors. The ^{239}Pu equivalent activity (AM) can be characterized by:

$$AM = \sum_{i=1}^{K} A_i / WF_i \ ,$$

where K is the number of TRU[1] radionuclides, or the number of radionuclides >1 Ci in LLW, A_i is the activity of radionuclide *i*, and WF_i is the PE-Ci weighting factor for radionuclide *i*.

WF_i is further defined as the ratio:

$$WF_i = E_0 / E_i \ ,$$

where E_0 (rem/µCi) is the 50-year effective whole-body dose commitment due to the inhalation of ^{239}Pu particulates with a 1.0-µm activity median aerodynamic diameter (AMAD) and a weekly pulmonary clearance class, and E_i (rem/µCi) is the 50-year, effective, whole-body dose commitment due to the inhalation of radionuclide (i) particulates with a 1.0-µm AMAD and the pulmonary clearance class resulting in the highest 50-year effective whole-body dose commitment.

The dose to a receptor is directly proportional to the activity inhaled and manifested through a radionuclide's Dose Conversion Factor (DCF), defined above as E_i. ^{239}Pu was chosen because it is already a standard used in calculations for waste acceptance calculations for the WIPP. PE-Ci is calculated using a 50-year committed effective dose equivalent (CEDE) due to inhalation of ^{239}Pu particulates with a 1.0-micron AMAD and the pulmonary clearance class resulting in the highest 50-year CEDE. For example, weighting factor $WF_{^{90}Sr}$ is the ratio of the ^{90}Sr DCF (1.3 rem/µCi intake) to the ^{239}Pu DCF (510 rem/µCi intake):

$$WF_{^{90}Sr} = \frac{^{239}Pu\ DCF}{^{90}Sr\ DCF} = \frac{510}{1.3} = 392\ .$$

Thus, 392 curies of ^{90}Sr is equivalent to 1 ^{239}Pu equivalent Ci. Another example is:

$$WF_{^{232}Th} = \frac{^{239}Pu\ DCF}{^{232}Th\ DCF} = \frac{510}{1600} = 0.32$$

Thus, 0.32 curies of ^{232}Th is 1 ^{239}Pu equivalent Ci. This definition of PE-Ci will be used for inventory control in the B695 Segment.

C.2 References

DOE (1988), Internal Dose Conversion Factors for Calculations of Dose to the Public, U.S. Department of Energy, Washington, DC (DOE/EH-0071, July 1988).

DOE (2008), *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, U.S. Department of Energy, Carlsbad Field Office (DOE/WIPP-02-3122, May 30, 2008).

EPA (1988), Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, U.S. Environmental Protection Agency, Office of Radiation Programs, Oak Ridge National Laboratory, Oak Ridge, TN (Federal Guidance Report No. 11, EPA-520/1-88-020).

LANL (1994), Specific Activities and DOE-STD-1027-92 Hazard Category 2 Thresholds, Los Alamos National Laboratory, Los Alamos, NM (LA-12846-MS, UC-902, November 1994).

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APPENDIX D
DESIGN PARAMETERS FOR THE B695 SEGMENT

The information provided in the following tables is derived from the DWTF Phase 3A and Phase 3B As-Built Specifications provided by GSE Construction Company, February 2002. The design of the facility is based on current codes and standards developed in 1993, or earlier. The primary design order was DOE Order 6430.1A, 1989. These specifications will be maintained and retrievable.

Table D-1. Building 695 design parameters

Structure/ System	Description	Design Specifications	Phase 3B Specifications Page No.
Design Requirements	Roof & Sidings	Roofing panels 18 gauge; Sidings 20 gauge Galvanized steel (ASTM A 446)	07465-2
	Foundation, floors & slabs	Concrete mix: compressive strength 4000 psi (28 days) 2500 psi (7 days) Slump: 3 inch	03300-3
	Walls & Misc. Concrete	3000 psi (28 days) 1800 psi (7 days) Slump: 4 inch	
Soil Preparation requirements	Under Building Slab	Top 6 inches to be scarified and re-compacted to 95% of maximum dry density. Upper 6 inches reconditioned to 2-5% over optimum moisture content	02223-3
	Paved & Unpaved Areas	Relative compaction of 95% of maximum density to a depth of 0.5 ft	
Metal Panel System		Wind and dead loads in accordance to ASCE 7 for wind speed of 72 mph, Exposure C, I=1.07 Maximum Allowable Deflection: 1/180	07421-2

Structure/ System	Description	Design Specifications	Phase 3B Specifications Page No.
Wall System	Air Infiltration Water Infiltration Fire Test Thermal Cycling Exterior face Interior face	ASTM E 283; maximum 1.09 cu meters/hr-sq meter (0.06) of wall area, static air pressure difference of 75 PA (1.57 psi) ASTM E 331: No uncontrolled water leakage at inward static air pressure difference of 8 lbs/sq ft ASTM E 84: flame spread 25 or less, fuel contribution 0, smoke developed less than 450 Panel inner surface maintained at 100^{o} F, 500 cycles, no delamination or panel failure Minimum 22 gauge galvanized sheet steel Minimum 26 gauge galvanized sheet steel	07421-2 07421-4
Vapor barrier		6-mil clear polyethylene	03300-3
Structural Framing	Studs Ceiling joists Floors or ceiling tracks	Maximum: 16-inch centers, not more than 2-inches from butted wall Maximum: 24-inch centers, double joist at each end of opening > 20-inch Secure with screws or welding at maximum of 24-inches on centers	05400-3
Fire Sprinkler System	Wet Pipe	Hydraulic Calculation: NFPA 13 with additional allowance of 500 gpm at the bottom of fire riser Seismic Calculation: ICBO UBC Section 1630, using Z=0.57, I=1.25, and Cp as specified in Table 16-0	15330-2 15330-4

Structure/ System	**Description**	**Design Specifications**	**Phase 3B Specifications Page No.**
Fire Alarm & Smoke Detection System	Alarm	NFPA 72 fire alarm system	16721-2
		All equipment & accessories shall be manufactured by Pyrotronics	16721-4
	Smoke Detection	Addressable Photoelectric Smoke Detector for Air Duct: Detector “AD-3ILP” and “ILP” with sampling tubes	16721-4
	Smoke Detection	Addressable Photoelectric Smoke Detector: “ILPT-1” with “DB3S” base	16721-4
	Initiating device module	TRI-B6R series Dual Input TRI-B6D Manual pull: MSI-10B single action	16721-4
Emergency Voice/Alarm & Paging System		NFPA 72 emergency voice/alarm communication with visual indicating appliances for the hearing impaired	16722-2

Structure/ System	**Description**	**Design Specifications**	**Phase 3B Specifications Page No.**
HEPA filter assemblies	HEPA Filter Units	Packaged skid-mounted, factory fabricated, assembled and DOP tested. Each unit consists of inlet plenum, 2-in pre-filter section, DOP in-place test section, HEPA filter, final DOP in-place test, and blower. Housing & hardware shall have a minimum thickness of 14 gauge 304 stainless steel and a welded 4-in SS base with minimum thickness of 11 gauge. Bag-out side loading type housing for 24 x 24 x 11-1/2 in. HEPA filter	15885-5
	HEPA filters	Separator-less type, nuclear grade, Type B in accordance w/ IESRP-CC-001-83-T and UL 586. Filter media must meet MIL-F-51079 for operating condition of 250^{o} F. Filter must be completely sealed to the mounting frame w/ acid resistant sealant. Filter seal shall be a fluid seal that is radiation and chemical resistant, and non-drying. Filter is required to have a minimum efficiency of 99.97% DOP, rated at 1250 cfm minimum at 1-in w.c., and capable of operating at a differential pressure of 10-in w.c.	15885-10
	Pre-filters	Non-woven cotton fabric type, effective filter media shall be > 4.5 sq ft of media per 1 sq ft of filter face and shall not contain < 15 pleats per linear ft. Average efficiency is 30% and average resistance of not < 90% by ASHRAE 52 test method using atmospheric dust. Listed as Class1–UL900.	15885-11
Stand-by Power System	Engine Generator Set	Reciprocating diesel engine, fueled by No. 2 diesel fuel, water-cooled, four stroke cycle, 1800 rpm maximum, single acting solid injection design with fuel oil tanks sized for at least 12 hours at 75% load	16622-4
General Building Ventilation		DOE O6430.1A, Division 11, Equipment	NA

