LOCKHEED MARTIN

ENVIRONMENTAL RESTORATION PROGRAM

ORNL/ER-403

Safety Analysis Report for the Gunite and Associated Tanks Project Remediation of the South Tank Farm, Facility 3507, Oak Ridge National Laboratory, Oak Ridge, Tennessee

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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contributed to the preparation of this document and should not be considered an eligible contractor for its review.

ORNL/ER-403

Safety Analysis Report for the Gunite and Associated Tanks Project Remediation of the South Tank Farm, Facility 3507, Oak Ridge National Laboratory, Oak Ridge, Tennessee

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Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
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APPROVALS

Safety Analysis Report
for the Gunite and Associated Tanks
Project Remediation
of the South Tank Farm, Facility 3507,
Oak Ridge National Laboratory,
Oak Ridge, Tennessee
(ORNL/ER-403)

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PREFACE

This *Safety Analysis Report for the Gunite and Associated Tanks Project Remediation of the South Tank Farm, Facility 3507, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (ORNL/ER-403) was prepared under Work Breakdown Structure 1.4.12.6.1.01.41.19.10 (Activity Data Sheet 3300, "Gunite and Associated Tanks Project").

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ABBREVIATIONS

AGL	above ground level
ALARA	as low as reasonably achievable
CFR	*Code of Federal Regulations*
CSEE	confined sluicing end effector
DOE	U.S. Department of Energy
EBA	Evaluation Basis Accident
Energy Research	Lockheed Martin Energy Research Corporation
Energy Systems	Lockheed Martin Energy Systems, Inc.
ER	Environmental Restoration
ETTP	East Tennessee Technology Park
FMCL	Fissionable Material Control Limit
GAAT	Gunite and Associated Tanks
GSEE	Gunite Scarifying End Effector
HEPA	High Efficiency Particulate Air
HMA	Hose Management Arm
HMS	Hose Management System
IDLH	Immediately Dangerous to Life and Health
LCO	limiting conditions for operation
LCS	limiting control setting
LLLW	Liquid Low-Level Waste
MLDUA	Modified Light-Duty Utility Arm
MSL	mean sea level
NCS	Nuclear Criticality Safety
NTF	North Tank Farm
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCM	Personnel Contamination Monitor
PHA	Preliminary Hazards Analysis
PMF	Probable Maximum Flood
QA	quality assurance
ROV	remotely operated vehicle
RQ	Reportable Quantity
SAR	Safety Analysis Report
SCS	Sludge Conditioning System
SL	safety limit
SSC	structure, system, or component
STF	South Tank Farm
TQ	Threshold Quantity
TSR	Technical Safety Requirements
WD&C	Waste Dislodging and Conveyance System

EXECUTIVE SUMMARY

E.1 SOUTH TANK FARM BACKGROUND

The South Tank Farm (STF) is a series of six, 170,000-gal underground, domed storage tanks, which were placed into service in 1943. The tanks were constructed of a concrete mixture known as gunite. They were used as a portion of the Liquid Low-Level Waste System for the collection, neutralization, storage, and transfer of the aqueous portion of the radioactive and/or hazardous chemical wastes produced as part of normal facility operations at Oak Ridge National Laboratory (ORNL). The last of the tanks was taken out of service in 1986, but the tanks have been shown by structural analysis to continue to be structurally sound. An attempt was made in 1983 to empty the tanks; however, removal of all the sludge from the tanks was not possible with the equipment and schedule available. Since removal of the liquid waste in 1983, liquid continues to accumulate within the tanks. The in-leakage is believed to be the result of groundwater dripping into the tanks around penetrations in the domes. The tanks are currently being maintained under a Surveillance and Maintenance Program that includes activities such as level monitoring, vegetation control, High Efficiency Particulate Air (HEPA) filter leakage requirement testing/replacement, sign erection/repair, pump-out of excessive liquids, and instrument calibration/maintenance. These activities are addressed in ORNL/ER-275[1].

E.2 REMEDIATION PROJECT OVERVIEW

The gunite tanks of the STF and the gunite and stainless steel tanks in the North Tank Farm (NTF) are known collectively as the Gunite and Associated Tanks (GAAT). These tanks are to undergo remediation and clean-up through the use of sludge removal techniques and equipment planned for use in other waste storage tanks throughout the U.S. Department of Energy (DOE) complex. Sludges in Tanks W-3 and W-4 in the NTF and Tanks W-5, W-6, W-7, W-8, W-9, and W-10 in the STF will be the subject of the first phase of the remediation project. A technique known as confined sluicing, which uses a high-pressure, low-volume water jet integrated with a jet pump, will be used to remove the sludge. Two deployment options are used for the confined sluicing. The first is a Modified Light-Duty Utility Arm (MLDUA), which is a remotely controlled robotic arm that can be used to position and manipulate the sluicing equipment The second is a remotely operated vehicle, a tracked vehicle equipped with a manipulator gripper that is used to position and manipulate the confined sluicing equipment and a plow-type blade that is used to move sludge around the tank. In addition to the confined sluicing, scarifying, with high-pressure water cutters, may be performed to remove contaminated material embedded in the surface of the walls and floors.

The MLDUA, remotely operated vehicle, and confined sluicing equipment transfer the sludge as a slurry out of the tank, through a Sludge Conditioning System (SCS) and transfer piping to Tank W-8 and/or W-9, and ultimately to the Melton Valley Storage Tanks in Building 7830. The SCS is currently only a booster pump to transfer the slurry to the receiving tank but in the future will include a mechanical equipment unit used to ensure the slurry does not inadvertently plug the intervalley transfer line.

E.3 HAZARD CLASSIFICATION

The hazards associated with the STF remediation project are identified in the hazard identification tables in Appendix A. The identified hazards were compared with screening values from ES/CSET-2/R2[2] to eliminate from further evaluation hazards considered insignificant, routine, or standard industrial. The remaining sources of hazardous material or energy were used to determine a nuclear and a nonnuclear facility hazard classification for the STF operations. The determination of the facility hazard classification is documented fully in Chap. 3. The STF remediation project was given a preliminary nuclear facility classification of "Category 2" and nonnuclear facility classification of "Low." After evaluation of the type and quantities of hazardous material, system components and configuration, and the type and magnitude of energy sources available for dispersal of the hazardous materials, the final nuclear hazard classification is "Category 3."

E.4 SAFETY ANALYSIS OVERVIEW

The purpose of this Safety Analysis Report (SAR) is to evaluate the operation of the GAAT Project remediation of the STF to adequately assess the risk to health and environment; to evaluate that risk based on the operational hazards; and to determine what preventive or mitigative features, such as system design or configuration, operational controls or limitations, staffing levels, specific safety features, and/or administrative controls, are necessary to lower the risk to below analysis guidelines. This analysis, first, identified the hazards associated with the STF remediation. Then, hazards that were not eliminated in the hazard screening as insignificant, routine, or standard industrial were further evaluated in the Preliminary Hazards Analysis (PHA).

The PHA (included as Appendix B) identified and qualitatively evaluated accidents initiated by both external events (natural phenomena and man-made) and internal process-related events. First, the frequency and the on-site and off-site consequences for each of these accidents were estimated. Then each accident was placed into bins for frequency and off-site consequence with no credit taken for preventive or mitigative features. On the basis of the frequency and off-site consequence bins chosen, each accident or event was assigned a Risk Category (I, II, III, or IV) indicating the relative risk to off-site personnel. Events whose risk was determined to be serious or major (Risk Category I or II) were retained for further quantitative evaluation in the accident analysis. Accidents with on-site consequences that exceeded analysis guidelines for on-site risk were re-evaluated with credit taken for prevention, detection, or mitigation features and controls necessary to reduce the frequency and/or the consequence below the analysis guidelines. The features and controls for which credit is taken are designated as safety-significant. Finally, the accident analysis was performed. This analysis included scenario and source term development, estimate of frequency, calculation of consequence, comparison with analysis guidelines, and determination of the need for safety-class or safety-significant structure, system or components or administrative controls.

E.5 ORGANIZATIONS

The GAAT Project remediation of the STF is the responsibility of the Lockheed Martin Energy Systems, Inc. (Energy Systems), Environmental Restoration (ER) Program. The tanks, equipment, and facilities are physically located at ORNL, which is managed by Lockheed Martin Energy Research Corporation (Energy Research). A Memorandum of Agreement outlines the procedures, accountable parties, roles, and responsibilities associated with interfaces between Energy Research and Energy Systems ER. Energy Systems ER is responsible for identification, remediation, and surveillance of the low-level radioactive waste tank systems at ORNL and for coordinating the prioritization of environmental restoration tasks at ORNL with appropriate regulatory agencies. Energy Research is responsible for providing environmental regulatory guidance, interpretation, and oversight; establishing safety and health requirements; providing health physicist support and oversight; providing technical support and oversight in the area of safety documentation; and providing quality assurance support and inspection services.

System Safety Engineering of Energy Systems is responsible for coordination of the safety documentation. Science Applications International Corporation, a subcontract consultant, prepared this SAR with guidance from System Safety Engineering and ER project personnel and facility manager.

E.6 SAFETY ANALYSIS CONCLUSIONS

The hazards identified for the STF remediation project were analyzed in the PHA, which identifies potential accident scenarios and qualitatively estimates the consequences. As a result, the PHA identifies features and controls necessary to maintain on-site consequences below analysis guidelines. These features and controls are designated safety-significant and are described further in Chaps. 3, 4, and 5. Additionally, accidents identified in the PHA as presenting significant risk to off-site personnel were evaluated further in the accident analysis in Chap. 3. The conclusion resulting from the accident analysis is that the STF remediation may be performed within the analysis guidelines with no designated safety-class features or controls.

E.7 SAR ORGANIZATION

The nuclear hazard classifications for the STF activities were determined to be "Category 3." "Category 3" facilities, by definition, are required to have SARs by DOE Order 5480.23[3]. The format and content of this document are based on the level of detail for a simple Hazard Category 3 facility as outlined in DOE-STD-3009-94[4].

E.8 REFERENCES

1. ORNL/ER-275, *Surveillance and Maintenance Plan for the Inactive Liquid Low-Level Waste Tanks at Oak Ridge National Laboratory,* Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee, November 1994.

2. ES/CSET-2/R2, *Safety Analysis Report Update Program Hazard Identification and Facility Classification Application Guide*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, December 1995.

3. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., April 30, 1992.

4. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., July 1994.

1. SITE CHARACTERISTICS

1.1 INTRODUCTION

The objective of this chapter is to describe the characteristics of the site on which the facility is located. This site information is necessary for identifying and evaluating potential external and natural phenomena accident initiators and for identifying and analyzing accident consequences outside the facility. The following information is included:

- The location of the site, the location of the facility within the site, and its proximity to the public and to other facilities.
- Quantification of those characteristics of the surrounding environment that influence the design, procedures, and safety of the operation.
- Determination of the historical basis for site characteristics in meteorology, hydrology, geology, seismology, and other natural phenomena to the extent needed for hazard and accident analyses.
- Identification of the design basis external limits to be examined.
- Specification of population sheltering, population location and density, and other aspects of the site that affect the surrounding area.
- Identification of on-site workers and site boundaries.

1.2 REQUIREMENTS

Requirements for siting, external hazards to be evaluated, and evaluation of hazards are contained in U.S. Department of Energy (DOE) Orders 420.1[1] and 5480.23[2].

1.3 SITE DESCRIPTION

1.3.1 Location and Access

The Gunite and Associated Tanks (GAAT) Project remediation of the South Tank Farm (STF) is located in the main laboratory complex area of Oak Ridge National Laboratory (ORNL) in Roane County, Tennessee. ORNL is located on the U.S. Government–owned Oak Ridge Reservation (ORR), which is within the corporate limits of the city of Oak Ridge. The ORR lies within the Tennessee Valley between the Cumberland and Southern Appalachian mountain ranges in the eastern portion of the state of Tennessee, as shown in Fig. 1.1. The ORR (shown on Fig. 1.2) occupies about 37,000 acres and includes three major complexes [the Oak Ridge Y-12 Plant, ORNL, and the East Tennessee Technology Park (ETTP)] with a total fenced area of about 2000 acres.

The eastern and southern boundaries of the ORR are defined by the Melton Hill Reservoir and the Clinch River. The western boundary is formed by the Clinch River backwaters of Watts Bar Reservoir on the Tennessee River. Black Oak Ridge forms the western portion of the ORR's northern boundary. The three complexes are located in separate but adjacent valleys on the ORR. The Y-12 Plant, situated in eastern Bear Creek Valley, is bounded on the south by Chestnut Ridge and on the north by Pine Ridge. The main ORNL facilities are located about 13 km (8 miles) southwest of the population center of the city of Oak Ridge in Bethel Valley between Haw Ridge and Chestnut Ridge, with ancillary facilities in Melton Valley to the south. ETTP is located in East Fork Valley, about 16 km (10 miles) west of the population center of the city of Oak Ridge. These geographic features are shown in Fig. 1.2.

The STF is located approximately 390 m (1280 ft) south of Bethel Valley Road. Figure 1.3 shows the location of the STF tanks within ORNL. The STF tanks are located south of Central Avenue and east of Third Street. Two public roads traverse the ORR and provide access to ORNL. State Highway 95 runs north-south approximately 1 mile west of the main ORNL complex. Bethel Valley Road runs east-west along the northern edge of ORNL. Both of these roads can be shut down, if needed, in the event of a serious accident at ORNL. Access to the STF is available from Bethel Valley Road via First Street to Central Avenue. All access roads onto ORNL (e.g., First Street) are closed to the public. Manned guard posts and unmanned physical barriers control access except during shift changes at ORNL (typically 6 AM to 9 AM and 4 PM to 6 PM). Access may be controlled during these hours as needed. Access to the main laboratory complex (where the STF is located) is controlled by manned guardhouses, badge readers, and turnstiles. The closest ORR boundary point is approximately 2.25 miles to the west-southwest at Clinch River.

1.3.2 Demography

The western portion of ORNL (including the main laboratory area and the STF) is located in Roane County; the remaining area is in Anderson County. Roane County is adjacent to both Knox County and Loudon County across the Clinch River to the east and south, respectively. Morgan County borders Roane County to the north. The combined 1990 population of the above five counties was 499,781, with the majority in Knox County. The area immediately surrounding the ORR is predominantly rural with the exception of the populated areas of the city of Oak Ridge along the northeast border.

The city limits of Oak Ridge encompass ORNL, although no city residents live near ORNL. The Knox County area west of Knoxville has recently been the fastest-growing area near ORNL; however, the population density is less than 50 persons per square mile within 5 miles of the STF. The demography of the area is not expected to change significantly.

Other than the roads within the ORR, the nearest major thoroughfare is Interstate 40, approximately 5.5 km (3.4 miles) southwest of the STF. Clinch River and Melton Hill Lake are components of the inland waterway system. Logs are kept of all traffic locked through Melton Hill Dam, which is located 4.7 km (2.9 miles) south-southwest of the STF. ORNL is not served directly by railroads; however, both the ETTP and the Y-12 Plant have railroad spur lines within 8 km (5 miles) of the STF.

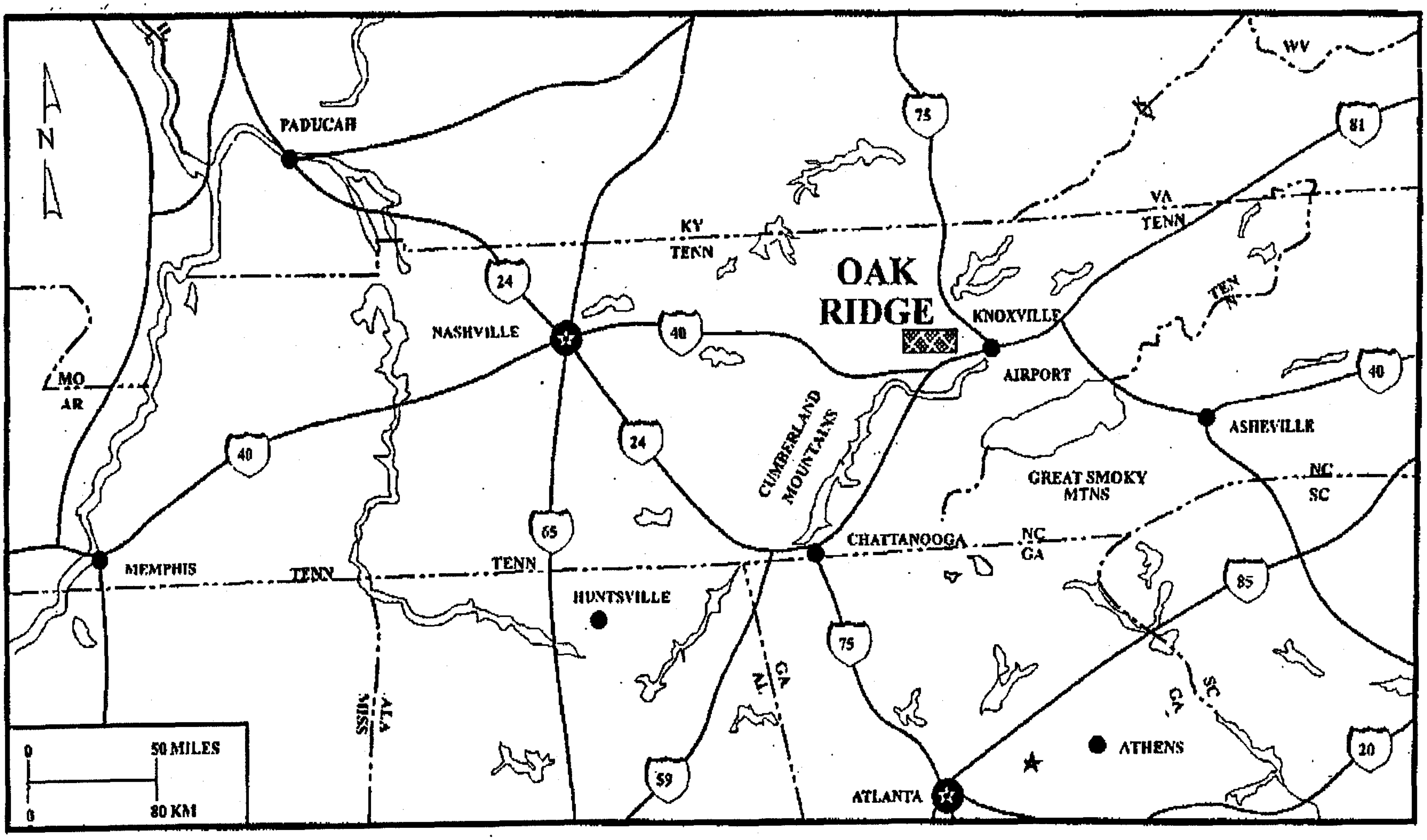

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Fig. 1.1. Location of Oak Ridge in region.

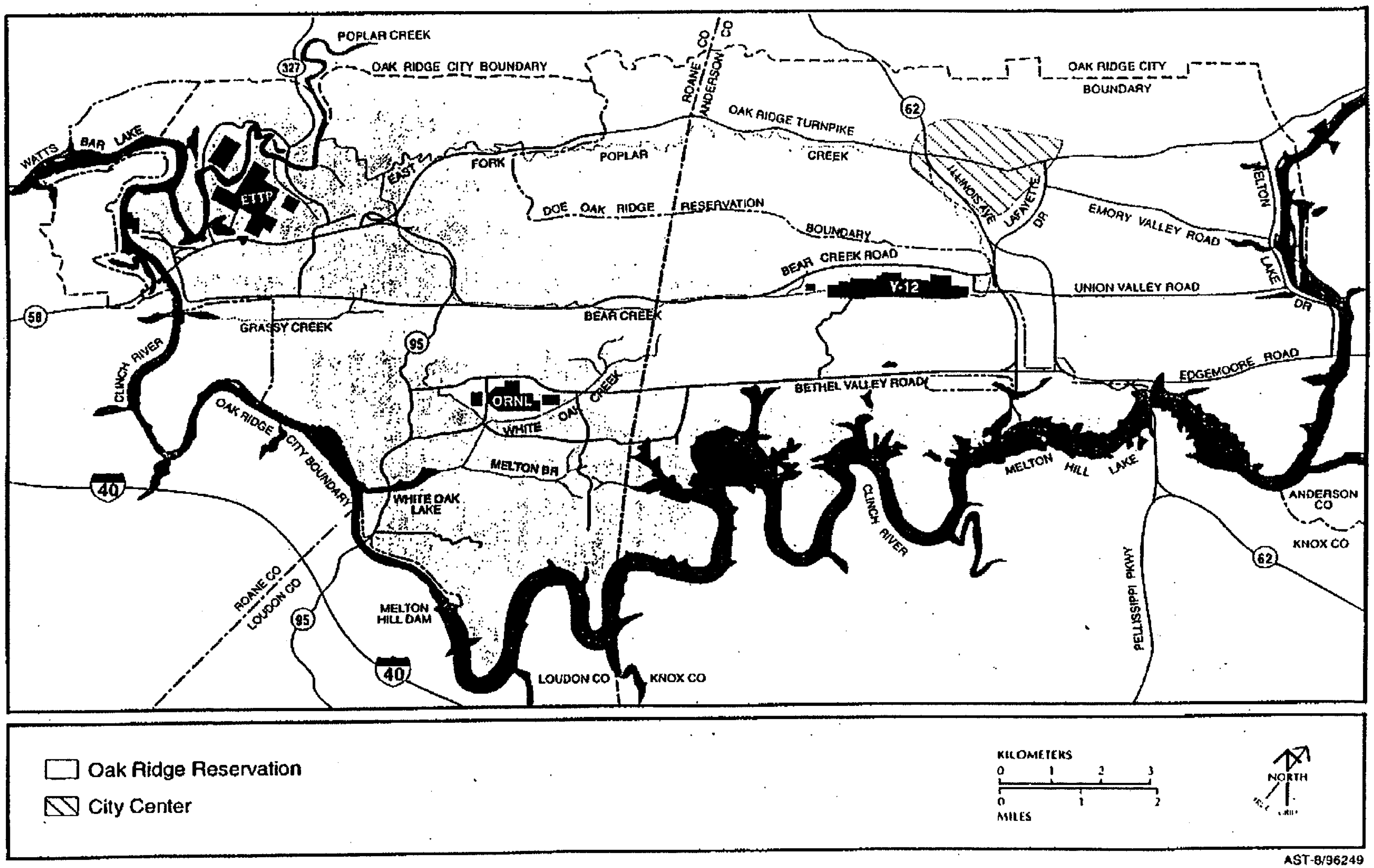

Fig. 1.2. Oak Ridge Reservation map.

1.4 ENVIRONMENTAL DESCRIPTION

1.4.1 Meteorology

1.4.1.1 Regional climatology

ORNL is located in the Tennessee Valley, which is a broad funnel-shaped valley in the eastern part of Tennessee. The Tennessee Valley, which contains the Tennessee River and its tributaries, is bordered to the northwest by the Cumberland Plateau with an average elevation of 2000 ft and to the southeast by the Great Smoky Mountains with peaks that rise as high as 6000 ft.

The Tennessee Valley experiences extreme temperature drops less frequently than locations at the same latitude to the west of the Cumberland Plateau. The winter minimum monthly average temperature is around 38°F. The summer monthly average temperature is between 75°F and 80°F. The temperature equals or exceeds 96°F an average of 6 days per year. The temperature falls below 10°F an average of 4 days per year. Low-level temperature inversions are frequent, occurring during approximately 57% of the hourly observations.

The average monthly precipitation during the winter gradually increases until it peaks in March, after which it decreases through June. Summer thunderstorm activity usually raises the average in July to near that of March. The average precipitation usually reaches a minimum in October. The annual precipitation averages between 50 and 60 in. and exceeds 65 in. about once in 10 years. Approximately once in 10 years, a thunderstorm will produce 2 in. of rain in an hour. The snowfall in the Tennessee Valley averages between 6 and 12 in. Maximum snowfalls in a single storm recorded at Oak Ridge and Knoxville were 15 and 23 in., respectively. An average of one dry period each year will extend 2 weeks or longer. Once in 10 years, a drought may extend to 4 weeks or longer.

The lowest daily average humidity is found in the late winter and early spring, and the highest is in the summer and early fall. The Tennessee Valley has a relatively high frequency of heavy fog. At the height of the fog season in October, heavy fog can be expected to occur on 5 or more days per month.

Damaging winds are relatively uncommon. Peak gusts recorded in the Tennessee Valley are generally in the 60- to 70-mph range for the months of January through July and less during the other months. The Tennessee Valley is infrequently subjected to tornadoes and hurricanes.

Eastern Tennessee has a relatively large number of forecast days of pollution potential (about 7 per year). Data indicate an average 12 stagnation days per year.

1.4.1.2 Local meteorology

Meteorological data and observations were obtained from five locations: the city of Oak Ridge, the Y-12 Plant area, the ETTP area, ORNL in Bethel Valley, and the ORNL Tower Shielding Facility on Copper Ridge.

The station in the city of Oak Ridge operated from 1956 until 1979 and has the most complete data on all meteorological parameters, including wind speed and direction, dry bulb temperature,

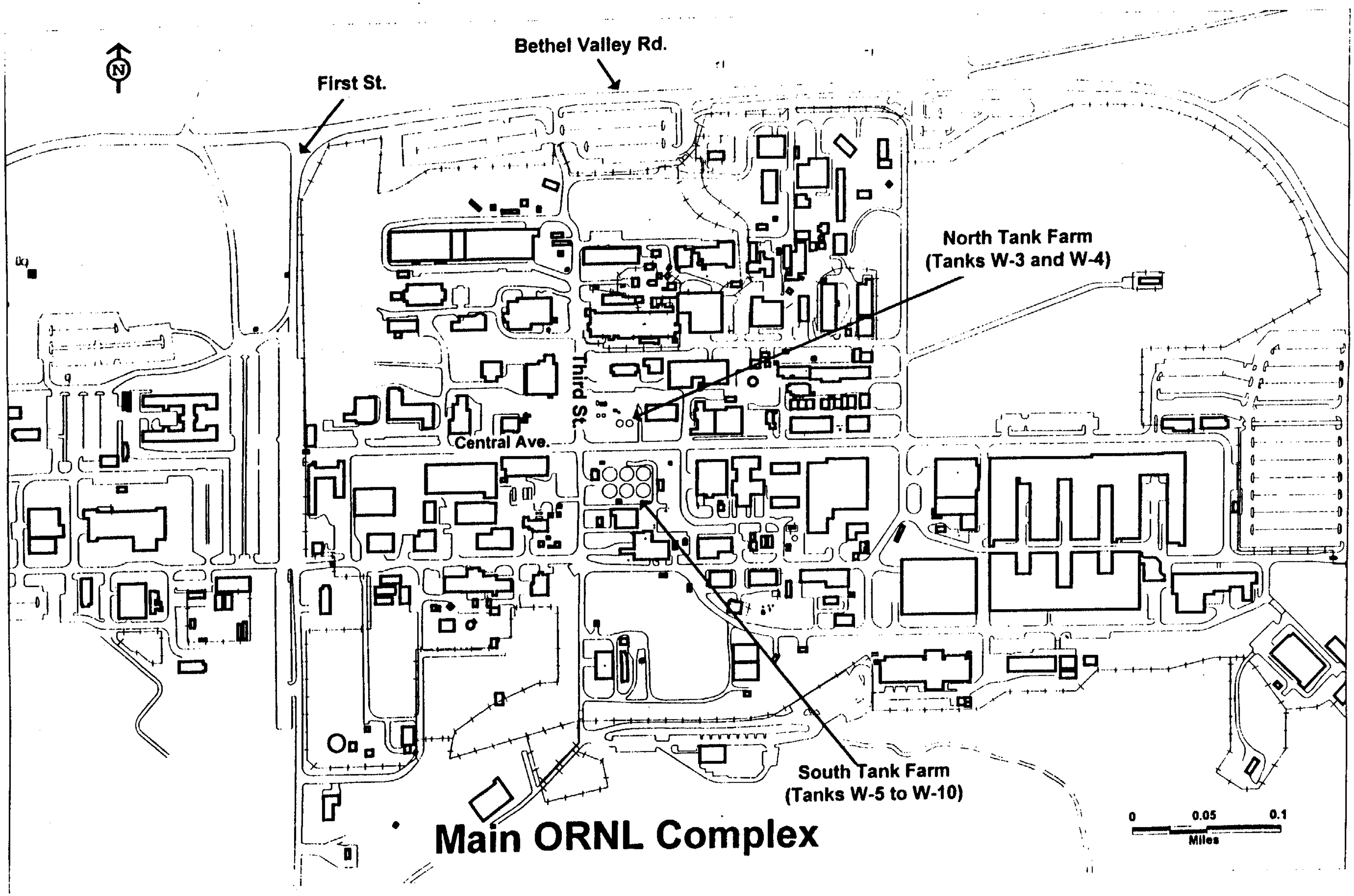

Fig. 1.3. Location of the South Tank Farm within Oak Ridge National Laboratory.

dew point, precipitation, and sky cover. Starting in December 1958, the single wind sensor at the Oak Ridge station was 41 ft above ground level (AGL) at an elevation of 955 ft above mean sea level (MSL). Before then, it was at an elevation of 46 ft. Data presented from the Oak Ridge National Weather Service Office were obtained from ISSN 0198-4861[3].

Data on wind speed and direction, dry-bulb temperature, dew point, temperature difference, and precipitation were collected hourly at the ORNL Bethel Valley Site meteorological station from 1955 through 1972. The meteorological tower for this station was a 140-ft structure located in the main area of ORNL on top of a ridge with an elevation of 886 ft above MSL. The lower temperature sensor was located 4 ft AGL, and the temperature difference measurements spanned 135 ft. The ORNL Tower Shielding Facility meteorological station was a 314-ft tower located on Copper Ridge south of the main area of ORNL and approximately 0.9 mile north of Melton Hill Dam at an elevation of 1072 ft above MSL. The parameters measured at this station from 1956 through 1972 include wind speed and direction, dry-bulb temperature, and temperature gradients. The wind sensor was 315 ft AGL, with an elevation of 1387 ft above MSL; the lower temperature sensor was 4 ft AGL; the span of the measured temperature difference was 310 ft.

The monthly average of the average daily temperatures varies from a low of 38°F in January to a high of 77°F in July. Temperatures above 100°F (105°F maximum) have been experienced in each of the months from June through September, whereas temperatures below 0°F (-17°F minimum) have been experienced in December and January.

The average annual precipitation is 54.76 in., with almost even monthly distribution. The months of lightest precipitation are August, September, and October. An average of at least one thunderstorm per month occurs throughout the year. Hail generally occurs in the months of February through August and only about 5 days every 2 years. Snow can be expected from late fall through early spring. January has the highest probability of snowfall; however, the greatest total monthly snowfall, 21 in., occurred in March 1960, and the maximum snowfall in a 24-h period of 15 in. occurred in March 1993. The mean snowfall each season is about 10.2 in., and the maximum recorded snowfall in one season was 41.4 in.

Fifteen or more consecutive days without precipitation can be expected at ORNL on an average of once a year. Consecutive days without precipitation can be expected to extend to 31 days about once every 10 years and to 63 days about once every 100 years.

The monthly average relative humidity at ORNL for the period of record (January 1951 through December 1964) ranged from 59.2% in April to 74.5% in August.

The frequency of occurrence of fog is greatest during the late summer and fall with the average monthly occurrence at a maximum of 8 days in October. Throughout the winter, spring, and early summer, fog can be expected on 2 days a month or less.

The wind direction above the ridge tops and within the Tennessee Valley at ORNL tends to be aligned with the orientation of the Tennessee Valley. The prevailing wind is from the southwest with a secondary maximum from the northeast during the winter, spring, and summer months. This situation is reversed in the fall, with the prevailing northeast wind. Wind speeds measured in the ORNL Bethel Valley area and at the Tower Shielding Facility are provided in Table 1.1.

Dispersion is related closely to atmospheric stability. The vertical temperature gradients were used to define stability classes in accordance with the requirements of Regulatory Guide 1.23 (Safety Guide 23) at the ORNL Bethel Valley site and the ORNL Tower Shielding Facility. The annual frequencies of occurrence of these stability classes are provided in Table 1.2.

Table 1.1. Wind speeds

Wind speed (mph)	Bethel Valley annual frequency of occurrence (%)	Tower Shielding Facility annual frequency of occurrence (%)
Calm	21	11
1–3	29	18
4–7	25	23
8–12	15	26
13–18	5	16
19–24	1	5
25+	<1	<1
Unknown	3	<1

Table 1.2. Atmospheric stability classes

Stability class	Bethel Valley Site annual frequency of occurrence (%)	Tower Shielding Facility annual frequency of occurrence (%)
A–Extremely Unstable	24	9
B–Moderately Unstable	2	2
C–Slightly Unstable	2	2
D–Neutral	16	27
E–Slightly Stable	23	41
F–Moderately Stable	33	19

1.4.2 Hydrology

1.4.2.1 Surface hydrology

Both Bethel Valley and Melton Valley are in the White Oak Creek drainage basin. Surface water flow in White Oak Creek is augmented by treated process wastewater, treated sanitary sewage effluent, and cooling tower discharges from various ORNL facilities. White Oak Creek is impounded by White Oak Dam about 805 m (2640 ft) above the confluence of White Oak Creek and the Clinch River. The impoundment, White Oak Lake, is used as a settling basin for waste effluent discharged from ORNL facilities. The Clinch River, the hydraulic sink for the Oak Ridge area, originates in southwest Virginia near the Kentucky border. Water flow on the Clinch River is extensively controlled by a series of Tennessee Valley Authority dams.

1.4.2.2 Subsurface hydrology

Groundwater flow on the ORR is primarily determined by water table conditions. Groundwater flow under water table conditions parallels closely the contours of the surface topography, and the water emerges to contribute to local stream flow. Recharge is derived primarily from precipitation, and groundwater discharge is through evapotranspiration, springs, and streams. The surface streams ultimately augment the water supply of the Clinch River, which is the hydraulic sink for the region. The riverbed lies at the base level of the zone of saturation, and all groundwater from both sides of the channel enter the river. Because the river bed is a major topographic feature set down in bedrock, it is unlikely any groundwater flow can pass beneath the Clinch River.

1.4.3 Geology

The ORR is located in the folded and faulted Tennessee Valley and Ridge Province of the Appalachians. Historic seismic activity in the vicinity of the ORR has occurred primarily in the Valley and Ridge Province in which Oak Ridge is located, although historically, some activity has occurred on the Cumberland Plateau to the west of Oak Ridge. The local geologic information was utilized to develop the seismic hazards and annual exceedance probabilities in UCRL-53582[4] and UCRL-15910[5].

1.5 NATURAL PHENOMENA THREATS

The following natural phenomena threats are considered as potential accident initiators (Chap 3).

1.5.1 Flooding

The Probable Maximum Flood (PMF) and Norris Dam failure were used as the basis for all evaluations. The PMF is the most severe flood that can reasonably be predicted to occur at a site as a result of hydrometeorological conditions. The PMF levels on White Oak Creek and the Clinch River have been determined in ES/CNPE-95/1[6]. The PMF level for White Oak Creek at mile 2.74 near the Building 3513 settling basin is 798.2 ft. The failure of Norris Dam will produce a flood elevation at the mouth of White Oak Creek of 799.4 ft.

1.5.2 High Winds/Tornados/Wind-Driven Missiles

A wind/tornado hazard model was developed for the Oak Ridge DOE facilities and is summarized in ES/CNPE-95/3, *Recommended High Speed Straight Wind and Tornado Hazard Levels for the Oak Ridge, Tennessee Department of Energy Reservation*[7]. The wind hazard wind speeds and associated return periods and annual probability of exceedance are shown in Fig. 1.4.

1.5.3 Seismic Activity

The seismic studies performed in accordance with DOE Order 5480.28[8] and DOE-STD-1020-94[9] for the DOE ORR are documented in ES/CNPE-95/2[10]. The results of the seismic hazard studies for peak horizontal rock accelerations are provided in Fig. 1.5. The vertical rock accelerations are two-thirds of the horizontal accelerations.

For soil supported facilities, the amplification of the above rock motions through the soil to the foundations of the facilities should be considered to determine the soil ground motions. Specific soil amplification studies have not been performed for the STF. However, studies performed for soil supported buildings at the Y-12 Plant Site (see ES/CNPE-95/2) indicate a soil amplification of the peak ground acceleration of about 2.5. This soil amplification results in the peak horizontal soil accelerations shown in Table 1.3.

Table 1.3. Seismic accelerations

Effective peak ground acceleration (g)	Recurrence interval (years)
0.15	500
0.20	1,000
0.30	2,000
0.65	10,000

1.6 EXTERNAL MAN-MADE THREATS

ANSI/ANS-2.12-1978, *American National Standard Guidelines for Combining Natural and External Man-made Hazards at Power Reactor Sites*[11] was used to identify potential external man-made accident initiators. The following external man-made threats were considered:

- aircraft crash (methodology from ORNL/ENG/TM-36, *The Annual Probability of an Aircraft Crash on the U.S. Department of Energy Reservation in Oak Ridge, Tennessee*[12] was used to determine that aircraft crash at the STF has a very low frequency of occurrence and therefore was not evaluated in Chap. 3; ORNL/ENG/TM-36 is based on the methodology provided by NUREG-0800, Sect. 3.5.1.6, "Aircraft Hazards"),

- industrial or military facility accident (no industrial or military facilities have been identified that may have an impact on STF remediation activities),

- rransportation accidents (evaluated in Chap. 3),

- explosions/missiles from natural gas pipelines or adjacent facilities (evaluated in Chap. 3),

- rorced evacuation (evaluated in Chap. 3),

- loss of facility services (evaluated in Chap. 3), and

- dam failure (evaluated in Chap. 3).

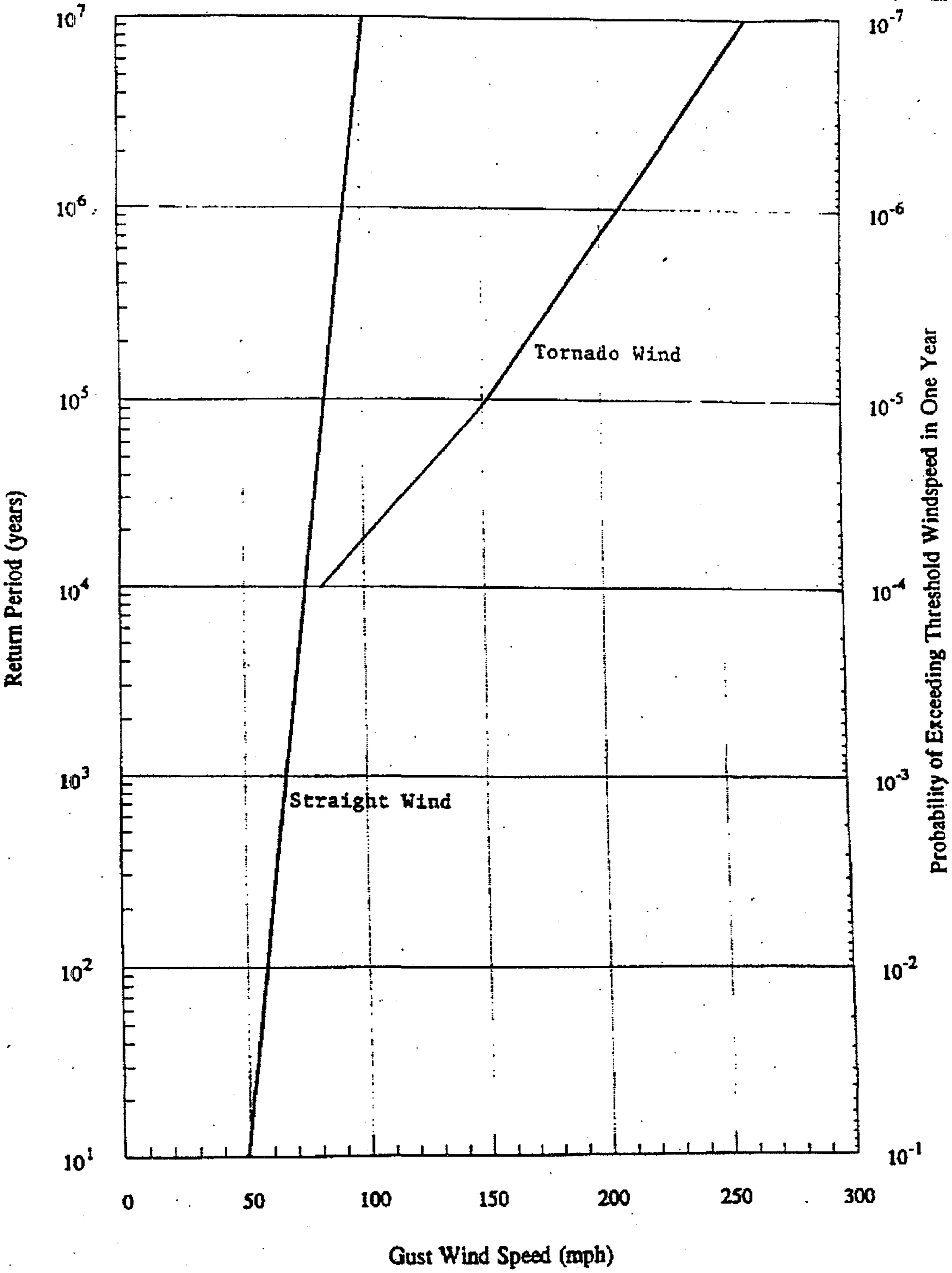

Fig. 1.4. Wind speeds and associated return periods for ORNL.

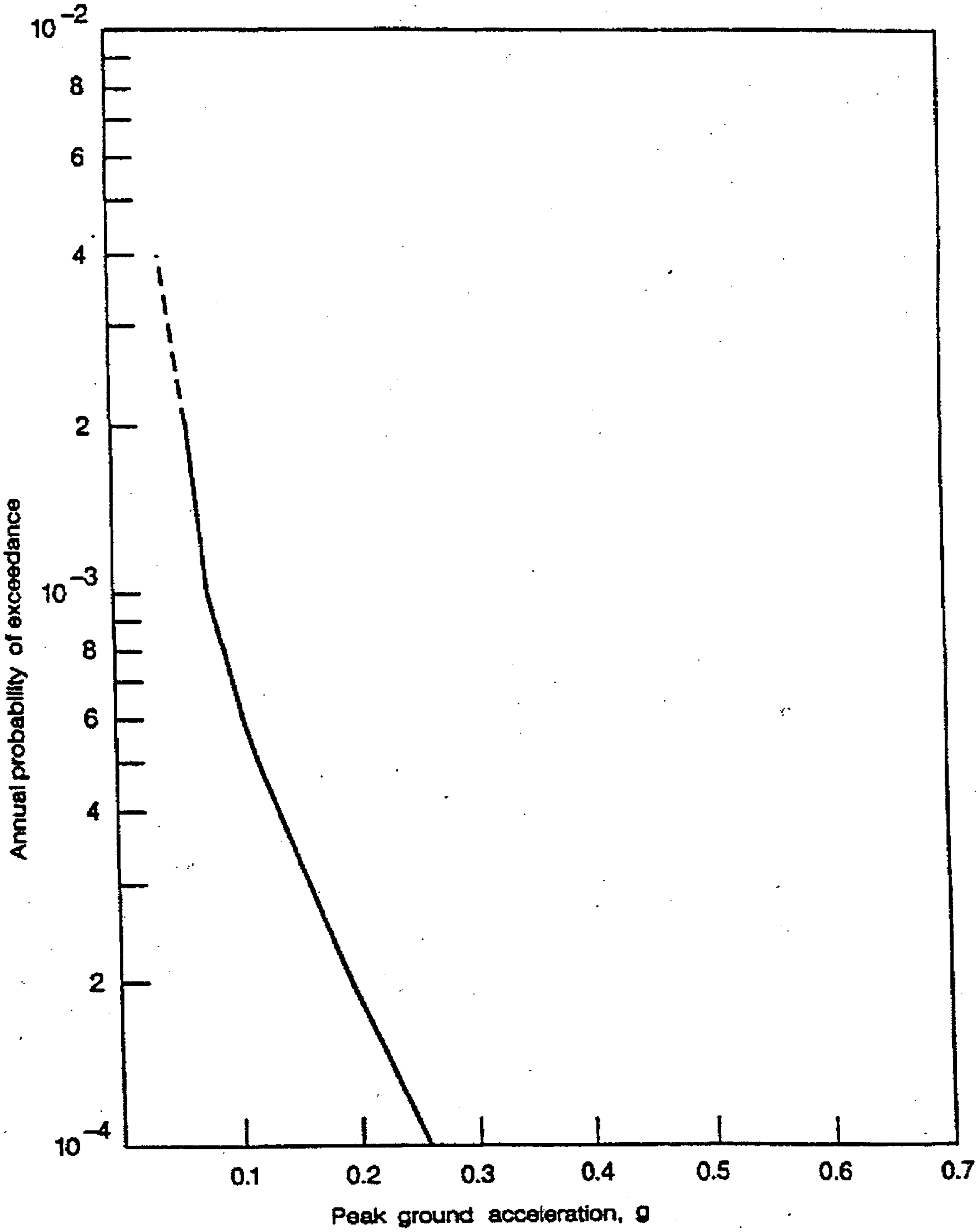

Fig. 1.5. Peak rock acceleration and associated annual probability of exceedance for the Oak Ridge Reservation.