Table D-2. Building 696S design parameters

Structure/ System	Description	Design Specifications	Phase 3B Specifications Page No.
Design Requirements	Roof & Sidings	Roofing panels 18 gauge; Sidings 20 gauge Galvanized Steel (ASTM A 446)	07465-2
	Foundation, floors & slabs	Concrete mix: compressive strength 4000 psi (28 days) 2500 psi (7 days) Slump: 3 inch	03300-3
	Walls & Misc. Concrete	3000 psi (28 days) 1800 psi (7 days) Slump: 4 inch	
Soil Preparation requirements	Paved & Unpaved Areas	Relative compaction of 95% of maximum density to a depth of 0.5 ft	02223-3
	Fill & Backfill	Compact to relative density of 95% (CALTRANS Sec 19, test 216 or 231)	02223-4
Metal Panel System		Wind and dead loads in accordance to ASCE 7 for wind speed of 72 mph, Exposure C, I=1.07 Maximum Allowable Deflection: 1/180	07421-2
Wall System	Air Infiltration	ASTM E 283; maximum 1.09 cu meters/hr-sq meter (0.06) of wall area, static air pressure difference of 75 PA (1.57 psi)	07421-2
	Water Infiltration	ASTM E 331: No uncontrolled water leakage at inward static air pressure difference of 8 lbs/sq ft	
	Fire Test	ASTM E 84: flame spread 25 or less, fuel contribution 0, smoke developed less than 450	
	Thermal Cycling	Panel inner surface maintained at 100^{o} F, 500 cycles, no delamination or panel failure	
	Exterior face	Min. 22 gauge galvanized sheet steel	07421-4
	Interior face	Min. 22 gauge galvanized sheet steel	
Vapor barrier		6-mil clear polyethylene	03300-3
Structural Framing	Studs	Maximum: 16-inch centers, not more than 2-inch from butted wall	05400-3
	Ceiling joists	Maximum: 24-inch centers, double joist at each end of opening > 20-inch	

Structure/ System	**Description**	**Design Specifications**	**Phase 3B Specifications Page No.**
Fire Sprinkler System	Wet Pipe	Hydraulic calculation: NFPA 13 with additional allowance of 500 gpm at the bottom of fire riser Seismic calculation: ICBO UBC Section 1630, using Z=0.57, I=1.25, and Cp as specified in Table 16-0	15330-2 15330-4
Fire Alarm & Smoke Detection System	Alarm Initiating Devices	NFPA 72 fire alarm system All equipment & accessories shall be manufactured by Pyrotronics Model TRI-60R series Dual Input Model TRI-60D Manual pull: Model MSI-10	16721-2 16721-4 16721-3
Emergency Voice/Alarm & Paging System		NFPA 72 emergency voice/alarm communication with visual indicating appliances for the hearing impaired	16722-2
General Building Ventilation		DOE O6430.1A, Division 11, Equipment	NA
Glove Box		DOE O6430.1A, Division 11, Equipment	NA
Cranes: CRB-601, and CRB-602		5-Ton Bridge Crane consisting of trolley assembly, overload warning light, control unit, bracing, crane bridge, and 5-ton hoist.	

APPENDIX E
SEGMENTATION JUSTIFICATION FOR THE B695 SEGMENT

E.1 Introduction

DOE-STD-1027-92 provides guidance in establishing the hazard categorization for nuclear facilities. For Hazard Category 3 nuclear facilities with simple operations and inventories at levels within thresholds established in DOE-STD-1027-92, a graded approach is recommended in developing the safety basis documentation.

Facility segmentation is one step in the process of determining the hazard categorization of a facility. According to DOE-STD-1027-92, Attachment 1, the following considerations are made in facility segmentation:

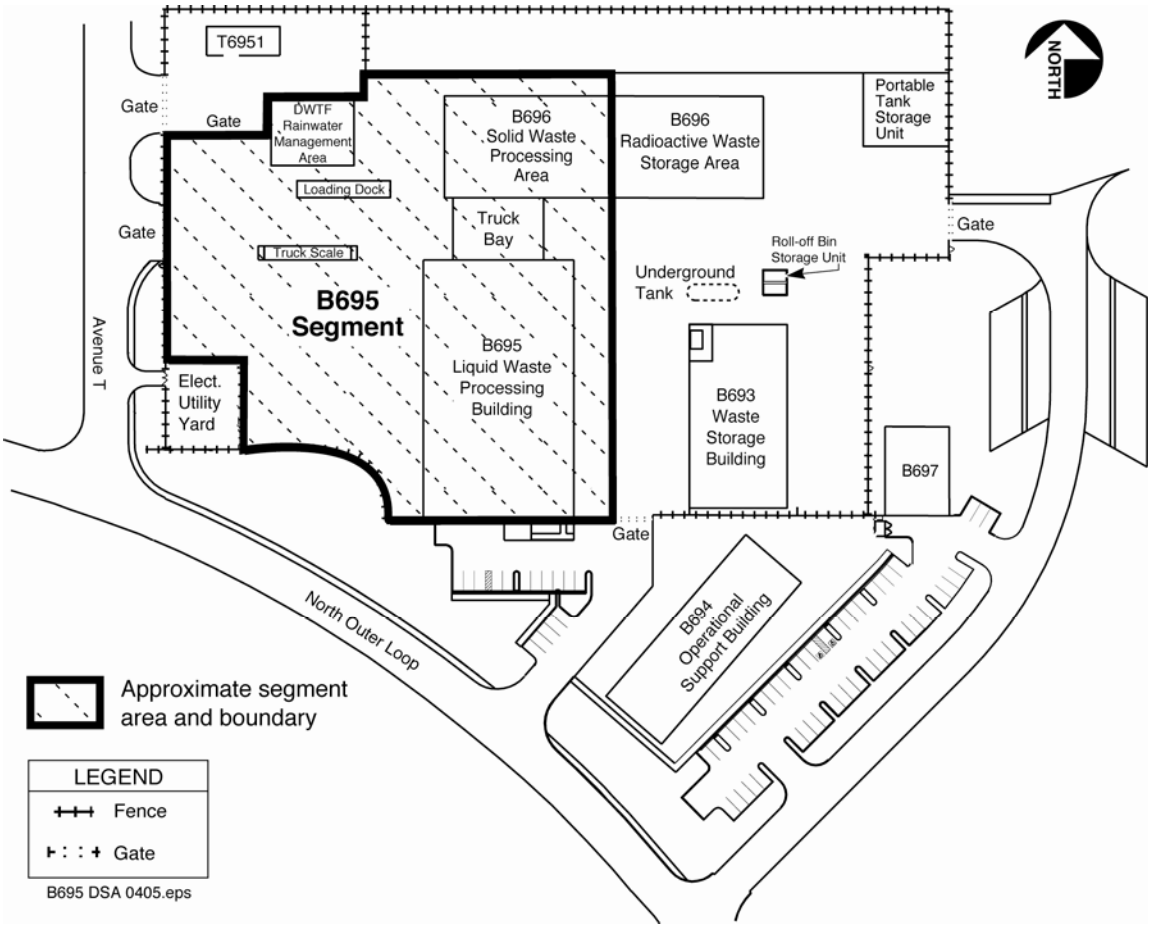
> "In facility categorization, flexibility must be allowed in the definition of facility segments. Many DOE facilities conduct a wide variety of activities in one facility, ranging from simple assay or lab experiments to complex fluid flow separations. It is necessary to avoid placing excessive requirements on simple or even trivial co-located operations. *The concept of independent facility segments should be applied where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon.*
>
> It should be noted that DOE 5480.23 states that *an analysis and categorization is to be performed on 'processes, operations, or activities'* and not necessarily whole facilities. For the purposes of hazard categorization and estimating hazardous material inventory, the objective is to understand the available hazards that could interact and cause harm to individuals or the environment. It is not desirable to estimate the potential consequences from an inventory of hazardous materials when facility features would preclude bringing this material together. Therefore, the standard permits the concept of facility segmentation provided the hazardous material in one segment could not interact with hazardous materials in other segments. For example, independence of HVAC and piping must exist in order to demonstrate independence for facility segmentation purposes. This independence must be demonstrated and places the 'burden of proof' on the analyst." [Italics added for emphasis]

LLNL has segmented Building 695, Building 696 SWPA, and their associated yard areas from other DWTF nuclear facilities, namely the Building 696 RWSA and Building 693 including yard area east of the Building 695 Segment (DWTF Storage Area), so that it may operate as a Hazard Category 3 nuclear facility. The purpose of the discussion is to demonstrate that the Building 695 Segment is adequately separated from nearby nuclear facilities to "preclude bringing material together or causing harmful interaction from a common severe phenomenon." A particular attention is paid to separation between Building 696 SWPA and Building 696 RWSA because the two are attached.

E.2 Facility Description

The Building 695 Segment is located in the northeast corner of the LLNL site between North Outer Loop Drive and the site boundary. The Building 695 Segment consists of Building 695, Building 696 SWPA, and adjacent yards to the west of Building 695, excluding the maintenance yard, trees to the north, DWTF rain water management area, loading dock, and the electrical utility yard, as shown in **Figure E-1**.

Figure E-1. Layout of the B695 Segment



Buildings 695 and 696 were designed and built to meet Performance Category 2 (PC-2) as defined in DOE-STD-1020-94 and DOE-STD-1021-92. These facilities will withstand structural loads exceeding the requirements of the 1994 Uniform Building Code.

The DWTF Storage Area includes Building 696 RWSA, Building 693, and associated yard areas. Building 693 and the DWTF Storage Area yard are separated from the Building 695 Segment by a distance exceeding 20 feet. There are no shared utilities between these areas and the Building 695 Segment.

Building 696 RWSA is separated from the Building 695 Segment, which includes Building 696 SWPA, by a fire-resistive partition. Building 696 RWSA is separated by a distance from Building 695 of approximately 45 ft. Additionally, a clear zone with a width of 20 ft is defined as a part of the facility for both Building 696 SWPA and Building 696 RWSA.

Much of the utilities are shared between Building 696 RWSA and the Building 695 Segment. A discussion of utilities for Building 695 Segment is provided in Section E3.1.

E.3 Technical Basis for Segmentation

As discussed in DOE-STD-1027-92, in order to utilize the concept of facility segmentation, it must be shown that hazardous material in one segment could not interact with hazardous materials in other segments. Severe phenomena such as aircraft crash, earthquake, and fire may affect radioactive inventories in different segments. In addition, failure or malfunction of shared utilities must not allow interaction of inventories in different segments.

The analysis in this section is based on the data and documentation available at the time of the analysis. There is no new information that invalidates the analysis. It is shown that Building 695 Segment inventories and inventories from other segments will not interact in the event of severe phenomena. In addition, it is shown that failure or malfunction of shared utilities would not cause the interaction of radioactive inventories in different segments.

E3.1 Shared Utilities

There are some common utilities shared between the Building 695 Segment and the Building 696 RWSA, including electrical systems, communication systems, hot and cold water supply, and the fire sprinkler system. Table E-1 summarizes the evaluation of shared utilities and when applicable the impact if the utility is lost.

No utilities were considered safety-significant or safety-class SSCs for the Building 696 RWSA [Reference 3]. The fire sprinkler system is defense-in-depth for Building 696 RWSA. It is anticipated that common systems will play a role of equal importance in Building 695 Segment to those in Building 696 RWSA.

It is concluded that there is no common severe phenomenon that would, by causing the loss any of these utilities, bring material together or cause harmful interaction.

Table E-1. Evaluation of shared utilities

Utility	Shared with Building 696R?	Impact
Shop Air	Yes	Loss of pneumatic tool use in both segments. Operational issue not directly impacting safety and health of the worker and public.
Instrument Air	No	No interface effect.
Breathing Air	No	No interface effect.

Utility	Shared with Building 696R?	Impact
Process Water	Yes	Loss of Eyewash, limits decontamination and cleaning abilities upon joint failure. Operational issue not directly impacting safety and health of the worker in both segments and public. While loss of eyewash may have an impact on the health and safety of individual workers if an accident occurs, it is not relevant to facility segmentation.
Tank and Floor Drains	No	No interface effect.
Natural Gas Distribution	No	No interface effect.
Air Monitoring	No	No interface effect.
Utilities above and hot water (supply and return)	Yes	Loss of space temperature control. Operational issue not directly impacting safety and health of the worker and public.
Fire Sprinkler System	Yes	Loss of fire suppression abilities. This would be a concern if there were a credible fire that would impact both segments. However, no scenarios were identified that could impact both segments given the presence of the partition and the established combustible loading limits that would preclude interaction between Building 696 SWPA and Building 696 RWSA. See Section E3.4 for further discussion.
Ventilation	No	No interface effect.
Electrical Distribution	Yes	Loss of non emergency lighting, loss of plug-in device use. Operational issue not directly impacting safety and health of the worker and public.
Signal and communications	Yes	Loss of phones, loss of fire panel supervision. Upon loss of this device, however, notification to Fire Department is automatic.

E3.2 Aircraft Crash

The probability of an aircraft crashing into the B695 Segment was evaluated using the method described in DOE-STD-3014-96. The probability of an aircraft crash into the B695 Segment must be evaluated to bound the risk presented by surrounding airports and types of aircraft and operations in those airports. The operations of general aviation aircraft at the Livermore Municipal Airport (LVK) dominate the risk of an aircraft crash to facilities at the LLNL. An assessment for Building 332 showed that general aviation associated with the LVK accounted for approximately 90% of the aircraft crash probability. Hence, the scope of the analysis is limited to quantification of the risk from general aviation at LVK.

The crash probability analysis does not take into account the surrounding structures, and includes the probability that a wing tip of a light aircraft nicks a building (refer to Figure B-3 in DOE-STD-3014-96), which would not lead to uncontrolled radioactive release. Hence, the probability of an aircraft crash obtained by the analysis is conservative even without the adjustment for other types of aircraft.

The following formula in DOE-STD-3014-96 is used to calculate the aircraft crash probability into Building 696 SWPA and Building 695:

$$F = \sum_i N_i P_i f_i(x,y) A_i$$

where F is estimated annual aircraft crash impact frequency for the facility, N is annual number of aircraft operations, P is the aircraft crash rate (crash/operations), $f(x,y)$ is the aircraft crash location probability ($mile^{-2}$), A is the combined effective area of Building 696 SWPA and Building 695 ($mile^2$), and i is the flight phase, i.e., takeoff, in-flight, and landing.

The operations are all conservatively assumed to be general aviation of the fixed wing single engine reciprocating type. The distance from the middle of the runway to nearest corner of the B695 Segment is approximately 6.6 miles. From Table B-1 of DOE-STD-3014-96, the generic crash rates are 1.1×10^{-5} per takeoff and 2.0×10^{-5} per landing, respectively.