1.7 NEARBY FACILITIES

The STF is located in the main laboratory complex of ORNL in Bethel Valley. As such, many laboratory facilities are within approximately 2000 ft of the STF. Figure 1.6 shows the location of facilities located nearest the STF.

1.8 VALIDITY OF EXISTING ENVIRONMENTAL ANALYSES

No significant discrepancies exist among any prior environmental analyses and impact statements for the STF and this current effort.

1.9 REFERENCES

1. DOE Order 420.1, *Facility Safety*, U.S. Department of Energy, Washington, D.C., October 24, 1996.

2. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., April 30, 1992.

3. ISSN 0198-4861, *1988 Local Climatological Data, Annual Summary with Comparative Data*, U.S. Department of Commerce, National Climatic Data Center, Oak Ridge, Tennessee.

4. Coats, D. W., and Murray, R. C., UCRL-53582, *Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites*, 1984.

5. *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, UCRL-15910, U.S. Department of Energy, Lawrence Livermore National Laboratory, June 1990.

6. *Flood Analysis for Department of Energy Y-12, ORNL and K-25 Plants*, ES/CNPE-95/1, Prepared for the Center for Natural Phenomena Engineering at the Oak Ridge Y-12 Plant, Lockheed Martin Energy Systems, Inc., Prepared by the Water Resources Division of the Tennessee Valley Authority, May 1995.

7. *Recommended High Speed Straight Wind and Tornadic Hazard Models for the Oak Ridge, Tennessee Department of Energy Reservation*, ES/CNPE-95/3, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, September 1995.

8. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, U.S. Department of Energy, Washington, D.C., January 15, 1993.

9. DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, U.S. Department of Energy, Washington, D.C., April 1994.

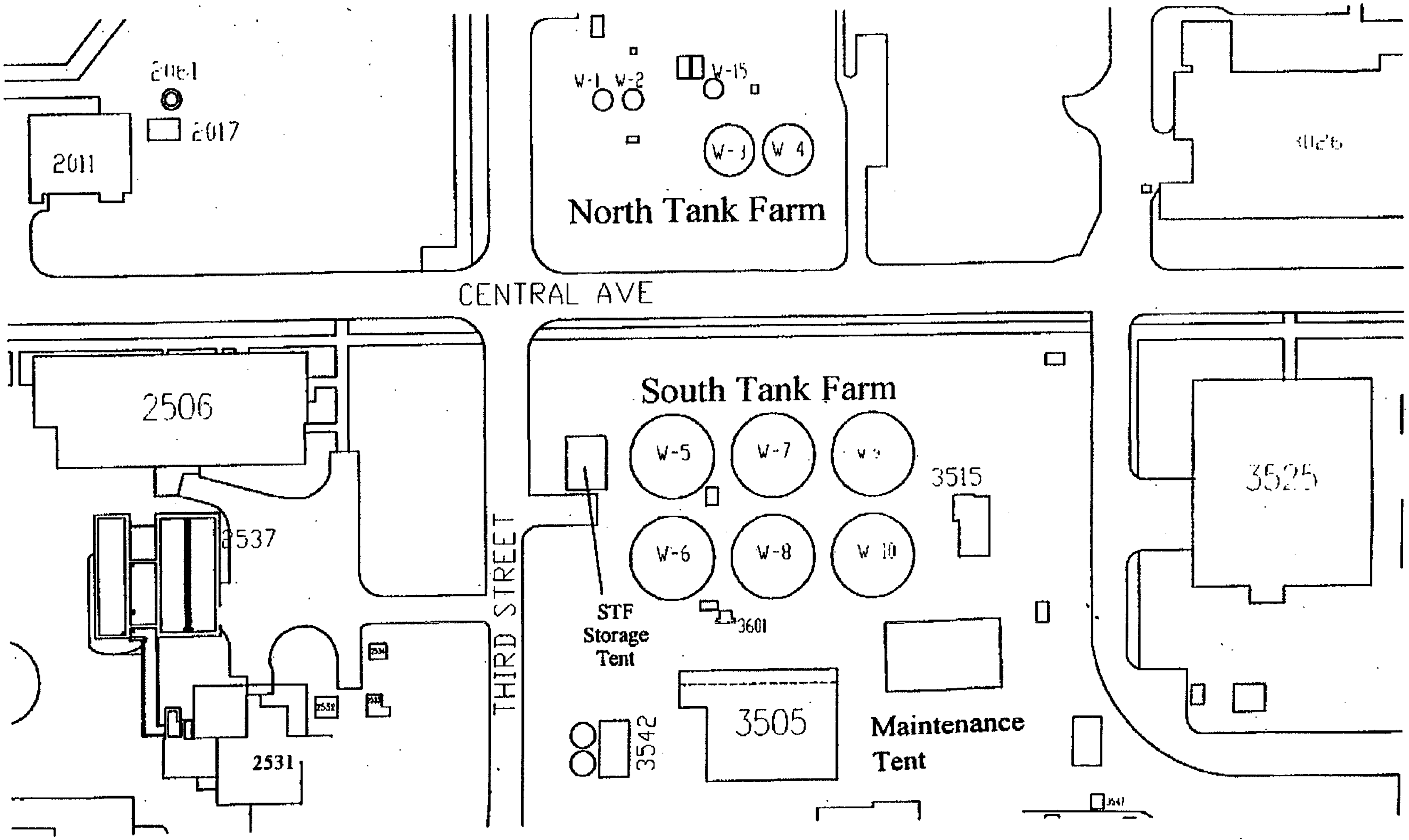

Fig. 1.6. Locations of facilities near the South Tank Farm.

10. ES/CNPE-95/2, *Seismic Hazard Criteria for the Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio, U.S. Department of Energy Reservations*, Lockheed Martin Energy Systems, Inc., December 1995.

11. ANSI/ANS-2.12-1978, *American National Standard Guidelines for Combining Natural and External Man-Made Hazards at Power Reactor Sites*, American Nuclear Society, La Grange Park, Illinois, July 25, 1978.

12. ORNL/ENG/TM-36, *The Annual Probability of an Aircraft Crash on the U.S. Department of Energy Reservation in Oak Ridge, Tennessee*, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee, November 1992.

2. FACILITY DESCRIPTION

2.1 INTRODUCTION

The purpose of this chapter is to describe the facility, its designed mission, processes, and structure, system, or components (SSCs). The description of the facility should provide an understanding of the facility operations and an appreciation of the facility structure and operations to the extent necessary to support assumptions used in hazard and accident analyses. The following information is included:

- Overview of the facility, including mission and history
- Description of the facility structure and design basis
- Description of the facility process systems and constituent components, instrumentation, controls, operating parameters, and relationships of SSCs
- Description of confinement systems
- Description of the facility safety support systems
- Description of the facility utilities
- Description of facility auxiliary systems and support facilities

2.2 REQUIREMENTS

The systems and components which will be used are a part of the GAAT Project remediation of the STF are designed and constructed in general accordance with applicable requirements of DOE Orders 420.1[1], 5820.2A[2], 440.1[3].

2.3 SOUTH TANK FARM FACILITY OVERVIEW

The STF consists of six underground liquid storage tanks (Tanks W-5, W-6, W-7, W-8, W-9, and W-10) set in a 2 x 3 array. Originally, they were utilized as a portion of the Liquid Low-Level Waste (LLLW) System for the collection, neutralization, and storage of radioactive and/or hazardous chemical wastes produced as part of normal facility operations at ORNL. Built in the 1940s, the underground storage tanks have since been removed from service because of age and changes in liquid waste system needs and requirements. Five of the tanks (W-5 through W-9) were taken out of service in 1978. The remaining tank, W-10, continued in service until 1986. Presently, the LLLW piping from all known LLLW generators to these tanks is inactive.

A campaign was undertaken from 1982 through 1984 to remove the accumulated sludges from these inactive tanks. The liquid phase was successfully pumped out and processed through the site LLLW system. Since that time, additional liquid has accumulated in the tanks from in-leakage. The in-leakage is believed to be rainwater entering the tanks as a result of inadequate sealing of the penetrations of the domes. In 1983, an attempt was made to sluice out the sludge from the tanks , and some of the sludges from the first five tanks were successfully transferred to Tank W-10. At that time, Tank W-10 was used as a collection tank for transferring material to the New Hydrofracture Facility. Sludge heels remain in Tanks W-5 through W-10.

Several sampling programs have been conducted on the liquid and solid phases in the STF tanks to define and quantify the amount of hazardous, fissionable, and radioactive contents remaining in each of the tanks after the transfers. The results of the sampling programs are detailed in reports ORNL-13[4], DOE/OR/01-1159&D1[5], ORNL/ER/Sub/87-99053/74[6], and ORNL/ER/Sub/87-99053/79[7]. Much of the information has been summarized in report ORNL/ER-365[8]. Inventories for the individual tanks are discussed in Chap. 3 and presented in Appendix A.

The GAAT Project remediation of the STF incorporates a new sludge removal technology to empty the tanks and transfer the LLLW, as a slurry, to a common collection tank (Tank W-8 and/or W-9) and then ultimately to the Melton Valley Storage Tanks. For the purposes of this report, the remediation project currently includes the tanks and their individual inventories, the interconnecting piping, a Sludge Conditioning System (SCS), and the in-tank removal equipment used to dislodge and transfer sludge from the tanks. The inventories of North Tank Farm (NTF) Tanks W-3 and W-4 also are included in the scope of the remediation project because the inventories in these tanks will be added to Tank W-8 or W-9 before or during the STF remediation.

Remediation activities include installation of supporting equipment, setup and removal of mobile equipment, sludge removal operations, and decontamination of removed equipment. Sludge removal is accomplished by remotely manipulating special equipment within the tank which dislodges the sludge and transfers the slurry out of the tank. The sludge and contaminated tank surface are removed using a high pressure, confined sluicing end effector (CSEE) or a Gunite Scarifying End Effector (GSEE). These can be attached to the end of the Modified Light-Duty Utility Arm (MLDUA) which is lowered into the tank or to the remotely operated vehicle (ROV) deployed into the tank. The overall system configuration for sludge removal operations is shown in Fig. 2.1. The in-tank configuration for sludge removal operations using the MLDUA is shown in Fig. 2.2 and the in-tank configuration for sludge removal operations using the ROV is shown in Fig. 2.3. Both the MLDUA and the ROV may be used in the same tank at the same time. However, there is only one CSEE or GSEE.

2.4 SOUTH TANK FARM STRUCTURES AND SYSTEMS

2.4.1 Tanks

Tanks W-5, W-6, W-7, W-8, W-9, and W-10 comprise the inactive STF tanks. The tanks were constructed in 1943 using an in-place gunite construction process. A portland cement and sand mixture call gunite was sprayed in layers onto rebar skeletons to form the tanks in place. Each tank is sitting an a 5-inch concrete pad. The floor is nominally 3 in. thick except at the juncture with the walls where it was increased to approximately 9 in. The floors are reinforced with one layer of welded wire mesh and reinforcing rods placed in the radial direction. The caps of the tanks are approximately 10 in. thick at the center and increases to approximately 30 in. at the cap to sidewall juncture. The walls are approximately 6 in. thick increasing to approximately 30 in. near the sidewall to cap juncture. The sidewalls are reinforced with three layers of welded wire mesh, vertical ½-inch rods and 21 horizontal rebar hoops. The walls and floors of the tanks were then coated with a layer of tar and then reinforced with an additional layer of wire mesh and 1.5-in. of gunite.

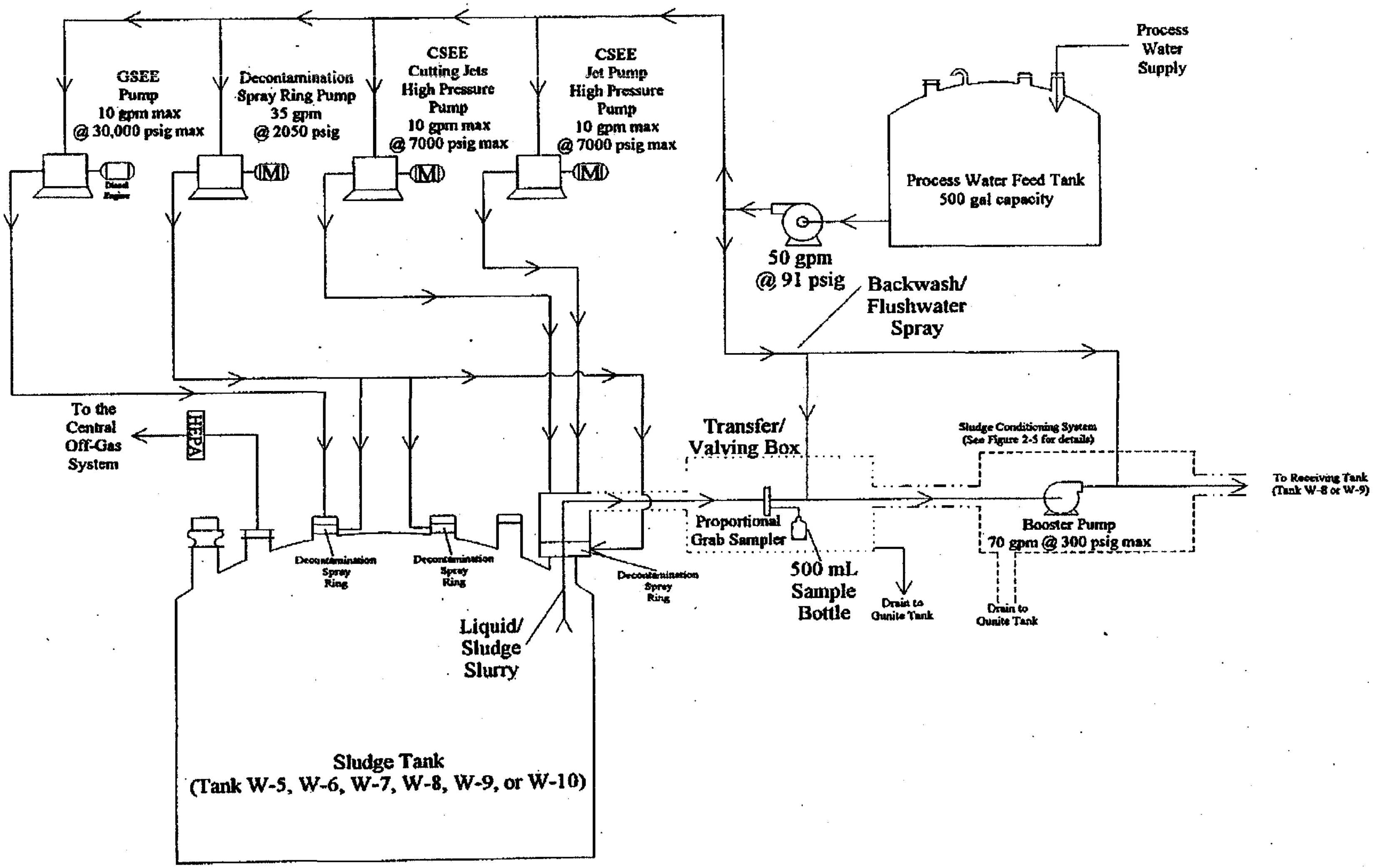

Fig. 2.1. System configuration of sludge removal operations.

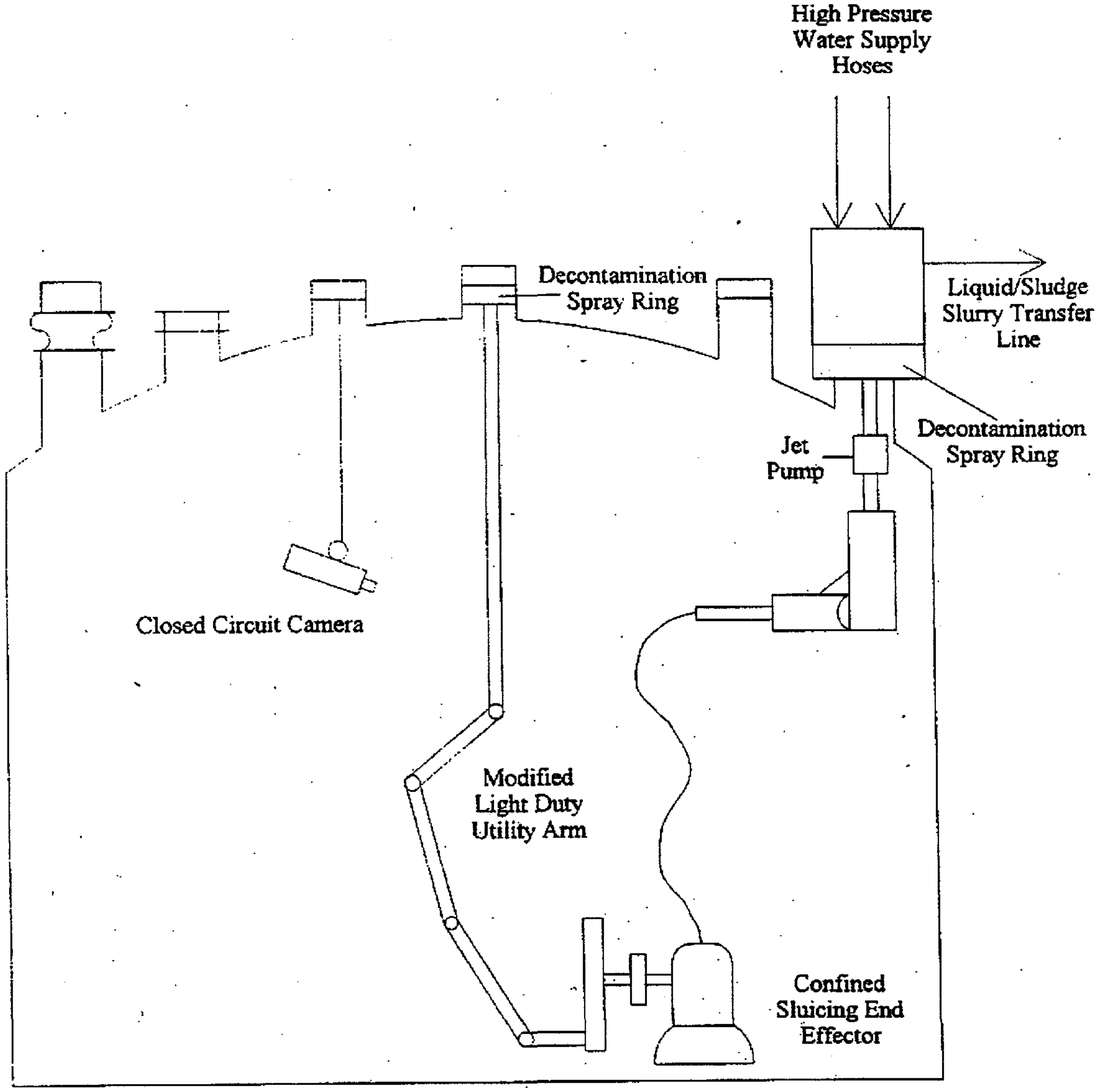

Fig. 2.2. In-tank equipment configuration for sludge removal using the MLDUA.

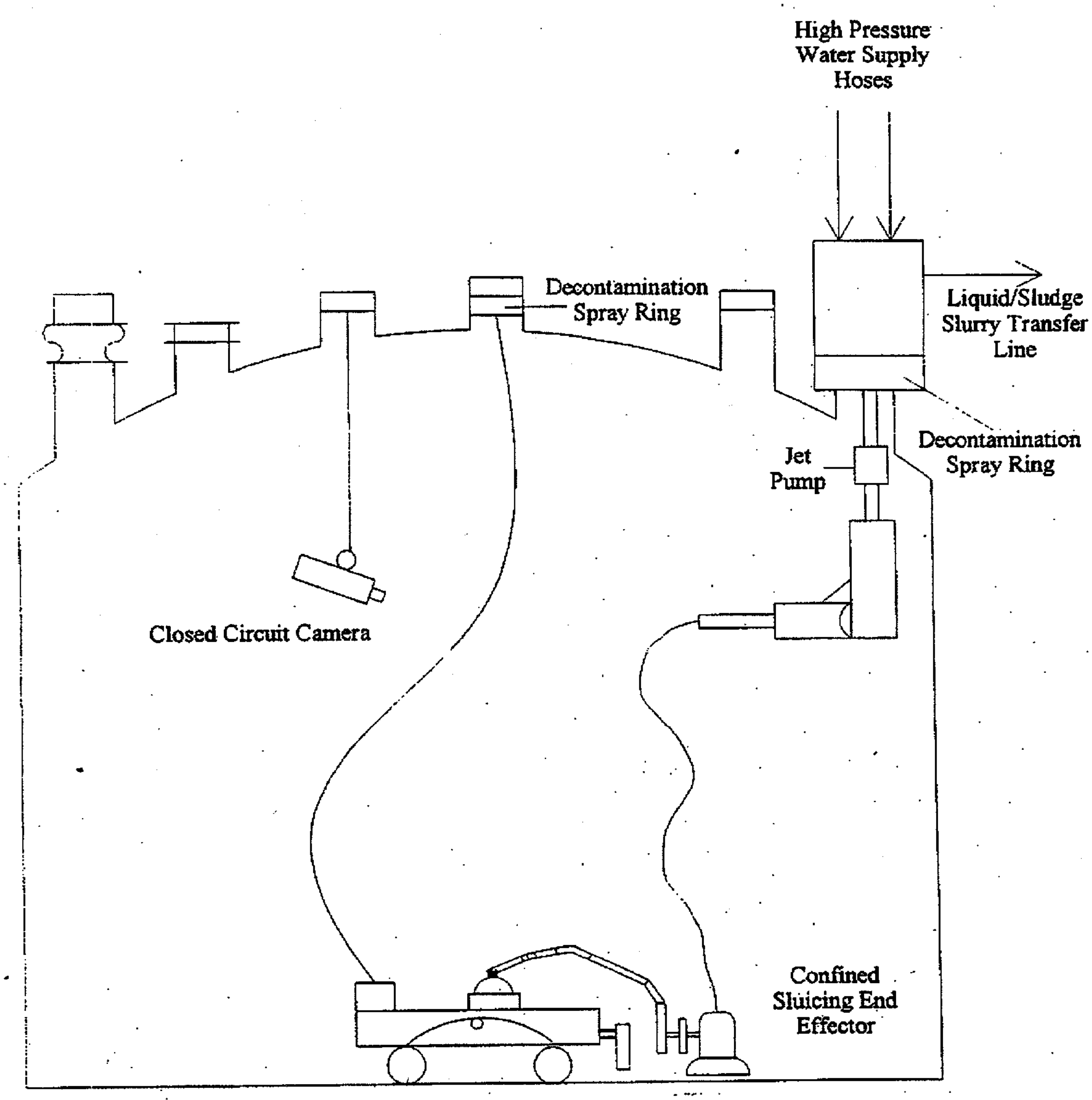

Fig. 2.3. In-tank equipment configuration for sludge removal using the remotely operated vehicle.

Each tank has a nominal capacity of 170,000 gallons. The vertical cylindrical tanks have a 50-ft inner diameter and a wall height of 12 ft. The tanks are surrounded by approximately three feet of gravel. The tanks are covered with a concrete cap which in turn is covered by approximately six feet of compacted clay soil. There are various manholes, vent lines, and sampling/level measurement lines still in use on the tanks. There is a ventilation system connected to the tanks which keeps the tanks under negative pressure with respect to the outside atmosphere. The ventilation system is connected by stainless steel piping and through a separate High Efficiency Particulate Air (HEPA) filter for each tank to the ORNL Central Off-gas System stack (Building 3039). Each of the tanks is equipped with a dry well system which collects any leakage or spillage and diverts the liquid through a six-inch underground pipe to the site Process Waste Treatment System. The dry wells are 2 ft x 2 ft concrete wells that extend from the surface to about 2 ft below the base of the respective tanks.

2.4.2 Remotely Operated Vehicle

The ROV is a compact, tracked vehicle designed to maneuver within the tank. When out of the tank, the ROV is stored in a confinement structure. When retracted into the confinement structure, the ROV is sprayed with high pressure water to reduce the amount of residual sludge on the vehicle. The vehicle, shown in Fig. 2.4, is operated by a controller located in the control trailer. The operator can view the ROV in its working environment through overhead camera systems deployed into the tank as well as through local camera systems located on the vehicle. The ROV is equipped with two tools: (1) the manipulator gripper, and (2) the plow. The gripper is used to grab and deploy sensors and waste removal equipment (such as the CSEE or the GSEE) as well as to retrieve objects from the tanks. The plow is used to loosen and to direct the solid or slurry waste to the removal equipment such as the CSEE.

The vehicle is a tethered, hydraulically-powered, track-driven, teleoperated, work machine with an expandable frame chassis that allows it to fit through a 0.61-m nominal diameter opening. When fully deployed, the vehicle has a footprint that is 1.1 m wide and 1.2 m in length. The vehicle is capable of moving over and through a variety of waste forms. It can operate fully submerged as long as sufficient support and traction is available. The operating console provides the operator with joysticks, foot pedals, a six degree of freedom "master" consolette, switches, and remote-viewing monitors to allow the operator to control the system from a remote location. The manipulator gripper has six degrees of freedom and is mounted to the vehicle frame and is used for object retrieval and operation of specialized tooling. The manipulator gripper is made of corrosion-resistant titanium. The standard interface to the manipulator is through the slave controller, which is mounted on the vehicle) and a "master" consolette that is integrated into control console.

The plow is mounted to the ROV for breaking up heels at the bottom of the tanks and mobilizing this material to the jet pump conveyance system for removal. The plow is instrumental in moving solid wastes from the edges to the center of the tank. Removable squeegees on the bottom and sides of the plow ensure that as much waste as possible is removed from the tank.

Two cameras are available on the ROV. The first camera has two lights for illumination and is mounted to a pan and tilt unit. The standard mounting of this unit is to the rear of the right track, several inches above track height. This camera is used for driving the vehicle, monitoring the tether, and gross positioning of the manipulator arm when attempting to grasp an object. The second camera is fixed to the manipulator arm, near the gripper. There are two lights mounted adjacent to the camera to illuminate the area directly in front of the grippers. This camera provides a useful view for performing dexterous tasks and is also be used for maneuvering within the tank.

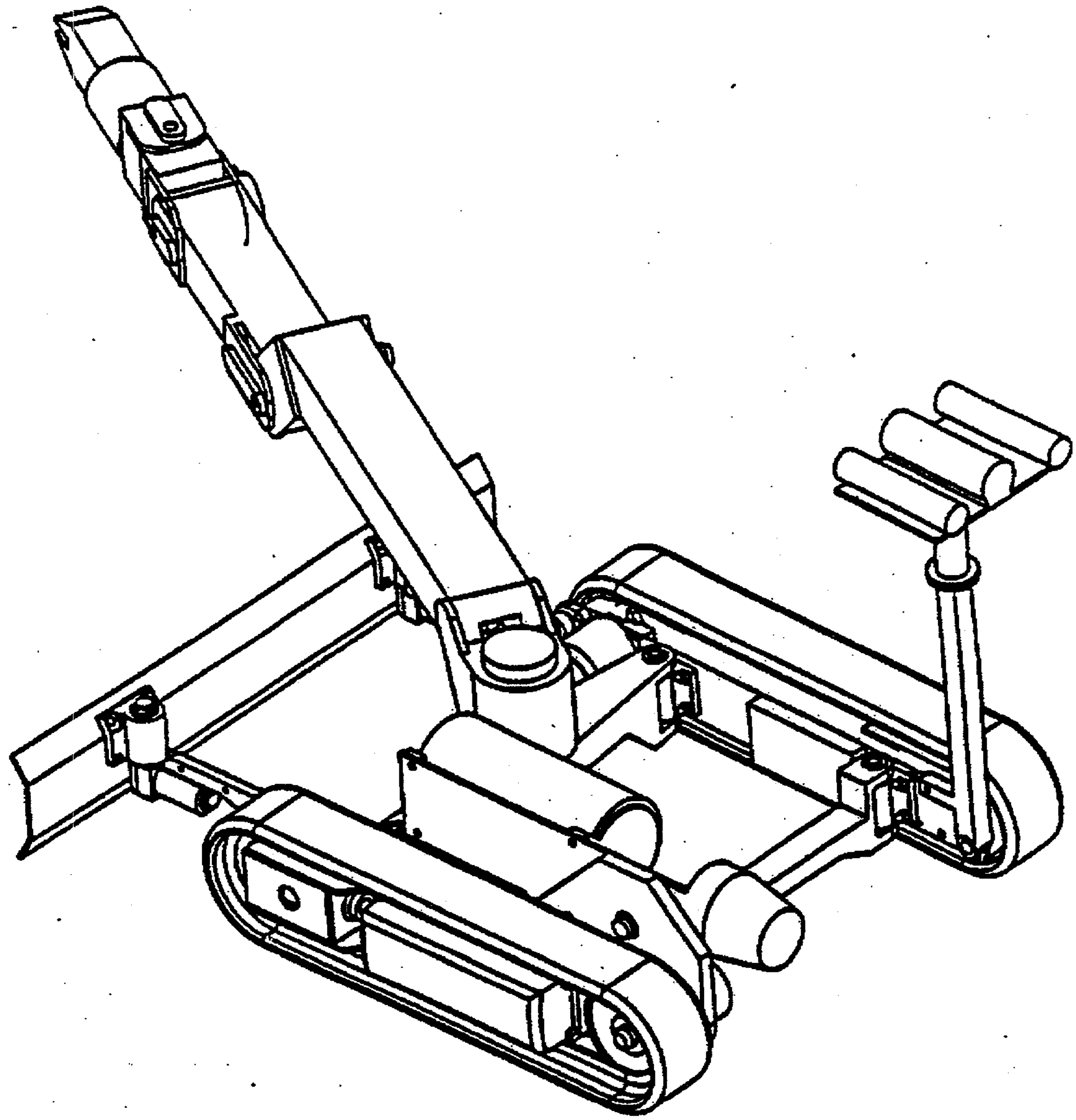

Fig. 2.4. Remotely operated vehicle .

2.4.3 Modified Light Duty Utility Arm System

The MLDUA provides a means of deploying various characterization and retrieval tools inside of the tanks. The MLDUA is suspended above the tank and accesses the waste material through the access penetrations. Specialized tooling, such as the CSEE or the GSEE, may be deployed separately and then grasped and manipulated by the MLDUA. The MLDUA provides a remotely operated system for positioning these tools within the tank volume, in the waste, and in contact with the tank structure.

The MLDUA is a robotic arm that enters the tank through a riser port and has seven degrees of freedom to maneuver and access areas within the tank. Five of the degrees of freedom use hydraulic actuators and two degrees of freedom use stepper motor actuators. The MLDUA is attached to a two-piece extendable mast that is used to vertically lower and raise the arm into and out of the tank. The mast is enclosed within a positive-pressure housing for confinement of any hazardous materials. The housing is designed to allow access to the equipment through glove ports for light maintenance. The housing is placed in the horizontal orientation for travel and storage and is raised to the vertical orientation for arm deployment into a tank. The mast is supported and positioned over the tank riser by the Mobile Deployment System.

A gripper end effector is located on the end of the MLDUA and allows the arm to attach the waste removal tooling or grasp objects within the tank. There are two cameras with lights located above the shoulder joint on the mast arm. The cameras and lights are mounted for pan and tilt. The cameras are equipped with auto focus and zoom. The MLDUA is controlled by the operator using two joysticks from a remote operating console.

2.4.4 Waste Dislodging and Conveyance System

The Waste Dislodging and Conveyance System (WD&C) includes the Hose Management System (HMS) and the sluicing system. These two subsystems are described in the following sections.

2.4.4.1 Hose Management System

The HMS supports the piping and conduit for the CSEE water supply and the sluicing system conveyance of the waste from the tank. The design of HMS allows deployment of the CSEE into different sections of the tank with either the MLDUA or the ROV. The HMS consists of the storage tube, mast, the confinement box, and Hose Management Arm (HMA). The HMS is mounted above the individual tanks and deployed into the tank through the dome access penetrations. A decontamination spray ring is positioned at the riser interface to allow for decontamination upon removal of the HMS.

The HMA is a 2-in. pipe, double-jointed, bulk material loading arm that is fitted with position sensors, a hose bundle, support cable, yaw joint drive motor, and various small diameter hoses and cables. The arm extends horizontally when fully deployed.

The mast assembly is a long, semi-circular pipe section that houses the waste conveyance jet pump, various small diameter hoses, pipes, tubing, rupture disk, and support cable. The mast has a swing arm guide to assist in placement of the HMA and to secure it during arm retraction and stowage.

The storage tube is a long cylindrical container above the tank and stores the hose management arm and the mast during periods of transportation, maintenance, and off-platform storage. The tube contains guide rails that index the rotational position of the hose management arm and mast in the confinement box.

The confinement box serves three basic functions: to provide (1) secondary containment for the waste piping, (2) glove port access for operational and maintenance activities, and (3) structural/mechanical support for the mast, HMA, and storage tube.

2.4.4.2 Sluicing system

The purpose of the sluicing system is to siphon and collect the sludges from inside the tanks and transfer the sludge from the tank to the desired location. During the sludge removal operation, this desired location will be to transfer the sludge to Tank W-8 and/or W-9.

Suction is provided by a jet pump mounted in the HMS arm. The jet pump motive force is high pressure water. This water becomes part of the sludge stream once introduced in the jet pump. At the discharge of the jet pump, and after the sludge hose exits the tank, the sludge enters the transfer/valving box which provides double containment for a series of back flush and flow control valves, a flow meter, and a proportional sampler. The transfer/valving box drains to the WD&C confinement box or to the gunite tank as described in the previous section.

2.4.5 Decontamination Spray Module

The decontamination spray module is a device that is placed into or onto the tank riser for the purpose of water cleaning the equipment that is removed through the tank riser. The system is designed to operate at 2,050 psig at the spray nozzles and has an impact pressure of about 1.5 psi on the surface being cleaned and decontaminated.

2.4.6 Scarifier System

During the STF Remediation Project, project personnel may elect to scarify, or remove the top layer (1/4-in.) of gunite from the inside of the STF tanks to remove embedded contamination. A high pressure water scarifier system is available consisting of a high pressure water pump (~30,000 psig), driven by a 200 hp diesel engine, and a GSEE used to direct the high pressure water spray toward the gunite tank walls and floor. The GSEE can be deployed using either the MLDUA or the ROV. The effect of scarifying the gunite tanks is to remove the top layer of gunite which is then included with the sludge that is removed from the tank using the CSEE and/or the sluicing system.

2.4.7 Sludge Conditioning System

The SCS is currently a booster pump to transfer sludges from the WD&C to the receiving tank. However, in the future, it will include a mechanical equipment unit used to condition the sludge heels for transfer into the intervalley transfer line. The waste slurry is received from the WD&C equipment through the liquid/slurry transfer line at a maximum flow rate of 70 gpm and a maximum discharge pressure of 300 psig. The SCS transfers the liquid/slurry to Tank W-8 and/or W-9. The initial SCS equipment is located in an enclosure in a tank riser (see Fig. 2.5). Additional equipment that may be required to support waste transfer from STF will be added at a later date as needed and are not addressed by this document.

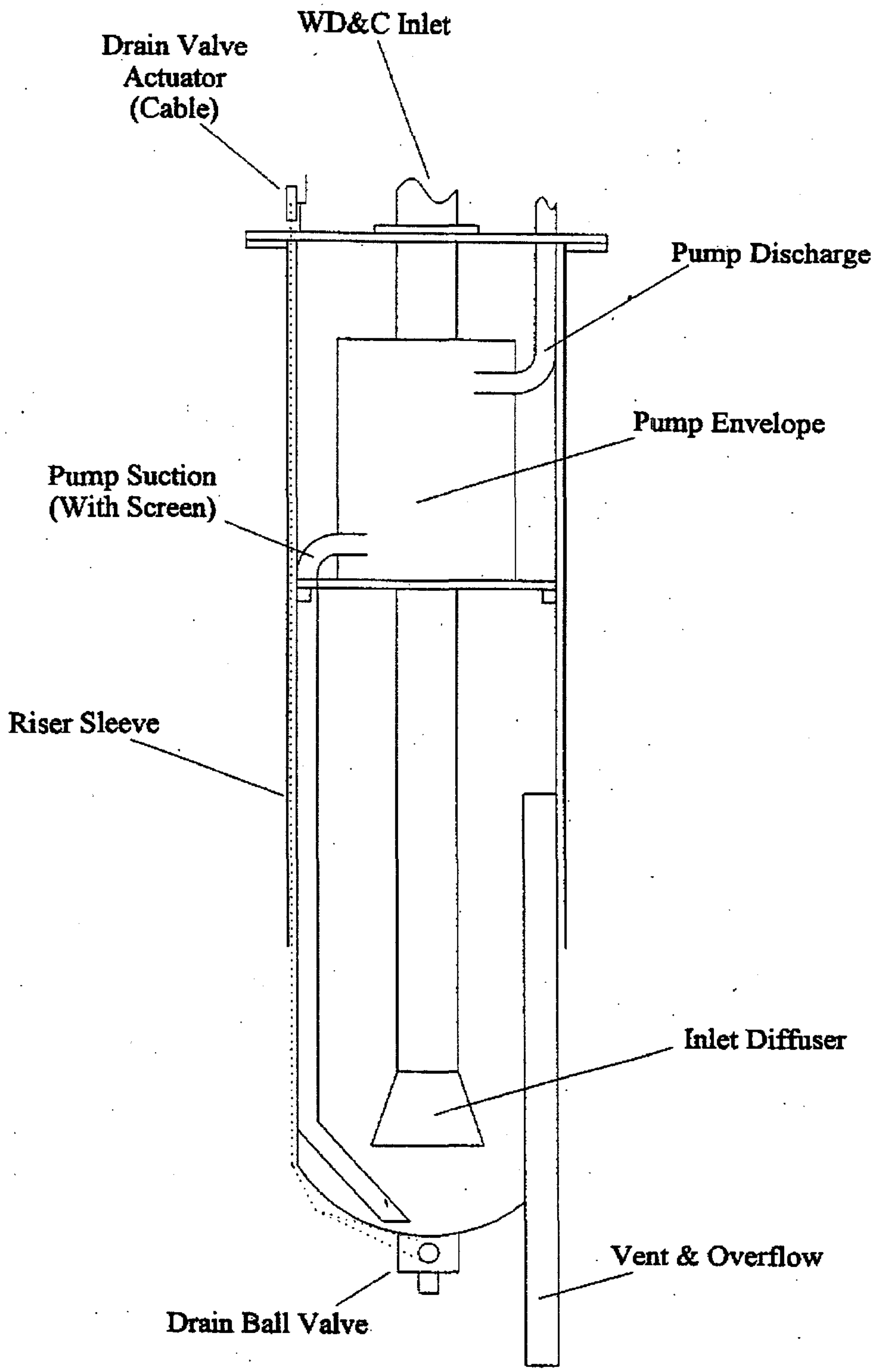

Fig. 2.5. Sludge conditioning system.

2.5 SOUTH TANK FARM ACTIVITIES AND PROCESSES

The STF tanks are all inactive (i.e., they no longer receive waste from active facilities). The LLLW piping from all known LLLW generators to these tanks is inactive. Surveillance and maintenance activities are the only normal operations occurring at the STF. The surveillance and maintenance activities at the STF include weekly site inspections, tank inventory level monitoring, monthly dry well monitoring, quarterly DOP (i.e., dioctyl phalate) testing of the HEPA filter, and semi-annual radiological surveys.

The remediation project operations include installation of supporting equipment, setup and removal of mobile equipment, decontamination of removed equipment, sludge removal, and SCS operations. The sludge removal is accomplished by remotely manipulating the CSEE using either the MLDUA or the ROV. The sludge is dislodged from the tank using high pressure water and removed using a jet pump. The sludge mixture is then transferred through transfer piping to the SCS and discharged to Tank W-8 and/or W-9.

2.6 SOUTH TANK FARM UTILITY SUPPORT SYSTEMS

The utility support systems for the STF include electrical power for lighting and instrumentation, process water, and ventilation. All are supplied by site distribution systems. The compressed air system is provided by a portable unit.

2.6.1 Compressed Air System

The compressed air system consists of a skid-mounted compressor and receiver, and a distribution header and hose connections to the various process equipment and instruments requiring compressed air. The system is designed to provide 34 cfm of dry, oil-free compressed air at a pressure of 175 psig at the skid discharge. The compressor is driven by an electric motor and provided with an inlet air filter to remove moisture, an 80 gal receiver, high efficiency filters to remove particulates to 0.1 microns, and a desiccant dryer.

2.6.2 Electrical System

The electrical system provides a connection to the ORNL power system and distribution to the operations control trailer and various systems and process equipment located on and around the equipment platform. The system provides 480/240/120 V AC power supplied from the ORNL power grid via a new 500 kVA transformer bank. Power is routed via temporary cables to a mobile power distribution center that provides cable connections to the equipment located on or near the platform and to the individual equipment skids.

2.6.3 Process Water System

The process water system includes of a low pressure system and a high pressure system. The low pressure system consists of two connections to the ORNL process water system. The connections to the ORNL water system are provided with manual valves to open/close the connections. One low pressure process water system connection supplies flow to the project feed water tank, the sluicing system transfer valving box for line flushing operations, and the scarifier system. The second connection supplies flow to the tent area.

The high pressure water supply system supplies flow to:

- the jet pump,
- the CSEE cutting jets,
- the Decontamination Spray Ring

High pressure water is provided by two 7,000 psig, 10 gpm pumps (for the CSEE and jet pumps) and one 2,050 psig, 35 gpm pump (for the decontamination spray rings). The 30,000 psig high pressure water supply is included within the SCS and discussed in Sect. 2.4.6.

The CSEE contains three water jets which require approximately 10 gpm of water at up to 7,000 psi. An electric motor within the end effector rotates the jet carrier between 0 and 600 rpm. The axis of rotation is normal to the waste surface. A sealed enclosure houses the motor drive and the jet carrier. This enclosure is mounted concentric to and outside the conveyance system inner shroud, which captures the dislodged waste and water and directs the collected waste out of the tank by a jet pump conveyance system through the HMS.

2.6.4 Ventilation System

The STF tanks are connected to the ORNL Central Off-Gas System. A local HEPA filter and tank differential pressure control are provided on the exhaust from each tank.

2.7 AUXILIARY SYSTEMS AND SUPPORT FACILITIES

Systems which support the Remediation Project are the decontamination tent and the storage tent.

2.7.1 Decontamination Tent

A temporary decontamination tent is located near the east end of Building 3505. The tent is used as a work area for decontamination of equipment removed from the tanks.

2.7.2 Storage Tent

A 20-ft x 60-ft tent used to house demolition activities for Building 3506 was left on the site and is now used to store miscellaneous contaminated and noncontaminated equipment.

2.8 REFERENCES

1. DOE Order 420.1, *Facility Safety*, Change 2, U.S. Department of Energy Washington, D.C., October 24, 1996.

2. DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C., September 26, 1988.

3. DOE Order 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, Change 1, U.S. Department of Energy, Washington, D.C., October 26, 1995.

4. ORNL/ER-13, *Sampling and Analysis of Inactive Waste Storage Tank Contents at ORNL*, Oak Ridge, Tennessee, September 1990.

5. DOE/OR/01-1159 & D1, *Waste Characterization Data Manual for the Inactive Liquid Low-Level Waste Tank Systems at Oak Ridge National Laboratory,* U.S. Department of Energy, Oak Ridge, Tennessee, June 1993.

6. ORNL/ER/Sub/87-99053/74, *Results of Fall 1994 Sampling of Gunite and Associated Tanks at the Oak Ridge National Laboratory*, Martin-Marietta Energy Systems, Incorporated, Oak Ridge, Tennessee, June 1995.

7. ORNL/ER/Sub/87-99053/79, *Results of 1995 Characterization of Gunite and Associated Tanks at Oak Ridge National Laboratory, oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Incorporated, Oak Ridge Tennessee, February 1996.

8. ORNL/ER-365, *Evaluation of Phase I and Phase II Sampling and Analysis Data for the Gunite and Associated Tanks* at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 1996.

3. HAZARD AND ACCIDENT ANALYSES

3.1 INTRODUCTION

The objective of this chapter is to systematically identify and evaluate the hazards present during the GAAT Project remediation of the STF. The term "facility" in this document refers to STF Tanks W-5, W-6, W-7, W-8, W-9, and W-10 and associated process piping and instrumentation. Additional equipment temporarily installed to perform the remediation is also considered part of the facility in this evaluation. This hazard evaluation is accomplished in three basic steps: (1) hazard identification and preliminary facility hazard classification, (2) hazard analysis and final facility hazard classification, and (3) accident analysis. In the first step, internal facility hazards are identified and the preliminary facility hazard classification is made by comparing hazardous material inventories with specified threshold quantities. The hazard analysis considers the complete spectrum of accidents that may occur as a result of remediation operations; analyzes potential accident consequences to the public and workers; estimates likelihood of occurrence; identifies and assesses associated preventive and mitigative features; identifies safety-significant SSCs and administrative controls; and identifies a selected subset of accidents, designated as evaluation basis accidents (EBAs), to be formally defined in the accident analysis. After the hazards analysis has been completed, a final facility hazard classification is determined based on an unmitigated release of available hazardous material. The accident analysis evaluates these EBAs for comparison with analysis guidelines to identify and assess the need for safety-class SSCs.

This chapter contains the following information:

- A description of the methodology for and approach to hazard and accident analyses.
- Identification of the hazardous materials and energy sources present by type, quantity, form, and location.
- The preliminary facility hazard classification.
- Identification (in the hazard analysis) of the spectrum of potential accidents at the facility in terms of qualitative consequence and frequency estimates. This activity also includes the following:
    - identification of planned design and operational safety improvements;
    - summary of defense in depth, including identification of safety-significant SSCs and other items that may need Technical Safety Requirements (TSR) coverage in accordance with DOE Order 5480.22[1];
    - summary of the significant worker safety features, including identification of safety-significant SSCs and any relevant programs that may need to be covered under TSR administrative controls;
    - summary of design and operational features that reduce the potential for large material releases to the environment; and

— identification of the limited set of unique and representative accidents (i.e., EBAs) to be assessed further in accident analysis.

- Final facility hazard classification.

- Accident analysis of EBAs identified in the hazard analysis. This activity includes the following:

  — estimation of source term and consequence,

  — documentation of the rationale for estimating frequency of occurrence in a broad range in hazard analysis, and

  — documentation of accident assumptions and identification of safety-class SSCs based on analysis guidelines.

3.2 REQUIREMENTS

The requirements for accident analysis are contained in DOE Order 5480.23[2]. Recommended practices for hazard screening, accident selection, and accident analysis are included in DOE-STD-1027-92[3], DOE-STD-3009-94[4], and ES/CSET-2/R2[5]. TSR requirements are contained in DOE Order 5480.22[1]. Natural phenomena requirements for structures and components and requirements for safety-class item design criteria are contained in DOE Order 420.1[6].

3.3 HAZARD ANALYSIS

This section describes the hazard identification, classification, and evaluation performed for the GAAT Project remediation of the STF. The purpose is to present a comprehensive evaluation of potential process-related, natural phenomena, and external hazards. Single or multiple failures resulting from these hazards can adversely affect the public, workers, and the environment.

Hazard identification and evaluation provide a thorough, predominantly qualitative evaluation of the spectrum of risks to the public, workers, and the environment due to accidents involving the identified unusual hazards. Hazard classification provides a relative ranking of the facility in terms of the potential unmitigated consequences of accidents involving the identified unusual hazards. The hazard evaluation process identifies preventive and mitigative features, including identification of expected operator response to incidents (e.g., accident mitigation actions or evacuation) if the operator actions are required, and provisions for operator protection in the accident environment.

3.3.1 Methodology

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

3.3.1.1 Hazard identification methodology

Hazardous materials and energy sources associated with GAAT Project remediation of the STF were identified in terms of quantity, form, and location. To facilitate the hazard identification process the overall remediation project structures and processes were divided into smaller discrete systems (i.e., the individual tanks, supernate and sludge removal systems). The hazards in the individual systems are identified by using a checklist provided in ES/CSET-2/R2[5]. Hazards were identified by reviewing facility documentation and drawings and by conducting discussions with operations staff. The hazards were grouped into the following 12 general hazard types:

- Hazardous Materials

  1) Fissionable materials
  2) Radiation source
  3) Toxic/corrosive/reactive materials
  4) Flammable materials
  5) Explosive/pyrophoric materials

- Energy Sources

  6) Electrical energy sources
  7) Thermal energy sources
  8) Kinetic energy sources
  9) Potential energy sources

- Special Equipment

  10) Lasers
  11) Accelerators
  12) X-ray machines

The hazards identified were analyzed and screened in accordance with the criteria in ES/CSET-2/R2[5], 40 *CFR* 302.4[7], and DOE-STD-1027-92[3] to eliminate from further consideration the insignificant, routine, and standard industrial hazards.

Insignificant and routine hazards were considered to be those of the type and magnitude routinely encountered by the public and workers in everyday life and the workplace (equal to or lower in magnitude than the preliminary hazard screening criteria in ES/CSET-2/R2[5]). Standard industrial hazards were considered to be those hazards that are not insignificant or routine, but are encountered in general industry in appropriate applications that are adequately controlled by the Occupational Safety and Health Administration regulations or one or more national consensus standards (e.g., American Society of Mechanical Engineers, American National Standards Institute, National Fire Protection Association, Institute of Electrical and Electronics Engineers, National Institute of Standards and Technology). These standards are adequate to define special safety requirements, unless they are in quantities or situations that can significantly impact large numbers of people.

The hazards that were not screened out as insignificant and routine hazards were evaluated to determine if they could be considered standard industrial hazards. For the hazards screened out as standard industrial hazards, the regulations and standards used to control the hazards are stated. The remaining hazards that were not screened out by this process are evaluated further in the accident analysis.

3.3.1.2 Preliminary hazard classification

The preliminary nuclear and nonnuclear hazard classifications are specified for the GAAT project remediation of the STF. The preliminary nuclear categorization was conducted according to DOE-EM-STD-5502-94[8]. The categorization logic for the preliminary nuclear and nonnuclear facility categorizations is shown in Fig. 3.1. The source terms for preliminary hazard categorization were developed using reported data from tank sampling campaigns at the NTF and STF[9]. This information and process system operating specifications were used to estimate the maximum amount of hazardous materials that can be released from accidents occurring while the GAAT project remediation of the STF is underway.

DOE Order 5480.23[2] states that "contractors shall be required to perform a hazards analysis of their nuclear activities and classify their processes, operations, or activities....The consequences of unmitigated releases of radioactive and/or hazardous material shall be evaluated and classified by the following hazard categories:"

- Category 1: The hazard analysis shows the potential for significant off-site consequences.
- Category 2: The hazard analysis shows the potential for significant on-site consequences.
- Category 3: The hazard analysis shows the potential for only significant localized consequences

Facilities which are shown to pose no "significant localized consequences" are assumed to be "Radiological" facilities.

Preliminary Nuclear Classification

To determine the preliminary nuclear classification, the radioactive material inventories are compared with the 40 *CFR* 302.4[7] Reportable Quantity (RQ) values, and the Category 3 and Category 2 Threshold Quantities (TQs) in DOE-STD-1027-92[3]. For the purpose of determining the preliminary hazard category, radiological hazards are defined as the maximum radioactive material inventories available for release in a facility. To determine the radioactive material inventories to compare with the category limits, the term "available for release" means the total amount of material within a facility segment. An example of a radioactive material inventory within a facility segment is the sludge and supernate inventory in an individual gunite tank. Facilities with radioactive material inventories above the Category 2 TQs are considered Nuclear Category 2 Facilities. Facilities with radioactive material inventories below the Category 2 TQs, but above the Category 3 TQs, are considered Nuclear Category 3 Facilities. Facilities with radioactive material inventories below the Category 3 TQs, but above the RQ values in 40 *CFR* 302.4[7] are considered Radiological Facilities. All other facilities are considered Industrial Facilities.

Nonnuclear Classification

The preliminary nonnuclear hazard classification for chemical hazards is determined by comparing the identified inventories with RQ values in 40 *CFR* 302.4[7] and TQ in 29 *CFR* 1910.119[20] or 40 *CFR* 355[21]. Chemical inventories below the RQ values in 40 *CFR* 302.4[7] are considered insignificant and the nonnuclear facility classification is "Industrial." Facilities with hazardous material inventories above 40 *CFR* 302,4[7] RQ values, but below TQs listed in 29 *CFR* 1910.119[20] and 40 *CFR* 355[21] are categorized as "Low" hazard unless it can be shown that the hazardous materials are routine or the consequences resulting from accidents involving the hazardous materials are negligible to on-site and off-site receptors. Facilities with hazardous material inventories above

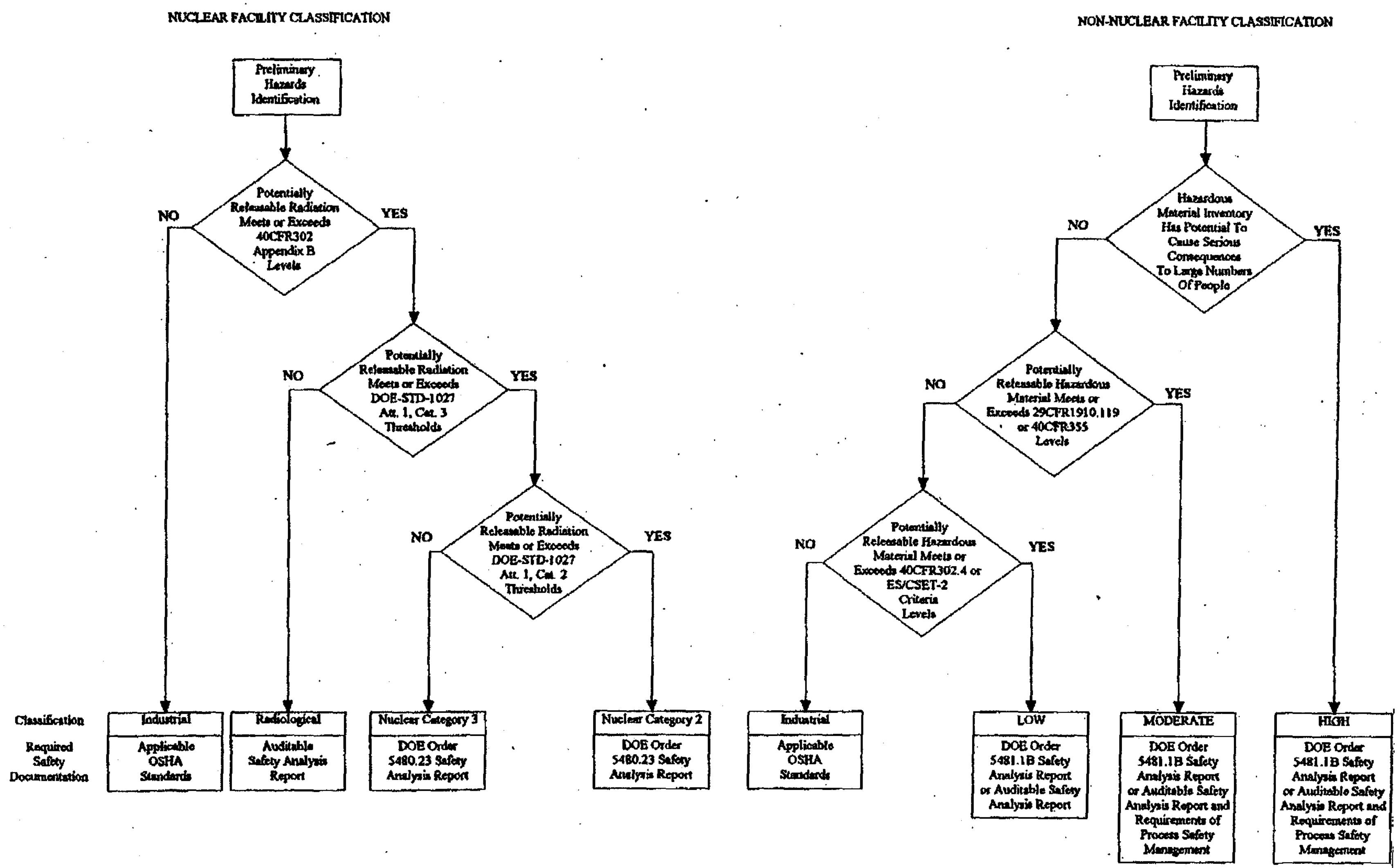

Fig. 3.1. Logic flow diagram for preliminary facility hazard categorization.

the TQs in 29 *CFR* 1910.119[20] and 40 *CFR* 355[21] are categorized as "Moderate" hazard. The "High" hazard categorization is reserved for extremely hazardous materials with the potential to cause serious consequences to large numbers of people, both on-site and off-site. Significant chemical hazards (>40 *CFR* 302.4[7] RQs) are evaluated for the consequential health effects using the methodology from ES/CSET-2/R2[5]. The definitions of health effects categories from ES/CSET-2/R2[5] expressed in terms of Immediately Dangerous to Life and Health (IDLH) values are included in Table 3.1. However, when actual information is available on the boundary between irreversible and reversible health effects, and the boundary between reversible and negligible health effects, this information should be used instead of the IDLH values.

Table 3.1. Chemical health effects exposure levels

Health effect	Exposure level[a,b]
IRREVERSIBLE	Concentration > 1.0 * IDLH
REVERSIBLE	0.1 ≤ IDLH Conc. ≤ 1.0 IDLH
NEGLIGIBLE	Concentration < 0.1 * IDLH

[a]These exposure levels are <u>only</u> to be used for facility hazard classification.

[b]Chemical concentrations should be the highest five minute time-weighted-average. If IDLH values are not available, use the following values in place of the IDLH values. They are listed in decreasing order of preference: 0.10 * LC_{50}, 1.00 * LC_{LO}, 0.01 * LD_{50}, 0.10 * LD_{LO}, 500. * TLV

3.3.1.3 Hazard evaluation

The South Tank Farm is an inactive group of tanks that are being remediated which includes relatively simple monitoring, sampling, and inspection activities. The main processes evaluated in this Safety Analysis Report (SAR) are the supernate and sludge removal processes and tank decontamination. Most of the remediation activities take place in the tanks and do not involve the introduction of any significant new hazards. Therefore, a relatively simple method of hazard evaluation is appropriate. The hazards are evaluated using a Preliminary Hazards Analysis (PHA) to identify safety significant SSCs and administrative controls for controlling consequences to the workers. The PHA also identifies accident scenarios that will be analyzed in detail in the accident analysis based on consequences to the public.

The PHA was performed in three steps. First, a fact sheet was produced with information on the STF tanks and the remediation operations. The fact sheet includes information about the hazard(s) of interest; the systems associated with the remediation operation; the energy sources identified in the tanks and remediation systems; the remediation operations, processes, and activities performed adjacent to or in the tanks; the operating modes for the facility; and the release paths identified for accidental release of hazards. The fact sheet provides basic information necessary to understand the remediation project for conducting the PHA. The second step of the PHA was to prepare the accident identification table. In general, an accident is considered to occur whenever the hazards of interest are released from primary confinement. Accident identification includes evaluation of both internal and external initiating events. The third step of the PHA is to determine the unmitigated consequences and frequencies for the identified accidents. The estimates of the consequences resulting from release of radioactive materials are evaluated in the *Radioactive Material Hazard and Safety Class Determination*[10].

A checklist of potential external initiating events was developed for each system through a review of industry standards, the facility design, physical construction, expected processes, and discussions with design and operations personnel. Each identified external initiating event was evaluated to determine if it should be:

- excluded from further analysis because the event is not applicable to the area (e.g., coastal erosion is not a concern for inland locations),
- excluded from further analysis because the event is not linked to the hazard of concern,
- excluded from further analysis because the event is bounded by another event (e.g., extreme winds are bounded by tornado evaluations),
- excluded from consideration based on regulatory guidelines,
- eliminated based on extremely low potential for occurrence (i.e., being a beyond design basis accident), or
- included in the hazard evaluation for the facility SAR.

An understanding of the facility, developed during preparation of the fact sheet, was used to identify internal initiating events. For each identified initiating event (both internal and external), the cause, consequence, frequency, and prevention/detection/mitigation factors were determined and listed.

The unmitigated on-site consequence, resulting from radioactive material release, of each accident scenario was determined in *Radioactive Material Hazard and Safety Class Determination*[10] at a reference point located 30 m from the release. Typically a greater distance is used to determine the consequence to an on-site individual not associated with the particular facility, process, or operation. However, 30 m was selected due to the location of the STF within the main ORNL complex. The STF is adjacent to a main laboratory thoroughfare, Central Avenue, with frequent daytime pedestrian and vehicular traffic. Thirty meters is approximately the distance from the center of the STF tanks to the center of Central Avenue and Third Street and to the center of the unmanned, inactive and locked Building 3505. The sidewalk between the STF and Central Avenue will be closed as necessary during transfers to route the main pedestrian traffic over 30 m distance between the transfer lines and pedestrians. The vehicular traffic westbound on Central Avenue and northbound on Third Street may be momentarily within the 30 meters depending on which tank is being remediated. Also occasional pedestrians who may walk down these traffic lanes would be within the 30 m distance. The short duration that the vehicular traffic is within the 30 meter distance, the infrequency of a person walking down these traffic lanes since no sidewalks are available on that side of the street, and the infrequency of Building 3505 inspections are acceptable conditions for onsite evaluations. The undetected, unprevented accident frequency is estimated and placed into a frequency category (see Table 3.2). Once all accident scenario consequences were determined, the analysis guidelines presented in Table 3.3 were used to identify accidents that require evaluation for safety significant SSCs or administrative controls to reduce the frequency and/or consequence of the accident scenarios with the highest localized consequences.

Consequences to facility workers are designated according to the consequence categories listed in ORNL/BIO/3507/ER/R0, *Basis for Interim Operation for Facility Number 3507, South Tank Farm*[22] with the addition of 25 rem as the upper threshold for "Negligible" consequences.

Table 3.2. Qualitative accident frequency ranges

Frequency category	Estimated frequency of occurrence	Description
Anticipated	$> 10^{-2}$ per year	Incidents that may occur during the lifetime of the facility (Incidents that commonly occur)
Unlikely	$10^{-4} \leq p < 10^{-2}$ per year	Accidents that are not anticipated to but could occur during the lifetime of the facility
Extremely unlikely	$10^{-6} \leq p < 10^{-4}$ per year	Accidents not expected to occur during the lifetime of the facility

Table 3.3. Analysis guidelines for on-site consequences

Accident frequency (per year)	Radiological evaluation guidelines (on-site)
$10^{-2} \leq p < 10^{-1}$	5 rem
$10^{-4} \leq p < 10^{-2}$	25 rem
$10^{-6} \leq p < 10^{-4}$	100 rem

For accidents with on-site consequences that exceed analysis guidelines, the prevention, detection, and mitigation features were reviewed. One or more feature was selected as safety-significant. The frequency and consequence for the accident was then re-evaluated with credit taken for the designated safety significant SSC or control. This process was repeated until on-site consequences fell below the analysis guideline for the associated frequency.

The off-site consequence of each accident scenario was estimated at the nearest point on the site boundary and placed into a consequence category (see Table 3.4). Each accident scenario is assigned a screening risk category corresponding to its estimated frequency and off-site consequence using the risk matrix in Fig. 3.2. The screening risk categories are:

- Category I— Major
- Category II— Serious
- Category III— Marginal
- Category IV— Negligible

Table 3.4. Binning criteria for screening off-site consequences
(off-site radiological accident consequence levels)

Consequence category	Public (off-site) dose
High	≥5 rem at site boundary
Moderate	≥0.1 rem at site boundary
Low	≥0.01 rem at site boundary
Negligible	<0.01 rem at site boundary

Consequence	Low (Extremely Unlikely)	Medium (Unlikely)	High (Anticipated)
High	II	I	I
Moderate	III	II	I
Low	IV	III	III

Frequency

I	Major
II	Serious
III	Marginal
IV	Negligible

Fig. 3.2. Off-site risk matrix for determination of the required analyses.

The assignment of screening risk categories to the accident scenarios facilitates prioritization of the scenarios for review or further analysis. Accident scenarios categorized in the low-consequence bins of the risk matrix should represent no more than a marginal concern regardless of frequency and are screened out from review and further analysis.

Accident scenarios identified as Risk Category III or IV are considered to present low risk. Accident scenarios identified as Category I or II are considered to present more significant risk and are retained for further detailed analysis in the accident analysis.

3.3.1.4 Final facility hazard classification

After completing the hazards analysis, the final hazard categorization can be made for the GAAT project remediation of the STF. The final categorization is based on an "unmitigated release" of the hazardous material inventory available for release. To quantify the unmitigated release, the term "unmitigated" takes into consideration the following factors: material quantity, physical form, location, dispersibility, and interaction with available energy sources, but does not consider the effects of safety features (i.e., containment systems, administrative controls, etc.) on preventing or mitigating the release. For facilities initially classified as Hazard Category 2, the preliminary categorization can be reevaluated based on the knowledge gained from the hazards analysis. If the credible release fractions can be shown to be significantly lower than the release fractions used for Hazard Category 2 in Attachment 1 of DOE-STD-1027-92[3], then the threshold inventory values for Category 2 in Table A.1 of the attachment may be increased by an amount equal to the ratio of the Category 2 release fraction to the credible release fraction supported by the hazards analysis. The unmitigated release inventories are then compared with the increased Category 2 threshold values to determine whether Category 2 is still the appropriate hazard category or placement of the facility in a lower hazard category is justified.

3.3.2 Hazard Identification Results

3.3.2.1 Hazard identification

The discussions of radioactive and hazardous material quantities in the sludge and supernate are based on sampling campaigns documented in ORNL/ER-365[9]. On the basis of information collected in August 1997 during initial operations at Tank W-3 in the North Tank Farm and then from subsequent measurements conducted in other tanks, the sludge volume estimates for the gunite tanks need to be revised. On the basis of the data collected, a revised estimate of the sludge volumes is documented in a letter to DOE[22]. The original supernate volumes were estimated based on the total tank volume minus the sludge volume. With the increased sludge volume estimates, the amount of supernate actually present in the tanks should decrease by a corresponding amount. The tanks in question are inactive (i.e., they are no longer receiving additional waste from generating facilities). It is conservatively assumed that the supernate volume is the same as originally estimated.

This section identifies the hazards associated with the remediation operations at the STF and discusses the applicability of the hazards to potential accidents. To aid in the hazard identification process and to present the information in a structured manner, the GAAT Project remediation of the STF is divided into separate systems. Each tank and its existing hazardous material inventory, instrumentation, and in-tank equipment is evaluated as a separate system in the hazard identification process. The tank remediation systems (WD&C, ROV, and MLDUA), the SCS, and tank ventilation system are also evaluated as separate systems. The hazards associated with each of the STF tanks, the tank remediation systems, the SCS, and the tank ventilation system are summarized in Table 3.5.

Table 3.5. Preliminary hazards identification results for the South Tank Farm remediation project

Facility or segment	Fissionable materials	Radiation sources	Toxic/corrosive/ reactive materials	Flammable materials	Explosive/ pyrophoric materials	Electrical energy sources	Thermal energy sources	Kinetic energy sources	Potential energy sources	Lasers
Tank W-5	●	●	●	●	●	●	●	●	●	●
Tank W-6	●	●	●	●	●	●	●	●	●	●
Tank W-7	●	●	●	●	●	●	●	●	●	●
Tank W-8	●	●	●	●	●	●	●	●	●	●
Tank W-9	●	●	●	●	●	●	●	●	●	●
Tank W-10	●	●	●	●	●	●	●	●	●	●
Support system	●	●	●			●		●	●	
WD&C	●	●	●			●		●	●	
MLDUA	●	●	●			●		●	●	
Decontaminati on spray ring	●	●	●			●		●	●	
Decontaminati on tent	●	●	●			●		●	●	
ROV	●	●	●			●		●	●	
Scarifier system	●	●	●	●		●		●	●	
SCS	●	●	●	●		●		●		

*Note: No hazards associated with accelerators or X-ray machines were identified in the STF remediation project.

Detailed listings of the hazards associated with the tanks, remediation systems, and associated confinement systems and interfacing utility systems are provided in Appendix A, Tables A-1 through A-15. As part of the remediation, the supernate and sludge inventories from all the STF tanks and NTF Tanks W-3 and W-4 will be transferred to Tank W-8 and/or Tank W-9. A hazards listing for the combined inventory including NTF Tanks W-3 and W-4 also is provided in Appendix A.

The hazards listed in Appendix A, Tables A-1 through A-13 are screened in accordance with the criteria in ES/CSET-2/R2[5], 40 *CFR* 302.4[7], and DOE-STD-1027-92[3] to eliminate from further consideration the insignificant, routine, and standard industrial hazards. The remaining hazards that were not screened out are listed in Table 3.6 and are evaluated further in the hazard evaluation, Sect. 3.3.3. A summary of the hazards and the justification for screening out the insignificant and standard industrial hazards are presented in the following sections.

Hazard Screening Results

Radiological hazards. Radiological hazards include both fissionable and radioactive material hazards. The fissionable and radioactive material sources are derived solely from the supernate and sludge in the STF tanks. The tanks and systems containing these hazards are identified in Table 3.5. The supernate and sludge in the tanks contain a wide variety of radionuclides including thorium, uranium, transuranics such as neptunium, plutonium, americium, curium, and californium, and fission products such as cobalt, cesium, strontium, iodine, and europium, among others. In addition to the radionuclide inventory in the supernate and sludge, radioactive material hazards are also present in the form of surface contamination on the remediation equipment, internal surfaces of the equipment confinement enclosures, ventilation ducts, and HEPA filters.

Fissionable isotopes of uranium, neptunium, plutonium, americium, and curium are present in low concentrations in the supernate and sludge in the STF tanks, WD&C transfer piping, SCS process piping and hoses; as airborne particulate in the tanks, confinement boxes, enclosures, and tank ventilation system ducting; as deposited particulate on the ventilation system HEPA filters; and as surface contamination on the remediation equipment.

A list of fissionable materials is included in the *ORNL Facility and Nuclear Criticality Safety Manual*[11], Procedure No. NCS-1.0, "Nuclear Criticality Safety Program." The procedure provides a method for normalizing the fissionability of other fissionable isotopes to that of ^{235}U to permit calculation of a single ^{235}U fissionable equivalent mass for mixtures of fissionable isotopes. If the quantity of fissionable isotopes is less than the Fissionable Material Control Limit (FMCL) of 250 g ^{235}U fissionable equivalent mass, a Nuclear Criticality Safety Approval is not required and the fissionable material hazard may be screened out. Nuclear criticality accidents are not possible under conditions available at ORNL for a mixture of fissionable nuclides in amounts less than 250 g ^{235}U fissionable equivalent mass. Additionally, the FMCLs have been chosen to make it practically impossible for a nuclear criticality to occur even if two FMCL amounts of fissionable nuclides were inadvertently brought together with no restriction on moderating and reflecting materials.

Table 3.6. List of hazards associated with the GAAT project remediation of the STF

Hazard type	Location	Quantity	Description
Radiation source	Tank W-5	4600 gal of sludge 27,964 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-1 for radioactive material concentrations and quantities
	Tank W-6	11,300 gal of sludge 41,479 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-2 for radioactive material concentrations and quantities
	Tank W-7	9800 gal of sludge 3565 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-3 for radioactive material concentrations and quantities
	Tank W-8	10,300 gal of sludge 64,581 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-4 for radioactive material concentrations and quantities
	Tank W-9	9200 gal of sludge 45,616 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-5 for radioactive material concentrations and quantities
	Tank W-10	24,400 gal of sludge 105,860 gal of supernate Up to 230 ft^3 of scarified gunite	See Table A-6 for radioactive material concentrations and quantities
	Tank W-8 or W-9	Up to 81,200 gal of sludge Up to 334,507 gal of supernate Up to 1540 ft^3 of scarified gunite	Combined inventories of Tanks W-5 through W-10 and Tanks W-3 and W-4 from NTF. Supernate will be transferred out of tank as necessary to prevent tank overfill (nominal capacity = 170,000 gal)
	WD&C and SCS transfer piping and hoses	Up to 70 gpm	See Tables A-1 through A-7 for possible radioactive material concentrations and quantities. 10 gpm will be process water
	Ventilation HEPA filters	Varying amounts of entrained particulates from tank ventilation air	See Tables A.1 through A.7 for possible radioactive material concentrations and quantities.
Toxic/Corrosive/ Reactive Material	In tanks and transfer piping and hoses	Same quantities and rates as listed for the radiation source hazard above.	See Tables A.1 through A.6 for toxic material concentrations.

Tables 3.7 through 3.13 list the total amounts of fissionable materials in the STF tanks (including the inventories transferred from NTF Tanks W-3 and W-4) and the corresponding ^{235}U fissionable equivalent mass. The quantities were determined by dividing the curie quantities determined in *Radioactive Material Hazard and Safety Class Determination*[10] by the specific activity for the fissionable nuclide. Comparing the tabulated results for the individual tanks, only Tank W-5, with an estimated ^{235}U fissionable equivalent mass of approximately 105 g has a fissionable material inventory less than the FMCL for ^{235}U of 250 g. For the remaining tanks, the ^{235}U fissionable equivalent mass exceeds the FMCL. Based on this criterion, the fissionable material inventories in the STF tanks, with the exception of W-5, can not be screened out. However, additional guidance

Table 3.7. Fissionable material inventory in Tank W-5

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-233	5.29E-01	5.29E-01	4.31E-02	1.10E+00	1.35	1.49E+00
U-235	5.16E+00	8.96E+01	2.09E+00	9.68E+01	1	9.68E+01
Np-237					0.035	
Pu-238	1.34E-05	5.11E-03	1.88E-03	7.00E-03	0.23	1.61E-03
Pu-239		3.28E+00	7.64E-02	3.35E+00	1.56	5.23E+00
Pu-240		1.26E-01	2.94E-03	1.29E-01	0.047	6.06E-03
Pu-241		3.79E-03	1.39E-03	5.18E-03	3.5	1.81E-02
Pu-242		7.95E-03	1.85E-04	8.14E-03	0.018	1.46E-04
Am-241					0.044	
Cm-244		3.73E-03	1.37E-03	5.09E-03	0.23	1.17E-03
					Total:	**1.05E+02**

Table 3.8. Fissionable material inventory in Tank W-6

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-235	5.72E+02	2.81E+03	2.05E+01	3.41E+03	1	3.41E+03
Np-237					0.035	
Pu-238	8.88E-04	1.32E-01	1.49E-02	1.48E-01	0.23	3.40E-02
Pu-239		2.08E+01	1.49E-01	2.10E+01	1.56	3.27E+01
Pu-240		7.12E-01	5.09E-03	7.17E-01	0.047	3.37E-02
Pu-241		1.10E-02	1.23E-03	1.22E-02	3.5	4.26E-02
Pu-242		3.74E-02	2.67E-04	3.76E-02	0.018	6.77E-04
Am-241					0.044	
Cm-244		3.18E-01	3.58E-02	3.54E-01	0.23	8.14E-02
					Total:	**3.49E+03**

Table 3.9. Fissionable material inventory in Tank W-7

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-235		2.71E+04	1.84E+02	2.73E+04	1	2.73E+04
Np-237					0.035	
Pu-238		1.79E-01	1.92E-02	1.99E-01	0.23	4.57E-02
Pu-239		1.70E+01	1.15E-01	1.71E+01	1.56	2.67E+01
Pu-240		8.47E-01	5.75E-03	8.52E-01	0.047	4.01E-02
Pu-241		4.05E-02	4.34E-03	4.49E-02	3.5	1.57E-01
Pu-242		1.14E-01	7.72E-04	1.14E-01	0.018	2.06E-03
Am-241		2.25E-01	1.69E-03	2.26E-01	0.044	9.96E-03
Cm-244	1.80E-06	2.26E-01	2.42E-02	2.50E-01	0.23	5.75E-02
					Total:	**2.73E+04**

Table 3.10. Fissionable material inventory in Tank W-8

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-235	1.14E+03	1.62E+03	1.50E+01	2.77E+03	1	2.77E+03
Np-237					0.035	
Pu-238	1.78E-03	3.39E-01	4.87E-02	3.89E-01	0.23	8.95E-02
Pu-239		7.29E+01	6.66E-01	7.36E+01	1.56	1.15E+02
Pu-240		4.18E+00	3.81E-02	4.22E+00	0.047	1.98E-01
Pu-241		9.30E-02	1.34E-02	1.06E-01	3.5	3.72E-01
Pu-242		2.22E-01	2.03E-03	2.24E-01	0.018	4.03E-03
Am-241		1.83E+00	1.85E-02	1.85E+00	0.044	8.15E-02
Cm-244	3.16E-03	3.07E-01	4.42E-02	3.54E-01	0.23	8.15E-02
					Total:	**3.12E+03**

Table 3.11. Fissionable material inventory in Tank W-9

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-235	1.59E+03	4.57E+03	3.43E+01	6.19E+03	1	6.19E+03
Np-237					0.035	
Pu-238	3.27E-05	1.07E+00	1.21E-01	1.19E+00	0.23	2.75E-01
Pu-239		9.87E+01	7.09E-01	9.94E+01	1.56	1.55E+02
Pu-240		5.61E+00	4.03E-02	5.65E+00	0.047	2.66E-01
Pu-241		1.27E-01	1.44E-02	1.42E-01	3.5	4.96E-01
Pu-242		1.20E+00	8.59E-03	1.20E+00	0.018	2.17E-02
Am-241		2.32E+00	1.84E-02	2.34E+00	0.044	1.03E-01
Cm-244	4.94E-04	8.07E-01	9.14E-02	8.99E-01	0.23	2.07E-01
					Total:	**6.49E+03**

Table 3.12. Fissionable material inventory in Tank W-10

Fissionable nuclide	Radionuclide mass in supernate (g)	Radionuclide mass in sludge (g)	Radionuclide mass in gunite (g)	Total radionuclide mass in tank (g)	Mass factor for ^{235}U fissionable equivalent f_{35}	^{235}U fissionable equivalent mass (g)
U-235	1.80E+02	1.10E+04	2.99E+01	1.12E+04	1	1.12E+04
Np-237					0.035	
Pu-238	2.66E-04	1.77E+00	7.56E-02	1.85E+00	0.23	4.25E-01
Pu-239		1.93E+02	5.23E-01	1.94E+02	1.56	3.02E+02
Pu-240		1.52E+01	4.12E-02	1.52E+01	0.047	7.17E-01
Pu-241		2.96E-01	1.26E-02	3.09E-01	3.5	1.08E+00
Pu-242		2.11E+00	5.72E-03	2.12E+00	0.018	3.81E-02
Am-241		4.50E+00	1.35E-02	4.51E+00	0.044	1.99E-01
Cm-244		1.82E+00	7.77E-02	1.90E+00	0.23	4.37E-01
					Total:	**1.20E+04**

Table 3.13. Combined fissionable material inventory in Tank W-8 and/or W-9
(includes material from NTF Tanks W-3 and W-4)

Fissionable nuclide	U-235 fissionable equivalent mass (g)								Combined inventory[a]
	Tank W-3	Tank W-4	Tank W-5	Tank W-6	Tank W-7	Tank W-8	Tank W-9	Tank W-10	
U-233	9.51E+01	6.02E+01	1.49E+00	5.36E+01	5.16E+01	2.34E+02	1.37E+02	5.06E+02	1.14E+03
U-235	1.63E+04	3.77E+04	9.68E+01	3.41E+03	2.73E+04	2.77E+03	6.19E+03	1.12E+04	1.05E+05
Np-237			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	1.03E-02	5.21E-03	1.61E-03	3.40E-02	4.57E-02	8.95E-02	2.75E-01	4.25E-01	8.86E-01
Pu-239	5.86E+01	1.60E+02	5.23E+00	3.27E+01	2.67E+01	1.15E+02	1.55E+02	3.02E+02	8.55E+02
Pu-240	5.70E-02	1.56E-01	6.06E-03	3.37E-02	4.01E-02	1.98E-01	2.66E-01	7.17E-01	1.47E+00
Pu-241	1.29E-01	1.93E-01	1.81E-02	4.26E-02	1.57E-01	3.72E-01	4.96E-01	1.08E+00	2.49E+00
Pu-242	6.22E-04	7.67E-04	1.46E-04	6.77E-04	2.06E-03	4.03E-03	2.17E-02	3.81E-02	6.81E-02
Am-241	1.59E-02		0.00E+00	0.00E+00	9.96E-03	8.15E-02	1.03E-01	1.99E-01	4.09E-01
Cm-244	3.22E-04	4.76E-04	1.17E-03	8.14E-02	5.75E-02	8.15E-02	2.07E-01	4.37E-01	8.66E-01
								Total:	**1.07E+05**

[a]Including inventory from NTF Tanks W-3 and W-4.

provided in the Waste Acceptance Criteria (WAC) for the LLLW System[12], allows for exclusion of some fissionable isotopes (^{233}U, ^{235}U, and $^{239\text{-}241}$Pu) from the determination of the fissionable mass equivalent when certain conditions are met. The WAC provides criteria for determining whether there is sufficient isotopic dilution or denaturing for a given mixture. When the ratio of ^{238}U to ^{235}U equals or exceeds 110 by weight and the ratio of ^{238}U to ^{233}U exceeds 200 by weight (Note: sufficient ^{238}U must be present to dilute both ^{233}U and ^{235}U. Same ^{238}U cannot be used as dilution for both), the uranium mixture is considered sufficiently depleted in the fissionable components ^{233}U and ^{235}U, that they can be excluded from the estimate of the ^{235}U fissionable equivalent mass and screened out from further consideration. Likewise, when the ratio of ^{232}Th to $^{239\text{-}241}$Pu exceeds 200 by weight, the fissionable plutonium isotopes in the mixture are considered sufficiently denatured by the ^{232}Th, that they also can be excluded from the estimate of the ^{235}U fissionable equivalent mass. Table 3.14 lists the calculated ratios for ^{233}U, ^{235}U, and $^{239\text{-}241}$Pu. All of the calculated ratios exceed the minimum required values and the ^{235}U fissionable equivalent mass is recalculated excluding these fissionable isotopes. The ^{235}U fissionable equivalent mass of the remaining mixture of fissionable isotopes, ^{237}Np, ^{238}Pu, ^{242}Pu, ^{241}Am, and ^{244}Cm, is significantly below the 250 g limit as shown in Table 3.15. Therefore, the fissionable material hazard is not retained for further evaluation. The source of the fissionable material hazards identified for other systems in the GAAT project remediation of the STF (support systems, WD&C, MLDUA, decontamination spray ring, scarifier, ROV, SCS, and decontamination tent) originates from the material in the tank. Therefore, because the fissionable material in the tanks have been screened from further evaluation, the fissionable material hazards present in the other systems may be screened out.

Inventories from NTF Tank W-3 and W-4. Prior to remediation of the STF tanks, the supernate and sludge from NTF Tanks W-3 and W-4 will be transferred to a STF receiving tank (W-8 and/or W-9). Therefore, the hazards associated with these inventories at the STF are evaluated as part of this hazards analysis. Up to approximately 15,700 gal of supernate at a density of 1.006 g/ml and 5500 gal of sludge at a density of 1.07 g/cm^3 will be transferred from NTF Tank W-3 to the STF. Up to approximately 29,800 gal of supernate at a density of 1.008 g/ml and 6100 gal of sludge at a median density of 1.275 g/cm^3 will be transferred from NTF Tank W-4 to the STF. Either tank inventory could be released during transfer from the NTF to the STF. The entire inventories of Tanks W-3 and W-4 could potentially be released from the STF receiving tank along with the existing inventory in the receiving tank resulting in a release of up to 150,000 gal of supernate and sludge. (Note: The receiving tank will also take supernate/sludge transfers from other STF tanks as the remediation progresses. The supernate and sludge bulk densities in the receiving tank will change as inventories from other tanks are added. The 150,000 gal volume is an estimated administrative limit based on a total tank capacity of 170,000 gal.) Initial screening of the Tank W-3 and W-4 inventories against the individual radionuclide RQ values was done as part of the hazard analysis for the NTF[13]. The NTF hazard analysis results showed that Tanks W-3 and W-4 contain quantities of radioactive material that exceed RQ values, so the radiation source hazards from these two tanks are retained for further evaluation.

Tank W-5. Up to approximately 28,000 gal of supernate at a density of 1.013 g/ml and 4600 gal of sludge at a median density of 1.165 g/cm^3 are in Tank W-5. The radionuclide inventory in STF tank W-5 is somewhat lower than the inventories in W-3 and W-4. Therefore, it is possible that the W-5 inventory could be screened out when compared to the 40 *CFR* 302.4[7] RQ values. The results of the comparison are listed in Table 3.16. The sum of the ratios of the quantities of each radionuclide to the corresponding RQ values exceeds one, so the radiation source hazard in Tank W-5 is retained for further evaluation.

Table 3.14. Determination of the isotopic dilution ratios for ^{235}U, ^{233}U, and ^{239}Pu in mixtures of fissionable materials in the tanks

Fissionable material	Supernate			Sludge			Scarified gunite		
	Mass ratio ^{238}U:^{235}U	Mass ratio ^{238}U:^{233}U	Mass ratio	Mass ratio ^{238}U:^{235}U	Mass ratio	Mass ratio ^{232}Th:$^{239-241}Pu$	Mass ratio ^{238}U:^{235}U	Mass ratio ^{238}U:^{233}U	Mass ratio ^{232}Th:$^{239-241}Pu$
Tank W-5	1.42E+03	2.58E+03	NC[a]	2.03E+02	3.68E+02	5.00E+04	2.03E+02	3.69E+02	4.96E+04
Tank W-6	1.42E+02	2.58E+02	NC[a]	1.60E+02	2.91E+02	3.12E+03	1.59E+02	2.89E+02	3.11E+03
Tank W-7	NC[b]	NC[b]	NC[b]	1.56E+02	2.84E+02	1.45E+04	1.56E+02	2.83E+02	4.12E+04
Tank W-8	1.42E+02	2.58E+02	NC[a]	1.51E+02	2.74E+02	9.85E+03	1.51E+02	2.74E+02	9.76E+03
Tank W-9	1.64E+02	2.98E+02	NC[a]	1.72E+02	3.13E+02	2.61E+03	1.72E+02	3.13E+02	2.58E+03
Tank W-10	1.64E+02	2.98E+02	NC[a]	1.72E+02	3.12E+02	1.98E+04	1.72E+02	3.12E+02	2.88E+04
Combined inventory (includes inventory from NTF Tanks W-3 and W-4)	1.56E+02	2.84E+02	9.28E+06	1.59E+02	2.89E+02	6.97E+03	1.59E+02	2.88E+02	8.45E+03

[a]As noted in hazard identification Tables A.1 through A.6, no $^{239-241}Pu$ is present in the supernate.
[b]As noted in hazard identification Table A.3, no ^{233}U, ^{235}U, or $^{239-241}Pu$ is present in Tank W-7 supernate.