There is a directional dependence for landing and takeoff because of the prevailing wind at the Livermore Municipal Airport (LVK). Approximately 82% of the flights take off and land in the east-west direction. In this case, crash location probabilities, values of $f(x, y)$, for landings and take-offs in Tables B-4 and B-5 in DOE-STD-3014-96 are 2.9×10^{-3} and 0, respectively. In the opposite direction, associated crash location probabilities are 6.5×10^{-4} and 1.5×10^{-3}, respectively.

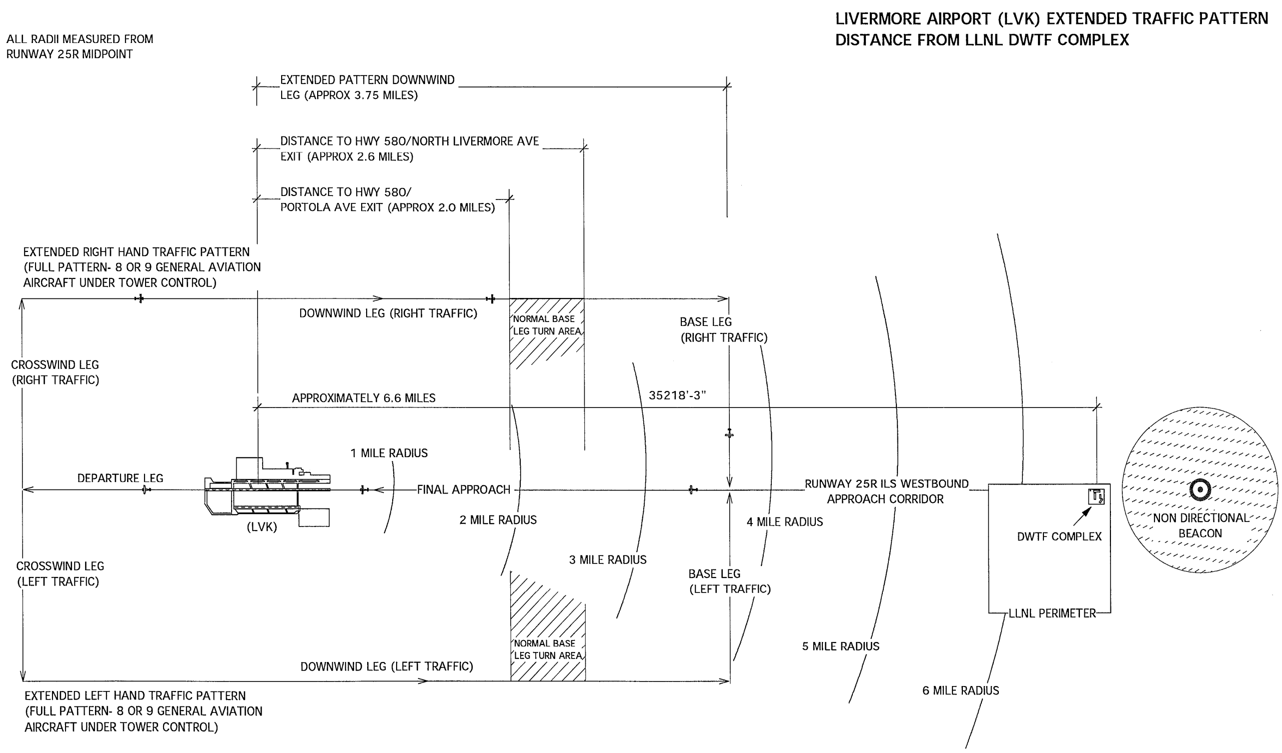
According to the latest posting on the Federal Aviation Administration website [Reference 1], the total number of aircraft operations is bounded by 240,000 operations per year. a large portion of the operations is from local operations that include “touch and go” at the airport for flight training. Because local operations are typically confined to the 4-mi radius from the airport and do not go over or near the LLNL, these are excluded from the crash probability calculation. For conservatism, an additional 10% was assumed for non-counted general aviation operations that occur outside airport control tower operational times.

The normal traffic pattern extends approximately 4 miles from the runway. It is extended in a mile increment during periods of unusual air traffic congestion. Periods of unusually heavy congestion when the traffic pattern is extended toward the LLNL occur infrequently. In those periods of congestion, aircraft are often required to (1) perform full stop landings, (2) exit the active runway and taxi back to the original departure position, and then (3) resume flight activities by requesting control tower access to the active runway prior to departure. When this happens, it changes the activity category from “touch and go” to the normal landing and takeoff. These are then included in the number of itinerant operations not associated with local operations within the flight pattern. In addition, flights in an extended traffic pattern over LLNL would be re-categorized as “in-flight” because of the hilly terrain surrounding the site, i.e., Altamont Pass.

This is further supported by the FAA regulatory language that addresses airspace boundaries in the pattern around airports in FAA Order 7400.2E, “Procedures for Handling Airspace Matters,” Change 1, July 7, 2001. In Section 10.3-2, “Airport Spacing Guidelines and Traffic Pattern Airspace Areas,” a full pattern in the airspace around Livermore, which consists of eight to nine aircraft in the pattern, extends downwind about 3.75 miles from the center of Runway 25R only a portion of the time when the predominant wind direction is from the west. This puts the turn into the base leg about 2.75 miles away from the Building 696. Anecdotal reports from flight instructors at LVK indicate that the majority of the time they make this turn (downwind to base leg) over the Portola Avenue exit from Highway 580. Relative positions of LVK, LLNL, and the extended pattern are illustrated in **Figure E-2**.

Excluding local operations that do not go over or near the LLNL, a total of 94,100 operations at the Livermore Municipal Airport are itinerant operations. Including a 10% margin for non-counted general aviation operations, 104,000 operations are assumed for the crash probability analysis. For simplicity, operations in each direction are assumed to be divided evenly between takeoff and landing.

Figure E-2. Extended traffic pattern for Livermore Airport (LVK)



The effective target area presented by the B695 Segment can be calculated using Equations B-3 to B-5 in DOE-STD-3014-96. Together, these equations yield the following:

$$A_{eff} = (WS + R)(S + H\cot\phi) + \frac{2 \cdot L \cdot W \cdot WS}{R} + L \cdot W$$

where *WS* is the aircraft wing span, *R* is the length of facility diagonal, *S* is the aircraft skid distance, *H* is the facility height, $cot\varphi$ is the cotangent of aircraft impact angle, *L* is the length of facility, and *W* is the width of facility.

Dimensions of Building 695 are 213-ft × 123-ft × 42.5-ft with a facility diagonal length of 246 ft. Dimensions of the Building 696 SWPA are 83-ft × 135-ft × 35-ft, with a facility diagonal length of 158.5 ft. The wingspan of a general aviation aircraft is 50 ft from Table B-16 of DOE-STD-3014-96. For general aviation, the value of $cot\varphi$ is 8.2-ft from Table B-17 and the skid distance is 60-ft from Table B-18 in DOE-STD-3014-96. Because the two buildings are not connected, two separate effective target area calculations are performed. The effective target area of the Building 695 is calculated as follows:

$$A_{eff} = \left[(50+246)\times(60+42.5\times8.2) + \left(\frac{2\times50}{246}+1\right)\times213\times123 \right]\times\left(5{,}280\ {ft}/{mi}\right)^{-2} = 5.7\times10^{-3}\ mi^2$$

Similarly, the effective target area of the Building 696 SWPA is calculated as follows:

$$A_{eff} = \left[(50+158.5)\times(60+35\times8.2) + \left(\frac{2\times50}{158.5}+1\right)\times83\times135 \right]\times\left(5{,}280\ {ft}/{mi}\right)^{-2} = 3.3\times10^{-3}\ mi^2$$

The combined effective target area of Building 695 and Building 696 SWPA is then 8.9×10^{-3} mi^2. The crash probability is calculated by compiling the data in Table E-2, shown below.