Table 3.15. Determination of tank fissionable equivalent masses without ^{233}U, ^{235}U, and $^{239\text{-}241}Pu$

Fissionable nuclide	U-235 fissionable equivalent mass (g)								Combined inventory[a]
	Tank W-3	Tank W-4	Tank W-5	Tank W-6	Tank W-7	Tank W-8	Tank W-9	Tank W-10	
Np-237									
Pu-238	1.03E-02	5.21E-03	1.61E-03	3.40E-02	4.57E-02	8.95E-02	2.75E-01	4.25E-01	8.86E-01
Pu-242	6.22E-04	7.67E-04	1.46E-04	6.77E-04	2.06E-03	4.03E-03	2.17E-02	3.81E-02	6.81E-02
Am-241	1.59E-02				9.96E-03	8.15E-02	1.03E-01	1.99E-01	4.09E-01
Cm-244	3.22E-04	4.76E-04	1.17E-03	8.14E-02	5.75E-02	8.15E-02	2.07E-01	4.37E-01	8.66E-01
								Total:	**2.23E+00**

[a]Including inventory from NTF Tanks W-3 and W-4.

Table 3.16. Comparison of the Tank W-5 radiation source term to RQ values

Radionuclide	40 CFR 302.4 RQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of RQ
Am-241	1.00E-02					
C-14	1.00E+01					
Cf-252	1.00E-01	2.19E-03		5.05E-05	2.24E-03	2.24E-02
Cm-244	1.00E-02	3.00E-01		1.11E-01	4.11E-01	4.11E+01
Co-60	1.00E+01	1.30E-01	3.95E-01	4.79E-02	5.72E-01	5.72E-02
Cs-134	1.00E+00					
Cs-137/Ba-137m	1.00E+00	1.51E+01	1.39E+01	5.56E+00	3.45E+01	3.45E+01
Eu-152	1.00E+01					
Eu-154	1.00E+01					
Eu-155	1.00E+01					
H-3	1.00E+02	6.03E-03	5.51E-03	2.23E-03	1.38E-02	1.38E-04
Np-237	1.00E-02					
Pu-238	1.00E-02	8.70E-02	2.32E-04	3.21E-02	1.19E-01	1.19E+01
Pu-239	1.00E-02	2.02E-01		4.74E-03	2.07E-01	2.07E+01
Pu-240	1.00E-02	2.86E-02		6.70E-04	2.93E-02	2.93E+00
Pu-241	1.00E+00	3.89E-01		1.43E-01	5.32E-01	5.32E-01
Pu-242	1.00E-02	3.11E-05		7.29E-07	3.18E-05	3.18E-03
Pu-244	1.00E+00	6.11E-09		1.43E-10	6.25E-09	6.25E-09
Sr-90/Y-90	1.00E-01	3.63E+01	2.37E-02	1.34E+01	4.97E+01	4.97E+02
Th-228	1.00E-02	1.86E-02	1.12E-06	4.39E-04	1.90E-02	1.90E+00
Th-230	1.00E-02	6.88E-02		1.62E-03	7.04E-02	7.04E+00
Th-232	1.00E-03	1.86E-02	1.12E-06	4.39E-04	1.90E-02	1.90E+01
U-233	1.00E-01	1.77E-02	5.17E-03	4.16E-04	2.33E-02	2.33E-01
U-234	1.00E-01	1.15E-02	2.81E-03	2.70E-04	1.46E-02	1.46E-01
U-235	1.00E-01	1.93E-04	1.13E-05	4.51E-06	2.08E-04	2.08E-03
U-236	1.00E-01	1.21E-04	1.08E-05	2.84E-06	1.35E-04	1.35E-03
U-238	1.00E-01	6.29E-03	2.95E-03	1.47E-04	9.38E-03	9.38E-02
					Totals:	**6.37E+02**

Tank W-6. Up to approximately 41,500 gal of supernate at a density of 1.02 g/ml and 11,300 gal of sludge at a median density of 1.19 g/cm^3 are in Tank W-6. The radionuclide inventories of the sludge and supernate in Tank W-6 are provided in Appendix A, Table A-2. By comparison to the Tank W-3 and W-4 radionuclide inventories, it is determined that the radionuclide inventory in Tank W-6 exceeds the RQ values, so its radiation source hazard is retained for further evaluation.

Tank W-7. Up to approximately 3,600 gal of supernate at a density of 1.02 g/ml and 9,800 gal of sludge at a median density of 1.35 g/cm^3 are in Tank W-7. The radionuclide inventories of the sludge and supernate in Tank W-7 are provided in Appendix A, Table A-3. By comparison to the Tank W-3 and W-4 radionuclide inventories, it is determined that the radionuclide inventory in Tank W-7 exceeds the RQ values, so its radiation source hazard is retained for further evaluation.

Tank W-8. Up to approximately 65,000 gal of supernate at a density of 1.015 g/ml and 10,300 gal of sludge at a median density of 1.19 g/cm^3 are in Tank W-8. The radionuclide inventories of the sludge and supernate initially in Tank W-8 are provided in Appendix A, Table A-4. By comparison to the Tank W-3 and W-4 radionuclide inventories, it is determined that the radionuclide inventory initially in Tank W-8 exceeds the RQ values, so its radiation source hazard is retained for further evaluation.

Tank W-9. Up to approximately 46,000 gal of supernate at a density of 1.011 g/ml and 9,200 gal of sludge at a median density of 1.25 g/cm^3 are in Tank W-9. The radionuclide inventories of the sludge and supernate initially in Tank W-9 are provided in Appendix A, Table A-5. By comparison to the Tank W-3 and W-4 radionuclide inventories, it is determined that the radionuclide inventory initially in Tank W-9 exceeds the RQ values, so its radiation source hazard is retained for further evaluation.

Tank W-10. Up to approximately 106,000 gal of supernate at a density of 1.013 g/ml and 24,400 gal of sludge at a median density of 1.23 g/cm^3 are in Tank W-10. The radionuclide inventories of the sludge and supernate in Tank W-10 are provided in Appendix A, Table A-6. By comparison to the Tank W-3 and W-4 radionuclide inventories, it is determined that the radionuclide inventory in Tank W-10 exceeds the RQ values, so its radiation source hazard is retained for further evaluation.

Combined Inventory in Tank W-8 or W-9. Before or during the GAAT project remediation of the STF, the supernate and sludge inventories from NTF Tanks W-3 and W-4 will be transferred to Tank W-8 and/or Tank W-9. As the supernate and sludge are removed from each of the other five STF tanks the supernate/sludge slurries, with water added from operation of the sluicing jet pump, scarifiers (CSEE and GSEE), and decontamination spray rings, are transferred to Tank W-8 and/or W-9. The final combined volume of supernate and sludge in these tanks could be as much as 150,000 gal. Because the combined radionuclide inventory will exceed the initial tank inventory, the combined inventory exceeds the RQ values and is retained for further evaluation.

Support Systems/Tank Ventilation System. The STF tanks are maintained at a negative pressure of approximately 2 in. of water to prevent the release of airborne contaminants in the tanks to the environment. The ventilation air passes through one stage of HEPA filters before entering the central off-gas system. The radioactive material inventories in the tank ventilation system consists of the concentrations of airborne contaminants in the ventilation piping between the tanks and the corresponding tank HEPA filter and the loadings on the HEPA filters. It is conservatively assumed that the quantity of radioactive materials which may accumulate on the HEPA filters exceeds the RQ values. Therefore, the radiation source hazard is retained for the ventilation system.

The contamination of the support system in-tank equipment, the MLDUA, the scarifier system in-tank equipment, and the ROV, and contamination present at the decontamination spray ring and the decontamination tent is expected to be a very small fraction of the total tank inventory and is assumed not to exceed RQ values. This contamination on equipment, which is primarily surface contamination outside and inside of the equipment, is that which remains after the components are flushed and sprayed to the extent reasonable. Therefore, the radiation source hazard associated with equipment contamination is not retained for further evaluation.

Radioactive liquid/sludge slurries may be transferred through piping and hoses in the WD&C system and the SCS. The maximum flow rate of the liquids is 70 gpm which includes 10 gpm of process water used to power the jet pumps. An accident involving release from piping in the WD&C system or the SCS could result in release of the entire inventory of the tank being sluiced. Therefore, the radiation source hazard associated with the WD&C system and the SCS is retained for further evaluation.

Nonradiological hazards. The nonradiological hazards associated with each tank are toxic, corrosive, and reactive materials as identified in Table 3.5. These materials, identified in the tank sample data[9], consist of a wide range of chemical reagents in the tank supernate and sludge originating from process, research, and analytical operations at the source facilities within ORNL. The reagents include Resource Conservation and Recovery Act metals, various process metals, anions, carcinogens, toxins, volatile organic compounds, semi-volatile organic compounds, and even small amounts of PCBs.

Elevated levels of toxic/corrosive/reactive materials can have serious health effects through inhalation, ingestion, or direct contact with the skin or eyes. Depending on the type material, its concentration, and method and duration of exposure, the reversible health effects encountered upon exposure could be minor burns, skin or eye irritation, nausea, or headaches. Higher concentrations for these materials may cause irreversible health effects such as severe chemical burns, injury to internal organs, or possibly death.

Toxic/corrosive/reactive materials are present in all of the STF tanks. Comparison of the chemical constituents of the liquids to regulatory limits contained in 40 *CFR* 302.4[7] is difficult because discreet chemicals are not easily distinguished by sampling. It is important to consider the intent of the regulatory limits. The RQ values listed in 40 *CFR* 302.4[7] are intended to identify facilities and processes with toxic material hazards that can have significant toxic consequences to on-site and off-site personnel during and following accidents. Most RQs are based on a pure chemical form that is susceptible to airborne release when spilled, heated, or ignited. The chemicals present in the liquids and sludges in the STF tanks are in aqueous solution and are not susceptible to cloud-type releases. The lowest listed RQ for hazardous chemicals is 1 lb. Based on the volume of liquid present in each tank, the concentration of a hazardous chemical necessary to exceed 1 lb is determined and compared to sampling data in DAC-PX495A02-SSE-008[15]. Calculations in DAC-PX495A02-SSE-008[15] indicate that quantities of hazardous chemicals in all the tanks exceed the RQ values. Therefore, the toxic/corrosive/reactive material hazard is retained for further evaluation.

Occupational Hazards

Occupational hazards include the hazard types not discussed in the "Radiological" or "Nonradiological" hazards discussion (i.e., flammable materials, explosive and pyrophoric materials, electrical energy, thermal energy, kinetic energy, potential energy, and lasers).

Flammable materials. The flammable material hazards discussed in this section are limited to materials with flash points of <100°F. All other materials are considered as combustible materials and are not discussed in this section. Flammable materials, if they spill or leak and are subsequently ignited, can result in burns and/or the inhalation of smoke/toxic vapors. In addition, flammable materials can result in a fire that may be an initiating event for a release of radioactive materials from confinement.

The only source of flammable materials in the GAAT project remediation of the STF are trace quantities of volatile organics in the LLLW.

There is no significant source of flammable material in the STF tanks. Gasoline and diesel fuel are used by the motor powering the scarifier pump and may be on trucks near the facility during normal operations; however, these are present in small amounts and are common to general industry. Therefore, they are not considered an unusual hazard and are not evaluated further.

Explosive/pyrophoric material. Hydrogen gas is generated in the STF tanks from radiolysis. Hydrogen will diffuse rapidly in the tank void space above the supernate and sludges. If it is contained and allowed to concentrate to its lower flammability limit of 4% in air by volume, it can deflagrate resulting in a sudden pressure and temperature rise in the volume. Calculations in DAC-

PX495A02-SSE-001[14] indicate that the time required to build-up to a 4% hydrogen atmosphere in a gunite tank without ventilation is several years. The calculation indicates that, conservatively assuming the tanks are at 80% volume and only the air is displaced by the hydrogen until a sufficient volume of hydrogen is generated and then the air and hydrogen are completely mixed, the following times are required to reach 4% by volume: W-5 requires 534 years, W-6 requires 14 years, W-7 requires 12 years, W-8 requires 7 years, W-9 requires 9 years, and W-10 requires 1 year. The duration of the GAAT project remediation of the STF is estimated to be several years. Therefore, no further evaluation is required.

Electrical energy sources. Electrical power is used throughout the facility for instrumentation and equipment. The maximum voltage used by the facility is 480 V. No unusual sources of electrical hazards are present, and the risk to operating personnel is controlled by adhering to national codes and standards used in industry. The electrical energy source is a routine hazard encountered in general industrial and public facilities and is not considered for further evaluation. Potential fires from shorts in the electrical power system are the only accidents identified that may be initiated by the identified electrical energy hazard sources.

Thermal energy sources. The only thermal energy source identified in the GAAT project remediation of the STF is heat generated by the decay of radionuclides in the supernate and sludges and cutting and welding operations. Calculations in DAC-PX495A02-SSE-005[10] indicate that the total heat generation by all tanks is only several hundred watts. There are no significant thermal energy sources associated with the proposed operations. Therefore, these hazards are not evaluated further.

Kinetic and potential energy sources. The sources of rotational kinetic energy in the tanks are the CSEE and GSEE rotating water jet nozzles used to dislodge sludge and scarify the tank walls. Failure of rotating equipment can result in operator injury and/or damage to equipment if missiles are generated and operating personnel are located nearby. Rotational kinetic energy is a routine hazard encountered in general industrial and public facilities and is not considered for further evaluation.

A source of potential energy for the remediation project is the construction crane. Operator error, an earthquake or other natural phenomena could cause the crane to tip over (particularly when moving a suspended load). Structural failure due to inadequate support can also cause equipment to fall on or hit personnel. These sources of potential energy are common to general industrial and public facilities and are not considered for further evaluation from the perspective of their own intrinsic hazard. The potential energy sources can initiate accidents involving other hazard sources in the facility (i.e., suspended load in a tank is dropped and impacts the tank bottom causing a crack resulting in a leak). These potential energy sources are evaluated further as accident initiators.

Potential energy is present in the form of the high pressure water supply for the CSEE and jet pumps (up to 7,000 psig) and in the scarifier system (10 gpm at up to 30,000 psig). The high pressure water supply exceeds the criteria from ES/CSET-2/R2[5]. The supply water is filtered process water, contains no hazardous or radioactive materials, and has a relatively low flow rate (10 gpm each in three pumps). The high pressure water is used to break up sludge deposits or remove the top layer of gunite in the tank before removal using a jet pump. The low volume and high pressure process water supply does not present any unique hazard to workers or the public. The high pressure water pumps are available commercially and are considered standard industrial use. The potential energy sources associated with high pressure systems are industrial hazards such as the rupture of a line, valve, or pressure relief device when the pump is operating. ORNL has a program to provide special review and approval for these high pressure systems. The ORNL Office of Safety and Health

Protection administers the safety review program. All of the recommendations of the high pressure review will be resolved and incorporated as necessary to ensure occupational health and safety during the use of the high pressure pumps. Therefore, the potential energy hazard is screened out and is not considered for further evaluation.

Lasers. The Topographical Mapping System utilizes a 30 milliwatt 820 nanometer infrared class 3b laser. ORNL Office of Safety and Health Procedure OSHP-005, "ORNL Laser Safety Program,"applies to all laser usage above class 1 lasers. The program requires hazard analysis for each class 3b and/or 4 laser/laser system operation. The direct consequences from the lasers are not included within the scope of this SAR since they are being evaluated and controlled by the Laser Hazard Control Program.

3.3.2.2 Preliminary hazard categorization

After hazards have been identified and screened, the facility is assigned a nuclear and a nonnuclear hazard categorization based on the types and amounts of hazardous materials present according to the methodology described in Sect. 3.3.1.2.

Preliminary Nuclear Hazard Categorization

STF remediation operations consist of the following activities:

1) Inserting, removing, and operating the MLDUA, WD&C, and ROV.
2) Changing end effectors on MLDUA, ROV, and WD&C.
3) Transferring supernate between tanks or to the LLLW System without mobilizing sludges.
4) Mobilizing and transferring sludges between tanks.
5) Conditioning sludges during transfer (operating the SCS)
6) Operating and maintaining closed circuit TV system.
7) Removing solid materials from the tanks.
8) Scarifying tank walls and bottoms.
9) Sampling and monitoring of waste and tank structures.
10) Maintenance/testing/modification.
11) Operating support systems (compressed air, process water, ventilation, etc.).

The preliminary nuclear hazard categorization for the individual tanks is determined by comparing each tank radionuclide inventory with the corresponding Category 3 and Category 2 TQ values in DOE-STD-1027-92[3]. Tables 3.17 through 3.22 provide the individual radionuclide concentrations (Bq/ml for supernate and Bq/g for sludge), total activities calculated in *Radioactive Material Hazard and Safety Class Determination*[10], and ratios of the activities to the corresponding Category 3 and Category 2 TQs.

Table 3.17 provides the comparison results for the inventory in Tank W-5. The sum of the Category 2 ratios for the individual radionuclides in the tank does not exceed one, so this inventory, alone, is not sufficient to require a Category 2 nuclear hazard categorization for the STF remediation. The sum of the Category 3 ratios for the radionuclides in the tank exceeds one, therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-5, considered by itself, is "Category 3."

Table 3.18 provides the comparison results for the inventory in Tank W-6. The sum of the Category 2 ratios for the individual radionuclides in the tank does not exceed one, so this inventory alone, is not sufficient to require a Category 2 nuclear hazard categorization for the STF remediation. The sum of the Category 3 ratios for the radionuclides in Tank W-6 significantly exceeds one, therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-6, considered by itself, is "Category 3."

Table 3.19 provides the comparison results for the inventory in Tank W-7. The sum of the Category 2 ratios for the individual radionuclides in the tank does not exceed one, so this inventory, alone, is not sufficient to require a Category 2 nuclear hazard categorization for the STF remediation. The sum of the Category 3 ratios for the radionuclides in Tank W-7 significantly exceeds one, therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-7, considered by itself, is "Category 3."

Table 3.20 provides the comparison results for the inventory in Tank W-8. The sum of the Category 2 ratios for the individual radionuclides in the tank exceeds one. Therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-8, considered by itself, is "Category 2."

Table 3.21 provides the comparison results for the inventory in Tank W-9 prior to addition of supernate and sludge from other tanks. The sum of the Category 2 ratios for the individual radionuclides in the tank exceeds one, therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-9, considered by itself, is "Category 2."

Table 3.22 provides the comparison results for the inventory in Tank W-10. The sum of the Category 2 ratios for the individual radionuclides in the tank exceeds one. Therefore, the preliminary nuclear hazard categorization for the inventory in Tank W-10, considered by itself, is "Category 2."

The planned remediation operations will transfer all sludges into Tank W-8 and/or W-9. For conservatism, it is assumed that all of the sludge will be in one tank. The worst case release event for local on-site consequences is a pipe or hose rupture in the WD&C transfer line or the SCS during transfer of the supernate and/or sludge between tanks. An unmitigated full pipe break could release up to 150,000 gal of supernate and sludge from Tank W-8 or Tank W-9, containing the total combined inventory of radionuclides in the STF. The inventory that would be released in this worst case scenario is estimated by summing the total sludge and supernate radionuclide inventories in Tables 3.17 through 3.22 and adding the inventory from Tanks W-3 and W-4 in the NTF that will be transferred to the STF before or during the remediation project. The sum of the Category 2 ratios for the combined inventory exceeds one (~10.0 times the Category 2 threshold). Therefore, the preliminary nuclear hazard categorization for the combined inventory in W-8 or W-9 is "Category 2."

The results of the preliminary nuclear hazard categorization are summarized in Table 3.23.

Preliminary Nonnuclear Hazard Categorization

The potential health effects resulting from accidents involving toxic chemical hazards are evaluated in DAC-PX495A02-SSE-008[15]. The worst potential consequence is that associated with the release and inhalation of uranium. Exposure to a release with the concentrations of uranium found in the STF tank results in consequences listed as "Mild Health Effects" to on-site receptors. Consequences resulting from exposure to all other toxic chemicals present in the STF tanks result in "negligible" health effects to both on-site and off-site receptors. Using the ES/CSET-2/R2[5]

Table 3.17. Tank W-5 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01						
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02	2.19E-03		5.05E-05	2.24E-03	7.01E-04	7.48E-06
Cm-244	1.00E+00	5.50E+01	3.00E-01		1.11E-01	4.11E-01	4.11E-01	7.47E-03
Co-60	2.80E+02	1.90E+05	1.30E-01	3.95E-01	4.79E-02	5.72E-01	2.04E-03	3.01E-06
Cs-134	4.20E+01	6.00E+04						
Cs-137/Ba-137m	6.00E+01	8.90E+04	1.51E+01	1.39E+01	5.56E+00	3.45E+01	5.76E-01	3.88E-04
Eu-152	2.00E+02	1.30E+05						
Eu-154	2.00E+02	1.10E+05						
Eu-155	9.40E+02	7.30E+05						
H-3	1.00E+03	3.00E+05	6.03E-03	5.51E-03	2.23E-03	1.38E-02	1.38E-05	4.59E-08
Np-237	4.20E-01	5.80E+01						
Pu-238	6.20E-01	6.20E+01	8.70E-02	2.32E-04	3.21E-02	1.19E-01	1.92E-01	1.92E-03
Pu-239	5.20E-01	5.60E+01	2.02E-01		4.74E-03	2.07E-01	3.98E-01	3.70E-03
Pu-240	5.20E-01	5.50E+01	2.86E-02		6.70E-04	2.93E-02	5.63E-02	5.33E-04
Pu-241	3.20E+01	2.90E+03	3.89E-01		1.43E-01	5.32E-01	1.66E-02	1.83E-04
Pu-242	6.20E-01	5.50E+01	3.11E-05		7.29E-07	3.18E-05	5.14E-05	5.79E-07
Pu-244	6.20E-01	5.50E+01	6.11E-09		1.43E-10	6.25E-09	1.01E-08	1.14E-10
Sr-90/Y-90	1.60E+01	2.20E+04	3.63E+01	2.37E-02	1.34E+01	4.97E+01	3.10E+00	2.26E-03
Th-228	1.00E+00	9.20E+01	1.86E-02	1.12E-06	4.39E-04	1.90E-02	1.90E-02	2.07E-04
Th-230	6.20E-01	8.90E+01	6.88E-02		1.62E-03	7.04E-02	1.14E-01	7.91E-04
Th-232	1.00E-01	1.80E+01	1.86E-02	1.12E-06	4.39E-04	1.90E-02	1.90E-01	1.06E-03
U-233	4.20E+00	2.20E+02	1.77E-02	5.17E-03	4.16E-04	2.33E-02	5.55E-03	1.06E-04
U-234	4.20E+00	2.20E+02	1.15E-02	2.81E-03	2.70E-04	1.46E-02	3.47E-03	6.63E-05
U-235	4.20E+00	2.40E+02	1.93E-04	1.13E-05	4.51E-06	2.08E-04	4.96E-05	8.69E-07
U-236	4.20E+00	5.50E+01	1.21E-04	1.08E-05	2.84E-06	1.35E-04	3.21E-05	2.45E-06
U-238	4.20E+00	2.40E+02	6.29E-03	2.95E-03	1.47E-04	9.38E-03	2.23E-03	3.91E-05
						Totals:	**5.09E+00**	**1.87E-02**

Table 3.18. Tank W-6 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01						
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02	1.10E-02		7.74E-05	1.11E-02	3.46E-03	3.69E-05
Cm-244	1.00E+00	5.50E+01	2.57E+01	1.41E-01	2.90E+00	2.88E+01	2.88E+01	5.23E-01
Co-60	2.80E+02	1.90E+05	1.68E+00	2.03E+00	2.10E-01	3.92E+00	1.40E-02	2.07E-05
Cs-134	4.20E+01	6.00E+04						
Cs-137/Ba-137m	6.00E+01	8.90E+04	2.24E+02	2.16E+03	4.77E+01	2.43E+03	4.05E+01	2.73E-02
Eu-152	2.00E+02	1.30E+05						
Eu-154	2.00E+02	1.10E+05	1.37E+00		1.55E-01	1.53E+00	7.64E-03	1.39E-05
Eu-155	9.40E+02	7.30E+05						
H-3	1.00E+03	3.00E+05	1.27E-02	6.70E-02	2.12E-03	8.18E-02	8.18E-05	2.73E-07
Np-237	4.20E-01	5.80E+01						
Pu-238	6.20E-01	6.20E+01	2.26E+00	1.55E-02	2.55E-01	2.53E+00	4.08E+00	4.08E-02
Pu-239	5.20E-01	5.60E+01	1.29E+00		9.24E-03	1.30E+00	2.50E+00	2.32E-02
Pu-240	5.20E-01	5.50E+01	1.62E-01		1.16E-03	1.64E-01	3.15E-01	2.97E-03
Pu-241	3.20E+01	2.90E+03	1.13E+00		1.27E-01	1.25E+00	3.92E-02	4.33E-04
Pu-242	6.20E-01	5.50E+01	1.47E-04		1.05E-06	1.48E-04	2.39E-04	2.69E-06
Pu-244	6.20E-01	5.50E+01	3.90E-08		2.79E-10	3.93E-08	6.34E-08	7.14E-10
Sr-90/Y-90	1.60E+01	2.20E+04	1.10E+03	1.30E+01	1.24E+02	1.24E+03	7.76E+01	5.64E-02
Th-228	1.00E+00	9.20E+01	7.35E-03	1.55E-05	5.30E-05	7.42E-03	7.42E-03	8.07E-05
Th-230	6.20E-01	8.90E+01		3.68E-01	2.45E-04	3.68E-01	5.94E-01	4.14E-03
Th-232	1.00E-01	1.80E+01	7.35E-03	1.55E-05	5.30E-05	7.42E-03	7.42E-02	4.12E-04
U-233	4.20E+00	2.20E+02	4.26E-03	3.86E-01	2.85E-04	3.90E-01	9.29E-02	1.77E-03
U-234	4.20E+00	2.20E+02	1.93E-01	3.44E-02	1.40E-03	2.29E-01	5.45E-02	1.04E-03
U-235	4.20E+00	2.40E+02	6.08E-03	1.26E-03	4.43E-05	7.38E-03	1.76E-03	3.08E-05
U-236	4.20E+00	5.50E+01	5.82E-04	1.81E-04	4.28E-06	7.67E-04	1.83E-04	1.40E-05
U-238	4.20E+00	2.40E+02	1.51E-01	3.12E-02	1.10E-03	1.83E-01	4.35E-02	7.62E-04
						Totals:	**1.55E+02**	**6.83E-01**

Table 3.19. Tank W-7 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01	7.71E-01		5.80E-03	7.77E-01	1.49E+00	1.41E-02
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02	1.68E-02		1.12E-04	1.69E-02	5.29E-03	5.64E-05
Cm-244	1.00E+00	5.50E+01	1.83E+01	1.49E-04	1.96E+00	2.02E+01	2.02E+01	3.68E-01
Co-60	2.80E+02	1.90E+05	5.82E+00	1.08E-01	6.43E-01	6.57E+00	2.35E-02	3.46E-05
Cs-134	4.20E+01	6.00E+04	1.35E-01		1.45E-02	1.50E-01	3.57E-03	2.50E-06
Cs-137/Ba-137m	6.00E+01	8.90E+04	2.61E+03	2.38E+02	3.23E+02	3.18E+03	5.29E+01	3.57E-02
Eu-152	2.00E+02	1.30E+05	2.17E+00		2.32E-01	2.40E+00	1.20E-02	1.84E-05
Eu-154	2.00E+02	1.10E+05	1.60E+00		1.71E-01	1.77E+00	8.85E-03	1.61E-05
Eu-155	9.40E+02	7.30E+05						
H-3	1.00E+03	3.00E+05	1.54E-01	7.07E-03	1.78E-02	1.79E-01	1.79E-04	5.98E-07
Np-237	4.20E-01	5.80E+01						
Pu-238	6.20E-01	6.20E+01	3.07E+00		3.28E-01	3.40E+00	5.48E+00	5.48E-02
Pu-239	5.20E-01	5.60E+01	1.05E+00		7.16E-03	1.06E+00	2.04E+00	1.89E-02
Pu-240	5.20E-01	5.50E+01	1.93E-01		1.31E-03	1.94E-01	3.74E-01	3.53E-03
Pu-241	3.20E+01	2.90E+03	4.17E+00		4.47E-01	4.62E+00	1.44E-01	1.59E-03
Pu-242	6.20E-01	5.50E+01	4.46E-04		3.03E-06	4.49E-04	7.25E-04	8.17E-06
Pu-244	6.20E-01	5.50E+01	4.60E-07		3.13E-09	4.64E-07	7.48E-07	8.43E-09
Sr-90/Y-90	1.60E+01	2.20E+04	1.18E+03	2.23E-01	1.26E+02	1.30E+03	8.14E+01	5.92E-02
Th-228	1.00E+00	9.20E+01	2.83E-02	3.10E-02	5.66E-04	5.98E-02	5.98E-02	6.51E-04
Th-230	6.20E-01	8.90E+01						
Th-232	1.00E-01	1.80E+01	2.83E-02	3.10E-02	5.66E-04	5.98E-02	5.98E-01	3.32E-03
U-233	4.20E+00	2.20E+02	3.66E-01		2.48E-03	3.68E-01	8.77E-02	1.67E-03
U-234	4.20E+00	2.20E+02	1.45E+00		9.88E-03	1.46E+00	3.48E-01	6.65E-03
U-235	4.20E+00	2.40E+02	5.85E-02		3.97E-04	5.89E-02	1.40E-02	2.45E-04
U-236	4.20E+00	5.50E+01	1.37E-03		9.30E-06	1.38E-03	3.28E-04	2.50E-05
U-238	4.20E+00	2.40E+02	1.42E+00		9.62E-03	1.43E+00	3.39E-01	5.94E-03
						Totals:	**1.66E+02**	**5.74E-01**

Table 3.20. Tank W-8 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01	6.29E+00		6.35E-02	6.35E+00	1.22E+01	1.16E-01
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02	5.02E-03		4.51E-05	5.06E-03	1.58E-03	1.69E-05
Cm-244	1.00E+00	5.50E+01	2.48E+01	2.60E-01	3.57E+00	2.87E+01	2.87E+01	5.21E-01
Co-60	2.80E+02	1.90E+05	5.15E+00	3.39E+00	7.51E-01	9.28E+00	3.32E-02	4.89E-05
Cs-134	4.20E+01	6.00E+04						
Cs-137/Ba-137m	6.00E+01	8.90E+04	8.58E+02	2.50E+03	1.32E+02	3.49E+03	5.82E+01	3.92E-02
Eu-152	2.00E+02	1.30E+05	2.73E+00		3.93E-01	3.13E+00	1.56E-02	2.40E-05
Eu-154	2.00E+02	1.10E+05	2.88E+00		4.13E-01	3.29E+00	1.64E-02	2.99E-05
Eu-155	9.40E+02	7.30E+05						
H-3	1.00E+03	3.00E+05		5.82E-02	2.01E-04	5.84E-02	5.84E-05	1.95E-07
Np-237	4.20E-01	5.80E+01						
Pu-238	6.20E-01	6.20E+01	5.79E+00	3.08E-02	8.33E-01	6.65E+00	1.07E+01	1.07E-01
Pu-239	5.20E-01	5.60E+01	4.52E+00		4.13E-02	4.56E+00	8.77E+00	8.15E-02
Pu-240	5.20E-01	5.50E+01	9.53E-01		8.70E-03	9.61E-01	1.85E+00	1.75E-02
Pu-241	3.20E+01	2.90E+03	9.58E+00		1.38E+00	1.10E+01	3.43E-01	3.78E-03
Pu-242	6.20E-01	5.50E+01	8.72E-04		7.96E-06	8.80E-04	1.42E-03	1.60E-05
Pu-244	6.20E-01	5.50E+01	2.35E-07		2.14E-09	2.37E-07	3.82E-07	4.31E-09
Sr-90/Y-90	1.60E+01	2.20E+04	3.45E+03	4.15E+00	4.96E+02	3.95E+03	2.47E+02	1.80E-01
Th-228	1.00E+00	9.20E+01	8.33E-02	2.16E-05	7.66E-04	8.41E-02	8.41E-02	9.14E-04
Th-230	6.20E-01	8.90E+01						
Th-232	1.00E-01	1.80E+01	8.33E-02	2.16E-05	7.66E-04	8.41E-02	8.41E-01	4.67E-03
U-233	4.20E+00	2.20E+02	9.02E-01	7.69E-01	8.41E-03	1.68E+00	4.00E-01	7.63E-03
U-234	4.20E+00	2.20E+02	1.33E-01	6.80E-02	1.23E-03	2.02E-01	4.82E-02	9.20E-04
U-235	4.20E+00	2.40E+02	3.50E-03	2.49E-03	3.25E-05	6.03E-03	1.43E-03	2.51E-05
U-236	4.20E+00	5.50E+01	1.31E-03	3.58E-04	1.20E-05	1.68E-03	3.99E-04	3.05E-05
U-238	4.20E+00	2.40E+02	9.03E-02	6.18E-02	8.38E-04	1.53E-01	3.64E-02	6.37E-04
						Totals:	3.69E+02	1.08E+00

Table 3.21. Tank W-9 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01	7.97E+00		6.33E-02	8.03E+00	1.55E+01	1.46E-01
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02						
Cm-244	1.00E+00	5.50E+01	6.53E+01	4.04E-02	7.39E+00	7.28E+01	7.28E+01	1.32E+00
Co-60	2.80E+02	1.90E+05	8.25E+00	4.50E-01	9.40E-01	9.64E+00	3.44E-02	5.07E-05
Cs-134	4.20E+01	6.00E+04	2.35E-02	4.01E-01	8.49E-03	4.33E-01	1.03E-02	7.22E-06
Cs-137/Ba-137m	6.00E+01	8.90E+04	4.20E+02	2.70E+02	5.14E+01	7.41E+02	1.23E+01	8.32E-03
Eu-152	2.00E+02	1.30E+05	4.38E+00		4.96E-01	4.88E+00	2.44E-02	3.75E-05
Eu-154	2.00E+02	1.10E+05	6.01E+00		6.79E-01	6.69E+00	3.34E-02	6.08E-05
Eu-155	9.40E+02	7.30E+05	6.12E-02		6.92E-03	6.81E-02	7.24E-05	9.33E-08
H-3	1.00E+03	3.00E+05		4.72E-02	6.86E-04	4.79E-02	4.79E-05	1.60E-07
Np-237	4.20E-01	5.80E+01			4.40E-04	4.40E-04	1.05E-03	7.58E-06
Pu-238	6.20E-01	6.20E+01	1.83E+01	5.66E-04	2.08E+00	2.04E+01	3.29E+01	3.29E-01
Pu-239	5.20E-01	5.60E+01	6.12E+00		4.39E-02	6.16E+00	1.18E+01	1.10E-01
Pu-240	5.20E-01	5.50E+01	1.28E+00		9.20E-03	1.29E+00	2.48E+00	2.34E-02
Pu-241	3.20E+01	2.90E+03	1.31E+01		1.48E+00	1.46E+01	4.56E-01	5.03E-03
Pu-242	6.20E-01	5.50E+01	4.70E-03		3.38E-05	4.73E-03	7.63E-03	8.61E-05
Pu-244	6.20E-01	5.50E+01	2.67E-07		1.92E-09	2.69E-07	4.34E-07	4.89E-09
Sr-90/Y-90	1.60E+01	2.20E+04	2.46E+03	1.62E+00	2.79E+02	2.74E+03	1.71E+02	1.25E-01
Th-228	1.00E+00	9.20E+01	2.98E-02	2.95E-05	2.16E-04	3.01E-02	3.01E-02	3.27E-04
Th-230	6.20E-01	8.90E+01						
Th-232	1.00E-01	1.80E+01	2.98E-02	2.95E-05	2.16E-04	3.01E-02	3.01E-01	1.67E-03
U-233	4.20E+00	2.20E+02	9.21E-01	5.01E-02	6.67E-03	9.78E-01	2.33E-01	4.45E-03
U-234	4.20E+00	2.20E+02	4.63E-01	8.44E-02	3.40E-03	5.51E-01	1.31E-01	2.50E-03
U-235	4.20E+00	2.40E+02	9.87E-03	3.47E-03	7.41E-05	1.34E-02	3.19E-03	5.59E-05
U-236	4.20E+00	5.50E+01	4.74E-03	1.71E-04	3.42E-05	4.94E-03	1.18E-03	8.99E-05
U-238	4.20E+00	2.40E+02	2.74E-01	8.86E-02	2.05E-03	3.64E-01	8.68E-02	1.52E-03
						Totals:	3.21E+02	2.08E+00

Table 3.22. Tank W-10 radioactive material inventory comparison with hazard category thresholds

Radionuclide	Cat. 3 TQ (Ci)	Cat. 2 TQ (Ci)	Sludge (Ci)	Supernate (Ci)	Gunite (Ci)	Total (Ci)	Fraction of Cat. 3 TQ	Fraction of Cat. 2 TQ
Am-241	5.20E-01	5.50E+01	1.55E+01		4.63E-02	1.55E+01	2.98E+01	2.82E-01
C-14	4.20E+02	1.40E+06						
Cf-252	3.20E+00	3.00E+02						
Cm-244	1.00E+00	5.50E+01	1.47E+02		6.29E+00	1.54E+02	1.54E+02	2.79E+00
Co-60	2.80E+02	1.90E+05	3.40E+01	1.33E+00	1.46E+00	3.68E+01	1.31E-01	1.94E-04
Cs-134	4.20E+01	6.00E+04	4.30E+00		1.83E-01	4.48E+00	1.07E-01	7.47E-05
Cs-137/Ba-137m	6.00E+01	8.90E+04	2.68E+04	2.18E+03	1.16E+03	3.02E+04	5.03E+02	3.39E-01
Eu-152	2.00E+02	1.30E+05	1.34E+01		5.74E-01	1.40E+01	7.01E-02	1.08E-04
Eu-154	2.00E+02	1.10E+05	2.17E+01		9.28E-01	2.27E+01	1.13E-01	2.06E-04
Eu-155	9.40E+02	7.30E+05						
H-3	1.00E+03	3.00E+05	3.62E-01	1.32E+00	2.37E-02	1.71E+00	1.71E-03	5.69E-06
Np-237	4.20E-01	5.80E+01						
Pu-238	6.20E-01	6.20E+01	3.03E+01	4.61E-03	1.29E+00	3.16E+01	5.10E+01	5.10E-01
Pu-239	5.20E-01	5.60E+01	1.20E+01		3.24E-02	1.20E+01	2.31E+01	2.14E-01
Pu-240	5.20E-01	5.50E+01	3.47E+00		9.39E-03	3.48E+00	6.69E+00	6.32E-02
Pu-241	3.20E+01	2.90E+03	3.05E+01		1.30E+00	3.18E+01	9.95E-01	1.10E-02
Pu-242	6.20E-01	5.50E+01	8.30E-03		2.25E-05	8.32E-03	1.34E-02	1.51E-04
Pu-244	6.20E-01	5.50E+01	1.49E-06		4.05E-09	1.50E-06	2.42E-06	2.72E-08
Sr-90/Y-90	1.60E+01	2.20E+04	2.20E+04	1.16E+01	9.38E+02	2.29E+04	1.43E+03	1.04E+00
Th-228	1.00E+00	9.20E+01	1.29E-01	2.19E-06	3.53E-04	1.30E-01	1.30E-01	1.41E-03
Th-230	6.20E-01	8.90E+01						
Th-232	1.00E-01	1.80E+01	1.29E-01	2.19E-06	3.53E-04	1.30E-01	1.30E+00	7.20E-03
U-233	4.20E+00	2.20E+02	3.54E+00	6.31E-02	9.62E-03	3.61E+00	8.61E-01	1.64E-02
U-234	4.20E+00	2.20E+02	1.16E+00	1.01E-02	3.16E-03	1.18E+00	2.80E-01	5.35E-03
U-235	4.20E+00	2.40E+02	2.37E-02	3.93E-04	6.45E-05	2.42E-02	5.76E-03	1.01E-04
U-236	4.20E+00	5.50E+01	1.23E-02	7.40E-05	3.34E-05	1.24E-02	2.96E-03	2.26E-04
U-238	4.20E+00	2.40E+02	6.71E-01	1.06E-02	1.82E-03	6.83E-01	1.63E-01	2.85E-03
						Totals:	2.20E+03	5.29E+00

methodology for nonnuclear facility hazard classification, the nonnuclear hazard classification is "Low" because there is the potential for "Reversible" health effects to a large number of on-site receptors.

3.3.3 Hazard Evaluation

3.3.3.1 Preliminary hazards analysis

The hazards associated with the GAAT Project remediation of the STF are identified and screened in Sect. 3.3.2.1. The only unusual hazards identified requiring further evaluation are the radiation material hazards and the toxic/corrosive/reactive material hazards associated with the supernate and sludge inventories in the STF tanks and the transfer of these inventories between the tanks and from the tanks to the LLLW system. These hazards are evaluated in a PHA included as Appendix B.

Calculations in DAC-PX495A02-SSE-008[15] indicate that the worst case consequences resulting from toxic material release, using accident analysis methodology and assumptions, taking credit for controls identified for radioactive materials, and considering limits on the CSEE rate of motion are "Negligible." Therefore, the consequences associated with release of toxic materials are not specifically listed in the PHA or the accident analysis.

Table 3.23. Preliminary nuclear hazard categorization results

	Nuclear facility categorization		
Radiation source	**Radiological**	**Category 3**	**Category 2**
W-5		X	
W-6		X	
W-7		X	
W-8			X
W-9			X
W-10			X
Combined inventory (including inventory from NTF Tanks W-3 and W-4)			X

3.3.3.2 Preliminary hazards analysis summary

Planned Design and Operational Safety Improvements

This SAR makes no commitment to planned design or operational safety improvements.

Defense in Depth

This section summarizes significant aspects of defense in depth and identifies associated safety-significant SSCs and other items needing TSR coverage. Facility design features and administrative controls are identified as defense in depth. In particular, facility design includes SSCs that function as:

- Barriers to contain uncontrolled hazardous material or energy sources
- Preventive systems to protect those barriers
- Systems to mitigate uncontrolled hazardous material or energy release upon barrier failure

Administrative features are typically linked to overall safety management programs that directly control operations. Administrative features include the following aspects of operator interfaces:

- Procedural restrictions or limits
- Operator monitoring of critical parameters
- Equipment support functions
- Response actions to limit abnormal conditions, accident progression, or potential personnel exposure

The prevention, detection, and mitigation SSCs and administrative controls identified in the PHA, completed in Appendix B, comprise the defense in depth for the GAAT project remediation of the STF. The defense in depth features, divided by function, are included in Table 3.24.

Table 3.24. Defense in depth features and controls

Defense in depth function	Defense in depth feature or control
	Facility design
1. Barriers	a. System structural design can withstand the effects of internal and external loads without failure; mechanical loads (i.e., dead weight, pressure, impact, vibration, etc.) , thermal loads; and degradation mechanisms (i.e., corrosion, radiation damage, etc.).
	b. Tanks located below grade.
	c. Tanks are generally structurally sound.
	d. Site has a slight engineered grade that will divert rainwater, etc. run-off away from tanks without significant accumulation. White Oak Creek flooding will not cover the tanks.
	e. Double confinement of the process waste piping and in-line components (pumps, valves, flanges, instrumentation, and utility support system tie-ins) outside of the tanks.
	f. Existing concrete barriers and other structures (steam piping) along the Central Ave. side of the STF provide protection against vehicle run-off-road type accidents.
	g. Equipment platforms provide a structural barrier between sludge transfer piping/hoses and potential impact threats (i.e., moving vehicles, construction equipment)
	h. Supernate/sludge process waste piping is designed and fabricated to appropriate consensus national standards.
	i. Fence installed around STF site perimeter and gated access at site entry points provides site access controls.

Table 3.24 (continued)

Defense in depth function	Defense in depth feature or control
2. Preventive systems	a. Transfer components are located above the elevation that is flooded from dam failure. b. WD&C and MLDUA systems have lightning protection. c. Ventilation system ensures air inflow at tank openings. d. MLDUA and ROV systems have only small quantities of hydraulic fluid and it is not highly combustible. e. Jet pump shutoff head not greater than the piping design pressure. Piping has a rupture disc for protection against overpressure. f. Operating pressure of interfacing systems is higher than the operating pressure of the WD&C transfer piping. g. Interfacing systems have a check valve before connection to the WD&C transfer piping to prevent reverse flow. h. Tanks equipped with local vacuum breakers and pressure control to prevent damage to the radioactive material confinement boundary by high negative pressures caused by the central off-gas system. i. Sampling indicates that the material is not a criticality hazard. j. MLDUA system has a 9:1 margin for safety for the arm hoist strength to arm weight. k. SCS hose connections are type that is not likely to have a sudden complete failure. l. SCS interfacing system connections are equipped with check valves to prevent contaminated process liquids from backflowing into the interfacing systems.

Table 3.24 (continued)

Defense in depth function	Defense in depth feature or control
3. Mitigative systems	a. Tank ventilation system normally operates and has a HEPA filter cleaning the discharge path. b. Tanks have level instrumentation that provides indication and alarm in the control room and WOCC. When operating in either Mode 1 (operation) or Mode 2 (warm standby), project personnel in the control room will monitor tank levels and take emergency response action in the event of an alarm. When in cold standby and project personnel are not present, the responsibility for monitoring tank levels and responding to tank level alarms transfers to the WOCC. c. Spill response prevents ingestion dose. d. Tank dry wells are continuously monitored for leaks and leak detection alarms are provided in the control room and WOCC. (Monitoring and alarm response responsibility for Modes 1 and 2 assumed by project personnel, when in Mode 3, by WOCC personnel) Dry wells are sampled monthly. e. Transfer piping skids/enclosures and WD&C confinement box will collect leakage and direct it back to one of the tanks. The tank ventilation system provides negative pressure to the enclosures. f. Sluicing and transfer operations can be terminated by more that one control point. g. Dry wells drain to process waste pump station #1 for transfer into the process waste system. Pump in pump station #1 has a diesel generator backed power supply. h. Modulating damper controls tank negative pressure (vacuum breaker is available for back-up if damper fails). i. HEPA filters have differential pressure instrumentation; loss of back pressure will cause an alarm in the control room. j. Process water system lines with tie-ins to waste process transfer line have a pressure instrument with an alarm. k. Camera can allow visual monitoring of important components. l. Portable pump is available to transfer liquid from tanks to other tanks or to the active LLLW system. m. Ventilation exhaust is treated by the central off-gas system, which has additional HEPA filters. n. Graded and gravel covered site surface will direct spilled liquids to a catch basin and reduce the amount of liquid in contact with surface air thereby reducing aerodynamic resuspension. o. SCS has hoses, piping, and components that are double contained such that all leakage from primary confinement will be directed back to a gunite tank. p. SCS components located at central area of STF which is away from external hazards (i.e. vehicle impacts, etc.). q. Tank ventilation system includes a demister for removing aerosols in the discharge path. r. Visible indication of location of buried tanks as a precaution against driveovers or placement of heavy loads over a tank. s. Sludge conditioning system secondary confinement drains to a gunite tank.

Table 3.24 (continued)

Defense in depth function	Defense in depth feature or control
	Administrative features
4. Procedural restrictions or limits	a. Process water normally isolated when operator not present. b. Operator present at facility during operation in Modes 1 and 2. c. Total area of tank openings is limited. d. New waste from outside the STF tank farm is not being added to the tanks with the exception of the inventories from NTF Tanks W-3 and W-4. These tank inventories have been sampled and evaluated and do not present a nuclear criticality hazard or flammable hazard. e. Deleted. f. Sluicing and operation of the decontamination spray rings and wands will not be permitted when a tank access is open to the outside environment without compensatory measures for aerosol control. [Note: "access open" means — without an equipment confinement box (i.e., HMS glove box, WD&C confinement box) or other sealed enclosure in place over access opening.] g. Item deleted. h. Operations will be terminated if accidents in adjacent buildings threaten safe operations. i. No heavy loads driven over tanks. j. Heavy construction equipment not allowed within 5 ft of the gunite tank walls without written permission from the Facility Manager.
5. Manual monitoring of critical parameters	a. Ventilation air inflow rate will be measured upon opening the access port, as deemed necessary, and periodically thereafter as necessary. b. Monitoring of the tank levels.
6. Equipment support functions	a. Maintenance program. b. HEPA filters are tested for proper installation.
7. Operator responses or actions	a. Operator training. b. Operating procedures. c. System design will allow quick termination of operations. d. If the expected wind speed exceeds the limit for the MLDUA enclosure for the erected position, it will be lowered. If the MLDUA enclosure can not be lowered, then sludge transfers will be suspended for the duration of the high wind condition. e. Sluicing and transfer operations can be terminated by more that one control point. f. Operating procedures will ensure ventilation system operation prior to opening large accesses. g. Operators will terminate operations prior to evacuating the site.

WOCC = Waste Operations Control Center

Safety-Significant SSCs and TSRs

Safety-significant SSCs or administrative controls are those features important for prevention or mitigation of accident consequences to on-site personnel or accident consequences to off-site personnel that do not require specification of safety-class SSCs or administrative controls. These features or controls are specified to call attention to their general importance to safety. However, they are not vital to the safety of off-site personnel and therefore are not required to meet the rigorous design or maintenance criteria set forth for safety-class items. In the PHA for the GAAT project remediation of the STF, accident scenarios with the potential for significant on-site consequences are listed. The accident frequencies and consequences are compared with the analysis guidelines in Table 3.3 to determine the need for safety-significant SSCs or administrative controls. Accidents that cause an above-ground spill or spray of sludge and supernate from the transfer line during a transfer operation require safety-significant SSCs and administrative controls to reduce their frequency and/or consequence. The establishment of these safety-significant SSCs and administrative controls will assure that the contribution to the risk to project personnel and other on-site workers from these potential accidents is within analysis guidelines.

Secondary confinement structures envelope the transfer piping and hoses that convey the supernate and sludge between tanks. These secondary confinement structures function to collect leaking supernate and sludge in case a pipe or hose leak occurs and transfer it back to a gunite tank. On-site consequences are also mitigated by rapid (<40 min) shut-down of the sludge transfer operation following the initiation of a large leak. The isolation of systems interfacing with the primary confinement is necessary to prevent backflow of process material into the interfacing system. The need for safety-significant SSCs or administrative controls based on off-site consequence is evaluated for each accident scenario in the accident analysis in Sect. 3.4.

Worker Safety

Worker safety is an important aspect of the GAAT Project remediation of the STF. Shielding, remote operations, and filtration of ventilation exhaust are employed to reduce exposure to radioactive materials to as low as reasonably achievable (ALARA). When it is necessary for operating personnel to enter or work near contaminated areas or radiation fields, the systems and piping are drained, if possible, and appropriate Health Physics monitoring is requested and protective clothing is worn. Site, division, and facility safety programs add to worker safety by ensuring that workers are properly trained to perform their jobs, are provided with necessary protective clothing, and that records of radiation exposure are maintained. Descriptions of the safety programs are included in subsequent chapters of this SAR.

Environmental Protection

Environmental protection is an important aspect of all GAAT Project remediation of the STF operations. Transfer piping, hoses, and in-line components that contain the LLLW supernate and sludge (referred to as primary containment components) are enclosed in secondary confinement structures that drain back to a gunite tank. The use of secondary confinement is an example of the defense-in-depth approach to engineering in safety features. The tanks and remediation system enclosures and confinement boxes are exhausted through a once-through ventilation system equipped with HEPA filtration. The filtration minimizes the airborne release of radioactive materials to the environment. The STF site will be graded and sloped to direct rainwater run-off and any spilled liquids to an existing storm drain. In addition to the physical features that protect the environment, administrative controls and site programs prevent and respond to environmental releases.

Accident Selection

Events identified by the PHA as off-site Risk Category I or II events are retained for further evaluation in the accident analysis. Risk Category I and II events are events that were determined, by qualitative evaluation, to have the potential for significant off-site consequences. The Risk Category I and II events undergo a quantitative analysis to determine the need to specify safety-class

SSCs or administrative controls. The events with Risk Category I or II ratings are listed in Table 3.25.

3.3.3.3 Final hazard categorization

Knowledge gained from development of the accident scenarios in the PHA determined the bounding radioactive material release is less than the total combined tank inventories assumed for preliminary hazard categorization. The equipment configuration limits the quantity of material that may credibly be released during accident situations. The MLDUA must enter the tank at each quadrant to allow complete coverage of the tank volume. It is conservatively assumed that at any time only about one half of the sludge inventory in a single tank is available for release from the remediation equipment. Additionally, the release fraction for the worst case aerosol release accidents at the STF is significantly lower than the release fractions used for Hazard Category 2 in Attachment 1 of DOE-STD-1027-92[3]. If a leak or rupture of the LLLW (sludge and/or supernate) slurry transfer line occurs, the LLLW slurry can be released as a spill or spray directly to the environment. The bounding respirable release fraction provided in Sect. 3.2.3 of DOE-HDBK-3010-94 [20] for a nonvolatile liquid spill is 10^{-4}. The PHA did not identify other contributing mechanisms (i.e., fire, explosion, chemical reaction) that could increase the aerosol release fraction for the worst case bounding accident. The fires and deflagration scenarios evaluated in the PHA involve much smaller inventories of released aerosols.

In accordance with the guidance provided by DOE in DOE-STD-1027-92 [3], the Category 2 release fraction for a nonvolatile, nonflammable liquid is 10^{-3}. The ratio of the Category 2 release fraction to the release fraction established in the PHA (10^{-4}) is 10. The Category 2 threshold inventory values in Table A.1 of Attachment 1 of DOE-STD-1027-92[3] are increased by a factor of 10. These adjusted threshold inventory values are compared with the adjusted inventories in the PHA to determine whether Category 2 is still the appropriate hazard category or placement of the facility in a lower hazard category is justified.

The results of the preliminary hazards categorization (see Sect. 3.3.2.2) were based on a worst case scenario of a release of the combined inventory in Tank W-8 or Tank W-9. The sum of the Category 2 ratios for the combined inventory based on the unadjusted Category 2 thresholds exceeds one (~10.0 times the Category 2 threshold). When all the Category 2 threshold values are increased by a factor of 10 and the inventory is reduced by one half, the sum of "adjusted" Category 2 ratios for the combined inventory is reduced by a factor of 20. Dividing the unadjusted sum of ratios comparison result (~10.0) by 20 gives the corresponding adjusted comparison result of ~0.5, a value less than one. The combined inventory accident scenario bounds all similar accident scenarios involving individual tank inventories, therefore, all "sum of ratio" results for individual tanks will be less than one and less than the combined inventory result. These results justify the final nuclear hazard categorization of the GAAT Project remediation of the STF as Hazard Category 3.

3.4 ACCIDENT ANALYSIS

This section examines the accident scenarios identified for analysis. Estimates of frequency and off-site consequence are used to evaluate the need to designate SSCs as safety-class or safety-significant, and identify necessary TSR controls.

Table 3.25 lists all of the accidents identified in the PHA that were retained for further evaluation in the accident analysis. A large number of events were identified with similar initiating events and potential consequences. For this reason, the accident scenarios were grouped into two general categories: 1) accidents that result in release of one or more tanks' inventories to the ground with little or no airborne release, and 2) accidents that result in release of liquid/sludge slurry from transfer piping, hoses, or equipment above ground.

Table 3.25. Risk Category 1 and II events identified in the PHA

	Accident scenario	Estimated frequency	Estimated off-site consequence category (from PHA)	Exposure Pathway
1)	Tank Leak (1) — leak from a STF tank caused by a random failure of the tank containment structure.	Unlikely	High	Ingestion
2)	Tank Leak (2.a) — the MLDUA, ROV, WD&C, or other large component is dropped into the tank, impacting the tank floor causing a crack or puncture.	Unlikely	High	Ingestion
3)	Tank Leak (2.b) — during operations to remove sludge or scarify the gunite, the MLDUA, ROV, or WD&C impacts the tank wall causing a crack or puncture or the scarifier penetrates the tank wall or floor:	Unlikely	High	Ingestion
4)	Tank Leak (2.c) — MLDUA or WD&C mast housing, etc., falls onto tank from random failure or operator error causing collapse of the tank dome.	Unlikely	High	Ingestion
5)	Tank Overfill (3) — LLLW sludge, supernate, or process water fills tank beyond capacity (liquid source not shut off, isolation valve seal failure, etc.)	Unlikely	Moderate	Ingestion
6)	Tank Leak (4) - Construction accident: large piece of equipment or platform structural member dropped on the ground above the tank.	Unlikely	High	Ingestion
7)	WD&C Transfer Piping Leak (8) — large leak from transfer line caused by a random failure of piping or component.	Extremely Unlikely	High	Ingestion
8)	WD&C Transfer Piping Leak (11) — construction activities damage transfer piping/in-line components causing leak in line.	Extremely Unlikely	High	Ingestion
9)	LLLW Backflows into WD&C Interfacing System (12) — Leak of LLLW slurry out openings in the interfacing system to the environment.	Extremely Unlikely	High	Ingestion
10)	SCS Process Component/Hose Leak (14) — Leak from system piping/in-line components/hoseline caused by a random failure of piping or component.	Extremely Unlikely	High	Ingestion
11)	LLLW Backflows into SCS Interfacing Flush System (15) — Leak of LLLW slurry out openings in the interfacing system to the environment.	Extremely Unlikely	High	Ingestion
12)	Tank Leak (18) — Earthquake causes crack and/or dome collapse of tank causing a below-surface leak of supernate and sludge.	Unlikely	High	Ingestion
13)	SCS Process Component/Hose or WD&C Transfer Piping Leak (19) — Earthquake causes rupture of transfer line and large leak of LLLW slurry into confinement box also damaged by earthquake.	Extremely Unlikely	High	Ingestion

Accident scenario	Estimated frequency	Estimated off-site consequence category (from PHA)	Exposure Pathway
14) SCS Process Component/Hose or WD&C Transfer Piping Leak (20) — High wind causes rupture/leak of system piping/in-line components/hoses. A large leak of LLLW slurry into an equipment enclosure or hose secondary confinement also damaged by the high wind.	Extremely Unlikely	High	Ingestion
15) SCS Hose Leak (23) — Lightning strikes SCS hose causing a large leak of LLLW slurry into the hose secondary confinement also damaged by lightning.	Extremely Unlikely	High	Ingestion
16) Tank fails due to flood loadings caused by heavy rainfall.	Unlikely	Moderate	Ingestion
17) Tank Overfill (26) — Site evacuated during LLLW slurry transfer causing tank to fill beyond capacity and spill over contents.	Unlikely	Moderate	Ingestion
18) WD&C Transfer Piping Leak (27) — Vehicle accident exposes transfer piping to possible impact, puncture, crush, or immersion in fire causing a leak or spray of LLLW slurry into the confinement box also damaged by the vehicle accident.	Extremely Unlikely	High	Ingestion
19) SCS Process Piping/Component/Hose Leak (28) — Vehicle accident exposes the SCS piping/components, hoses to a possible impact, puncture, crush, or immersion in fire causing a leak or spray of LLLW slurry into the confinement box also damaged by the vehicle accident.	Extremely Unlikely	High	Ingestion
20) WD&C or SCS Process Piping/Component/Hose Leak (31) — construction activities damage transfer piping, in-line components, or hoses causing leak in system.	Extremely Unlikely	High	Ingestion

Note: This table presents the results of the binning process to determine which events will receive accident analysis in Sect. 3.4.2. The criteria to establish these binning consequences are provided in Table 3.4. As stated in Sect. 3.4, the analysis guidelines used to identify the need for safety class SSCs is 25 rem off-site consequences.

3.4.1 Methodology

Analysis of each event type includes five basic components: 1) scenario development, 2) source-term analysis, 3) consequence analysis, 4) comparison to guidelines, and 5) safety-class and safety-significant SSCs and TSR controls. The methodology used to complete each of the five components is discussed in the following sections.

3.4.1.1 Scenario development

The accident scenario is developed by identifying the initiating event(s) and the subsequent conditional events or actions that lead to the release of radioactive materials in the supernate and sludge to the environment. Prevention, detection, and mitigation features are identified and their effect on the potential consequence is qualitatively evaluated (large release, small release, no release). The initiating event frequency is estimated into one of four annual frequency ranges: $<10^{-6}$; between 10^{-6} and 10^{-4}; between 10^{-4} and 10^{-2}; and $>10^{-2}$. The frequency estimate is determined using industry failure data, standard human error probabilities, natural phenomena frequency data, or engineering judgement, as appropriate.

3.4.1.2 Source term analysis

The source term for an accident scenario is determined for the worst-case accident consequence with no credit taken for detection, prevention, or mitigation features. Source terms are developed for each of the STF tanks, the Tank W-3 and W-4 inventories transferred from the NTF, and the combined inventory accumulated in Tank W-8 and/or W-9. The tank sampling and analysis data in ORNL/ER-365[9] permits the characterization of the source terms in terms of their individual radionuclide constituents. The source terms are initially defined as mixtures of radionuclides in relative strengths defined by their individual activity concentrations. Total amounts of the radionuclide constituents can be computed from the density and volume information provided in the references. To simplify computations with mixtures of radionuclides the source terms are normalized to a single radionuclide, in this case ^{90}Sr. The objective is to compute the dose consequence, therefore, the normalization is made in terms of equivalent dose. The normalization is done separately for the two different exposure pathways, inhalation and ingestion. When normalized in this manner, a complex source term can be expressed in terms of a single value and subsequent calculations are simplified.

There have been some transfers of supernate inventory between tanks following the tank sampling campaigns, therefore, the inventories reported for these source terms may be different from the current inventories in the tanks. However, no material was transferred into the STF, so the combined radionuclide inventory for all the tanks has not increased. A conservative, upper bound for each source term is obtained by using the upper 95% confidence limit values from the statistical analysis of the tank sampling data from ORNL/ER-365[9].

3.4.1.3 Consequence analysis

The off-site consequences of accident scenarios are determined for inhalation dose from breathing air contaminated with radioactive materials and for ingestion dose from drinking water contaminated with radioactive materials. The methodology for each is discussed in the following paragraphs.

Inhalation Dose

Inhalation doses are determined for off-site personnel at the nearest point of public access. The inhalation dose is determined by calculating the integral of air concentration for the time during which the receptor is exposed, multiplying by the breathing rate of the individual, and then multiplying by the dose conversion factor for the radioactive material of interest. The following equations are used:

$$I_P = \frac{Q}{\pi U A_y A_z} \sum_{j=0}^{j=1} \left[\frac{1}{s_j (1+s_j)} \right] e^{-\left(\frac{H_j}{(1+s_j)} \right)}$$

$$X_A = \left(\frac{X}{A_y} \right)^2$$

$$H_j = \left(\frac{Y}{A_y}\right)^2 + \frac{(Z - H)^2 + 4\,j\,Z\,H}{A_z^{\,2}}$$

$$s_j = \sqrt{1 + \left(\frac{H_j}{X_A}\right)}$$

where:

I_P = the infinite-time, concentration-time integral close to a point source (Ci sec/m^3)
Q = amount of material released to the air (Ci)
U = velocity of the air carrying the material from the source in the X direction (m/sec)
X = downwind distance of the receptor from the release (m)
Y = horizontal distance of the receptor measured from the X axis (m)
Z = vertical distance of the receptor measured from the X axis (m)
A_y = horizontal dispersion coefficient (m)
A_z = vertical dispersion coefficient (m)
H = vertical position of the point source measured from the X axis (m)
j = counting variable with values 0 and 1

$$Q = dQ/dt * t_D$$

$$dQ/dt = RR * C * RRF$$

RRF = ARF × RF (from DOE HDBK-3010-94[16])

where:

t_D = the smaller of the exposure time or the duration of the release (s)
RR = liquid release rate (L/s)
C = liquid concentration (Ci/L)
RRF= respirable release fraction
ARF= airborn release fraction

The horizontal and vertical dispersion parameters are calculated by the following equation and the equations listed in the table below. The larger of the two values is used.

$$A_y,\ A_z = 0.175\ \sqrt{X}$$

Stability category	A_y	A_z
A	$(0.22\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.20\ X)$
B	$(0.16\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.12\ X)$
C	$(0.11\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.08\ X)(1.0 + 0.0002\ X)^{-1/2}$
D	$(0.08\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.06\ X)(1.0 + 0.0015\ X)^{-1/2}$
E	$(0.06\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.03\ X)(1.0 + 0.0003\ X)^{-1}$
F	$(0.04\ X)(1.0 + 0.0001\ X)^{-1/2}$	$(0.016\ X)(1.0 + 0.0003\ X)^{-1}$

The inhalation dose is calculated using the following equation:

$$D = I \times B_R \times DCF$$

where:

D = dose (rem)
B_r = breathing rate (m^3/s)
DCF= dose conversion factor (rem/Ci)

The following assumptions are applied to the calculation of inhalation dose:

- The off-site receptor exposure time is 2 h because only highway traffic occurs at the site boundary.
- The mean wind speed is 1 m/s. (A 1 m/s wind speed coupled with 'F' atmospheric stability is generally considered conservative for ground level release.)
- Averaging time is 5 min.
- The atmospheric stability category is 'F'. ('F' provides conservative consequences for ground level releases with a ground level receptor.)
- Releases are at ground level (H = 0 m). (Releases from ventilation system are from an elevated stack. Assuming a ground level release results in conservatively higher consequences.)
- The respirable release fraction for simple liquid spills is 1.0E-04 (Ref. 5).
- The receptor breathing rate is 1.2 m^3/h.

Ingestion Dose

Two models have been developed for estimating the dilution of contaminated liquids spilled to the White Oak Creek. The first model uses a mixing box approach to approximate mass transfer in White Oak Lake and to calculate the dilution versus time at White Oak Dam after an accidental spill. The second model[17] uses the results of the first model and three-dimensional computational fluid dynamics simulations to quantify concentration levels at the ETTP potable water intake resulting from an instantaneous spill of 50,000 gal into the White Oak Creek watershed. Because this portion of the Clinch River is often at a no-flow condition, the scenario where contaminant accumulates in the river was conservatively assumed. Based on historical flow data taken at Melton Hill Dam, a 20-h no-flow time period was selected. This duration corresponds to a 95% nonexceedance level. During the 20 h period when the Clinch River flow is zero, it is assumed that the contaminant spills into the Clinch River via White Oak Creek and accumulates in a concentrated area, forming a "slug" in the river. After 20 h, when Melton Hill Dam starts producing power again, the slug is washed down the river during the "flushing transient." Cases were run for two different flow rates (discharges): the 95% nonexceedance flow of 20,800 cfs (high flow), and the 5% nonexceedance flow of 8800 cfs (low flow). Simulations were performed for the high and low flow conditions with and without the accumulation of the 20-h slug.

Results of the dilution models were examined to determine the worst case in terms of ingestion exposure to the receptor. The time vs. concentration results, along with conservative river flow characteristics, were used to estimate the ingestion doses[18]. The receptors were assumed to consume 2 L of contaminated liquid per day during passage of the slug past the ETTP intake. The following equation was derived for estimating the ingestion doses resulting from spills into the White Oak Creek:

$$D = 6.27E\text{-}04 \times C \times V$$

where:

D = Ingestion dose to receptor (rem)
C = Concentration of spilled contaminated liquid (Ci/gal ^{90}Sr ingestion hazard equivalent)
V = Volume of liquid spilled (gal)

3.4.1.4 Comparison to guidelines

The analysis guideline used to identify the need for safety class SSCs and TSR controls is 25 rem for off-site consequences. If the consequences of an accident are approaching the guideline, then preventive or mitigative measures may need to be taken to lower the consequence below the guideline. These measures are in the form of safety class SSCs or TSR controls. Safety-significant SSCs or controls may be necessary to prevent or mitigate consequences of accidents that do not require safety-class SSCs or controls when the consequences are approaching the 25 rem limit as described in Fig. 3.3. The analysis guidelines used to identify the need to evaluate for safety-significant SSCs and controls based on consequences to off-site receptors are presented in Fig. 3.3.

3.4.1.5 Safety-class and safety-significant SSCs and TSR controls

Each safety-class and safety-significant SSC and TSR control is identified based on the analysis guideline discussed in Sect. 3.4.1.4 above and its safety function is delineated.

3.4.2 Evaluation Basis Accidents

3.4.2.1 Accidents that result in release of tank(s) inventory to the ground with no significant airborne release

Scenario Development

This event type bounds the following events identified as Risk Category I or II in Table 3.25:

- Leak from a STF tank caused by random failure of the tank containment structure
- The MLDUA, ROV, WD&C, or other large component is dropped into the tank, impacting the tank floor causing a crack or puncture
- During operations to remove sludge or scarify the gunite, the MLDUA, ROV, or WD&C impacts the tank wall causing a crack or puncture or the scarifier penetrates the tank wall or floor
- MLDUA or WD&C mast housing falls onto tank from random failure or operator error causing collapse of the tank dome
- Construction accident: Large piece of equipment or platform structural member dropped on the ground above the tank
- Earthquake causes crack and/or dome collapse of tank causing a below-surface leak of supernate and sludge
- Flood causes failure of tank floor resulting in release of tank contents

All of the bounded accidents involve a failure of the tank primary confinement boundary and subsequent release of tank contents to the ground. In the cases of accidents involving tank dome failure, an airborne release of aerosols, generated by sludge removal operations, in the tank vapor space also is assumed to occur. With the exception of the earthquake scenario, all of the scenarios are initiated by component failure or human error. The human error initiators range from operator error manipulating process equipment to human error resulting in construction accidents. The component failures range from random failure of the primary confinement tank to control failures of process equipment and failure of hoisting and rigging equipment. The frequency that one of the identified human error or component failures results in a tank failure and a large release of tank contents is assumed, based on qualitative judgement, to be in the "Unlikely" frequency range.

Consequence Threshold	Consequence
Radiological Off-site — >25 rem at the off-site boundary (at 390 m)	High Consequence
Radiological On-site — >100 rem (at 30 m) Worker — prompt death **Chemical** Off-site — >Emergency Response Planning Guideline (ERPG) 2 On-site — >ERPG 3 (at 30 m) Worker — prompt death	High Consequence
Radiological Off-site — >5 rem (at 390 m) On-site — >25 rem (at 30 m) Worker — serious injury **Chemical** Off-site — N/A On-site — N/A Worker — N/A	Moderate Consequence
Radiological Off-site — >0.5 rem (at 390 m) On-site — >5 rem (at 30 m) Worker — significant injury **Chemical** Off-site — >ERPG 1 On-site — >ERPG 2 (at 30 m) Worker — significant injury	Low Consequence
Radiological Off-site — <0.5 rem (at 390 m) On-site — <5 rem (at 30 m) Worker — no significant injury **Chemical** Off-site — <ERPG 1 On-site — <ERPG 2 (at 30 m) Worker — no significant injury	Negligible Consequence

REQUIRES THE IDENTIFICATION OF SAFETY CLASS SSCs

EVALUATE THE NEED FOR SAFETY SIGNIFICANT SSCs

(Note that the use of SSCs designated as Safety Significant for off-site consideration is an expanded definition of Safety Significant from that provided in DOE-STD-3009.)

NO SAFETY SIGNIFICANT SSCs REQUIRED

Extremely Unlikely Event	Unlikely Event	Anticipated Event
Not expected to occur during life of the facility	Not expected to occur, but could during life of facility	May occur during life of facility

Accident Frequency Range

Fig. 3.3. Analysis guidelines — safety class and safety significant SSCs.

Source Term Analysis

The source term characterization for the supernate and sludge in each tank and for the combined inventory (including inventory from NTF Tanks W-3 and W-4) were converted to ^{90}Sr ingestion and inhalation hazard equivalent concentrations for use in the consequence analysis. The results of these efforts are listed in Tables 3.26 through 3.34. A summary of the results is listed below:

Tank	^{90}Sr ingestion hazard equivalent sludge concentration (Ci/gal)	^{90}Sr inhalation hazard equivalent sludge concentration (Ci/gal)	^{90}Sr ingestion hazard equivalent supernate concentration (Ci/gal)	^{90}Sr inhalation hazard equivalent supernate concentration (Ci/gal)
W-3	8.43E-02	4.32E-01	5.79E-05	1.87E-04
W-4	8.66E-02	6.07E-01	9.43E-04	6.97E-04
W-5	1.68E-02	7.03E-02	1.96E-04	5.61E-05
W-6	1.74E-01	7.70E-01	2.05E-02	5.71E-03
W-7	3.03E-01	8.15E-01	2.60E-02	1.45E-02
W-8	5.28E-01	1.67E+00	1.51E-02	3.42E-03
W-9	5.81E-01	3.43E+00	2.34E-03	8.53E-04
W-10	1.57E+00	3.28E+00	8.04E-03	7.12E-04
Combined Inventory	6.80E-01	1.87E+00	8.70E-03	1.94E-03

Note: The scarified gunite activity was added to the sludge activity with no added volume.

For inhalation consequences, the dose to the receptor is determined primarily by the release rate and concentration. In general, inhalation consequence will be bounded by using the highest ^{90}Sr inhalation hazard equivalent concentration. As shown in the summary above, the highest ^{90}Sr inhalation hazard equivalent is associated with the sludge in Tank W-9.

For ingestion consequences, the total activity released determines the ingestion dose to the receptor. The worst case ingestion dose source term would be release of one half of the sludge inventory of 8.12E+04 gal of sludge at 6.80E-01 Ci/gal ^{90}Sr ingestion hazard equivalent and the combined inventory of 3.35E+05 gal of supernate at 8.70E-03 Ci/gal ^{90}Sr ingestion hazard equivalent. The total activity released is then determined to be 3.05E+04 Ci ^{90}Sr ingestion hazard equivalent.

Consequence Analysis

The worst case ingestion dose results when the accident causes release of one half of all of the sludges from all of the tanks. Two ways for this to happen are 1) an earthquake that results in failure of all of the tanks containing supernate and/or sludge, and 2) an accident that causes failure of Tank W-8 or W-9 after the contents of all of the other tanks have been transferred to it. In the second scenario, all of the sludges from all of the tanks could be present. However, due to physical limitations presented by the tank capacity, not all of the supernate from all of the tanks could be present. The formula for determining off-site ingestion dose from Sect. 3.4.1.3 is used along with the volumes and concentrations to determine the bounding ingestion consequence.

Table 3.26. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-3 contents

Radionuclide	Dose Conv. Factors		Sludge			Supernate		
	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	2.25E-04	7.80E-03	9.02E-02			
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02						
Cm-244	2.30E+00	2.70E+02	2.06E-05	3.64E-04	4.28E-03			
Co-60	2.60E-02	1.50E-01	2.75E-06	5.49E-07	3.17E-07	2.42E-08	4.83E-09	2.79E-09
Cs-134	7.40E-02	4.70E-02						
Cs-137/Ba-137m	5.00E-02	3.20E-02	5.35E-03	2.06E-03	1.32E-04	1.19E-04	4.59E-05	2.94E-06
Eu-152	6.00E-03	2.20E-01						
Eu-154	9.10E-03	2.60E-01	8.69E-06	6.09E-07	1.74E-06			
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	2.59E-07	1.25E-10	1.25E-11	1.07E-07	5.20E-11	5.20E-12
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	1.40E-04	4.09E-03	4.95E-02	3.25E-08	9.51E-07	1.15E-05
Pu-239	4.30E+00	5.10E+02	4.24E-04	1.40E-02	1.66E-01			
Pu-240	4.30E+00	5.10E+02	5.07E-05	1.68E-03	1.99E-02			
Pu-241	8.60E-02	1.00E+01	6.91E-04	4.57E-04	5.32E-03			
Pu-242	4.10E+00	4.80E+02	2.47E-08	7.77E-07	9.10E-06			
Pu-244	4.00E+00	4.80E+02						
Sr-90/Y-90	1.30E-01	1.30E+00	5.30E-02	5.30E-02	5.30E-02	7.74E-06	7.74E-06	7.74E-06
Th-228	3.80E-01	3.10E+02	9.60E-07	2.81E-06	2.29E-04	2.20E-09	6.43E-09	5.25E-07
Th-230	5.30E-01	3.20E+02						
Th-232	2.80E+00	1.60E+03	9.60E-07	2.07E-05	1.18E-03	2.20E-09	4.74E-08	2.71E-06
U-233	2.70E-01	1.30E+02	1.21E-04	2.51E-04	1.21E-02	9.59E-07	1.99E-06	9.59E-05
U-234	2.60E-01	1.30E+02	1.50E-04	3.01E-04	1.50E-02	3.39E-07	6.78E-07	3.39E-05
U-235	2.50E-01	1.20E+02	6.37E-06	1.22E-05	5.88E-04	1.33E-08	2.55E-08	1.23E-06
U-236	2.50E-01	1.20E+02	3.12E-07	6.00E-07	2.88E-05	1.91E-09	3.66E-09	1.76E-07
U-238	2.30E-01	1.20E+02	1.55E-04	2.75E-04	1.43E-02	3.29E-07	5.83E-07	3.04E-05
			Totals:	**8.43E-02**	**4.32E-01**	**Totals:**	**5.79E-05**	**1.87E-04**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.27. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-4 contents

	Dose Conv. Factors		Sludge			Supernate		
Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02						
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02	8.95E-07	6.47E-06	8.95E-05			
Cm-244	2.30E+00	2.70E+02	2.75E-05	4.86E-04	5.70E-03			
Co-60	2.60E-02	1.50E-01	2.40E-06	4.81E-07	2.77E-07	1.32E-05	2.65E-06	1.53E-06
Cs-134	7.40E-02	4.70E-02						
Cs-137/Ba-137m	5.00E-02	3.20E-02	3.67E-02	1.41E-02	9.03E-04	1.63E-03	6.27E-04	4.01E-05
Eu-152	6.00E-03	2.20E-01						
Eu-154	9.10E-03	2.60E-01						
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	3.94E-07	1.91E-10	1.91E-11	2.88E-07	1.39E-10	1.39E-11
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	8.90E-05	2.60E-03	3.15E-02	7.89E-09	2.31E-07	2.79E-06
Pu-239	4.30E+00	5.10E+02	1.04E-03	3.44E-02	4.09E-01	7.57E-09	2.50E-07	2.97E-06
Pu-240	4.30E+00	5.10E+02	1.24E-04	4.11E-03	4.87E-02	7.57E-09	2.50E-07	2.97E-06
Pu-241	8.60E-02	1.00E+01	9.31E-04	6.16E-04	7.16E-03			
Pu-242	4.10E+00	4.80E+02	1.79E-06	5.65E-05	6.62E-04			
Pu-244	4.00E+00	4.80E+02	3.28E-13	1.01E-11	1.21E-10			
Sr-90/Y-90	1.30E-01	1.30E+00	2.88E-02	2.88E-02	2.88E-02	3.07E-04	3.07E-04	3.07E-04
Th-228	3.80E-01	3.10E+02	2.35E-06	6.86E-06	5.60E-04	1.64E-08	4.80E-08	3.91E-06
Th-230	5.30E-01	3.20E+02						
Th-232	2.80E+00	1.60E+03	2.35E-06	5.05E-05	2.89E-03	1.64E-08	3.53E-07	2.02E-05
U-233	2.70E-01	1.30E+02	6.96E-05	1.45E-04	6.96E-03	1.59E-07	3.29E-07	1.59E-05
U-234	2.60E-01	1.30E+02	3.37E-04	6.75E-04	3.37E-02	1.52E-06	3.04E-06	1.52E-04
U-235	2.50E-01	1.20E+02	1.30E-05	2.51E-05	1.20E-03	6.15E-08	1.18E-07	5.68E-06
U-236	2.50E-01	1.20E+02	7.32E-07	1.41E-06	6.76E-05	7.70E-09	1.48E-08	7.11E-07
U-238	2.30E-01	1.20E+02	3.18E-04	5.62E-04	2.93E-02	1.54E-06	2.72E-06	1.42E-04
			Totals:	**8.66E-02**	**6.07E-01**	**Totals:**	**9.43E-04**	**6.97E-04**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.28. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-5 contents

	Dose Conv. Factors		Sludge			Supernate		
Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02						
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02	4.88E-07	3.53E-06	4.88E-05			
Cm-244	2.30E+00	2.70E+02	8.93E-05	1.58E-03	1.85E-02			
Co-60	2.60E-02	1.50E-01	3.86E-05	7.71E-06	4.45E-06	1.41E-05	2.82E-06	1.63E-06
Cs-134	7.40E-02	4.70E-02						
Cs-137/Ba-137m	5.00E-02	3.20E-02	4.48E-03	1.72E-03	1.10E-04	4.98E-04	1.91E-04	1.23E-05
Eu-152	6.00E-03	2.20E-01						
Eu-154	9.10E-03	2.60E-01						
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	1.79E-06	8.70E-10	8.70E-11	1.97E-07	9.54E-11	9.54E-12
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	2.59E-05	7.57E-04	9.16E-03	8.29E-09	2.42E-07	2.93E-06
Pu-239	4.30E+00	5.10E+02	4.50E-05	1.49E-03	1.77E-02			
Pu-240	4.30E+00	5.10E+02	6.37E-06	2.11E-04	2.50E-03			
Pu-241	8.60E-02	1.00E+01	1.16E-04	7.65E-05	8.90E-04			
Pu-242	4.10E+00	4.80E+02	6.92E-09	2.18E-07	2.56E-06			
Pu-244	4.00E+00	4.80E+02	1.36E-12	4.18E-11	5.02E-10			
Sr-90/Y-90	1.30E-01	1.30E+00	1.08E-02	1.08E-02	1.08E-02	8.47E-07	8.47E-07	8.47E-07
Th-228	3.80E-01	3.10E+02	4.14E-06	1.21E-05	9.86E-04	4.02E-11	1.17E-10	9.58E-09
Th-230	5.30E-01	3.20E+02	1.53E-05	6.24E-05	3.77E-03			
Th-232	2.80E+00	1.60E+03	4.14E-06	8.91E-05	5.09E-03	4.02E-11	8.66E-10	4.95E-08
U-233	2.70E-01	1.30E+02	3.95E-06	8.20E-06	3.95E-04	1.85E-07	3.84E-07	1.85E-05
U-234	2.60E-01	1.30E+02	2.56E-06	5.12E-06	2.56E-04	1.01E-07	2.01E-07	1.01E-05
U-235	2.50E-01	1.20E+02	4.29E-08	8.24E-08	3.96E-06	4.04E-10	7.77E-10	3.73E-08
U-236	2.50E-01	1.20E+02	2.70E-08	5.19E-08	2.49E-06	3.87E-10	7.45E-10	3.58E-08
U-238	2.30E-01	1.20E+02	1.40E-06	2.47E-06	1.29E-04	1.06E-07	1.87E-07	9.74E-06
			Totals:	**1.68E-02**	**7.03E-02**	**Totals:**	**1.96E-04**	**5.61E-05**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.29. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-6 contents

	Dose Conv. Factors		Sludge			Supernate		
Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02						
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02	9.81E-07	7.09E-06	9.81E-05			
Cm-244	2.30E+00	2.70E+02	2.53E-03	4.48E-02	5.26E-01	3.41E-06	6.03E-05	7.08E-04
Co-60	2.60E-02	1.50E-01	1.67E-04	3.35E-05	1.93E-05	4.90E-05	9.80E-06	5.65E-06
Cs-134	7.40E-02	4.70E-02						
Cs-137/Ba-137m	5.00E-02	3.20E-02	2.40E-02	9.25E-03	5.92E-04	5.21E-02	2.00E-02	1.28E-03
Eu-152	6.00E-03	2.20E-01						
Eu-154	9.10E-03	2.60E-01	1.35E-04	9.47E-06	2.71E-05			
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	1.31E-06	6.34E-10	6.34E-11	1.62E-06	7.83E-10	7.83E-11
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	2.22E-04	6.50E-03	7.87E-02	3.73E-07	1.09E-05	1.32E-04
Pu-239	4.30E+00	5.10E+02	1.15E-04	3.81E-03	4.52E-02			
Pu-240	4.30E+00	5.10E+02	1.45E-05	4.79E-04	5.68E-03			
Pu-241	8.60E-02	1.00E+01	1.11E-04	7.35E-05	8.54E-04			
Pu-242	4.10E+00	4.80E+02	1.31E-08	4.13E-07	4.83E-06			
Pu-244	4.00E+00	4.80E+02	3.48E-12	1.07E-10	1.28E-09			
Sr-90/Y-90	1.30E-01	1.30E+00	1.09E-01	1.09E-01	1.09E-01	3.14E-04	3.14E-04	3.14E-04
Th-228	3.80E-01	3.10E+02	6.55E-07	1.92E-06	1.56E-04	3.75E-10	1.09E-09	8.93E-08
Th-230	5.30E-01	3.20E+02	2.17E-08	8.84E-08	5.34E-06	8.87E-06	3.62E-05	2.18E-03
Th-232	2.80E+00	1.60E+03	6.55E-07	1.41E-05	8.07E-04	3.75E-10	8.07E-09	4.61E-07
U-233	2.70E-01	1.30E+02	4.02E-07	8.35E-07	4.02E-05	9.29E-06	1.93E-05	9.29E-04
U-234	2.60E-01	1.30E+02	1.72E-05	3.44E-05	1.72E-03	8.28E-07	1.66E-06	8.28E-05
U-235	2.50E-01	1.20E+02	5.42E-07	1.04E-06	5.00E-05	3.04E-08	5.84E-08	2.80E-06
U-236	2.50E-01	1.20E+02	5.19E-08	9.98E-08	4.79E-06	4.36E-09	8.39E-09	4.03E-07
U-238	2.30E-01	1.20E+02	1.34E-05	2.37E-05	1.24E-03	7.52E-07	1.33E-06	6.94E-05
			Totals:	**1.74E-01**	**7.70E-01**	**Totals:**	**2.05E-02**	**5.71E-03**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.30. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-7 contents

	Dose Conv. Factors		Sludge			Supernate		
Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	7.93E-05	2.75E-03	3.17E-02			
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02	1.73E-06	1.25E-05	1.73E-04			
Cm-244	2.30E+00	2.70E+02	2.06E-03	3.65E-02	4.29E-01	4.17E-08	7.38E-07	8.67E-06
Co-60	2.60E-02	1.50E-01	6.60E-04	1.32E-04	7.61E-05	3.03E-05	6.05E-06	3.49E-06
Cs-134	7.40E-02	4.70E-02	1.53E-05	8.70E-06	5.53E-07			
Cs-137/Ba-137m	5.00E-02	3.20E-02	3.00E-01	1.15E-01	7.38E-03	6.68E-02	2.57E-02	1.64E-03
Eu-152	6.00E-03	2.20E-01	2.45E-04	1.13E-05	4.14E-05			
Eu-154	9.10E-03	2.60E-01	1.81E-04	1.26E-05	3.61E-05			
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	1.76E-05	8.52E-09	8.52E-10	1.98E-06	9.61E-10	9.61E-11
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	3.47E-04	1.01E-02	1.23E-01			
Pu-239	4.30E+00	5.10E+02	1.08E-04	3.58E-03	4.25E-02			
Pu-240	4.30E+00	5.10E+02	1.98E-05	6.56E-04	7.78E-03			
Pu-241	8.60E-02	1.00E+01	4.71E-04	3.12E-04	3.63E-03			
Pu-242	4.10E+00	4.80E+02	4.59E-08	1.45E-06	1.69E-05			
Pu-244	4.00E+00	4.80E+02	1.68E-10	5.18E-09	6.22E-08			
Sr-90/Y-90	1.30E-01	1.30E+00	1.33E-01	1.33E-01	1.33E-01	6.26E-05	6.26E-05	6.26E-05
Th-228	3.80E-01	3.10E+02	2.94E-06	8.60E-06	7.02E-04	8.70E-06	2.54E-05	2.07E-03
Th-230	5.30E-01	3.20E+02						
Th-232	2.80E+00	1.60E+03	2.94E-06	6.34E-05	3.62E-03	8.70E-06	1.87E-04	1.07E-02
U-233	2.70E-01	1.30E+02	3.76E-05	7.80E-05	3.76E-03			
U-234	2.60E-01	1.30E+02	1.49E-04	2.99E-04	1.49E-02			
U-235	2.50E-01	1.20E+02	6.01E-06	1.16E-05	5.55E-04			
U-236	2.50E-01	1.20E+02	1.41E-07	2.70E-07	1.30E-05			
U-238	2.30E-01	1.20E+02	1.45E-04	2.57E-04	1.34E-02			
			Totals:	**3.03E-01**	**8.15E-01**	**Totals:**	**2.60E-02**	**1.45E-02**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.31. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-8 contents