Table E-2. Aircraft crash probability data and results for B695 Segment

	Number of operations	*x*, mi	*y*, mi	*f(x,y)*	*P*	*A*	Impact frequency
General aviation takeoff (EW)	42,640	-6.6	0.036	0.0	1.1×10^{-5}	8.9×10^{-3}	0.0
General aviation landing (EW)	42,640	-6.6	0.036	2.9×10^{-3}	2.0×10^{-5}	8.9×10^{-3}	2.2×10^{-5}
General aviation takeoff (WE)	9,360	6.6	-0.036	1.5×10^{-3}	1.1×10^{-5}	8.9×10^{-3}	1.4×10^{-6}
General aviation landing (WE)	9,360	6.6	-0.036	6.5×10^{-4}	2.0×10^{-5}	8.9×10^{-3}	1.1×10^{-6}
Total	104,000						2.5×10^{-5}

Given the calculated annual probability of 2.5×10^{-5}, an aircraft crash into the B695 Segment is credible.

E3.2.1 Probability of plane crash on the segmenting wall

As a part of the hazard categorization of Building 695 Segment, it was required by the DOE/OAK to establish segmentation of Building 696 SWPA and Building 696 RWSA. One of the considerations in determining segmentation is the structural integrity of individual segments in a postulated plane crash. The purpose of the analysis is to determine the probability of the plane crash onto the partition separating Building 696 SWPA and Building 696 RWSA. The potential impact on the segmenting wall, which is 20-ft tall, is evaluated. For simplicity, only the contribution from general aviation from Livermore Airport is computed because it is the predominant factor in the overall crash probability.

The methodology in DOE-STD-3014-96 does not provide means to estimate the probability of breach of structural integrity of an inner wall that is protected by the surrounding structures of the building. The methodology in DOE-STD-3014-96 must be adopted in a way to allow estimation of the probability of a plane crash into the segmenting wall. The location and, thus, the crash frequency, for the plane would remain the same. The change related to the crash probability into the segmenting wall is the effective target area.

E3.2.2 Assumptions

The following assumptions were used in computing the probability of crash into the segmenting wall:

1. The probability of crash on four sides of the buildings is uniform, independent of the flight direction.
2. It is assumed that solid fragments that may damage the segmenting wall, i.e., the engine, propellers, main stringer, and landing gear, from the postulated plane crash travel in the same direction at the time of the impact.
3. Based on engineering judgment, a plane cannot traverse the entire length of the building after crashing in the absence of any intervening walls. Both Building 696 RWSA and Building 696 SWPA are divided into two compartments with load-bearing walls. Hence, solid fragments cannot penetrate more than two load-bearing walls. See Section E3.2.4 for further discussion on structural impact.
4. Because the solid fragments that may damage the structures are limited to the engine, propellers, main stringer, and landing gears, the effective wingspan of the general aviation aircraft is assumed to be 25 ft, one half of the wingspan specified in DOE-STD-3014-96 for general aviation. The wingspan of Cessna 210, for example, is less than 37 ft. Additionally, because the segmenting wall is an internal structure, only solid fragments that can penetrate the load-bearing walls can damage the segmenting wall. Therefore, the assumed wingspan is conservative.
5. The thickness of the segmenting wall is 1.5 ft.
6. The methodology in DOE-STD-3014-96 is adopted by treating the segmenting wall as a three-dimensional structure.

E3.2.3 Analysis of total effective target area

The total length of Building 696 RWSA is 120 ft. Building 696 RWSA is divided evenly into two 60-ft × 83-ft × 20-ft compartments separated by a one-hour fire-rated partition. The total length of Building 696 SWPA is 135 ft. Building 696 SWPA is divided into one 90-ft × 83-ft × 35-ft and one 45-ft × 83-ft × 35-ft compartment separated by a one-hour fire-rated partition. Because of the difference in geometry, the effective target area will change depending on the impact angle. Consequently, target areas from four cardinal directions are addressed separately in order to determine the total effective target area.

E3.2.3.1 Target area from West

The skid impact from a plane crash would not reach the segmenting wall between Building 696 SWPA and Building 696 RWSA. Thus, it is not included in the effective target area calculation. The effective target area on the western end of the Building 696 SWPA is comprised solely of the shadow area cast by the 20-ft high wall.

There are three potential outcomes from the impact through Building 696 SWPA depending on the angle of impact. First, if the impact angle is very low, the 20-ft high segmenting wall would not be impacted because of the two loading bearing walls in Building 696 SWPA. The dividing impact angle is determined by the arctangent of the length of Building 696 SWPA (135 ft) and the remaining 15-ft section of segmenting wall. Second, for impact angles greater than the arctangent of the length of Building 696 SWPA (135 ft) and the total height of the segmenting wall (35 ft), the shadow area is the projected horizontal area of the 20-ft high segmenting wall.

Last, for impact angles in between, the Building 696 SWPA roof provides shielding, which reduces the target area by the shadow area projected by the 15-ft high section above the segmenting wall. For steeper angles, the plane can penetrate the roof and impact the segmenting wall.

In summary, the effective target area from the west is summarized as follows:

$$A_{WEST} = (W + WS) \times \begin{cases} 0 \quad \text{for } \phi \le \tan^{-1}\left(H_1 / L_S \right) \\ L_S - H_1 \times \cot\phi \ \text{ for } \tan^{-1}\left(H_1 / L_S \right) < \phi \le \tan^{-1}\left(H / L_S \right) \\ H_2 \times \cot\phi \quad \text{for } \phi > \tan^{-1}\left(H / L_S \right) \end{cases}$$

where W is the width of Building 696 SWPA, WS is the wingspan, L_S is the length of the compartment in Building 696 SWPA contiguous to the segmenting wall (90 ft), H_1 is the remaining height above the wall separating Building 696 SWPA and Building 696 RWSA (15 ft), H is the total height of the wall separating Building 696 SWPA and Building 696 RWSA (35 ft), and ϕ is the impact angle. The two critical impact angles dividing the target area considerations in the equation above are 9.46° and 21.3°.

E3.2.3.2 Target area from East

Likewise, the skid impact from a plane crash would not reach the wall separating Building 696 SWPA and Building 696 RWSA. Thus, it is not included in the effective target area calculation. Depending on the impact angle, the target area is either the area of the roof of Building 696 RWSA or the shadow area of the segmenting wall horizontally projected by the impact angle. Thus, the target area is calculated, as follows:

$$A_{EAST} = MIN[H_2 \times \cot\phi, L_R] \times (W + WS)$$

where H_2 is the height of the wall separating Building 696 SWPA and Building 696 RWSA, and L_R is the length of the compartment in Building 696 RWSA contiguous to the segmenting wall (60 ft).

E3.2.3.3 Target areas from North and South

Unlike the potential impact on the east and west ends of Building 696, the skid impact from a plane crash can damage the segmenting wall between Building 696 SWPA and Building 696 RWSA. Thus, it must be included in the effective target area calculation. In addition, the target area presented in the two directions is symmetrical. Thus, the target area in either direction would be doubled in calculating the total effective target area.

As discussed, the skidding impact is plausible from north and south if surrounding structures, e.g., Building 693, are ignored. The area presented by the skidding plane is:

$$A_{sk} = S \times (\delta + WS)$$

where S and δ are the skid length of the general aviation aircraft (60 ft) and the thickness of the wall (1.5 ft assumed), respectively.

In addition, the direct impact on the segmenting wall within the wingspan of general aviation aircraft, e.g., Cessna 210, is assumed to damage the structural integrity of the segmenting wall. Therefore, the area presented by the segmenting partition between Building 696 RWSA and Building 696 SWPA is calculated as follows:

$$A_{sh} = (H_2 \times \cot\phi + W) \times (\delta + WS)$$

The target area consideration included the potential plane crash that would come to a full stop at the wall in the north-south direction without causing damage to the structure. In addition, results ignore the clear area north of the facility. Since the crash frequency includes all modes of failure, only a portion of which is incapacitation of the pilot, the outcome of the analysis would be very conservative.

E3.2.3.4 Total effective target area

Assuming a uniform probability of impact in all directions, the effective target area presented by the segmenting wall between Building 696 SWPA and Building 696 RWSA is integrated in all directions. In this case, it is the average of the four directional target area based on assumptions, as follows:

$$A_{TOTAL} = \frac{1}{4} \times \{A_{EAST} + A_{WEST} + 2 \times (W + H_2 \times \cot\phi + S) \times (\delta + WS)\}$$

Because of the dependence, the total effective target area must be evaluated for a range of impact angles. Results are shown in **Table E-3**.

Table E-3. Total effective target area for various impact angles

ϕ	3°	7°	15°	30°	60°	85°
S, ft	60	60	60	60	60	60
H_1, ft	15	15	15	15	15	15
H_2	20	20	20	20	20	20
WS, ft	25	25	25	25	25	25
W, ft	83	83	83	83	83	83
$\cot\phi$	19.1	8.2	3.9	2.1	1.2	1.0
L_R, ft	60	60	60	60	60	60
A_E, ft^2	6,480	6,480	6,480	3,781	1,247	189
A_E, mi^2	2.32×10^{-4}	2.32×10^{-4}	2.32×10^{-4}	1.34×10^{-4}	4.47×10^{-5}	6.78×10^{-5}
L_S	90	90	90	90	90	90
A_W, ft^2	0	0	3,674	3,741	1,247	189
A_W, mi^2	0.0	0.0	1.32×10^{-4}	1.34×10^{-4}	4.47×10^{-5}	6.78×10^{-5}
$A_{N/S}$, ft^2	13,658	8,136	5,749	4,796	4,361	4,250
$A_{N/S}$, mi^2	4.89×10^{-4}	2.92×10^{-4}	2.03×10^{-4}	1.66×10^{-4}	1.44×10^{-4}	1.35×10^{-4}
A_T, mi^2	3.03×10^{-4}	2.04×10^{-4}	1.93×10^{-4}	1.50×10^{-4}	9.44×10^{-5}	7.09×10^{-5}

If the probability distribution function for the impact angle is conservatively ignored, a bounding probability can be obtained. As a bounding value, if it is assumed that the impact angle is always at 7°, chosen as the value for the general aviation aircraft crash angle in DOE-STD-3014-96, the effective target area for the wall separating Building 696 RWSA and Building 696 SWPA is 2.04×10^{-4} mi^2. The annual plane crash probability is then 6×10^{-7}. The calculation for the impact angle of 7° is shown in Table E-4. Even if an impact angle of 3° is assumed, the effective target area is 3.03×10^{-4} mi^2. Even then, the annual crash probability is less than 1.0×10^{-6} at 9×10^{-7}. Again, hypothetical results ignored the range of probable impact angles and assumed that the crash angle had the probability of unity. This is extremely conservative.

Table E-4. General aviation aircraft crash probability on segmenting wall of Building 696

	Number of operations	*x*, mi	*y*, mi	*f(x,y)*	*P*	*A*	Impact frequency
General aviation takeoff (EW)	42,640	-6.6	0.036	0.0	1.1×10^{-5}	2.0×10^{-4}	0.0
General aviation landing (EW)	42,640	-6.6	0.036	2.9×10^{-3}	2.0×10^{-5}	2.0×10^{-4}	4.9×10^{-7}
General aviation takeoff (WE)	9,360	6.6	-0.036	1.5×10^{-3}	1.1×10^{-5}	2.0×10^{-4}	3.1×10^{-8}
General aviation landing (WE)	9,360	6.6	-0.036	6.5×10^{-4}	2.0×10^{-5}	2.0×10^{-4}	2.4×10^{-8}
Total	104,000						5.5×10^{-7}

It is, thus, concluded that the annual crash probability of an aircraft onto the segmenting wall is not credible.

E3.2.4 Conservatism in the plane crash probability analysis

A structural evaluation of the potential aircraft crash on Building 696 RWSA was performed. The evaluation showed that a direct vertical impact by a 450-lb missile traveling at 87 mph on the most vulnerable roof beam at the point of maximum deflection in Room 1010 in Building 696 RWSA would result in yielding, but not puncture, of the beam.

It is assumed that solid fragments, such as the engine, landing gears, etc., that penetrate the roof would damage the segmenting wall. A structural evaluation demonstrated that assuming penetration of the Building 696 RWSA roof is overly conservative. Structural beams in Building 696 SWPA are bigger; thus, the conclusion would remain unchanged.

The structural beams are placed 20 ft apart. The potentially vulnerable roof area is then limited to the spacing between the structural beams minus the width of the solid fragments. There are additional K-bracings near the segmenting wall to prevent shear failure in the event of an earthquake. These provide further protection against a potential plane crash on the segmenting wall by limiting the effective target area for penetration through the roof. Thus, the computed total effective target area is bounding. The predicted crash probability of an aircraft impinging on the segmenting wall is conservative and bounding; therefore, the plane crash damaging the segmenting wall is not credible.

E3.3 Natural Phenomena

Natural phenomena are design and siting issues that are not a part of the segmentation consideration for "processes, operations, or activities" in hazard categorization. However, they are typically evaluated in the hazards analysis in documented safety analyses. An evaluation of the natural phenomena, specifically, earthquakes and strong winds, is performed for completeness.

Seismic analyses were performed using the static force method detailed in DOE-STD-1020-94 for Performance Category 2 (PC-2) structures, systems and components. These analyses were performed using a peak ground acceleration (PGA) of 0.57 g. The horizontal seismic force obtained was 0.189 W, where "W" is the aggregate of the facility weight and includes roof, wall, and appurtenance weights contributing to the total seismic dead load at the facility roof line. Design and construction of the facility meets or exceeds requirements resulting from these calculations.

Assumed wind loads are based on a basic wind speed of 72 mph coupled with a facility importance factor of 1.07 in accordance with ASCE 7-93, "Minimum Design Loads for Buildings and Other Structures." Steel bracings, support struts, and columns are designed to withstand the design basis wind with the parameters discussed previously.

When materials are out of doors and may be impacted by wind or flood, it is believed that the frequency of interaction is beyond extremely unlikely. These phenomena are generally not abrupt so that personnel can respond (e.g., move waste in doors). In addition, moving containers of material from one segment to the next and then breaching them so that they combine or have harmful interaction will not occur for these NPH (e.g., 72 mph wind or 10" flooding) events.

It is concluded that there is no common severe natural phenomenon that would bring material together or cause harmful interaction.

E3.4 Fire

Two potential vulnerabilities have been identified with respect to the impact of fire on the technical basis for segmentation of Building 696. This section evaluates these fire scenarios.

E3.4.1 Impact of Building 696 RWSA Fire on Roof Beams

The following potential vulnerability was identified in the November 2003 Building 696 Fire Hazards Analysis [Reference 2]:

> *"This partition is considered at least equivalent to 2-hr. fire-rated area separation partition. It would not, however, qualify as a 2-hr. fire-rated building separation wall, because exposed steel roof beams, on each side of the partition, are directly tied into this partition. In the event of a fire on one side of this partition that resulted in roof failure, the collapsing roof would pull this partition down with it, permitting the fire to spread to the other side of the partition."*

The identified vulnerability presented an issue that would invalidate the technical basis for segmentation. Therefore, an evaluation was necessary to address the potential vulnerability identified in the November 2003 FHA.

The magnitude of the potential fire assumed in the FHA was not defined. A large fire postulated in the yard in the Waste Storage Facilities DSA, from a truck collision that subsequently spilled diesel fuel from its punctured fuel tank, was assumed in the building for the purpose of the evaluation. The magnitude of the postulated fire in the Waste Storage Facilities DSA [Reference 3] is an 8.9-MW fire involving a 2.7-m (8.9-ft) diesel fuel pool.