Radionuclide	Dose Conv. Factors		Sludge			Supernate		
	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	6.17E-04	2.14E-02	2.47E-01			
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02	4.91E-07	3.55E-06	4.91E-05			
Cm-244	2.30E+00	2.70E+02	2.76E-03	4.88E-02	5.73E-01	4.02E-06	7.12E-05	8.35E-04
Co-60	2.60E-02	1.50E-01	5.73E-04	1.15E-04	6.61E-05	5.24E-05	1.05E-05	6.05E-06
Cs-134	7.40E-02	4.70E-02						
Cs-137/Ba-137m	5.00E-02	3.20E-02	9.61E-02	3.70E-02	2.37E-03	3.87E-02	1.49E-02	9.54E-04
Eu-152	6.00E-03	2.20E-01	3.04E-04	1.40E-05	5.14E-05			
Eu-154	9.10E-03	2.60E-01	3.19E-04	2.24E-05	6.39E-05			
Eu-155	1.30E-03	3.90E-02						
H-3	6.30E-05	6.30E-05	1.96E-08	9.48E-12	9.48E-13	9.01E-07	4.36E-10	4.36E-11
Np-237	3.90E+00	4.90E+02						
Pu-238	3.80E+00	4.60E+02	6.43E-04	1.88E-02	2.28E-01	4.78E-07	1.40E-05	1.69E-04
Pu-239	4.30E+00	5.10E+02	4.43E-04	1.47E-02	1.74E-01			
Pu-240	4.30E+00	5.10E+02	9.33E-05	3.09E-03	3.66E-02			
Pu-241	8.60E-02	1.00E+01	1.06E-03	7.04E-04	8.19E-03			
Pu-242	4.10E+00	4.80E+02	8.55E-08	2.70E-06	3.16E-05			
Pu-244	4.00E+00	4.80E+02	2.30E-11	7.08E-10	8.50E-09			
Sr-90/Y-90	1.30E-01	1.30E+00	3.83E-01	3.83E-01	3.83E-01	6.42E-05	6.42E-05	6.42E-05
Th-228	3.80E-01	3.10E+02	8.16E-06	2.39E-05	1.95E-03	3.35E-10	9.80E-10	7.99E-08
Th-230	5.30E-01	3.20E+02						
Th-232	2.80E+00	1.60E+03	8.16E-06	1.76E-04	1.00E-02	3.35E-10	7.22E-09	4.13E-07
U-233	2.70E-01	1.30E+02	8.84E-05	1.84E-04	8.84E-03	1.19E-05	2.47E-05	1.19E-03
U-234	2.60E-01	1.30E+02	1.30E-05	2.61E-05	1.30E-03	1.05E-06	2.10E-06	1.05E-04
U-235	2.50E-01	1.20E+02	3.43E-07	6.59E-07	3.16E-05	3.86E-08	7.43E-08	3.56E-06
U-236	2.50E-01	1.20E+02	1.28E-07	2.46E-07	1.18E-05	5.55E-09	1.07E-08	5.12E-07
U-238	2.30E-01	1.20E+02	8.85E-06	1.56E-05	8.16E-04	9.56E-07	1.69E-06	8.83E-05
			Totals:	**5.28E-01**	**1.67E+00**	**Totals:**	**1.51E-02**	**3.42E-03**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.32. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-9 contents

Radionuclide	Dose Conv. Factors: Ingestion DCF (rem/uCi)	Dose Conv. Factors: Inhalation DCF (rem/uCi)	Sludge: Sludge Conc. (Ci/gal)	Sludge: Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sludge: Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate: Supernate Concentration (Ci/gal)	Supernate: Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Supernate: Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	8.73E-04	3.02E-02	3.49E-01			
C-14	2.10E-03	2.10E-03						
Cf-252	9.40E-01	1.30E+02						
Cm-244	2.30E+00	2.70E+02	7.91E-03	1.40E-01	1.64E+00	8.86E-07	1.57E-05	1.84E-04
Co-60	2.60E-02	1.50E-01	9.99E-04	2.00E-04	1.15E-04	9.86E-06	1.97E-06	1.14E-06
Cs-134	7.40E-02	4.70E-02	3.48E-06	1.98E-06	1.26E-07	8.79E-06	5.00E-06	3.18E-07
Cs-137/Ba-137m	5.00E-02	3.20E-02	5.12E-02	1.97E-02	1.26E-03	5.91E-03	2.27E-03	1.45E-04
Eu-152	6.00E-03	2.20E-01	5.30E-04	2.45E-05	8.97E-05			
Eu-154	9.10E-03	2.60E-01	7.27E-04	5.09E-05	1.45E-04			
Eu-155	1.30E-03	3.90E-02	7.40E-06	7.40E-08	2.22E-07			
H-3	6.30E-05	6.30E-05	7.45E-08	3.61E-11	3.61E-12	1.03E-06	5.01E-10	5.01E-11
Np-237	3.90E+00	4.90E+02	4.78E-08	1.43E-06	1.80E-05			
Pu-238	3.80E+00	4.60E+02	2.22E-03	6.49E-02	7.85E-01	1.24E-08	3.63E-07	4.39E-06
Pu-239	4.30E+00	5.10E+02	6.70E-04	2.21E-02	2.63E-01			
Pu-240	4.30E+00	5.10E+02	1.40E-04	4.63E-03	5.50E-02			
Pu-241	8.60E-02	1.00E+01	1.59E-03	1.05E-03	1.22E-02			
Pu-242	4.10E+00	4.80E+02	5.15E-07	1.62E-05	1.90E-04			
Pu-244	4.00E+00	4.80E+02	2.92E-11	8.99E-10	1.08E-08			
Sr-90/Y-90	1.30E-01	1.30E+00	2.98E-01	2.98E-01	2.98E-01	3.55E-05	3.55E-05	3.55E-05
Th-228	3.80E-01	3.10E+02	3.27E-06	9.55E-06	7.79E-04	6.46E-10	1.89E-09	1.54E-07
Th-230	5.30E-01	3.20E+02						
Th-232	2.80E+00	1.60E+03	3.27E-06	7.03E-05	4.02E-03	6.46E-10	1.39E-08	7.95E-07
U-233	2.70E-01	1.30E+02	1.01E-04	2.09E-04	1.01E-02	1.10E-06	2.28E-06	1.10E-04
U-234	2.60E-01	1.30E+02	5.07E-05	1.01E-04	5.07E-03	1.85E-06	3.70E-06	1.85E-04
U-235	2.50E-01	1.20E+02	1.08E-06	2.08E-06	9.97E-05	7.62E-08	1.46E-07	7.03E-06
U-236	2.50E-01	1.20E+02	5.19E-07	9.98E-07	4.79E-05	3.75E-09	7.22E-09	3.47E-07
U-238	2.30E-01	1.20E+02	3.00E-05	5.30E-05	2.77E-03	1.94E-06	3.44E-06	1.79E-04
			Totals:	**5.81E-01**	**3.43E+00**	**Totals:**	**2.34E-03**	**8.53E-04**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.33. Determination of ^{90}Sr hazard equivalent concentrations for Tank W-10 contents

	Dose Conv. Factors		Sludge			Supernate		
Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Sludge Conc. (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)	Supernate Concentration (Ci/gal)	Sr-90 Ingestion Hazard Equiv. Conc. (Ci/gal)	Sr-90 Inhalation Hazard Equiv. Conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	6.35E-04	2.20E-02	2.54E-01	0.00E+00	0.00E+00	0.00E+00
C-14	2.10E-03	2.10E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cf-252	9.40E-01	1.30E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244	2.30E+00	2.70E+02	6.30E-03	1.11E-01	1.31E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	2.60E-02	1.50E-01	1.45E-03	2.91E-04	1.68E-04	1.26E-05	2.51E-06	1.45E-06
Cs-134	7.40E-02	4.70E-02	1.84E-04	1.05E-04	6.64E-06	0.00E+00	0.00E+00	0.00E+00
Cs-137/Ba-137m	5.00E-02	3.20E-02	1.15E+00	4.41E-01	2.82E-02	2.06E-02	7.93E-03	5.07E-04
Eu-152	6.00E-03	2.20E-01	5.75E-04	2.65E-05	9.72E-05	0.00E+00	0.00E+00	0.00E+00
Eu-154	9.10E-03	2.60E-01	9.29E-04	6.51E-05	1.86E-04	0.00E+00	0.00E+00	0.00E+00
Eu-155	1.30E-03	3.90E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	6.30E-05	6.30E-05	1.58E-05	7.67E-09	7.67E-10	1.25E-05	6.04E-09	6.04E-10
Np-237	3.90E+00	4.90E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	3.80E+00	4.60E+02	1.30E-03	3.79E-02	4.58E-01	4.35E-08	1.27E-06	1.54E-05
Pu-239	4.30E+00	5.10E+02	4.92E-04	1.63E-02	1.93E-01	0.00E+00	0.00E+00	0.00E+00
Pu-240	4.30E+00	5.10E+02	1.42E-04	4.71E-03	5.59E-02	0.00E+00	0.00E+00	0.00E+00
Pu-241	8.60E-02	1.00E+01	1.30E-03	8.63E-04	1.00E-02	0.00E+00	0.00E+00	0.00E+00
Pu-242	4.10E+00	4.80E+02	3.41E-07	1.08E-05	1.26E-04	0.00E+00	0.00E+00	0.00E+00
Pu-244	4.00E+00	4.80E+02	6.14E-11	1.89E-09	2.27E-08	0.00E+00	0.00E+00	0.00E+00
Sr-90/Y-90	1.30E-01	1.30E+00	9.39E-01	9.39E-01	9.39E-01	1.09E-04	1.09E-04	1.09E-04
Th-228	3.80E-01	3.10E+02	5.31E-06	1.55E-05	1.27E-03	2.07E-11	6.06E-11	4.94E-09
Th-230	5.30E-01	3.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-232	2.80E+00	1.60E+03	5.31E-06	1.14E-04	6.54E-03	2.07E-11	4.46E-10	2.55E-08
U-233	2.70E-01	1.30E+02	1.46E-04	3.02E-04	1.46E-02	5.97E-07	1.24E-06	5.97E-05
U-234	2.60E-01	1.30E+02	4.79E-05	9.57E-05	4.79E-03	9.58E-08	1.92E-07	9.58E-06
U-235	2.50E-01	1.20E+02	9.76E-07	1.88E-06	9.01E-05	3.71E-09	7.14E-09	3.43E-07
U-236	2.50E-01	1.20E+02	5.06E-07	9.73E-07	4.67E-05	6.99E-10	1.34E-09	6.46E-08
U-238	2.30E-01	1.20E+02	2.76E-05	4.88E-05	2.54E-03	1.01E-07	1.78E-07	9.28E-06
			Totals:	**1.57E+00**	**3.28E+00**	**Totals:**	**8.04E-03**	**7.12E-04**

Note: Sludge concentration includes all activity from scarified gunite with no additional volume.

Table 3.34. Determination of ^{90}Sr hazard equivalent concentrations for the combined tank inventories

Radionuclide	Ingestion DCF (rem/uCi)	Inhalation DCF (rem/uCi)	Combined sludge inventory (Ci)	Total sludge volume (gals)	Combined sludge conc. (Ci/gal)	Sr-90 ingestion hazard equiv. conc. (Ci/gal)	Sr-90 inhalation hazard equiv. conc. (Ci/gal)	Combined supernate inventory (Ci)	Total supernate volume (gals)	Combined supernate conc. (Ci/gal)	Sr-90 ingestion hazard equiv. conc. (Ci/gal)	Sr-90 inhalation hazard equiv. conc. (Ci/gal)
Am-241	4.50E+00	5.20E+02	3.19E+01	8.12E+04	3.93E-04	1.36E-02	1.57E-01		3.35E+05			
C-14	2.10E-03	2.10E-03		8.12E+04					3.35E+05			
Cf-252	9.40E-01	1.30E+02	4.08E-02	8.12E+04	5.02E-07	3.63E-06	5.02E-05		3.35E+05			
Cm-244	2.30E+00	2.70E+02	3.04E+02	8.12E+04	3.75E-03	6.63E-02	7.78E-01	4.42E-01	3.35E+05	1.32E-06	2.34E-05	2.74E-04
Co-60	2.60E-02	1.50E-01	5.91E+01	8.12E+04	7.28E-04	1.46E-04	8.40E-05	8.09E+00	3.35E+05	2.42E-05	4.84E-06	2.79E-06
Cs-134	7.40E-02	4.70E-02	4.66E+00	8.12E+04	5.74E-05	3.27E-05	2.08E-06	4.01E-01	3.35E+05	1.20E-06	6.82E-07	4.33E-08
Cs-137/Ba-137m	5.00E-02	3.20E-02	3.29E+04	8.12E+04	4.05E-01	1.56E-01	9.98E-03	7.42E+03	3.35E+05	2.22E-02	8.53E-03	5.46E-04
Eu-152	6.00E-03	2.20E-01	2.44E+01	8.12E+04	3.01E-04	1.39E-05	5.09E-05		3.35E+05			
Eu-154	9.10E-03	2.60E-01	3.60E+01	8.12E+04	4.43E-04	3.10E-05	8.87E-05		3.35E+05			
Eu-155	1.30E-03	3.90E-02	6.81E-02	8.12E+04	8.39E-07	8.39E-09	2.52E-08		3.35E+05			
H-3	6.30E-05	6.30E-05	5.86E-01	8.12E+04	7.22E-06	3.50E-09	3.50E-10	1.51E+00	3.35E+05	4.53E-06	2.19E-09	2.19E-10
Np-237	3.90E+00	4.90E+02	4.40E-04	8.12E+04	5.41E-09	1.62E-07	2.04E-06		3.35E+05			
Pu-238	3.80E+00	4.60E+02	6.60E+01	8.12E+04	8.13E-04	2.38E-02	2.88E-01	5.25E-02	3.35E+05	1.57E-07	4.59E-06	5.55E-05
Pu-239	4.30E+00	5.10E+02	3.40E+01	8.12E+04	4.18E-04	1.38E-02	1.64E-01	2.25E-04	3.35E+05	6.73E-10	2.23E-08	2.64E-07
Pu-240	4.30E+00	5.10E+02	7.15E+00	8.12E+04	8.81E-05	2.91E-03	3.45E-02	2.25E-04	3.35E+05	6.73E-10	2.23E-08	2.64E-07
Pu-241	8.60E-02	1.00E+01	7.33E+01	8.12E+04	9.02E-04	5.97E-04	6.94E-03		3.35E+05			
Pu-242	4.10E+00	4.80E+02	2.56E-02	8.12E+04	3.16E-07	9.95E-06	1.17E-04		3.35E+05			
Pu-244	4.00E+00	4.80E+02	3.70E-06	8.12E+04	4.56E-11	1.40E-09	1.68E-08		3.35E+05			
Sr-90/Y-90	1.30E-01	1.30E+00	3.27E+04	8.12E+04	4.02E-01	4.02E-01	4.02E-01	3.99E+01	3.35E+05	1.19E-04	1.19E-04	1.19E-04
Th-228	3.80E-01	3.10E+02	3.19E-01	8.12E+04	3.92E-06	1.15E-05	9.36E-04	3.16E-02	3.35E+05	9.44E-08	2.76E-07	2.25E-05
Th-230	5.30E-01	3.20E+02	7.06E-02	8.12E+04	8.70E-07	3.55E-06	2.14E-04	3.68E-01	3.35E+05	1.10E-06	4.48E-06	2.71E-04
Th-232	2.80E+00	1.60E+03	3.19E-01	8.12E+04	3.92E-06	8.45E-05	4.83E-03	3.16E-02	3.35E+05	9.44E-08	2.03E-06	1.16E-04
U-233	2.70E-01	1.30E+02	6.87E+00	8.12E+04	8.46E-05	1.76E-04	8.46E-03	1.29E+00	3.35E+05	3.86E-06	8.02E-06	3.86E-04
U-234	2.60E-01	1.30E+02	6.32E+00	8.12E+04	7.79E-05	1.56E-04	7.79E-03	2.50E-01	3.35E+05	7.48E-07	1.50E-06	7.48E-05
U-235	2.50E-01	1.20E+02	2.17E-01	8.12E+04	2.67E-06	5.14E-06	2.47E-04	9.67E-03	3.35E+05	2.89E-08	5.56E-08	2.67E-06
U-236	2.50E-01	1.20E+02	2.67E-02	8.12E+04	3.29E-07	6.33E-07	3.04E-05	1.05E-03	3.35E+05	3.15E-09	6.06E-09	2.91E-07
U-238	2.30E-01	1.20E+02	5.42E+00	8.12E+04	6.67E-05	1.18E-04	6.16E-03	2.46E-01	3.35E+05	7.35E-07	1.30E-06	6.79E-05
					Sludge Totals:	**6.80E-01**	**1.87E+00**			**Supernate Totals:**	**8.70E-03**	**1.94E-03**

$$D = 6.27E\text{-}04 \times C \times V$$

where:

D = Ingestion dose to receptor (rem)
C = Concentration of spilled contaminant (Ci/gal ^{90}Sr ingestion hazard equivalent)
    Sludge = 0.680 Ci/gal
    Supernate = 8.7E-03 Ci/gal
V = Volume of the spill (gal)
    Sludge = 8.12E+04 gal/2 = 4.06E+04
    Supernate = 3.35E+05 gal

D = 6.27E-04 rem/Ci * [(0.680 Ci/gal * 4.06E+04 gal)+(8.7E-03 Ci/gal * 3.35E+05 gal)]

D = 19 rem

The worst case inhalation consequence for these accident scenarios results from release of the aerosol material suspended by tank remediation activities in the tank vapor space above the tank. In the event of dome failure of the tank the suspended material is released to the atmosphere. It has been determined that visibility in the tank would be limited if particle concentration exceeded 0.08 g/m^3 (Internal Correspondence from H. O. Weeren to H. A. Nelms, March 11, 1981[19]). It is assumed that the entire volume of the tank contains suspended particles at this density. It is further conservatively assumed that the accident occurs in the tank containing sludges at the highest ^{90}Sr inhalation hazard equivalent concentration (Tank W-9 at 3.43 Ci/gal, density = 1.25 g/cm^3) and that all of the suspended material is released during the two hour off-site exposure time. The methodology in Sect. 3.1.4.3 is used to determine the bounding inhalation consequence from these accident scenarios.

Tank Volume = 170,000 gal = 644 m^3

Concentration of suspended material in tank = 3.43 Ci/gal / 3785.4 cm^3/gal / 1.25 g/cm^3 = 7.25E-4 Ci/g

Q = amount of material released (Ci) = 644 m^3 * 0.08 g/m^3 * 7.25E-4 Ci/g = 3.73E-2 Ci ^{90}Sr inhalation hazard equivalent mass

U = mean wind speed, 1 m/sec

H = Release height = 0 m

Distance to off-site receptor = 390 m

For "F" atmospheric stability category,

A_y = 15.3 m
A_Z = 5.59 m

Since material is already suspended ARF = 1.0.

With the above assumptions, and the receptor located at the plume centerline, H_0 and H_1 both are equal to zero. Therefore, s_0 and s_1 are equal to one.

I_P = 3.73E-2 Ci / (π * 1 m/sec * 15.3 m * 5.59 m) = 1.39E-4 Ci sec/m^3

B_R = Breathing rate = 1.2 m^3/hr

DCF = 1.3E+06 rem/Ci for ^{90}Sr

D = 1.39E-4 Ci sec/m^3 * 1.2 m^3/hr / 3600 sec/hr * 1.3E+06 rem/Ci

D = 6.02E-2 rem = 60.2 mrem

Comparison to Guidelines

The analysis guidelines for determination of safety-class SSCs and administrative controls is 25 rem. Neither of the bounding consequences (inhalation and ingestion) exceed the analysis guideline. Therefore, there is no requirement to designate SSCs or administrative controls as safety class.

The analysis guideline for determination of when to evaluate the need for safety significant SSCs or administrative controls as a result of off-site consequences is shown in Fig. 3.3. The analysis guidelines are a function of frequency and consequence. All of the accidents included in this section occur with a frequency that is considered to be in the "Unlikely" frequency range. The analysis guideline for accidents in the "Unlikely" frequency range is 5 rem off-site dose. The bounding ingestion consequence exceeds the analysis guideline. Therefore, it is necessary to evaluate the need for safety-significant SSCs or administrative controls to prevent or mitigate the accidents covered in this section.

Safety-class and Safety-Significant SSCs and TSR Controls

As stated in the previous section, the consequences resulting from tank failure do not exceed the safety-class analysis guideline. Therefore, there are no safety-class SSCs or TSR controls associated with this type of accident. The bounding ingestion consequences of the tank failure accident, however, do exceed the safety-significant analysis guideline and, therefore, the need for safety-significant SSCs or TSR controls must be evaluated.

The bounding ingestion consequence calculation included the following conservative assumptions:

- All of the material in all of the tanks is involved in the release. This assumption requires that a single event cause failure of all of the tanks (earthquake) or that the accident occur at Tank W-8 or Tank W-9 after sludges have been transferred out of all of the other tanks. The maximum ingestion consequence resulting from failure of a single tank is at Tank W-10 with 10.3 rem.

- One-half of the 81,200 gal of sludge and 334,507 gal of supernate in the failed tanks escapes from primary confinement. This assumes that a mechanism exists that will cause half of the supernate and sludge to exit the tanks through the crack or hole in the tanks. Location of the leaks could limit some or all of the material in the tank from escaping. After consolidation in tanks W-8 and/or W-9, the remediation equipment would require over 6 hours of continual pumping at the maximum rate to pump half of the sludges out of the tank. Some of the sludge is thick and crusty and would not be likely to exit the tank, even in the event of catastrophic tank failure.

- All of the material escaping the tank enters the White Oak Creek. For the released material to reach White Oak Creek, it must go over 700 ft. The most likely release path for all of the sludges and supernate to be released is the drywell drain system. The drain system is an 8-in. pipe that drains to the process waste system pumping station #1. This pump is diesel backed and pumps the sludge to diversion box 1. The Process Waste System has 1,700,000 gallons of tank storage capacity. If the pump should fail or the inflow rate exceeds the pump capacity, the sludges will overflow pump station #1 into the Equalization Basin (Building 3524) which is a half acre impoundment. The Equalization Basin is approximately 300 ft from the White Oak Creek. The Equalization Basin will cause much of the sludge to settle and must fail or overflow to allow the final release to White Oak Creek. The bounding consequence calculation takes no credit for loss during transit. This is a very conservative assumption, particularly for the sludges which account for most of the ingestion dose.

- There is no settling of radioactive materials in the White Oak Creek, White Oak Lake, or the Clinch River. A significant portion of the activity assumed to be released is in the form of sludges or suspended particles in the supernate. The sludges have higher density than the water in the creek, lake, and river and could reasonably be expected to experience significant settling before reaching the ETTP potable water intake.

- There is no credit taken for detection of the release and initiation of emergency response actions to prevent or minimize the ingestion dose. Several of the accidents considered are self-announcing, such as earthquake and tank dome collapse. In these instances, it is reasonable to assume that actions would be taken to verify the tanks integrity and take mitigating actions if it is found to be leaking. The other accidents considered in this section are initiated by remediation actions inside of the tank (dropped equipment, malfunction of sludge removal equipment, operator error). These initiators would occur while operations are on-going in the tank. The chances of operations personnel being alerted of loss of inventory are much greater for releases from a tank being remediated than from the other tanks. Detection of loss of inventory and subsequent emergency response actions can prevent off-site ingestion consequences completely. The released material must pass multiple radiation detectors in the White Oak Creek, White Oak Dam outfall, and the intake pumping station which are specifically installed to detect this type of release.

Because time to exposure following release is long, the conservatism involved in the consequence calculation assumptions, and the multiple detection systems, no safety-significant SSCs or TSR controls are designated for the tank failure accident scenarios for off-site exposure.

3.4.2.2 Accidents resulting in above ground release of tank contents

Scenario Development

This event type bounds the following events identified as Risk Category I or II in Table 3.25:

- LLLW sludge, supernate, or process water fills tank beyond capacity (liquid source not shut off, isolation valve seal failure, etc.)

- Large leak from WD&C primary confinement equipment caused by random equipment failure
- Construction activities damage WD&C primary confinement equipment
- LLLW backflows into WD&C interfacing system
- Large leak from SCS primary confinement equipment caused by random equipment failure
- LLLW backflows into SCS interfacing system
- Earthquake causes rupture of WD&C or SCS primary confinement equipment
- High wind damages WD&C or SCS primary confinement equipment
- Lightning strike damages SCS primary confinement equipment
- Tank overfills as a result of site evacuation
- Vehicle accident damages WD&C primary confinement equipment
- Vehicle accident damages SCS primary confinement equipment
- Construction activities damage SCS primary confinement equipment

The tank overfill scenarios may occur at any time as a result of misdirected transfers, valve failures, operator errors, etc. The frequency of the initiators for tank overfill are assumed to be in the "Unlikely" frequency range. All other scenarios must occur during sludge transfer operations. At the maximum sludge transfer rate (60 gpm) all of the sludge in all of the tanks could be transferred in approximately 12 hours. Therefore these accidents must occur during this 12 hour "window" in order for a significant consequence to result. The overall frequency of each of the initiating events that could result in release from WD&C or SCS primary confinement equipment (random equipment failure, construction and vehicle accidents, earthquake, high wind, explosion, etc.) is in the "Unlikely" frequency range. However, for a significant consequence to result, the initiating event must occur during the sludge transfer activities. The conditional probability of the initiating event occurring during sludge transfer is assumed, based on qualitative judgement, to be in the "Extremely Unlikely" frequency range.

Source Term Analysis

The source terms detailed in Sect. 3.4.2.1 are applicable to this event category as well. Tank overfill will involve primarily supernate releases. All other events will involve primarily sludge releases. For ingestion consequences, the bounding consequence results from release of all the activity available. For the tank overfill scenarios, the tank containing the most activity in the form of supernate is Tank W-8 (6.46E+04 gal at 1.51E-02 Ci/gal ^{90}Sr ingestion hazard equivalent activity = 975 Ci ^{90}Sr ingestion hazard equivalent). For all other releases, it is assumed that the accident occurs during a sludge transfer involving half of all of the sludges from all of the tanks (2.76E+04 Ci ^{90}Sr ingestion hazard equivalent).

For inhalation consequences, the release rate, release concentration, and duration of release determine the magnitude of the consequences. For all scenarios, the maximum release rate is assumed to be the maximum transfer rate between tanks of 70 gpm (i.e, 60 gpm sludge/supernate plus 10 gpm process water). The off-site inhalation exposure time is assumed to be 2 hours. The maximum volume of material that may be released in two hours is 8,400 gal. For the overfill scenario, all of the volume is assumed to be supernate. For all other scenarios, the release is assumed to be composed of 60 gpm of sludge and 10 gpm of process water (total release = 7,200 gal of sludge and 1,200 gal of process water). The worst case source term for inhalation doses is the one that results in release of the most activity during the two hour exposure. The following is a list of the inhalation hazard equivalent activities, the volume available for release, the amount released in two hours and the activity released.

Tank/material	^{90}Sr inhalation hazard equivalent concentration (Ci/gal)	Volume in tank (gal)	Volume released in 2 hours (gal)	^{90}Sr inhalation hazard equivalent activity released (Ci)
W-5 Sludge	7.03E-02	4.60E+03	4.60E+03	3.23E+02
W-6 Sludge	7.70E-01	1.13E+04	7.20E+03	5.54E+03
W-7 Sludge	8.15E-01	9.80E+03	7.20E+03	5.87E+03
W-8 Sludge	1.67E+00	1.03E+04	7.20E+03	1.40E+04
W-9 Sludge	3.43E+00	9.20E+03	7.20E+03	2.47E+04
W-10 Sludge	3.28E+00	2.44E+04	7.20E+03	2.36E+04
W-5 Supernate	5.61E-05	2.80E+04	8.40E+03	4.71E-01
W-6 Supernate	5.71E-03	4.15E+04	8.40E+03	4.80E+01
W-7 Supernate	1.45E-02	3.57E+03	3.57E+03	5.18E+01
W-8 Supernate	3.42E-03	6.46E+04	8.40E+03	2.87E+01
W-9 Supernate	8.53E-04	4.56E+04	8.40E+03	7.17E+00
W-10 Supernate	7.12E-04	1.06E+05	8.40E+03	5.98E+00

As can be seen, the worst case source term for overfill releases is from Tank W-7 while the worst case source term for releases from above ground primary confinement equipment results during sludge transfer from Tank W-9.

Consequence Analysis

The ingestion dose resulting from tank overfill is determined using the formula in Sect. 3.4.1.3 as follows:

$$D = 6.27E\text{-}04 \times C \times V$$

where:

D = Ingestion dose to receptor (rem)
C = Concentration of spilled contaminant = 1.51E-02 Ci/gal ^{90}Sr ingestion hazard equivalent
V = Volume of spill = 6.46E+04 gal

$$D = 6.12E\text{-}01 \text{ rem}$$

The ingestion dose resulting from release during sludge transfers is determined using the formula in Sect. 3.4.1.3 as follows:

C = 6.80E-01 Ci/gal ^{90}Sr ingestion hazard equivalent
V = 8.12E+04 gal * 0.5 = 4.06E+04 gal

$$D = 17.3 \text{ rem}$$

The inhalation consequences of the tank overfill events is determined using the methodology in Sect. 3.4.1.3 as follows:

ARF = 1.0E-4

dQ/dt = 1.0E-4 * 70 gpm * 1.45E-02 Ci/gal ^{90}Sr inhalation hazard equivalent = 1.02E-04 Ci/min

t = 51 min (limited by volume of supernate available for release)

Q = dQ/dt * t = 5.20E-03 Ci ^{90}Sr inhalation hazard equivalent

U = mean wind speed = 1 m/sec

H = release height = 0 m

Distance to off-site receptor = 390 m

For "F" atmospheric stability category,

A_Y = 15.3 m
A_Z = 5.59 m

With the above assumptions and the receptor located at the plume centerline, H_0 and H_1 both are equal to zero. Therefore, s_0 and s_1 are equal to one.

I_P = 5.20E-03 Ci / (π * 1 m/sec * 15.3 m * 5.59 m) = 1.94E-5 Ci sec/m^3

B_R = Breathing rate = 1.2 m^3/hr

DCF = 1.30E+06 rem/Ci for ^{90}Sr

D = 1.94E-05 Ci sec/m^3 * 1.2 m^3/hr / 3600 sec/hr * 1.30E+06 rem/Ci

D = 8.41E-03 rem = 8.4 mrem

Using the same methodology and assumptions, the inhalation consequences resulting from release from above ground primary confinement equipment during sludge transfers conservatively assuming all 70 gpm is sludges are determined as follows:

ARF = 1.0E-04

$dQ/dt = 1.0E\text{-}04 * 70$ gpm * 3.43 Ci/gal ^{90}Sr inhalation hazard equivalent = 2.40E-02 Ci/min

t = 120 min (2 hr)

Q = 2.40E-02 Ci/min * 120 min = 2.88 Ci ^{90}Sr inhalation hazard equivalent

I_P = 2.88 Ci / (π * 1 m/sec * 15.3 m * 5.59 m) = 1.07E-02 Ci sec/m^3

D = 1.07E-02 Ci sec/m^3 * 1.2 m^3/hr / 3600 sec/hr * 1.30E+06 rem/Ci

D = 4.65 rem

Comparison to Guidelines

The analysis guideline for determination of safety-class SSCs and administrative controls is 25 rem. Neither of the bounding consequences (inhalation and ingestion) exceeds the analysis guideline. Therefore, there is no requirement to designate SSCs or administrative controls as safety class.

The analysis guideline for determination of when to evaluate the need for safety significant SSCs or administrative controls as a result of off-site consequences is shown in Fig. 3.3. The analysis guidelines are a function of frequency and consequence. The tank overfill scenarios included in this section occur with a frequency that is considered to be in the "Unlikely" frequency range. The analysis guideline for accidents in the "Unlikely" frequency range is 5 rem off-site dose. Neither the ingestion nor the inhalation dose resulting from tank overfill exceeds the analysis guideline. The accident scenarios resulting in release from above ground primary confinement equipment during sludge transfers occur with a frequency that is considered to be in the "Extremely Unlikely" frequency range. The analysis guideline for accidents in the "Extremely Unlikely" frequency range is 25 rem off-site dose. Neither the ingestion nor the inhalation dose resulting from releases during sludge transfers exceeds the analysis guideline. The conservatism used in the ingestion analysis is sufficient such that the actual doses would be much lower. Some of these conservatisms are assuming that 50% of the sludges are released when mechanical means are required to suspend the sludges, assuming that 100% of the released sludges migrate to White Oak Creek and that none settles out between the tanks and the ETTP intake, assuming optimum flow rates of the White Oak Lake and Clinch River for a maximum ingestion, and assuming that the receptor consumes 2 L of water a day for several days as the slug of contaminated water slowly passes the intake. Therefore, there are no safety-significant SSCs or administrative controls designated for the above ground release accident scenarios.

Safety-Class and Safety-Significant SSCs and TSR Controls

As stated in the previous section, there is no need to designate SSCs or administrative controls as safety-class or safety-significant for the above ground release accident scenarios.

3.5 REFERENCES

1. DOE Order 5480.22, *Technical Safety Requirements*, Change 2, U.S. Department of Energy, Washington, D.C., January 23, 1996.

2. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, Change 1, U.S. Department of Energy, Washington, D.C., March 10, 1994.

3. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., December 1992.

4. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., July 1994.

5. ES/CSET-2/R2, *Safety Analysis Report Update Program Hazard Identification and Facility Classification Application Guide*, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., December 1995.

6. DOE Order 420.1, *Facility Safety*, Change 2, U.S. Department of Energy, Washington, D.C., October 24, 1996.

7. 40 *CFR* 302, *Designation, Reportable Quantities, and Notification*, Section 4, "Designation of hazardous substances," Code of Federal Regulations.

8. DOE-EM-STD-5502-94, *Hazard Baseline Documentation*, U.S. Department of Energy, Washington, D.C., August 1994.

9. ORNL/ER-365, *Evaluation of Phase I and Phase II Sampling and Analysis Data for the Gunite and Associated Tanks at the Oak Ridge National Laboratory*, Oak Ridge, Tennessee, March 1996.

10. DAC-PX495A02-SSE-005, *Radioactive Material Hazard and Safety Class Determination*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, November 1997.

11. Oak Ridge National Laboratory, *Facility and Nuclear Criticality Safety Manual*, Procedure No. NCS-1.0, "Nuclear Criticality Safety Program," February 1994.

12. Guidance Document No. WM-LWS-WAC, *Waste Acceptance Criteria for Liquid Low-Level Waste System, Process Waste Treatment Complex-Building 3544, and Process Waste Treatment Complex-Building 3608 at Oak Ridge National Laboratory*, Waste Management and Remedial Action Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1997.

13. Oak Ridge National Laboratory, *Auditable Safety Analysis for the North Tank Farm, Tank W-11, and the Gunite and Associated Tanks - Treatability Study*, ORNL/ER-382/R1, March 1997.

14. DAC-PX495A02-SSE-001, *Hydrogen Generation in the STF Tanks*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, November 1997.

15. DAC-PX495A02-SSE-008, *Non-nuclear Hazard Classification for the Remediation Activities in the South Tank Farm*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, November 1997.

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

17. Wendel, M. W., memorandum to Platfoot, J. H., *Completion of Clinch River Contaminant Transport Simulations*, Lockheed Martin Energy Research Corporation, Oak Ridge, Tenn., December 3, 1996.

18. Calc-note No. DAC-AX251708-SSE-003, "LLLW Safety Documentation, Determination of the Basis for the Ingestion Dose at the K-25 Intake," Lockheed Martin Energy Systems, Inc., Oak Ridge, Tenn., December 9, 1996.

19. Union Carbide Nuclear Division Internal Correspondence from H.O. Weeren to H.A. Nelms, *Calculation of Potential Airborne Contamination During Sluicing of Gunite Tank*, Oak Ridge, Tennessee, March 11, 1981.

20. 29 *CFR* 1910.119, *Process Safety Management of Highly Hazardous Chemicals*.

21. 40 *CFR* 355, *Emergency Planning and Notification.*

22. Van Hoesen, S. D., letter to Powell, J. (U.S. Department of Energy), *Revised Sludge Volume Estimates for Gunite Tank Project*, Lockheed Martin Energy Research Corporation, Oak Ridge, Tennessee, September 12, 1997.

4. SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

The purpose of this chapter is to provide details on facility structures, systems, and components that are necessary for the GAAT Project remediation of the STF to satisfy analysis guidelines, provide defense in depth, or contribute to worker safety. Descriptions are provided of the functional requirements and performance criteria required to support the safety functions identified in the hazard and accident analyses and to support subsequent derivation of TSRs. The scope of this chapter includes as applicable:

- Descriptions of safety SSCs, including safety functions
- Identification of support systems that safety SSCs depend upon to carry out safety functions
- Identification of the functional requirements necessary for the SSCs to perform their safety functions, and the general conditions caused by postulated accidents under which the safety SSCs must operate
- Identification of the performance criteria necessary to provide reasonable assurance that the functional requirements will be met
- Identification of the assumptions needing TSR coverage.

4.2 REQUIREMENTS

The requirements for the designation of safety SSCs, their functional requirements, and their performance criteria are listed in DOE Orders 5480.23[1], and 420.1[2], and DOE Standard DOE-STD-3009-94[3]. TSR requirements are contained in DOE Order 5480.22[4].

4.3 SAFETY-CLASS SYSTEMS, STRUCTURES, AND COMPONENTS

SSCs that require safety-class designation are those features or controls required in order to limit the off-site consequences of an accident to below 25 rem. No safety class SSCs are identified for the STF remediation activities.

4.4 SAFETY-SIGNIFICANT SYSTEMS, STRUCTURES, AND COMPONENTS

Safety-significant SSCs or administrative controls are those features important for prevention or mitigation of accident consequences to on-site personnel or accident consequences to off-site personnel that do not require the specification of safety-class SSCs or administrative controls. The designation of these features or controls as safety-significant emphasizes their general importance to safety. Safety -significant SSCs are not required to consider performance criteria traditionally associated with safety-class SSCs or traditional nuclear standards in general. Performance criteria for a safety-significant SSC should be representative of the general rigor associated with nonnuclear power reactor industrial and Occupational Safety and Health Administration practices. Performance criteria for safety-significant SSCs are developed by SAR preparers using engineering judgement based on the expected functions for which it was designated a safety-significant SSC and its overall importance to safety.

The accident analysis in Sect. 3.4 does not designate any SSCs or administrative controls as safety-significant on the basis of off-site consequences. The PHA in Appendix B identified several accident scenarios that result in on-site consequences with the potential to exceed analysis guidelines. A summary list of the SSCs designated safety significant is included in Table 4.1. The following sections provide details on the features identified to prevent or mitigate these accidents.

4.4.1 Secondary Confinement of Aboveground Transfer Equipment

4.4.1.1 Safety function

Protection against sludge transfer line failures (i.e., pipe/hose ruptures or leaks, component leaks, leaks at flanges or hose connections) is required to maintain the inhalation exposure to on-site workers below analysis guidelines. Secondary confinement of the transfer line is provided and is identified as a safety-significant feature. It is necessary that most of the leaking LLLW be either retained within the secondary confinement or diverted back to a tank by a collection and drain system provided by the confinement system.

4.4.1.2 System description

The secondary confinement system for the above ground piping and hoses which transfer the sludges and supernate between tanks consists of four major parts as shown in Figure 2.1. The first part is the secondary confinement provided by the WD&C confinement box as the pipe and hoses exit the tank being sluiced. Second, the WD&C confinement box is attached to the transfer/valving box confinement which houses isolation valves, sampler and a flush line. Third, the transfer line exits the transfer/valving box confinement with hoses which are doubly contained. Fourth, the doubly contained hoses connect to the SCS System which is located in a tank riser as shown in Figure 2.5. The transfer line from the SCS System is doubly contained hoses which go to a riser in tanks W-8 and/or W-9.

The WD&C confinement box is mounted on a tank riser and provides secondary containment for the waste piping, glove port access for operational and maintenance activities, and structural/mechanical support for the mast, HMA, and storage tube. Material collected by the WD&C confinement box drains to the gunite tank on which it is mounted.

The transfer/valving box houses part of the waste transfer line and a series of backflush and flow control valves, a flow meter, and a proportional sampler. It has a bolted connection to the WD&C and has a 10 inch square opening through which the transfer line passes into the transfer/valving box. The transfer/valving box secondary confinement has a 2 inch drain line at the bottom which drains to a tank riser. If the size of the leak overwhelms the drain then the released liquid can drain back to the WD&C through the 10 inch square opening and into tank being sluiced.

The sludge conditioning system consists of a booster pump located inside a metal enclosure that fits within a tank riser. Slurry from the WD&C confinement box is deposited in the bottom of the enclosure through an inlet diffuser. The booster pump suction line draws slurry from the bottom of the enclosure and pumps it out of the tank riser to the receiving tank. Overflow from the enclosure drains to the gunite tank on which it is mounted.

Table 4.1. Summary list of safety-significant SSCs

Safety significant SSC	Chap. 3 rationale for designation	Safety function	Functional requirements	Performance criteria requiring TSR coverage
1. Secondary Confinement for Above Ground Transfer Pipes and Hoses	Random failures, etc., of the primary pipes and hoses release aerosols and expose on-site personnel. The secondary confinement collects most of the leakage and directs it back to one of the tanks. If the secondary confinement leaks up to 5 gpm, an exposed on-site person would not exceed the analysis guidelines even if exposed for the duration of the release.	Collect the leakage from a primary pipe or hose failure and direct the leakage back to a tank with the secondary confinement leaking no more than 5 gpm. These apply to events which do not simultaneously damage both the primary and secondary confinement barriers.	Collect up to 70 gpm of released sludges and supernate and direct them back to a tank with a secondary confinement leak rate of less than 5 gpm.	1. The WD&C, the transfer box, and the hoses secondary confinement must be inspected to ensure proper installation of flanges, removable covers, and other openings or mechanical joints that form the confinement boundary. The hose secondary confinement may be pressure tested instead of visually inspected.
2. Isolation of Systems Interfacing with the Primary Confinement Pipes and Hoses.	During a transfer of sludges and supernate through the pipes and hoses, release paths from pipes that interface with the primary confinement piping and hoses must be isolated.	Provide backup isolation of lines interfacing with the primary confinement piping and hoses to ensure no reverse flow occurs even if the normal isolation valve leaks, fails open, or is inadvertently left open.	Prevent reverse flow from the primary confinement piping to an interfacing system. The primary system piping operates at ambient temperatures and up to 75 psig. The relief valve can leak at a rate of 5 gpm and not exceed the analysis guidelines as discussed for the secondary confinement boundary SS SSC.	1. Perform a leak rate check of the check valve to ensure that its leak rate does not exceed the 5 gpm limit.
3. HCV-111C (Process water isolation valve supply to jet pump high pressure pump) 4. 480v Supply Disconnect Switch to the Jet Pump High Pressure Pump. 5. 480V Emergency Disconnect Breaker Supply to the Transformer Trailer Which Supplies the Jet Pump High Pressure Pump.	During external man-made events and natural phenomena events which simultaneously damage both the primary and secondary confinement boundaries, the transfer must be terminated within 40 minutes to prevent on-site exposures which exceed the analysis guidelines assuming a maximum transfer rate with maximum suspended sludges.	Provide a backup transfer termination capability if the normal shutdown and Emergency-Kill (i.e., E-Kill) termination fail. The three diverse isolation methods are physically separated so that the man-made event or natural phenomena will not prevent all three methods from being available for transfer termination.	Must turn off the high pressure water supply to the jet pump which transfers the sludges and supernate out of the tanks by isolating the low pressure water supply to the pump or interrupting the electrical supply to the high pressure pump motor.	1. Ensure that access to the isolation devices is not blocked. 2. Ensure that damage or a modification have not occurred which would render the isolation devices unable to terminate the transfer. 3. Ensure that the trailers containing the devices have not been located so that any two of the devices are within 30 feet of another device.