Exposed roof beams are located 20-ft above the floor in Building 696 RWSA and 35-ft above the floor in Building 696 SWPA. Using the data for the postulated fire, the flame height can be calculated based on the Heskestad flame height correlation [Reference 5], as follows:

$$L_f = 0.23\dot{Q}_c^{2/5} - 1.02D_{eq}, \quad \text{for } 7 < \frac{\dot{Q}_c^{2/5}}{D_{eq}} < 700\,\frac{\text{kW}^{2/5}}{\text{m}}$$

where Q_c is the magnitude of the fire in kW and D_{eq} is the equivalent diameter of the postulated pool fire in m. The magnitude of the postulated fire in the Waste Storage Facilities DSA is an 8.9-MW fire involving a spilled diesel fuel pool with a diameter of 2.7 m (8.9 ft). Based on the data, the flame height is as follows:

$$L_f = 0.23 \times (8{,}920)^{2/5} - 1.02 \times (2.7) = 6.0\ \text{m}\ (20\ \text{ft})$$

The flame impingement is not a concern for Building 696 SWPA; the roof beams are located 35 ft from the floor.

For Building 696 RWSA, there is a potential for flame impingement and subsequent failure of the exposed roof beams. However, roof beams are placed 20 ft apart and failure, if any, will be localized. Based on the qualitative structural evaluation, localized failure of a single roof beam is not a catastrophic failure of the roof in Building 696 RWSA, and will not lead to subsequent failure of the partition.

It is concluded that the partition separating Building 696 SWPA and Building 696 RWSA is not subject to a catastrophic failure as discussed in the November 2003 FHA.

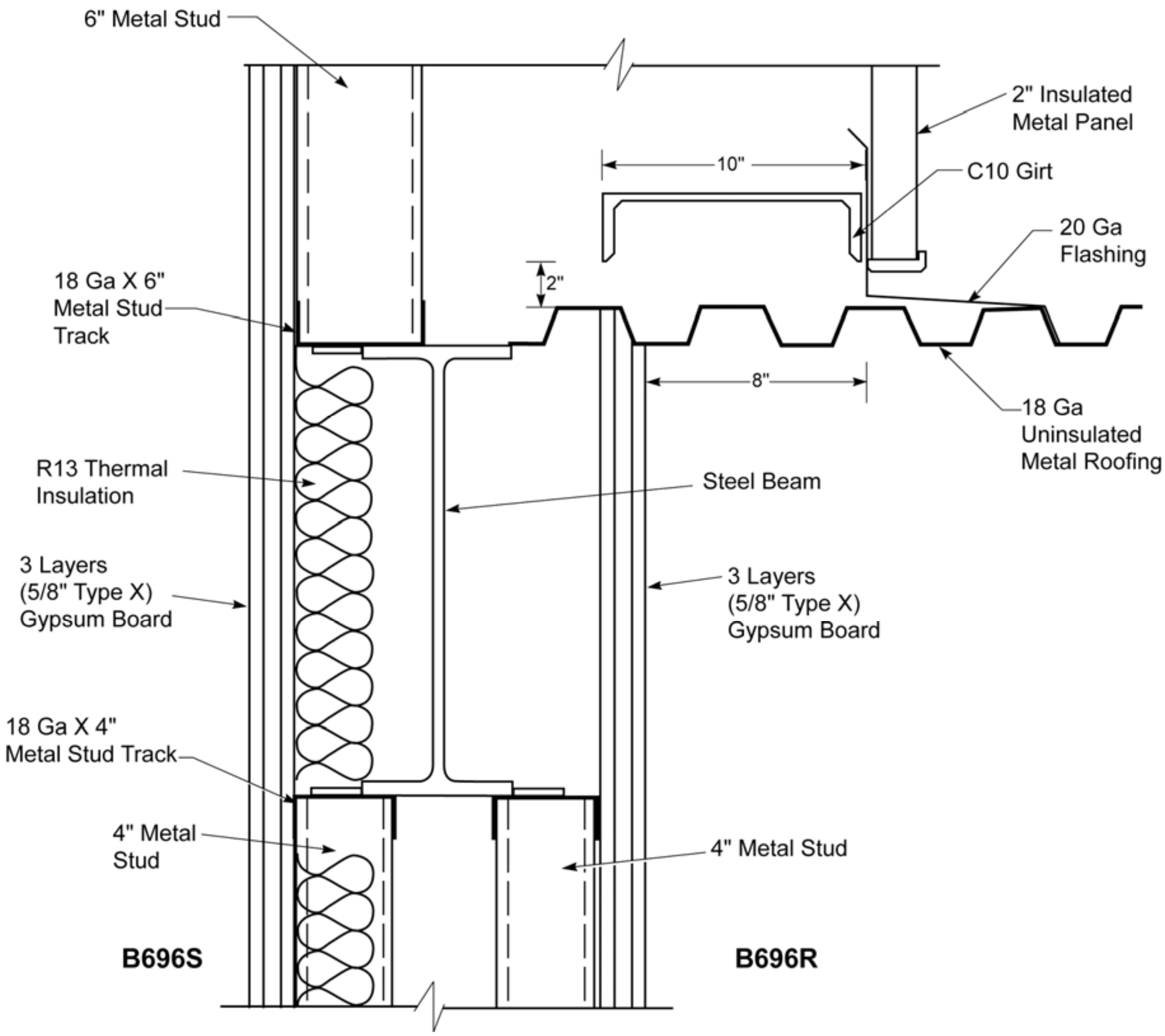
E3.4.2 Impact of Building 696 RWSA Fire on Partition-Roof Interface

An additional vulnerability related to the B696R partition-roof interface was identified in a December 2006 assessment by an LLNL Fire Protection Engineer (FPE) (References 6 and 7). This assessment called into question an assumption associated with the adequacy of the partition between B696R and B696S. The fire rating of the partition between B696R and B696S from the true floor to the true ceiling was unquestioned; however, the adequacy of the B696R partition-roof interface was brought into question by the assessment.

The assessment (Reference 6) stated, "The wall in question has construction similar to walls that are listed by a NRTL [Nationally Recognized Testing Laboratory] and have a 3 hour rating. However, the wall ceiling junction is the weak point that would let heat and fire into the interior of the wall that could damage the support structure of the wall to the point of failure."

As shown in Figure E-2, the exterior wall (an insulated metal panel) of the B696S high bay extends above the B696R low bay and has a slight overhang (approximately 8-in.) relative to B696R. The fire protection assessment identified that this construction creates a potential vulnerability such that in the event of a fire in B696R adjacent to the B696S/B696R partition, heat from the fire could burn through the uninsulated metal roof deck and allow heat and smoke to enter the cavity formed by the high bay wall in B696S Room 1009 and the exterior wall panel. This heat could potentially damage the B696S/B696R partition.

Figure E-2. Cross-section Showing B696R Wall-Ceiling Interface



Two engineering assessments were performed to evaluate the potential vulnerability raised by the fire protection assessment and to determine whether the basis for segmentation remains valid. These assessments are discussed below.

A qualitative analysis of the B696S/B696R partition's expected performance in the event of a fire was prepared to evaluate this potential vulnerability (Reference 8). The analysis evaluated the expected progression of a theoretical 2-hr equivalent fire and a fire limited by the TSR combustible loading control of 7 lb/ft^2 and documented the expected impact on the B696S/B696R partition.

The analysis concluded that a 2-hr fire in B696R Room 1010 adjacent to the B696S/B696R partition will result in entry of heat into the interior of the upper B696S high bay wall (above the B696R roof deck), while obstructions (primarily a steel beam and metal stud tracks) in the wall will preclude any significant entry of heat into the lower portion separating B696S and B696R. The heat in the upper portion of the high bay wall is likely to result in cracking damage on the upper wall that will allow heat intrusion into the upper volume of the B696S high bay. However, fire is not expected to propagate as this area inherently has little, if any, combustible material. The lower portion of the wall that separates B696R from B696S will not be impacted by the heat entering the upper portion of the wall and will experience only the normal damage expected from a fire, consistent with the construction of the wall. The conclusion of the analysis of the theoretical 2-hr fire is as follows:

> In the event of a 2-hr equivalent fire in B696R Room 1010, the fire is not expected to propagate from B696R to B696S. The wall will perform its safety function of reducing the likelihood of fire propagation from B696R to B696S.

The analysis concluded that in a 7 lb/ft^2 equivalent fire, the potential failure mechanism at the partition-roof interface does not occur. The conclusion of the analysis of the 7 lb/ft^2 equivalent fire is as follows:

> In the event of a 7-lb/ft^2 equivalent fire in B696R Room 1010, the fire is not expected to challenge the wall or wall-roof interface in a manner that would allow the fire to circumvent the wall or propagate from B696R to B696S. The wall will perform its safety function of reducing the likelihood of fire propagation from B696R to B696S.

Additionally, an evaluation of the B696S/B696R partition was performed by a registered fire protection engineer (subcontractor to LLNL) to provide an independent assessment of the wall performance (Reference 9). The conclusions of the independent evaluation were that based on the established use of the facility:

- The B696S/B696R partition meets the construction requirements for a 2-hr fire barrier as described in National Fire Protection Association (NFPA) 221, "Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls."

- The fire barrier wall is adequate to prevent the transmission of heat and fire for the intended duration of 2 hours.

The aggregate information in these assessments demonstrates that the combination of the existing B696S/B696R partition and the TSR combustible loading limits precludes a fire from propagating from B696R to B696S. Therefore, this vulnerability has no impact on the basis for segmentation.

E3.4.3 Use of Distance and Fire Loading in Segmentation

Additional discussion was requested by NNSA personnel in DOE to justify the use of distance and fire loading as part of the technical basis for segmentation of Building 695 Segment. In past discussions of DSA development and facility segmentation, 20 ft was assumed to be adequate for physical separation.

Spacing should be at least twice the height of the stacked materials to prevent the spread of fire from stack to stack or from stack to building. The largest material stacked outdoors will be the double-stacked 4-ft × 4-ft × 7-ft waste boxes. The height of the stacked boxes will be approximately eight feet, so twice this height is sixteen feet which is less than the proposed 20-ft fire break.

Additionally, the NFPA also provides guidance for protecting buildings from exposure to exterior fires. By determining the width-to-height ratio for the hypothetical fire, the minimum separation distance can be calculated using some parameters of the exposed building. The first step in this calculation is to determine the severity of the fire loading in the area. The NFPA classifies 7 lbs/ft^2 of combustible materials as a "light" severity of fire loading. A worst-case scenario would be for the double-stacked waste boxes to catch on fire. The stacked waste boxes have a width-to-height ratio of 0.875, which will be rounded up to a value of 1.0. A conservative assumption would be to assume that the side of the building exposed to the fire is totally open so as to expose the contents of the building to the fire. Following the table provided by the NFPA, the minimum separation distance can be determined by multiplying the smaller dimension of the fire (either width or height) by 1.39 and adding five feet to the result:

$$\text{Minimum Separation} = 7' \times 1.39 + 5' = 14.73\,feet$$

The minimum separation calculated is in relative agreement with the previous NFPA citation that recommended a sixteen-foot separation based on a "rule of thumb" determination. Though this calculative procedure is used primarily for determining distances between buildings, NFPA 231 recommended this procedure when storing commodities next to buildings.

Potential fires around Building 696 would not involve combined material at risk from either Building 696 RWSA or the Building 695 Segment because there is adequate separation.

The anticipated combustible loading in RHWM facilities, consisting of transient and fixed combustibles, is lower than 7 lb/ft^2. The separation in a building containing this concentration of combustibles requires one-hour fire-rated partitions. The partition separating the SWPA from the RWSA in Building 696 is of equal construction to various listed 3 hour rated designs (Reference 7). Limiting the combustible material storage in B696S Room 1009 and in B696R to 7 lb/ft^2 essentially limits the potential damage to the partition and ensures that the partition will not be breached due to a fire.

E.4 Conclusion

According to DOE-STD-1027-92, Attachment 1, the following considerations are made in facility segmentation:

> "It is necessary to avoid placing excessive requirements on simple or even trivial co-located operations. The concept of independent facility segments should be applied where *facility features* preclude bringing material together or causing harmful interaction from a common severe phenomenon."

In order to satisfy the requirement in DOE-STD-1027-92, potential accidents that could invalidate the technical basis for segmentation were evaluated to ensure that "facility features" are adequate, as follows:

- Shared utilities
- Aircraft crash
- Natural phenomena
- Fire

It was shown in Section E3.1 that failure or malfunction of shared utilities for Building 696 RWSA and Building 695 Segment would lead to interruptions in operations. However, it was shown that failure or malfunction would not bring radioactive inventories together to pose undue risk to the public, workers or environment.

The potential for an aircraft crash into the partition separating Building 696 SWPA and Building 696 RWSA was evaluated in Section E3.2. A structural evaluation using conservative assumptions showed that a direct impact on the most vulnerable roof beam would result in yielding, but not puncture, of the beam. The probability estimate, however, assumed puncture upon impact for conservatism. Even then, the estimated annual probability of impact was determined to be less than 1×10^{-6}. A range of impact angles was evaluated in Section E3.2, results of which showed that the conclusion remains unchanged.

Natural phenomena were evaluated in Section E3.3. Building 696 and Building 695 are seismically qualified structures to preclude release of radioactivity in the event of natural phenomena, in particular, earthquakes and strong winds.

The potential for fire propagation that would adversely affect the radioactive inventories in the two segments was evaluated in Section E3.4. The evaluation addressed the vulnerabilities identified in the November 2003 FHA and December 2006 fire protection assessment with the potential for invalidating the segmentation of Building 696 SWPA and Building 696 RWSA. Based on the anticipated combustible loading and the magnitude of potential fires, it was shown that fire separation provided by the partition and the physical separation of 20 ft around the Building 695 Segment were adequate to prevent fire propagation.

It is concluded that there is no common severe phenomenon that would bring material together or cause harmful interaction. Therefore, the Building 695 Segment as a Hazard Category 3 nuclear facility satisfies the requirement in DOE-STD-1027-92 for segmentation.

E.5 References

1. Federal Aviation Administration, <http://aspm.faa.gov/main/atads.asp> (March 14, 2008).

2. "Fire Hazard Analysis of Building 696, Decontamination and Waste Treatment Facility, Solid Waste Processing & Storage Building," Revision 2, November, 2003.

3. "Documented Safety Analysis for the Waste Storage Facilities," latest revision.

4. Introduction to Fire Dynamics, Douglas Drysdale, 2nd edition, Wiley & Sons, 1998.

5. Fire Protection Handbook, Arthur E. Cote, et. al., 18th edition, National Fire Protection Association, 1997.

6. Memorandum from Michael L. Jones to Kerry Cadwell, "Clarification of Building 696 Fire Barrier Wall Hour Rating vs. Failure Time. (Question from E-mail dated 14 December 2006 from Kerry Cadwell)," December 21, 2006.

7. Memorandum from Michael L. Jones to Pat Epperson, "Bldg 696 Fire Partition Wall Between Room 1009 and 1010 Determination of Construction Fire Resistance Rating of Wall," December 6, 2006.

8. RHWM Calculation WM/FS B696-07-01, "Impact of fire on wall in B696," May 18, 2007, Rev. 1.

9. Letter from Patrick C. Ward, Schirmer Engineering Corporation, to David Larsen, LLNL, "Fire Barrier Wall, LLNL Building 696, Livermore, California, SEC Project No. 1607003-000," February 14, 2007.