Transfer hoses/piping between the transfer/valving box and the sludge conditioning system and between the sludge conditioning system and the receiving tank are double-walled. The annular space between the walls of the double-walled pipe collects any material released from primary confinement and diverts it back to the transfer/valving box, the sludge conditioning system enclosure, or directly back to a gunite tank.

4.4.1.3 Functional requirements

The secondary confinement equipment must be capable of containing a complete line break during sludge transfer operations with no more than a 5 gpm release rate from secondary confinement. This requirement ensures that all releases from primary confinement without simultaneous failure of the secondary confinement will result in consequences that are below the analysis guidelines. Access plates and other penetrations through the secondary confinement boundary must contain seals which prevent leakage of the released material. The released material will be at ambient temperature and not contain any harsh chemicals that will quickly attack the boundary. The transfer/valving box and the WD&C enclosure have large flow areas so no backpressure in the secondary confinement enclosures will occur as the material flows to the tank. The outer transfer hose must be capable of withstanding the full pressure of the jet pump since a backpressure may buildup in the outer hose. The secondary confinement features operate in a nonharsh environment. Commercially available components are adequate for these features.

4.4.1.4 System evaluation

The WD&C secondary confinement enclosure is welded 14 gauge carbon steel covering carbon steel structural members. The enclosure contains access ports made of either carbon steel or of lexan if viewing through the port is necessary. The port covers are bolted to the enclosure with seals between the joint to prevent leakage. Pipes and conduits that pass through the enclosure are welded to the enclosure to ensure leak tightness. Eight glove ports also penetrate the enclosure which are used for access inside of the enclosure. Seven of the ports contain 15 mill butyl gloves. The eight port is used to bag in or out small components. The bags are assembled by the ORNL Boot Shop and are made of 11 gauge embossed vinyl which contains small amounts of polyvinyl chloride for improved welding. The seams are approximately 3/16 wide and made with an electronic sealer resulting in water tightness.

The transfer/valving box secondary confinement enclosure is welded 1/4 inch carbon steel plate on the bottom and 3/16 inch carbon steel plate on the top and sides. The enclosure contains access ports made of either carbon steel or of lexan if viewing through the port is necessary. The port covers are bolted to the enclosure with seals between the joint to prevent leakage. Pipes and conduits that pass through the enclosure are welded to the enclosure to ensure leak tightness. The enclosure contains two glove ports with 15 mill butyl gloves.

The SCS is located inside a tank riser so that the riser provides the secondary confinement and any leakage naturally flows back into the tank.

The transfer hoses are enclosed inside a second hose which has a pressure rating above the discharge head of the jet pump. The hoses are connected so that any leakage into the secondary confinement hose will be directed to one of the ends of the hose which allows the leaked material to flow back into either the sending or receiving tank.

4.4.1.5 TSR controls

The safety function of the secondary confinement system is to collect the leaked sludges and supernate and direct them back to a tank without a leak rate of more than 5 gpm. The maximum leak rate from the primary confinement and the maximum pressure is well known and not likely to change. The secondary confinement may be damaged from operational activities or may have some of the access ports removed for maintenance. The transfer hoses will be laying on the ground and may be damaged by operational activities. TSR controls will be established to ensure the operability of the confinement systems such that primary confinement leakage will be collected without a secondary confinement leak rate exceeding 5 gpm. Surveillance of the secondary confinement will include daily inspections and postmodification inspections when the primary transfer line is being used to transfer waste.

4.4.2 Isolation of Interfacing Systems

4.4.2.1 Safety function

A potential leak path for transferred sludges is through connections with interfacing systems. SSCs installed to prevent this occurrence are designated as safety-significant.

4.4.2.2 System description

The process water lines for flushing the transfer line penetrates secondary confinement and are equipped with isolation valves to isolate flow during sludge transfer operations. These systems are also equipped with backup check valves that prevent backflow of material from the sludge transfer equipment into the interfacing system in the event of isolation valve failure or operator failure to close the isolation valve during sludge transfers. These check valves are designated as safety significant SSCs. The check valves are spring loaded carbon steel check valves.

4.4.2.3 Functional requirements

The check valves must prevent backflow of slurries being transferred through the transfer hoses/piping into the interfacing systems. The maximum pressure the jet pump can generate is 75 psig. A rupture disc in the line just downstream of the jet pump has a rupture pressure of 150 psig to provide further assurance of the maximum pressure. The check valves operate with clean process water at ambient temperatures. The PHA in Appendix B indicates that a leak rate of up to 5 gpm will ensure that consequences are below the analysis guidelines. Commercially available components are adequate for this feature.

4.4.2.4 System evaluation

The check valves must be capable of preventing reverse flow into the process water line in the primary isolation valve is open or leaks. The check valve must be able to prevent reverse flow of process water at pressures up to 150 psig and at ambient temperatures. The check valve is located several feet away from the transfer line so, with the spring loaded closure characteristic, the check valve will not be closing with water containing suspended solids.

4.4.2.5 TSR controls

The check valves must be periodically tested to ensure that they do not exceed their allowable leak rate.

4.4.3 Termination of Sludge Transfer Activities

4.4.3.1 Safety function

If a large leak occurs from an external initiator simultaneously damaging both primary and secondary confinement, it is necessary to shutdown transfer operations within 40 minutes to prevent on-site consequences from exceeding analysis guidelines. The system has a normal shutdown process and Emergency-Kill switches at several locations which can terminate a transfer. These processes rely on computer generated signals to perform its function. The events which require the termination are those that caused by external man-made initiators or natural phenomena and damage both the primary and secondary confinements at the same time. The safety function is to have multiple physically separate methods to stop a transfer if the primary and secondary confinements are catastrophically destroyed.

4.4.3.2 System description

The following control points selected for shutting down transfer operations are:

- The 480V supply disconnect switch (device number 1-33-5-2-4-1) to the jet pump high pressure pump motor which is located on the jet pump high pressure pump trailer,

- The process water isolation valve HCV-111C (1/4 turn ball valve) on the low pressure process water supply trailer, and

- The 480V emergency disconnect breaker (device number 1-33-5-2), which is located on power pole #6, supply to the transformer trailer which supplies the jet pump high pressure pump.

The 480V supply disconnect switch to the jet pump high pressure pump motor is located on the trailer that has the pump and its motor. The trailer sits in the area of the tank being sluiced but located outside of the immediate area with a hose running to the WD&C connection point to the jet pump supply. The process water isolation valve HCV-111C is located on the trailer which contains the 500-gallon process water supply tank and the 91 psig process water supply pump. The valve is a 1 inch, 1/4-turn, bronze body ball valve. This trailer is also located in the general area of the tank being sluiced but not in the immediate area because hoses are used to provide water to various pumps and flushing connections. The 480V emergency disconnect breaker is mounted at ground level on power pole #6 and located at the extreme west end of the tank farm. Both 480V devices have simple hand operated levers for disconnecting the power.

4.4.3.3 Functional requirements

The control points must be capable of shutting down transfer operations quickly after detection of leak from secondary confinement. Some of the accident initiators may also disable or prevent access to one or more control points for system shutdown. Therefore, at least three physically separate and independent means of system shutdown are required to be available during sludge transfer operations. The control points operate in a nonharsh environment. The physically separate locations ensure that at least one of them will be available for the operator to terminate the transfer. The isolation valve is located in the process water supply to the jet pump high pressure pump. The process water flow rate is 10 gpm and 91 psig at ambient temperature. The isolation valve must stop flow to the jet pump high pressure pump such that the jet pump is not capable to pumping the sludges and supernate. The electrical disconnect switch and breaker are located in 480 volt supply to the pump motors and must be able to reliably operate. Commercially available components are adequate for these features.

4.4.3.4 System evaluation

Each of the isolation devices are simple operating commonly found devices being used in nonharsh environments. The devices are located at ground level and has easily understandable actions for terminating a transfer. Each device will be physically separated for the other two devices to ensure that at least one is available for isolation. Safety significant items do not require redundance so the multiple devices are to ensure availability and not for random failures as with safety class items.

4.4.3.5 TSR controls

The TSR controls for the devices are an inspection to ensure that the device is accessible to the operator and to ensure that no damage or modifications have occurred which will prevent the devices operation. Additionally a periodic functional test of the device is required to ensure that it operates as anticipated.

4.5 REFERENCES

1. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., April 30, 1992.

2. DOE Order 420.1, *Facility Safety*, Change 1, U.S. Department of Energy, Washington, D.C., November 16, 1995.

3. DOE Standard DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., July 1994.

4. DOE Order 5480.22, *Technical Safety Requirements*, Change 2, U.S. Department of Energy, Washington, D.C., January 23, 1996.

5. DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

The purpose of this chapter is to build upon the control functions described as essential in Chap. 3, "Hazards and Accident Analyses," and Chap. 4, "Safety Structures, Systems, and Components" and to derive TSRs. This chapter supports and provides the information necessary for the separate TSR document required by DOE Order 5480.22[1]. Derivation of TSRs involves summarizing and referencing pertinent sections of the SAR in which design (i.e., SSCs) and administrative features (i.e., non-SSCs) required to prevent or mitigate the consequences of accidents are described. Design and administrative features include those that: 1) provide significant defense in depth in accordance with the screening criteria of DOE 5480.22[1], 2) provide for significant worker safety, or 3) maintain consequences of facility operations below the analysis guidelines. This chapter contains the following information as applicable to South Tank Farm Remediation Project operations:

- Information with sufficient basis from which to derive, as appropriate, any of the following TSR parameters for individual TSRs:

  — Safety limits (SLs)
  — Limiting control settings (LCSs)
  — Limiting conditions for operation (LCOs)
  — Surveillance requirements.

- Information with sufficient basis from which to derive TSR administrative controls for specific control features or to specify programs necessary to perform institutional safety functions

- Identification of passive design features addressed in the SAR

- Identification of TSRs from other facilities that affect the facility's safety basis.

5.1 INTRODUCTION

The accident analysis documented in Sect. 3.4 and the PHA documented in Appendix B identified no SSCs that require designation as safety-class. The need for safety-significant secondary confinement features was identified for all primary confinement equipment located outside of the source and destination tanks. The need for safety-significant features to isolate interfacing systems was identified for systems connecting to the primary confinement system. The need for an additional safety significant features and control for maintaining capability to shutdown transfer operations from multiple control points was identified. The following sections develop the bases and requirements for the safety-significant SSCs and controls.

5.2 REQUIREMENTS

The requirements for TSRs are included in DOE Order 5480.22, *Technical Safety Requirements*[1].

5.3 TECHNICAL SAFETY REQUIREMENT COVERAGE

5.3.1 Features or Controls that Provide Significant Defense in Depth

These features are safety-significant SSCs noted in Sect. 3.3.3.2 and their associated assumptions requiring TSR coverage identified in Sect. 4.4, and any other TSR assumptions identified in accordance with screening criteria of DOE 5480.22[1] in Sect. 3.3.3.2.

No defense-in-depth SSCs were designated as safety-significant in Chap. 3 or Chap. 4.

5.3.2 Features or Controls that Provide for Significant Worker Safety

These features are safety-significant SSCs or controls identified in Sect. 3.3.3.2 and their associated assumptions requiring TSR coverage identified in Sect. 4.4 and any programs identified as needing coverage in TSR administrative controls in Sect. 3.3.3.2. The PHA in Appendix B identified the need for safety-significant secondary confinement, controls on isolation of interfacing systems, and maintaining capability to shutdown transfer operations from multiple control points. These SSCs and controls are discussed in Sect. 5.5.

5.3.3 Features or Controls that Maintain Consequences of Facility Operations Below Off-Site Safety-Class or Safety-Significant Analysis Guidelines

These features are safety-class or safety-significant SSCs and assumptions requiring TSR coverage identified in Sects. 3.4.2 and 4.3.

No features or controls were identified in Chap. 3 or Chap. 4 that are required to maintain off-site consequences below safety-class or safety-significant analysis guidelines.

5.4 DERIVATION OF FACILITY MODES

The facility modes are derived based on the types of accidents that may occur during each mode.

The Operation Mode is defined as the system state wherein transfers of sludge are possible. During the operation mode, there is the potential to have releases from the above ground transfer piping/hoses and there is also the potential to generate aerosols in the tank as a result of sluicing or scarifying activities. These situations provide the potential for the highest consequences in the shortest time to on-site and off-site receptors. This mode requires the closest monitoring and fastest response times.

The Warm Standby Mode is defined as the state wherein transfers of sludge are not possible because the process water to the CSEE, GSEE, jet pump, and scarifier is isolated. However, all other equipment may be powered up. In this mode, an aboveground release from transfer equipment is not possible. The only release modes involve damage to the tank caused by equipment movement or drop and tank overfill caused by unchecked flow of process water into the tank. Accidents that damage the tank result in a release to the ground. There are very minor consequences to on-site personnel and consequences to off-site personnel are slow developing (ingestion pathway). There are also many detection and mitigation features available to prevent or reduce the off-site consequence. Tank overflow with process water results in release of a much diluted slurry. The consequences associated with tank overflow are much lower that releases from transfer piping/hoses.

The Cold Standby Mode is defined as the state wherein transfers of sludge are not possible, intank equipment (including the MLDUA, ROV, and WD&C System) are powered down, and process water to the tank is isolated. This mode represents the most stable mode and routine monitoring by personnel in the Waste Operations Control Center is sufficient to ensure operations are maintained within analysis guidelines.

The following facility modes are defined for the GAAT Project Remediation of the STF:

1)	Operation Mode	Inventory above Category 3 quantities present and process water to CSEE, GSEE, or jet pump (when in tank) is not isolated
2)	Warm Standby Mode	Inventory above Category 3 quantities present and process water isolated to CSEE, GSEE, and jet pump (when in tank). MLDUA, ROV, and WD&C System powered up and process water which can cause tank overflow not isolated
3)	Cold Standby Mode	Inventory present above Category 3 quantities and (1) process water to CSEE, GSEE, or jet pump (when in tank), (2) MLDUA, ROV, and WD&C System powered down, and (3) all process water which can cause tank to overflow isolated

5.5 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

5.5.1 Secondary Confinement

5.5.1.1 Safety limits, limiting control settings, and limiting conditions for operations

There are no SLs or LCSs associated with the secondary confinement features in the STF Remediation Project. An LCO must be established when in Mode 1 requiring that secondary confinement for all primary confinement equipment located outside of the source and destination tanks contain material released from primary confinement. Analysis performed in support of the PHA demonstrates that releases to the environment at flow rates less than 5 gpm result in consequences that do not exceed analysis guidelines on-site or off-site for accidents in the "Unlikely" frequency range. The functional requirement of the secondary confinement is that it be capable of containing a release at 100% of the maximum transfer rate (70 gpm) without leaking more than 5 gpm.

The following equation in Shaw and Loomis[2] was used to determine the hole size in the secondary confinement that would result in a 5 gpm leak rate at the expected conditions.

$$Q = 19.636\ Kd^2\sqrt{h}$$

where:

Q = flow (gpm)
d = diameter of orifice or nozzle opening (in.)
h = differential head at orifice (ft H_2O)

K = discharge coefficient

The value for K is 0.82 for a squared edge orifice with the opening in full contact with the fluid. A differential head of 2 ft. 4 in. H_2O is used to represent the distance from the bottom of the transfer/valving box to the height in the WD&C were the fluid starts flowing into the tank. For these conditions a circular hole diameter of 0.5 in. will release 5 gpm. A circular hole has a higher flow capacity than a noncircular opening such as a rectangular opening. By determining the length and width of rectangular opening that have the same flow area as the circular opening will provide hole size with less than the limit of 5 gpm. For instance, a crack 0.1 in. wide would have to be 1.6 in. long to have the same flow area. Similarly a 0.2 in. by 0.8 in. crack, 0.3 in. by 0.5 in. crack, and 0.4 in. by 0.4 in. crack have the same flow area. These opening sizes are within the range of visual detection. Therefore visual inspection is sufficient to ensure that the 5 gpm limit is not exceeded.

Some of the transfer hoses may be located inside of protective enclosures such as enclosed concrete trays, which make daily inspections unreasonable. Although the location of the hoses in the protective enclosures will significantly reduce the probability that the hose is damaged from external forces and will provide additional mitigation of a release if a failure should occur, alternative measures are necessary to ensure the pressure integrity of the secondary confinement hose. A pressure decay test of the secondary confinement hose can provide the equivalent assurance that the secondary confinement hose can perform its safety function of collecting the leakage from the primary transfer hose and transporting that leakage to a tank without a greater than 5 gpm leak from the secondary hose to the environment. Calculation DAC-PX495A02-SSE-009[3] was prepared to determine the rate of pressure decay in a bounding volume assumed to be a 250-ft length of 4-in. nominal diameter hose. No consideration was included for the volume that the primary hose would occupy in the secondary confinement hose. The volume was initially pressurized to 15 psig and to 20 psig. The depressurization rate was determined for 0.5-in. hole, a 0.25-in. hole, and a 0.125-in. hole, with each hole assumed to be a circular opening with a discharge coefficient of 0.6. The results of the calculation indicate that with the initial pressure in the secondary hose at 15 psig, the pressure will decay to less than approximately 12 psig in 3 sec for the 0.5-in. hole, in 13 sec for the 0.25-in. hole, and in 50 sec for the 0.125-in. hole. Additionally, the results of the calculation indicate that with the initial pressure in the secondary hose at 20 psig, the pressure will decay to less than approximately 12 psig in 8 sec for the 0.5-in. hole, in 31 sec for the 0.25-in. hole, and in 124 sec for the 0.125-in. hole. The acceptance criteria for the pressure decay is that the line, which is initially pressurized between 15 and 20 psig, must not decay to a pressure less than 12 psig within a 3 min test duration. A decay to less than 12 psig will provide clear indication that the actual pressure in the secondary confinement hose has decreased during the test.

5.5.1.2 Surveillance requirements

The surveillance requirements associated with secondary confinement features include visual inspections and pressure tests to ensure that functional requirements are met. Releases which require the secondary confinement features occur only in Mode 1. At a minimum these inspections should occur before entry into Mode 1, daily while in Mode 1, and following any equipment maintenance or other event which could affect the ability of the secondary confinement to perform its intended safety function.

Analysis performed in support of the PHA demonstrates that a release of 100% of the maximum transfer rate results in consequences that exceed on-site analysis guidelines if allowed to continue for more than 40 minutes. Detection of deficiencies in the secondary confinement do not necessarily indicate that there has been a failure in the primary confinement. Therefore, if a deficiency is detected, re-establishment of the secondary confinement to meet its functional requirements within 1 hour is sufficient to meet analysis guidelines. If confinement functioning cannot be re-established within 1 hour, the facility must be transferred to a mode where the confinement is not required.

5.5.1.3 Administrative controls

No administrative controls were identified associated with the secondary confinement features for the GAAT Project Remediation of the STF.

5.5.2 Isolation of Interfacing Systems

5.5.2.1 Safety limits, limiting control settings, and limiting conditions for operation

There are no SLs or LCSs associated with isolation of interfacing systems. An LCO must be established when in Mode 1 to ensure physical protection against backflow of process materials into interfacing systems during transfer operations. When in Mode 1, systems interfacing with the primary confinement transfer piping/hoses provide a release path from the primary confinement to the environment. To reduce the likelihood of release through this release path, means of isolating the interfacing systems must be established. All interfacing systems are equipped with an isolation valve that is closed during transfer operations. These systems are equipped with at least one check valve as a back-up to prevent backflow of process liquid into the interfacing system in the event of isolation valve failure or operator failure to close the isolation valve.

5.5.2.2 Surveillance requirements

The check valves are standard, commercially available equipment that operate in a nonharsh environment. The check valves must be tested annually and following any maintenance activity or other event which could affect check valve operability. The check valve shall be considered operable if the annual test demonstrates a leak rate less than 0.05 gal/min which is 1% of the amount needed to exceed the consequence limit. If the check valve is found to be inoperable, the system will be transferred to a mode in which the interfacing system isolation is not required. This requirement applies to valves CV-105 (flush line check valve to transfer line in the transfer/valving box) and CV-330 (flush line to the booster pump system).

5.5.2.3 Administrative controls

There are no administrative controls associated with isolation of interfacing systems.

5.5.3 Termination of Sludge Transfer Activities

5.5.3.1 Safety limits, limiting control settings, and limiting conditions for operation

There are no SLs or LCSs associated with termination of sludge transfer activities at the STF Remediation Project. An LCO must be established when in Mode 1 that provides operations personnel the ability to quickly shut down sludge transfer operations in the event of natural phenomena or external man-made event that causes simultaneous failure of both the primary and the secondary confinement. It is essential that multiple, physically separate, and independent control points are available to operations personnel for quick termination of sludge transfer activities. If one location is damaged or physically inaccessible during an accident, other control locations will be readily available and functional.

5.5.3.2 Surveillance requirements

Visual inspection of the control points shall be performed daily and following any maintenance activities or other events that could affect the control points' operability. The inspection shall be for physical condition of the control point, for accessibility, and for changes in configuration. The valves and breakers used to shut down transfer operations are highly reliable commercial equipment. Annual verification of operation is suitable to ensure their operability. Therefore, functional testing of the control points shall be performed annually and following any maintenance activity or other event that could affect the control points' operability. This requirement applies to the disconnect switch to the jet pump motor on pump skid L-03 (device number 1-33-5-2-4-1); the main feed circuit breaker on pole #6, which supplies power to the jet pump skid L-03 (device number 1-33-5-2); and the process water isolation valve on the process water skid (equipment number HV-111C).

5.5.3.3 Administrative controls

Procedures must be in place that describe actions to be taken upon detection of failure of both the primary and secondary confinement systems.

5.6 DESIGN FEATURES

There were no design features identified in Chap. 3 or Chap. 4 that provide safety class or safety-significant functions.

5.7 INTERFACE WITH TECHNICAL SAFETY REQUIREMENTS FROM OTHER FACILITIES

There are no identified TSRs at other facilities that affect operations during the STF Remediation Project.

5.8 REFERENCES

1. DOE Order 5480.22, *Technical Safety Requirements*, Change 2, U.S. Department of Energy, Washington, D.C., January 23, 1996.

2. Shaw, G. V., and Loomis, A. W., *Cameron Hydraulic Data - A handy reference on the subjects of hydraulics, steam, and water vapor*, Fourteenth Edition, Fifth Printing, Ingersoll-Rand Company, Woodcliff Lake, New Jersey.

3. DAC-PX495A01-SSE-009, Gunite and Associated Tanks Remediation Project (Transfer Hose Depressurization Rate), Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, November 1997.

6. PREVENTION OF INADVERTENT CRITICALITY

6.1 INTRODUCTION

The purpose of this chapter is to provide information demonstrating compliance with applicable requirements for prevention of inadvertent criticality. This chapter describes the criticality safety and protection program delineating requirements for criticality control and its implementation.

6.2 REQUIREMENTS

The requirements for prevention of inadvertent criticality are included in ORNL Nuclear Criticality Safety Procedure NCS-1.0[1], and DOE Order 420.1[2].

6.3 CRITICALITY CONCERNS

It was shown in Chap. 3, "Hazard Analysis", that the amount of fissionable materials, excluding the denatured uranium and plutonium detected in the STF tanks and NTF Tanks W-3 and W-4 during sampling operations is well below the fissionable material control limit of 250 g ^{235}U fissionable equivalent mass. These quantities are below the quantities which require the application of the ORNL Nuclear Criticality Safety Program controls as discussed in ORNL Nuclear Criticality Safety Procedure NCS-1.0[1]. The fissionable material hazard is evaluated in Sect. 3.3.2 of this SAR.

6.4 CRITICALITY CONTROLS

6.4.1 Engineering Controls

No engineering controls are used in the STF tanks or associated process systems.

6.4.2 Administrative Controls

Sampling has indicated that the total amount of fissionable material in all tanks is below 250 g ^{235}U fissionable equivalent mass. Therefore, no nuclear criticality safety analysis is required and no special controls are needed to prevent an criticality accident.

6.4.3 Application of Double-Contingency Principle

Criticality is excluded by nature of process: in particular, because fissionable nuclides are adequately diluted (denatured) with ^{238}U and ^{232}Th and because there are no credible mechanisms to alter this dilution.

6.5 CRITICALITY PROTECTION PROGRAM

The criticality safety program provides controls for the safe handling, use, and storage of fissionable material in a verifiable manner. DOE Order 5480.24[2] establishes nuclear criticality safety program requirements. Lockheed Martin Energy Research Corporation (Energy Research) has submitted an implementation plan for the order and has implemented a nuclear criticality safety program that accomplishes the following objectives:

- Nuclear Criticality Safety (NCS) operations involving fissionable materials is addressed and reviewed if there are fissionable nuclide quantities exceeding a threshold limit
- management authorization of operations involving fissionable materials are documented
- criticality accident alarm system (CAAS) requirements are evaluated
- facilities incorporate and operate criticality accident alarm systems in conformance with the order when the evaluation shows the need
- fissionable material workers and supervisors receive NCS training
- NCS inspections/audits are performed
- NCS infractions are reported and corrected

The criticality safety program for the GAAT Project remediation of the STF is implemented by site procedures.

6.6 REFERENCES

1. NCS-1.0, *Nuclear Criticality Safety Program*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 18, 1994.

2. DOE Order 420.1, *Facility Safety*, U.S. Department of Energy, Washington, D.C., October 24, 1996.

7. RADIATION PROTECTION

7.1 INTRODUCTION

The purpose of this chapter is to briefly describe the essential features of the Radiation Protection Program.

7.2 REQUIREMENTS

Radiation protection standards and program requirements for DOE and DOE contractor operations with respect to the protection of the worker from ionizing radiation are contained in DOE Order 5480.11[1], 10 *CFR* 835[2], and ORNL/ER-397[3].

7.3 RADIATION PROTECTION PROGRAM AND ORGANIZATION

A site Radiation Protection Program is maintained by Energy Research that is consistent with the requirements of DOE Order 5480.11[1] and 10 *CFR* 835[2]. The comprehensive Radiation Protection Program includes provisions for policy, training, monitoring, exposure limits, handling, processing, storing radioactive materials, labeling, equipment design, shielding, and the ALARA principle. The Energy Research Radiation Protection Program is designed to protect workers from the harmful effects of radiation. The program is implemented by site procedures and accomplishes the following objectives:

- Maintaining radiation exposure at levels that are ALARA
- Limiting internal and external radiation exposure of occupational workers
- Monitoring and recording occupational exposure
- Labeling radioactive materials
- Posting and establishing entry control programs for areas where elevated radiation fields may be present
- Providing periodic radiation safety training

7.4 RADIOLOGICAL MONITORING

Radiological monitoring is performed periodically at the STF to ensure that personnel doses are maintained ALARA and to minimize the spread of contamination by early detection. In the STF, the tank dry wells are monitored and sampled monthly, the off-gas systems are tested quarterly, and radiological surveys are taken semi-annually. Health physics personnel will monitor Remediation Project operations and perform radiological surveys as needed or requested.

7.5 RADIOLOGICAL PROTECTION INSTRUMENTATION

There is no permanently installed radiation protection instrumentation provided for the STF tanks. When personnel are required to enter the area, information on radiation exposure is collected using personal radiation detectors. Appropriate radiation protection instrumentation for personnel frisking upon exiting is specified and provided by the Office of Radiation Protection as needed.

Radiation protection instrumentation such as the half-body counter Personnel Contamination Monitor (PCM)-1B, will be located near the controlled area egress point for monitoring. The PCM-1B will be used where frisking is required to exit the potentially contaminated areas. Hand frisking will be used as necessary as a backup to the PCM-1B. Health Physics will provide additional radiological protection instrumentation during Remediation Project operations to ensure that contamination is detected and controlled and that personnel exposures are maintained ALARA.

7.6 OCCUPATIONAL RADIATION EXPOSURES

"Dose Rates for Gunite Tanks"[4] calculates an estimate of exposure rates resulting from transfer of LLLW through piping between the tanks. Table 7.1 lists the exposure rates from Tank W-10 sludges (highest external dose potential) in transfer piping at the pipe surface and one foot from the pipe surface. It is not expected that personnel will be routinely present on the platform during transfer operations. Most operations can be performed remotely. When operations require access to the platform during transfer, Health Physics will closely monitor the dose received by the person(s) performing the work.

7.7 REFERENCES

1. DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, D.C., November 30, 1988.

2. Title 10, Code of Federal Regulations, Part 835, *Occupational Radiation Protection*.

3. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1997.

4. "Dose Rate Calcs for Gunite Tanks," Central Engineering Records System, Project Records Number X1994-0055, Transmittal Number GAATTS 587, dated March 7, 1996.

Table 7.1. Estimated dose rates from transfer piping during Tank W-10 sludge transfer

Case condition	Dose rate, surface (rem/hour)			Dose rate, 1 ft (rem/hour)		
	Neutrons	Photons	Total	Neutrons	Photons	Total
2-in. Sch. 40 stainless steel pipe, unshielded	0.002	4.210	4.212	<0.001	0.309	0.310
2-in. Sch. 40 stainless steel pipe, 1.0 cm Pb shield	0.001	0.636	0.637	<0.001	0.068	0.068
2-in. Sch. 40 stainless steel pipe, 1.5 cm Pb shield	0.001	0.307	0.308	<0.001	0.037	0.037
2-in. Sch. 40 stainless steel pipe, 2.0 cm Pb shield	0.001	0.154	0.155	<0.001	0.020	0.020

8. HAZARDOUS MATERIAL PROTECTION

8.1 INTRODUCTION

The purpose of this chapter is to briefly describe the essential features of the Hazardous Material Protection Program.

8.2 REQUIREMENTS

Hazardous material protection requirements are contained in 29 *CFR* 1910[1] and ORNL/ER-397[2].

8.3 HAZARDOUS MATERIAL PROTECTION AND ORGANIZATION

The Hazardous Material Protection Program provides for identification and control of hazardous materials, and training of personnel to minimize occupational exposure to hazardous materials. Energy Research has implemented a Hazardous Material Protection Program that accomplishes the following objectives:

- Work areas are protected against hazards that cause illness, impaired health, or significant discomfort
- Employees are informed of hazards that may be encountered in their work area
- Exposure to hazardous materials are maintained ALARA.

The Hazardous Material Protection Program is implemented by ORNL site procedures. The procedures establish hazardous material protection requirements for conduct of ORNL operations and activities and assigns the responsibilities of ORNL organizations for implementing the requirements.

8.4 REFERENCES

1. Title 29, Code 1910 Federal Regulations, Part 1910, *Occupational Safety and Health Standards*.

2. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1997.

9. RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 INTRODUCTION

The objective of this chapter is to briefly describe the provisions for radioactive and hazardous waste management.

9.2 REQUIREMENTS

The policies, guidelines, and requirements by which DOE manages its radioactive and mixed waste and contaminated facilities are contained in DOE Order 5820.2A[1] and ORNL/ER-397[2].

9.3 RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT PROGRAM AND ORGANIZATION

The STF tanks contain LLLW supernate and sludges. The tanks no longer receive LLLW from the laboratory sources and there are no additional waste streams generated at the tanks other than the planned transfer of NTF Tanks W-3 and W-4 contents to the STF. The Energy Research Radioactive and Hazardous Materials Waste Management Program provides the controls and procedures for the safe management of radioactive and hazardous waste material at ORNL. The program addresses the following topics:

- Segregation and packaging of radioactive and hazardous waste materials
- Waste minimization
- Waste storage and disposal.

The Energy Research Waste Management and Remedial Action Division manages the treatment, storage, and disposal of legacy and newly generated wastes at ORNL in a manner that protects the health and safety of on-site personnel, the public, and the environment. Transportation of wastes is managed by the Energy Research Transportation Department. The Radioactive and Hazardous Materials Waste Management Program is implemented by divisional procedures.

9.4 RADIOACTIVE AND HAZARDOUS WASTE STREAMS AND SOURCES

During the Remediation Project activities which will transfer LLLW through the slurry transfer piping and remediation equipment, these will be contaminated with the wastes. A decontamination spray ring is provided at the tank for the in-tank removal equipment. A decontamination tent will be provided for additional decontamination efforts. Also, other radioactive and hazardous wastes that may be generated includes swipes from normal surveys, and small amounts of protective clothing or other items that can occasionally become contaminated. These waste are packaged, handled and disposed of in accordance with the Energy Research Radioactive and Hazardous Materials Waste Management Program.

9.5 REFERENCES

1. DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C., September 26, 1988.

2. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1997.

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

10.1 INTRODUCTION

The purpose of this chapter is to briefly describe the essential features of the initial testing, in-service surveillance, and maintenance programs required for safe operation of the GAAT Project remediation of the STF. No safety-class items were identified for STF remediation activities.

10.2 REQUIREMENTS

DOE Orders pertinent to testing include DOE Orders 4330.4B[1], 5480.19[2], 5480.31[3], and 5700.6C[4]. DOE requirements for maintenance are included in DOE Order 4330.4B[1].

10.3 PROVISIONS FOR INITIAL TESTING, SURVEILLANCE, AND MAINTENANCE

The testing program includes both initial testing of new equipment and surveillance testing of equipment following installation. This program consists of several areas that overlap with other areas of safety management. The GAAT Project has implemented a testing program that accomplishes the following objectives:

- Vendor testing of ordered equipment meets requirements
- Proper equipment is received and installed
- Installed equipment satisfies specifications and demonstrates satisfactory performance

Lockheed Martin Energy Systems, Inc. (Energy Systems), has implemented a policy procedure that establishes the planning, execution, and reporting of Energy Systems' surveillance activities. The surveillance program is implemented by corporate procedures and standards. The surveillance program accomplishes the following minimum objectives:

- Identifies the activities to be monitored
- Identifies the frequency of the surveillance
- Identifies the individual or organization responsible for conducting the surveillance
- Generates surveillance schedules
- Assesses compliance
- Documents surveillances
- Documents nonconformances and initiates corrective actions

The maintenance program ensures that DOE property is maintained in a manner which promotes operational safety, worker health, environmental protection and compliance, property preservation, and cost effectiveness while meeting the programmatic mission. The GAAT Project has implemented a maintenance program. The program accomplishes the following minimum objectives:

- Structures, systems, and components that are important to safe operation are subject to a maintenance program in order to meet or exceed the design requirements throughout their life.

- Periodic inspection of structures, systems, components, and equipment is performed to determine deterioration which threaten performance and/or safety.

- Primary responsibility, authority, and accountability for the direction and management of the maintenance programs for all property reside with the line management assigned direct programmatic responsibility.

The operational testing program for the in-tank sludge removal equipment is detailed in ORNL/ER-361[5]. The operational testing program identifies operational testing to be performed to demonstrate the technical feasibility of methods proposed for the removal of radiochemical sludge heels from Tanks W-3 and W-4, reduce the uncertainty in meeting Comprehensive Environmental Response, Compensation, and Liability Act requirements, and minimize the overall costs.

The initial testing program includes evaluation of design alternatives, acceptance tests of purchased components with performance specifications, and functional tests on equipment. Functional testing activities will be initially conducted in a nonradioactive environment at ORNL. This will permit the design and initial performance testing and training activities to be completed while minimizing the risk, employee exposure, and costs associated with the testing effort. The Treatability Study in the NTF constitutes additional testing of equipment within a radiological facility.

10.4 REFERENCES

1. DOE Order 4330.4B, *Maintenance Management Program*, U.S. Department of Energy, Washington, D.C., February 10, 1994.

2. DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, D.C., July 9, 1990.

3. DOE Order 5480.31, *Startup and Restart of Nuclear Facilities*, U.S. Department of Energy, Washington, D.C.

4. DOE Order 5700.6C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C., August 21, 1991.

5. ORNL/ER-361, *Treatability Study Operational Testing Program and Implementation Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, March 1996

11. OPERATIONAL SAFETY

11.1 INTRODUCTION

The purpose of this chapter is to briefly discuss the programs, plans, and procedures used to ensure that facility operation is managed, organized, conducted, and controlled in a safe manner.

11.2 REQUIREMENTS

The requirements for worker safety are contained in DOE Orders 232.1[1], 5480.7A[2], 5480.10[3], 5480.11[4], 5480.19[5], and 5483.1A[6], and ORNL/ER-397[7].

11.3 CONDUCT OF OPERATIONS

The conduct of operations program ensures that operations at DOE facilities are managed, organized, and conducted in a manner to assure an acceptable level of safety. The STF remediation activities will require that an operational safety program accomplishes the following objectives:

- Facility operators have procedures in place to control the conduct of their operations,

- Line organizations review existing and planned programs important to safe and reliable facility operations, and

- Line organizations assess the effectiveness of corporate directives, plans, or procedures at facilities under their cognizance.

The STF Facility manager is responsible for ensuring that procedures are in place for all activities and that the activities adhere to corporate, site, and division policies and procedures governing industrial hygiene and safety. Site programs are maintained that provide requirements for industrial safety and industrial hygiene at ORNL. These programs include detailed procedures that apply to all ORNL operations and activities.

The industrial hygiene program includes provisions for:

- Hazard communication,
- Health hazard management,
- Hearing conservation,
- Respiratory protection,
- Embryo/fetus protection,
- Employee education and training,
- Hazardous waste operations and emergency response,
- Investigation of health hazard incidents and concerns, and
- Hazardous materials inventory.

The industrial safety program includes provisions for:

- Safety and health program,

- Unusual occurrence reporting,
- Recordable injury and illness investigation,
- Safety and health suggestions,
- Safety orientation and training,
- Eye, face, hand, and foot protection,
- Compressed gas cylinders,
- Electrical safety,
- Use of safety work permits,
- Operating rules and qualification test for operators of forklift trucks,
- Lockout/tagout of hazardous energy sources,
- Use of "Do Not Operate" tags and other safety-related tags, and
- Safety showers and eye/face wash facilities.

The only operations routinely conducted in the STF currently are surveillance and maintenance activities. The activities performed include site inspections, tank monitoring, dry well monitoring, radiological surveys, and various maintenance activities as required. The STF facility manager is responsible for ensuring that procedures are in place for all activities and that the activities adhere to corporate, site, and division policies and procedures governing industrial hygiene and safety.

The operations for the Remediation Project implements confined sluicing technology, to remove the sludge heels from the gunite tanks of the STF. This technology which uses a high-pressure, low-volume water jet is employed to empty each of the tanks of their contents and transfer the sludge in the form of a slurry to Tank W-8 and/or W-9. The WD&C system performs the waste removal operations. The MLDUA positions and manipulates the WD&C suction hose to achieve full tank coverage and the remotely located control system directs and integrated all activities including the auxiliary components and systems. The activities performed as part of the project include deployment of the Treatability Study equipment at the STF, remote operation of sludge removal equipment for sluicing and scarifying within the tanks, and transfer of waste slurry through the SCS to Tank W-8 or W-9.

Individual procedures for conducting operations will be developed to define each operational activity and to establish preliminary conditions, safety precautions, sequencing, and operating parameters. Any maintenance or other work that is performed will be done so in appropriate personal protective equipment and following ORNL radiological protection procedures. Operator training will be accomplished during the component system performance tests in a nonradiological environment. The conduct of operations for the testing program is outlined in ORNL/ER-361[8]. The activities performed as part of the Treatability Study include initial testing of equipment and systems and evaluation of sludge removal equipment by transferring sludges between Tanks W-3 and W-4 at the NTF. Guidelines for the preparation of these procedures are included in ORNL/ER-361[8].

11.4 FIRE PROTECTION

A site fire protection program is planned, implemented, and maintained at ORNL to meet contractual obligations; state and federal laws; and necessary & sufficient elements of DOE orders, policies, and guides. The fire protection program is administered by the Director of the Office of Laboratory Protection. Major program elements are the responsibility of the Fire Protection Engineering Department of the Office of Laboratory Protection and the site Fire Department of the Energy Systems Protective Services Organization. Program responsibilities include the following:

- maintaining an emergency response firefighting crew on a 24 hour basis;
- investigating and reporting on all fires;
- inspecting, testing, and maintaining fire protection equipment at ORNL;
- providing fire protection engineering services;
- conducting required training/education for emergency responders and general employee population; and
- conducting facility fire safety/prevention inspections.

Fire exit or evacuation drills at ORNL are conducted periodically as determined necessary by the Emergency Preparedness Department or facility manager.

11.5 REFERENCES

1. DOE Order 232.1, *Occurrence Reporting and Processing of Operations Information,* U.S. Department of Energy, Washington, D.C., September 1995.

2. DOE Order 5480.7A, *Fire Protection,* U.S. Department of Energy, Washington, D.C., February 17, 1993.

3. DOE Order 5480.10, *Contractor Industrial Hygiene Program,* U.S. Department of Energy, Washington, D.C., June 26, 1985.

4. DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, D.C., December 21, 1988.

5. DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities,* U.S. Department of Energy, Washington, D.C., May 18, 1992.

6. DOE Order 5483.1A, *Occupational Safety and Health Program for DOE Contractor Employees at Government-owned Contractor-operated Facilities*, U.S. Department of Energy, Washington, D.C., June 22, 1983.

7. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1997.

8. ORNL/ER-361, *Treatability Study Operational Testing Program and Implementation Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, March 1996.

12. PROCEDURES AND TRAINING

12.1 INTRODUCTION

The purpose of this chapter is to briefly describe the procedures and training provisions for safe operation of the GAAT Project remediation of the STF. The procedures and training provisions discussed below ensure that operations are conducted in accordance with the TSRs for the facility and with minimal risk of injury to facility workers.

12.2 REQUIREMENTS

The requirements for safe operations and training of personnel are included in DOE Orders 5480.5[1], 5480.18B[2], 5480.20A[3], and 5820.2A[4], and ORNL/ER-397[5].

12.3 PROCEDURE PROGRAM

The procedures program provides for the development, implementation, and maintenance of procedures governing operation of ORNL facilities. The STF remediation activities require that a procedure program accomplishes the following objectives:

- Procedures identify the responsible implementing organizations and/or individuals and the actions required,
- Procedures are kept current by formal issuance of revisions as conditions change,
- New procedures and revisions to procedures are subject to a documented review and approved by the facility manager or his designee, and
- Current revisions of procedures approved for use are retrievable and placed on controlled distribution to identified users.

The procedures program is implemented by project plans, procedures and guidance, as well as site procedures and standards. Project operating procedures are developed and prepared to define methods for carrying out the individual operations based on experience and current technology. The level of written operating procedures are defined as required to do the job adequately. All operating procedures are subject to documented review by appropriate advising groups or individuals prior to issue and are subject to approval. Operating procedures are kept current by formal issuance as conditions change. Modifications to procedures are subject to the same review and approval as new procedures.

12.4 TRAINING PROGRAM

The training program provides for general safety training for site employees as well as initial and periodic safety training for operators. The STF remediation activities require that a training program accomplishes the following objectives:

- On-site personnel receive general employee training to acquaint the individual with site-wide procedures, alarms, and responsibilities,
- Personnel receive periodic training to maintain a level of proficiency consistent with assigned tasks, and
- Personnel are qualified to carry out their assigned responsibilities.

Specific requirements for training on in-tank sludge removal equipment use, operation, and control will be performed during the Treatability Study[6]. Future training will be performed under the direct supervision of competent technical personnel.

12.5 REFERENCES

1. DOE Order 5480.5, *Safety of Nuclear Facilities*, U.S. Department of Energy, Washington, D.C., September 23, 1986.

2. DOE Order 5480.18B, *Nuclear Facility Training Accreditation Program*, U.S. Department of Energy, Washington, D.C., August 31, 1994.

3. DOE Order 5480.20A, *Personnel Selection, Qualification, Training, and Staffing Requirements for DOE Nuclear Facilities*, U.S. Department of Energy, Washington, D.C., November 15, 1994.

4. DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C., September 26, 1988.

5. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1997.

6. ORNL/ER-361, *Treatability Study Operational Testing Program and Implementation Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, March 1996.

13. HUMAN FACTORS

13.1 INTRODUCTION

The purpose of this chapter is describe the human factors engineering considered in the facility design and operations to ensure the safety function of systems, components, and controls during normal, abnormal and emergency operations.

13.2 REQUIREMENTS

The requirements for human factors engineering are contained in DOE Order 5480.23[1].

13.3 HUMAN FACTORS PROCESS

Human Factors engineering is the evaluation of the system and equipment design, configuration and operation and the element of safety based on the limitations incurred by human interfaces. A systematic evaluation of the human-machine interfaces, procedures, training, staffing levels, and automated control functions is to performed. The STF remediation activities include human factors engineering considerations that accomplish the following objectives:

- Furnished instrumentation are sufficient to support timely and reliable assessment of the system status for appropriate human operations.
- Design, layout and labeling of controls and instrumentation is consistent with reliable performance of the human activities.
- Work environment is conducive to maintaining a high degree of reliable work performance for all phases of the operations and various modes of operation.
- Documentation required to support operations is clear, complete, and maintained up-to-date.
- Training of workers on the procedures for appropriate action during all modes of operation is implemented.

13.4 REFERENCES

1. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., March 10, 1994.

14. QUALITY ASSURANCE

14.1 INTRODUCTION

The purpose of this chapter is to discuss the aspects of quality assurance (QA) that have been incorporated to ensure implementation of the organizational, functional, and administrative control required to maintain an acceptable level of quality in design, procurement, construction, testing, and operation of components and systems.

14.2 REQUIREMENTS

The requirements for QA are contained in 10 *CFR* 830.120[1] and DOE Order 5700.6C[2].

14.3 QUALITY ASSURANCE PROGRAM AND ORGANIZATION

The QA Program describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing adequacy of work. Energy Systems Environmental Restoration (ER) Program has a QA Program that is outlined in the ORNL/ER-225 and is applicable to the activities and facilities.

14.4 QUALITY IMPROVEMENT

The QA management program and processes are to be implemented to correct conditions adversely affecting quality. This includes establishing and implementing processes to detect and prevent quality problems to ensure quality improvement.

14.5 DOCUMENTS AND RECORDS

Document control and a records management program is to be established by Energy Systems ER which ensures the required documents are prepared, reviewed, and approved according to prescribed guidelines and that these documents are kept on file, the most up-to-date version is available, and appropriate revision processes are implemented.

14.6 QUALITY ASSURANCE PERFORMANCE

The Quality Assurance program ensures the work performed meets the established requirements and accomplishes the following objectives:

- Ensuring that personnel are trained and qualified to perform their assigned work and are provided continuing training to ensure that job proficiency is maintained.

- Performing the work to established technical standards, safety criteria, and administrative controls.

- Designing items and processes using sound engineering/scientific principles, appropriate standards, design codes, and operating guidelines.
- Ensuring inspection and acceptance-test specified items and processes meet established acceptance and performance criteria.
- Ensuring that procured items, systems, and services meet established requirements and design criteria.
- Assessing at all levels the integrated quality assurance program and its performance.
- Preforming independent assessments of quality and process effectiveness to promote improvement.

14.7 REFERENCES

1. Title 10, Code of Federal Regulations, Part 830, Section 830.120, *Quality Assurance Rule.*

2. DOE Order 5700.6C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C., August 21, 1991.

15. EMERGENCY PREPAREDNESS PROGRAM

15.1 INTRODUCTION

The purpose of this chapter is to describe briefly the Emergency Preparedness Program for the operations of the South Tank Farm.

15.2 REQUIREMENTS

Emergency Preparedness Program requirements are contained in the DOE Order 5500 Series, *Emergency Preparedness*[1].

15.3 SCOPE OF EMERGENCY PREPAREDNESS

The emergency preparedness program is provided to ensure the safety and health of workers and members of the general public, as well as protect the environment. The STF remediation activities require that an emergency preparedness program accomplishes the following objectives:

- Develop and maintain emergency planning, preparedness, and response capabilities, as well as effective public and interagency communications, in order to minimize the consequence to workers, national security, the public, and the environment from incidents involving DOE operations,

- Respond to emergencies in an effective and timely manner to mitigate the consequences and bring the emergency situation under control, and

- Provide support, within resource constraints, to other local, state, and Federal agencies and international organizations, as requested, and in accordance with pertinent Federal regulations and plans, appropriate interagency agreements, and international conventions.

The emergency management program is implemented by site plans and procedures and corporate standards.

15.4 EMERGENCY PREPAREDNESS PLANNING

The health and safety plans for the project provide the initial emergency preparedness controls and interfaces with the site emergency preparedness program. The GAAT Project has a programmatic health and safety plan[2] for the entire project. The programmatic plan provides the overall plan for the emergency control and interfaces with the site emergency preparedness program and applies to all of the tanks in the GAAT Project. An activity specific addendum to the programmatic plan will be prepared that provides the detailed information which is specific to the STF remediation activity. The documents familiarize individuals working in the facility with the emergency service units and guidelines that are available and provides the course of action to pursue if an emergency condition develops. All facility personnel are to be familiar with the content and location of the health and safety plans.

15.5 REFERENCES

1. DOE Order 5500 Series, *Emergency Preparedness,* U.S. Department of Energy, Washington, D.C.

2. Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/ER-397, issued April 1997.

16. PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

16.1 INTRODUCTION

The purpose of this chapter is to describe briefly the plans and provisions for decontamination and decommissioning of the STF tanks and support equipment.

16.2 DESCRIPTION OF CONCEPTUAL PLANS

The activities of the sludge removal and tank scarifying is for the purpose of decontamination and decommissioning of the STF tanks. The operation for the Remediation Project implements confined sluicing technology to remove the sludge heels from the gunite tanks of the STF. This technology, which uses a high-pressure, low-volume water jet, is employed to empty each of the tanks of their contents and transfer the sludge in the form of a slurry to STF Tank W-8 or W-9. The WD&C system performs the waste removal operations. The MLDUA positions and manipulates the WD&C suction hose to achieve full tank coverage and the remotely located control system directs and integrated all activities including the auxiliary components and systems. The GSEE is used for the higher pressures needed to achieve scarifying of the tank walls to remove the embedded radiological and hazardous materials. Systems and equipment that may be contaminated are designed to be relocated to different tanks as remediation activities continue. The tank risers used to move equipment into and out of the tanks are equipped with decontamination spray rings to aid in the decontamination of equipment as it is removed from the tanks. This mobile equipment may also be removed from the tank farm and disposed, if necessary, following remediation activities.

Upon completion of the STF remediation, the ancillary equipment and transfer piping will undergo decontamination. A decontamination tent is provided to perform some of this activity. The support equipment and systems, such as SCS, are portable and can be used in conjunction with in-tank sludge removal equipment for other decommissioning efforts.

17. MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 INTRODUCTION

The purpose of this chapter is to briefly describe the overall structure of the organizations and personnel at ORNL with responsibilities for facility safety and the programs that promote safety consciousness and morale, including safety culture, performance assessment, configuration and document control, occurrence reporting, and staffing and qualification.

17.2 REQUIREMENTS

The basic requirements for management, organization, and institutional safety provisions are included in DOE Orders 5480.1B[1], 5480.4[2], and 5480.5[3], and ORNL/ER-397[4].

17.3 ORGANIZATIONAL STRUCTURE, RESPONSIBILITIES, AND INTERFACES

Operations in the STF are the direct responsibility of the STF facility manager. The facility manager reports to the Gunite and Associated Tanks (GAAT) Project Manager. The GAAT Project Manager reports to the Senior Project Manager: Melton Valley, Bethel Valley, White Oak Creek , who reports to the Project Execution Director for the Environmental Management and Enrichment Facilities (EMEF) Business Unit. The project operations are the direct responsibility of the GAAT Project Manager. The Project Manager has project direct reports of Business Manager, Technical Manager, Design Manager, Construction Manager, Environmental Compliance Manager, Site Development and Operations Manager, Waste Removal Operations Manager, Health and Safety Manager, and Facility Manager[5].

17.4 SAFETY MANAGEMENT POLICIES AND PROGRAMS

17.4.1 Safety Review and Performance Assessment

Various programs have been established for reviewing the safety of ORNL facilities. These programs ensure and verify safety in the areas of radiation protection, criticality safety, industrial hygiene, industrial safety, fire protection, environmental monitoring, emergency preparedness, and facility safety analysis. For each of these areas, safety reviews are performed by the line organization for the project. Periodic independent safety reviews are initiated by ORNL.

17.4.2 Configuration and Document Control

The STF remediation activities require that a configuration and document control program accomplishes the following objectives:

- Configuration management requirements, responsibilities, and interfaces are clearly established, communicated, understood, and supported;

- Design bases or design requirements that are unavailable are identified and re-established as required to support (1) safe operation; (2) compliance with known facility, activity, process, or experiment requirements; (3) resolution of significant concerns; or (4) change control;

- Changes to configuration items are properly and thoroughly analyzed, approved, implemented, and documented to ensure conformance to design and administrative requirements;

- Operational and maintenance activities are controlled to ensure that the facility, activity, process, or experiment's configuration is kept consistent with design or administrative requirements; and

- Configuration item documents and records are correct and readily available.

17.4.3 Occurrence Reporting

The conduct of operations program ensures that operations at DOE facilities are managed, organized, and conducted in a manner to assure an acceptable level of safety. The STF remediation activities require that an occurrence reporting program accomplishes the following objectives:

- Identifying and documenting abnormal events,

- Reporting procedure to DOE,

- Developing and implementing of corrective actions, and

- Communicating lessons learned.

17.5 REFERENCES

1. DOE Order 5480.1B, *Environmental, Safety, and Health Program for DOE Operations*, U.S. Department of Energy, Washington, D.C., September 23, 1986.

2. DOE Order 5480.4, *Environmental Protection, Safety, and Health Standards*, U.S. Department of Energy, Washington, D.C., May 15, 1984.

3. DOE Order 5480.5, *Safety of Nuclear Facilities*, U.S. Department of Energy, Washington, D.C., September 23, 1986.

4. ORNL/ER-397, *Project Health and Safety Plan for the Gunite and Associated Tanks at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, April 1996.

5. *Gunite and Associated Tanks Project Plan*, Lockheed Martin Energy Systems, Inc., Oak Ridge Tennessee, December 19, 1996.

APPENDIX A

GUNITE AND ASSOCIATED TANKS PROJECT REMEDIATION OF THE SOUTH TANK FARM PRELIMINARY HAZARDS IDENTIFICATION TABLES

Table A-1. Preliminary Hazards Identification Listing for Tank W-5 Inventory

HAZARD TYPE	DESCRIPTION
Fissionable materials	1. Approximately 4,600 gallons of sludge containing fissionable radionuclide concentrations up to:

^{233}U	3.24E+01 Bq/g	^{235}U	3.51E-01 Bq/g
^{238}Pu	1.59E+02 Bq/g	^{239}Pu	3.69E+02 Bq/g
^{240}Pu	5.22E+01 Bq/g	^{241}Pu	7.09E+02 Bq/g
^{242}Pu	5.68E-02 Bq/g	^{244}Pu	1.11E-05 Bq/g
^{244}Cm	5.47E+02 Bq/g		

2. Approximately 27,964 gallons of supernate containing fissionable

^{233}U	1.78E+00 Bq/ml	^{235}U	3.90E-03 Bq/ml
^{238}Pu	8.00E-02 Bq/ml		

3. Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{233}U	4.16E-04 Ci	^{235}U	4.51E-06 Ci
^{238}Pu	3.21E-02 Ci	^{239}Pu	4.74E-03 Ci
^{240}Pu	6.70E-04 Ci	^{241}Pu	1.43E-01 Ci
^{242}Pu	7.29E-07 Ci	^{244}Cm	1.11E-01 Ci

HAZARD TYPE	DESCRIPTION
Radiation source	1. Approximately 4,600 gallons of sludge containing nonfissionable radionuclide concentrations up to:

^{3}H	1.10E+01 Bq/g	^{60}Co	2.36E+02 Bq/g
^{137}Cs	2.75E+04 Bq/g	^{90}Sr	6.61E+04 Bq/g
^{252}Cf	4.00E+00 Bq/g	^{234}U	2.10E+01 Bq/g
^{236}U	2.21E-01 Bq/g	^{238}U	1.15E+01 Bq/g
^{244}Pu	1.11E-05 Bq/g	^{228}Th	3.39E+01 Bq/g
^{230}Th	1.25E+02 Bq/g	^{232}Th	3.39E+01 Bq/g

(Note: The fissionable radionuclides listed for the sludge are also part of the sludge radiation source inventory)

2. Approximately 27,964 gallons of supernate containing nonfissionable radionuclide concentrations up to:

^{3}H	1.90E+00 Bq/ml	^{60}Co	1.36E+02 Bq/ml
^{137}Cs	4.80E+03 Bq/ml	^{90}Sr	8.18E+00 Bq/ml
^{234}U	9.70E-01 Bq/ml	^{236}U	3.74E-03 Bq/ml
^{238}U	1.02E+00 Bq/ml	^{228}Th	3.93E-04 Bq/ml
^{232}Th	3.93E-04 Bq/ml		

(Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)

3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{3}H	2.23E-03 Ci	^{60}Co	4.79E-02 Ci
^{137}Cs	5.56E+00 Ci	^{234}U	2.70E-04 Ci
^{90}Sr	1.34E+01 Ci	^{228}Th	4.39E-04 Ci
^{236}U	2.84E-06 Ci	^{232}Th	4.39E-04 Ci
^{238}U	1.47E-04 Ci	^{252}Cf	5.05E-05 Ci
^{244}Pu	1.43E-10 Ci		

(Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-1. Preliminary Hazards Identification Listing for Tank W-5 Inventory

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 4,600 gallons of sludge containing: RCRA metals — Ag, Ba, Be, Cd, Cr, Ni, As, Se, Hg: Highest concentration is Cr at 1.58E+03 mg/kg. Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 5.27E+04 mg/kg. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is PO_4 at 3.65E+03 mg/kg. Organic compounds — Total Organic Compounds (TOC) is 8.47E+02 mg/kg. 2. Approximately 27,964 gallons of supernate containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 6.21E-01 mg/l. Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 4.25E+03 mg/l. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is PO_4^- at 2.27E+03 mg/l. Organic compounds — Total Organic Compounds (TOC) is 7.7E+01 mg/l. Carcinogens — Carbon Tetrachloride — 6.8E-02 mg/l
Flammable materials	Approximately 27,964 gallons of supernate containing: Trichloroethylene — 1.38E-01 mg/l Methylene Chloride — 6.0E-03 mg/l Acetone — 1.9E-02 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac.
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During planned activities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-2. Preliminary Hazards Identification Listing for Tank W-6 Inventory

HAZARD TYPE	DESCRIPTION

Fissionable materials

1. Approximately 11,300 gallons of sludge containing fissionable radionuclide concentrations up to:

^{233}U	– 3.09E+00 Bq/g	^{235}U	– 4.42E+00 Bq/g
^{238}Pu	– 1.64E+03 Bq/g	^{239}Pu	– 9.39E+02 Bq/g
^{240}Pu	– 1.18E+02 Bq/g	^{241}Pu	– 8.20E+02 Bq/g
^{242}Pu	– 1.07E-01 Bq/g	^{244}Cm	– 1.87E+04 Bq/g

2. Approximately 41,479 gallons of supernate containing fissionable radionuclide concentrations up to:

^{233}U	– 8.91E+01 Bq/ml	^{235}U	– 2.91E-01 Bq/ml
^{238}Pu	– 3.58E+00 Bq/ml	^{244}Cm	– 3.27E+01 Bq/ml

3. Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{233}U	– 2.85E-04 Ci	^{235}U	– 4.43E-05 Ci
^{238}Pu	– 2.55E-01 Ci	^{239}Pu	– 9.24E-03 Ci
^{240}Pu	– 1.16E-03 Ci	^{241}Pu	– 1.27E-01 Ci
^{242}Pu	– 1.05E-06 Ci	^{244}Cm	– 2.90E+00 Ci

Radiation source

1. Approximately 11,300 gallons of sludge containing nonfissionable radionuclide concentrations up to:

^{3}H	– 9.20E+00 Bq/g	^{60}Co	– 1.22E+03 Bq/g
^{137}Cs	– 1.63E+05 Bq/g	^{90}Sr	– 8.03E+05 Bq/g
^{252}Cf	– 8.00E+00 Bq/g	^{154}Eu	– 9.99E+02 Bq/g
^{236}U	– 4.23E-01 Bq/g	^{234}U	– 1.40E+02 Bq/g
^{244}Pu	– 2.84E-05 Bq/g	^{238}U	– 1.09E+02 Bq/g
^{228}Th	– 5.35E+00 Bq/g	^{232}Th	– 5.35E+01 Bq/g

(Note: The fissionable radionuclides listed for the sludge are also part of the sludge radiation source inventory)

2. Approximately 41,479 gallons of supernate containing nonfissionable radionuclide concentrations up to:

^{3}H	– 1.55E+01 Bq/ml	^{60}Co	– 4.69E+02 Bq/ml
^{137}Cs	– 4.99E+05 Bq/ml	^{234}U	– 7.94E+00 Bq/ml
^{90}Sr	– 3.01E+03 Bq/ml	^{228}Th	– 3.66E-03 Bq/ml
^{236}U	– 4.18E-02 Bq/ml	^{230}Th	– 8.50E+01 Bq/ml
^{238}U	– 7.21E+00 Bq/ml	^{232}Th	– 3.66E-03 Bq/ml

(Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)

3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{3}H	– 2.12E-03 Ci	^{60}Co	– 2.10E-01 Ci
^{137}Cs	– 4.77E+01 Ci	^{154}Eu	– 1.55E-01 Ci
^{90}Sr	– 1.24E+02 Ci	^{234}U	– 1.40E-03 Ci
^{236}U	– 4.28E-06 Ci	^{228}Th	– 5.30E-05 Ci
^{238}U	– 1.10E-03 Ci	^{230}Th	– 2.45E-04 Ci
^{244}Pu	– 2.79E-10 Ci	^{232}Th	– 5.30E-05 Ci
^{252}Cf	– 7.74E-05 Ci	^{252}Cf	– 7.74E-05 Ci

(Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-2. Preliminary Hazards Identification Listing for Tank W-6 Inventory

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 11,300 gallons of sludge containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Pb 7.32E+03 mg/kg. Process metals — Al, B, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is U at 9.11E+04 mg/kg. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is NO_3^- at 1.23E+04 mg/kg. Organic compounds — Total Organic Compounds (TOC) is 1.17E+04 mg/kg. Carcinogens — Carbon Tetrachloride — 1.0+0 mg/kg, Vinyl Chloride — 1.0E+00 mg/kg, Benzene — 1.0E+00 mg/kg Hexachlorobenzene — 9.0E-01 mg/kg. 2. Approximately 41,479 gallons of supernate containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 5.06E+00 mg/l. Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 6.44E+03 mg/l. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is NO_3^- at 6.26E+03 mg/l. Organic compounds — Total Organic Compounds (TOC) is 5.9E+01 mg/l. Carcinogens — Carbon Tetrachloride — 5.0E-03 mg/l, Vinyl Chloride — 5.0E-03 mg/l, Benzene — 1.0E-02 mg/l.
Flammable materials	1. Approximately 11,300 gallons of sludge containing: Toluene — 1.0E+00 mg/kg Chlorobenzene — 1.0E+00 mg/kg Acetone — 1.0E+01 mg/kg Methanol — 1.0E+01 mg/kg Benzene — 1.0E+01 mg/kg Ethyl Ether — 1.0E+01 mg/kg Vinyl Chloride — 1.0E+00 mg/kg 2 Nitropropane — 1.0E+00 mg/kg Ethyl Benzene — 1.0E+01 mg/kg Trichloroethylene — 1.0E+00 mg/kg Methylene Chloride — 1.0E+00 mg/kg Methyl Ethyl Ketone — 1.0E+01 mg/kg n-Butyl Alcohol — 1.6E+01 mg/kg Cyclohexane — 1.0E+00 mg/kg 1,1 Dichloroethylene — 1.0E+00 mg/kg Pyridine — 1.0E+01 mg/kg Isobutanol — 1.0E+01 mg/kg Carbon Disulfide — 1.0E+00 mg/kg 2. Approximately 41,479 gallons of supernate containing: Toluene — 1.0E-02 mg/l Chlorobenzene — 5.0E-03 mg/l Acetone — 1.11E-01 mg/l Benzene — 1.0E-02 mg/l Propyl Alcohol — 3.0E+00 mg/l Trichloroethylene — 8.2E-02 mg/l Methylene Chloride — 9.0E-03 mg/l Methyl Ethyl Ketone — 7.5E-02 mg/l Cyclohexane — 5.0E-03 mg/l Methyl Isobutyl Ketone — 9.1E-02 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac throughout the STF.
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During plannedactivities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.

Table A-2. Preliminary Hazards Identification Listing for Tank W-6 Inventory

HAZARD TYPE	DESCRIPTION
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-3. Preliminary Hazards Identification Listing for Tank W-7 Inventory

HAZARD TYPE	DESCRIPTION
Fissionable materials	1. Approximately 9,800 gallons of sludge containing fissionable radionuclide concentrations up to: ^{233}U — 2.70E+02 Bq/g; ^{235}U — 4.32E+01 Bq/g ^{238}Pu — 2.27E+03 Bq/g; ^{239}Pu — 7.78E+02 Bq/g ^{240}Pu — 1.43E+02 Bq/g; ^{241}Pu — 3.08E+03 Bq/g ^{242}Pu — 3.30E-01 Bq/g; ^{241}Am — 5.70E+02 Bq/g ^{244}Cm — 1.35E+04 Bq/g
	2. Approximately 3,565 gallons of supernate containing fissionable radionuclide concentrations up to: ^{244}Cm — 4.00E-01 Bq/ml
	3. Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process: ^{233}U — 2.48E-03 Ci; ^{235}U — 3.97E-04 Ci ^{238}Pu — 3.28E-01 Ci; ^{239}Pu — 7.16E-03 Ci ^{240}Pu — 1.31E-03 Ci; ^{241}Pu — 4.47E-01 Ci ^{242}Pu — 3.03E-06 Ci; ^{241}Am — 5.80E-03 Ci ^{244}Cm — 1.96E+00 Ci
Radiation source	1. Approximately 9800 gallons of sludge containing nonfissionable radionuclide concentrations up to: ^{3}H — 1.14E+02 Bq/g; ^{60}Co — 4.30E+03 Bq/g ^{134}Cs — 1.00E+02 Bq/g; ^{137}Cs — 1.93E+06 Bq/g ^{152}Eu — 1.60E+03 Bq/g; ^{154}Eu — 1.18E+03 Bq/g ^{90}Sr — 8.70E+05 Bq/g; ^{234}U — 1.07E+03 Bq/g ^{236}U — 1.01E+00 Bq/g; ^{238}U — 1.05E+03 Bq/g ^{244}Pu — 3.40E-04 Bq/g; ^{232}Th — 2.09E+01 Bq/g ^{228}Th — 2.09E+01 Bq/g (Note: The fissionable radionuclides listed for the sludge are also part of the sludge radiation source inventory)
	2. Approximately 3,565 gallons of supernate containing nonfissionable radionuclide concentrations up to: ^{3}H — 1.90E+01 Bq/ml; ^{60}Co — 2.90E+02 Bq/ml ^{137}Cs — 6.40E+05 Bq/ml; ^{90}Sr — 6.00E+02 Bq/ml ^{228}Th — 8.50E+01 Bq/ml; ^{232}Th — 8.50E+01 Bq/ml (Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)
	3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process: ^{3}H — 1.78E-02 Ci; ^{60}Co — 6.43E-01 Ci ^{134}Cs — 1.45E-02 Ci; ^{137}Cs — 3.23E+02 Ci ^{152}Eu — 2.32E-01 Ci; ^{154}Eu — 1.71E-01 Ci ^{90}Sr — 1.26E+02 Ci; ^{234}U — 9.88E-03 Ci ^{236}U — 9.30E-06 Ci; ^{238}U — 9.62E-03 Ci ^{228}Th — 5.66E-04 Ci; ^{232}Th — 5.66E-04 Ci ^{244}Pu — 3.13E-09 Ci; ^{252}Cf — 1.12E-04 Ci (Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-3. Preliminary Hazards Identification Listing for Tank W-7

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 9,800 gallons of sludge containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 3.37E+02 mg/kg. Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is U at 1.95E+05 mg/kg. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is NO_3^- at 3.85E+04 mg/kg. Organic compounds — Total Organic Compounds (TOC) is 1.74E+03 mg/kg. Carcinogens — Carbon Tetrachloride — 1.0E+00 mg/kg, Vinyl Chloride — 1.0E+00 mg/kg, Benzene — 1.0E+00 mg/kg Hexachlorobenzene — 6.0E-01 mg/kg 2. Approximately 3,565 gallons of supernate containing: Carcinogens — Carbon Tetrachloride — 1.088E+00 mg/kg
Flammable materials	1. Approximately 9,800 gallons of sludge containing: Toluene — 1.0E+00 mg/kg Chlorobenzene — 1.0E+00 mg/kg Acetone — 1.0E+01 mg/kg Methanol — 1.0E+01 mg/kg Benzene — 1.0E+00 mg/kg Ethyl Ether — 1.0E+01 mg/kg 1,2 Dichlorobenzene — 1.0E+00 mg/kg Cyclohexane — 1.0E+00 mg/kg Ethyl benzene — 1.0E+00 mg/kg Trichloroethylene — 1.0E+00 mg/kg Methylene Chloride — 1.0E+00 mg/kg Methyl Ethyl Ketone — 1.0E+01 mg/kg n-Butyl Alcohol — 1.0E+01 mg/kg Ethyl alcohol — 1.0E+01 mg/kg 1,1 Dichloroethylene — 1.0E+00 mg/kg 2-Nitropropane — 1.0E+00 mg/kg Pyridine — 1.0E+01 mg/kg 2. Approximately 3,565 gallons of supernate containing: Toluene — 1.4E-02 mg/l Acetone — 3.1E-02 mg/l Methyl Isobutyl Ketone — 7.0E-03 mg/l Methylene Chloride — 7.0E-03 mg/l Methanol — 1.4E+01 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac throughout
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During planned activities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-4. Preliminary Hazards Identification Listing for Tank W-8 Inventory

HAZARD TYPE	DESCRIPTION
Fissionable materials	1. Approximately 10,300 gallons of sludge containing fissionable radionuclide concentrations up to:

^{233}U	—	7.20E+02 Bq/g	^{235}U	—	2.79E+00 Bq/g
^{238}Pu	—	4.62E+03 Bq/g	^{239}Pu	—	3.61E+03 Bq/g
^{240}Pu	—	7.60E+02 Bq/g	^{241}Pu	—	7.64E+03 Bq/g
^{242}Pu	—	6.96E-01 Bq/g	^{241}Am	—	5.02E+03 Bq/g
^{244}Cm	—	1.98E+04 Bq/g			

2. Approximately 64,581 gallons of supernate containing fissionable radionuclide concentrations up to:

^{233}U	—	1.15E+02 Bq/ml	^{235}U	—	3.72E-01 Bq/ml
^{238}Pu	—	4.60E+00 Bq/ml	^{244}Cm	—	3.87E+01 Bq/ml

3. Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{233}U	—	8.41E-03 Ci	^{235}U	—	3.25E-05 Ci
^{238}Pu	—	8.33E-01 Ci	^{239}Pu	—	4.13E-02 Ci
^{240}Pu	—	8.70E-03 Ci	^{241}Pu	—	1.38E+00 Ci
^{242}Pu	—	7.96E-06 Ci	^{241}Am	—	6.35E-02 Ci
^{244}Cm	—	3.57E+00 Ci			

HAZARD TYPE	DESCRIPTION
Radiation source	1. Approximately 10,300 gallons of sludge containing nonfissionable radionuclide concentrations up to:

^{90}Sr	—	2.75E+06 Bq/g	^{60}Co	—	4.10E+03 Bq/g
^{137}Cs	—	6.84E+05 Bq/g	^{152}Eu	—	2.18E+03 Bq/g
^{252}Cf	—	4.00E+00 Bq/g	^{154}Eu	—	2.29E+03 Bq/g
^{236}U	—	1.04E+00 Bq/g	^{234}U	—	1.06E+02 Bq/g
^{244}Pu	—	1.87E-04 Bq/g	^{238}U	—	7.20E+01 Bq/g
^{228}Th	—	6.64E+01 Bq/g	^{232}Th	—	6.64E+01 Bq/g

(Note: The fissionable radionuclides listed for the sludge are also part of the sludge radiation source inventory)

2. Approximately 64,581 gallons of supernate containing nonfissionable radionuclide concentrations up to:

^{3}H	—	8.67E+00 Bq/ml	^{60}Co	—	5.05E+02 Bq/ml
^{137}Cs	—	3.73E+05 Bq/ml	^{90}Sr	—	6.19E+02 Bq/ml
^{234}U	—	1.01E+01 Bq/ml	^{236}U	—	5.34E-02 Bq/ml
^{238}U	—	9.21E+00 Bq/ml	^{228}Th	—	3.28E-03 Bq/ml
			^{232}Th	—	3.28E-03 Bq/ml

(Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)

3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{3}H	—	2.01E-04 Ci	^{60}Co	—	7.51E-01 Ci
^{137}Cs	—	1.32E+02 Ci	^{152}Eu	—	3.93E-01 Ci
^{90}Sr	—	4.96E+02 Ci	^{154}Eu	—	4.13E-01 Ci
^{236}U	—	1.20E-05 Ci	^{234}U	—	1.23E-03 Ci
^{238}U	—	8.38E-04 Ci	^{228}Th	—	7.66E-04 Ci
^{244}Pu	—	2.14E-09 Ci	^{232}Th	—	7.66E-04 Ci
			^{252}Cf	—	4.51E-05 Ci

(Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-4. Preliminary Hazards Identification Listing for Tank W-8

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 10,300 gallons of sludge containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Pb at 1.52E+03 mg/kg. Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Th at 1.64E+04 mg/kg. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4: Highest concentration is SO_4^- at 4.30E+03 mg/kg. Organic compounds — Total Organic Compounds (TOC) is 8.40E+03 mg/kg. Carcinogens — Hexachlorobene — 9.0E-01 mg/kg, Vinyl chloride — 1.0E+00 mg/kg, Benzene — 1.0E+00 mg/kg, Carbon Tetrachloride — 1.0E+00 mg/kg, 2. Approximately 64,581 gallons of supernate containing: RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 7.60E+00 mg/l. Process metals — Al, B, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 4.370E+03 mg/l. Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4: Highest concentration is NO_3^- at 2.50E+03 mg/l. Carcinogens — Benzene 6.0E-03 mg/l, Vinyl chloride — 5.0E-03 mg/l, Carbon Tetrachloride — 5.0E-03 mg/l. Organic compounds — Total Organic Compounds (TOC) is 1.07E+02 mg/l.
Flammable materials	1. Approximately 10,300 gallons of sludge containing: Toluene — 1.0E+00 mg/kg Chlorobenzene—1.0E+00 mg/kg Methylene Chloride —1.0E+00 mg/kg Methyl Ethyl Ketone - 1.0E+01 mg/kg n-Butyl Alcohol — 1.0E+01 mg/kg Cyclohexane — 1.0E+00 mg/kg Ethyl Ether — 1.0E+01 mg/kg 1,1 Dichloroethylene - 1.1E+00 mg/kg Isobutanol — 1.0E+01 mg/kg 1,2 Dichloroethane — 1.0E+00 mg/kg Trichloroethylene — 1.0E+00 mg/kg Pyridine — 1.0E+01 mg/kg Methanol — 1.0E+01 mg/kg Acetone — 1.0E+01 mg/kg Benzene — 1.0E+00 mg/kg Ethyl Alcohol — 1.0E+01 mg/kg Vinyl Chloride — 1.0E+00 mg/kg Carbon disulfide — 1.0E+00 mg/kg Ethylbenzene — 1.0E+00 mg/kg 2 Nitropropane — 1.0E+00 mg/kg

Table A-4. Preliminary Hazards Identification Listing for Tank W-8

HAZARD TYPE	DESCRIPTION
	2. Approximately 64,581 gallons of supernate containing: Toluene — 5.0E - 03 mg/l Chlorobenzene — 5.0E - 03 mg/l Methanol — 1.0E+00 mg/l Methyl Ethyl Ketone — 1.0E+00 mg/l n-Butyl Alcohol — 2.0E+00 mg/l Vinyl Chloride — 5.0E - 03 mg/l Methyl isobutyl ketone — 1.5E - 02 mg/l Methyl-n-butyl ketone — 4.1E - 02 mg/l 1,2 Dichloroethylene — 5.0E - 03 mg/l Trichloroethylene — 5.0E - 03 mg/l Methylene Chloride — 1.2E - 02 mg/l Acetone — 3.0E+00 mg/l Benzene — 6.0E - 03 mg/l Cyclohexane — 5.0E - 03 mg/l 2 Nitropropane — 5.0E - 03 mg/l Ethylbenzene — 5.0E - 03 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac throughout
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During planned activities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-5. Preliminary Hazards Identification Listing for Tank W-9 Inventory

HAZARD TYPE	DESCRIPTION

Fissionable materials

1. Approximately 9,200 gallons of sludge containing fissionable radionuclide concentrations up to:

^{233}U	7.83E+02 Bq/g	^{235}U	8.39E+00 Bq/g
^{238}Pu	1.56E+04 Bq/g	^{239}Pu	5.20E+03 Bq/g
^{240}Pu	1.09E+03 Bq/g	^{241}Pu	1.11E+04 Bq/g
^{242}Pu	4.00E+00 Bq/g	^{241}Am	6.78E+03 Bq/g
^{244}Cm	5.55E+04 Bq/g	^{237}Np	5.20E+01 Bq/g

2. Approximately 45,616 gallons of supernate containing fissionable radionuclide concentrations up to:

^{233}U	1.06E+01 Bq/ml	^{235}U	7.37E-01 Bq/ml
^{244}Cm	8.57E+00 Bq/ml	^{238}Pu	1.20E-01 Bq/ml

3. Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{233}U	6.67E-03 Ci	^{235}U	7.41E-05 Ci
^{238}Pu	2.08E+00 Ci	^{239}Pu	4.39E-02 Ci
^{240}Pu	9.20E-03 Ci	^{241}Pu	1.48E+00 Ci
^{242}Pu	3.38E-05 Ci	^{237}Np	4.40E-04 Ci

Radiation source

1. Approximately 9,200 gallons of sludge containing nonfissionable radionuclide concentrations up to:

^{60}Co	7.01E+03 Bq/g	^{134}Cs	2.00E+01 Bq/g
^{137}Cs	3.57E+05 Bq/g	^{152}Eu	3.73E+03 Bq/g
^{154}Eu	5.10E+03 Bq/g	^{155}Eu	5.20E+01 Bq/g
^{90}Sr	2.09E+06 Bq/g	^{234}U	3.94E+02 Bq/g
^{236}U	4.03E+00 Bq/g	^{238}U	2.33E+02 Bq/g
^{244}Pu	2.27E-04 Bq/g	^{228}Th	2.54E+01 Bq/g
^{228}Th	2.54E+01 Bq/g		

(Note: The fissionable radionuclides listed for the sludge are also part of the sludge

2. Approximately 45,616 gallons of supernate containing nonfissionable radionuclide concentrations up to:

^{3}H	1.00E+01 Bq/ml	^{60}Co	9.53E+01 Bq/ml
^{134}Cs	8.50E+01 Bq/ml	^{137}Cs	5.71E+04 Bq/ml
^{90}Sr	3.43E+02 Bq/ml	^{234}U	1.79E+01 Bq/ml
^{236}U	3.63E-02 Bq/ml	^{238}U	1.88E+01 Bq/ml
^{228}Th	6.32E-03 Bq/ml	^{232}Th	6.32E-03 Bq/ml

(Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)

Table A-5. Preliminary Hazards Identification Listing for Tank W-9 Inventory

HAZARD TYPE	DESCRIPTION
Radiation Source (continued)	3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{3}H	—	6.86E-04 Ci	^{60}Co	—	9.40E-01 Ci
^{134}Cs	—	8.49E-03 Ci	^{137}Cs	—	5.14E+01 Ci
^{152}Eu	—	4.96E-01 Ci	^{154}Eu	—	6.79E-01 Ci
^{155}Eu	—	6.92E-03 Ci	^{90}Sr	—	2.79E+02 Ci
^{234}U	—	3.40E-03 Ci	^{236}U	—	3.42E-05 Ci
^{238}U	—	2.05E-03 Ci	^{228}Th	—	2.16E-04 Ci
^{232}Th	—	2.16E-04 Ci	^{244}Pu	—	1.92E-09 Ci

(Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-5. Preliminary Hazards Identification Listing for Tank W-9

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 9,200 gallons of sludge containing:
	RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Pb at 5.13E+02 mg/kg.
	Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is U at 3.16E+04 mg/kg.
	Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is PO_4^- at 3.66E+03 mg/kg.
	Organic compounds — Total Organic Compounds (TOC) is 2.93E+03 mg/kg.
	Carcinogens — Hexachlorobenzene — 9.0E-01 mg/kg, Benzene — 1.0E+00 mg/kg, Vinyl chloride — 1.0E+00 mg/kg, Carbon Tetrachloride — 1.0E+00 mg/kg.
	2. Approximately 45,616 gallons of supernate containing:
	RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 4.84E+00 mg/l.
	Process metals — Al, B, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 2.64E+03 mg/l.
	Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4: Highest concentration is PO_4^- at 1.31E+00 mg/l.
	Organic compounds — Total Organic Compounds (TOC) is 8.9E+01 mg/l.
	Carcinogens — Carbon Tetrachloride — 5.0E-03 mg/l, Benzene — 5.0E-03 mg/l, Vinyl chloride — 5.0E-03 mg/l
Flammable materials	1. Approximately 9,200 gallons of sludge containing:
	Toluene — 1.0E+00 mg/kg Trichloroethylene — 1.0E+00 mg/kg Chlorobenzene — 1.0E+00 mg/kg Methylene Chloride — 1.0E+00 mg/kg Acetone — 1.0E+01 mg/kg Methyl Ethyl Ketone - 1.0E+01 mg/kg Methanol — 1.0E+01 mg/kg n-Butyl Alcohol — 1.0E+01 mg/kg Benzene — 1.0E+00 mg/kg Cyclohexane — 1.0E+00 mg/kg Ethyl Ether — 1.0E+01 mg/kg Ethylbenzene — 1.0E+00 Isobutanol — 1.0E+01 mg/kg 1,2 Dichloroethene — 1.0E+00 mg/kg 1,1 Dichloroethylene — 1.4E+00 mg/kg 2 Nitropropane — 1.0E+00 mg/kg Carbon Disulfide — 1.0E+00 mg/kg Pyridine — 1.0E+01 mg/kg Vinyl chloride — 1.0E+00 mg/kg
	2. Approximately 45,616 gallons of supernate containing:
	Toluene — 9.0E-03 mg/l Trichloroethylene — 5.0E-03 mg/l Chlorobenzene — 5.0E-03 mg/l Methylene Chloride — 1.3E-02 mg/l Cyclohexane — 5.0E-03 mg/l Acetone — 7.0E-02 mg/l Benzene — 5.0E-03 mg/l 1,2 Dichloroethylene — 5.0E-03 mg/l Vinyl Chloride — 5.0E-03 mg/l 2 Nitropropane — 5.0E-03 mg/l Methyl Isobutyl Ketone — 1.1E-02 mg/l Ethyl benzene — 5.0E-03 mg/l Carbon disulfide — 5.0E-03 mg/l 1,1 Dichloroethylene — 5.0E-03 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate

Table A-5. Preliminary Hazards Identification Listing for Tank W-9

HAZARD TYPE	DESCRIPTION
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac throughout the STF.
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During planned activities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-6. Preliminary Hazards Identification Listing for Tank W-10 Inventory

HAZARD TYPE		DESCRIPTION
Fissionable materials	1.	Approximately 24,400 gallons of sludge containing fissionable radionuclide concentrations up to: ^{233}U — 1.15E+03 Bq/g; ^{235}U — 7.73E+00 Bq/g ^{238}Pu — 9.87E+03 Bq/g; ^{239}Pu — 3.90E+03 Bq/g ^{240}Pu — 1.13E+03 Bq/g; ^{241}Pu — 9.94E+03 Bq/g ^{242}Pu — 2.70E+00 Bq/g; ^{241}Am — 5.03E+03 Bq/g ^{244}Cm — 4.80E+04 Bq/g
	2.	Approximately 105,860 gallons of supernate containing fissionable radionuclide concentrations up to: ^{233}U — 5.76E+00 Bq/ml; ^{235}U — 3.58E-02 Bq/ml ^{238}Pu — 4.20E-01 Bq/ml
	3.	Inventory of fissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process: ^{233}U — 9.62E-03 Ci; ^{235}U — 6.45E-05 Ci ^{238}Pu — 1.29E+00 Ci; ^{239}Pu — 3.24E-02 Ci ^{240}Pu — 9.39E-03 Ci; ^{241}Pu — 1.30E+00 Ci ^{242}Pu — 2.25E-05 Ci; ^{241}Am — 4.63E-02 Ci
Radiation source	1.	Approximately 24,400 gallons of sludge containing nonfissionable radionuclide concentrations up to: ^{3}H — 1.18E+02 Bq/g; ^{60}Co — 1.11E+04 Bq/g ^{134}Cs — 1.40E+03 Bq/g; ^{137}Cs — 8.73E+06 Bq/g ^{152}Eu — 4.38E+03 Bq/g; ^{154}Eu — 7.08E+03 Bq/g ^{90}Sr — 7.16E+06 Bq/g; ^{234}U — 3.79E+02 Bq/g ^{236}U — 4.01E+00 Bq/g; ^{238}U — 2.18E+02 Bq/g ^{244}Pu — 4.87E-04 Bq/g; ^{228}Th — 4.21E+01 Bq/g ^{232}Th — 4.21E+01 Bq/g (Note: The fissionable radionuclides listed for the sludge are also part of the sludge
	2.	Approximately 105,860 gallons of supernate containing nonfissionable radionuclide concentrations up to: ^{3}H — 1.20E+02 Bq/ml; ^{60}Co — 1.21E+02 Bq/ml ^{137}Cs — 1.99E+05 Bq/ml; ^{90}Sr — 1.05E+03 Bq/ml ^{234}U — 9.24E-01 Bq/ml; ^{236}U — 6.75E-03 Bq/ml ^{238}U — 9.70E-01 Bq/ml; ^{228}Th — 2.03E-04 Bq/ml ^{232}Th — 2.03E-04 Bq/ml (Note: The fissionable radionuclides listed for the supernate are also part of the supernate radiation source inventory)

Table A-6. Preliminary Hazards Identification Listing for Tank W-10 Inventory

HAZARD TYPE	DESCRIPTION
Radiation Source (continued)	3. Inventory of nonfissionable radionuclides in approximately 230 ft^3 of Gunite removed from the tank wall and floor by scarification process:

^{3}H	—	2.37E-02 Ci	^{60}Co	—	1.46E+00 Ci
^{134}Cs	—	1.83E-01 Ci	^{137}Cs	—	1.16E+03 Ci
^{152}Eu	—	5.74E-01 Ci	^{154}Eu	—	9.28E-01 Ci
^{90}Sr	—	9.38E+02 Ci	^{234}U	—	3.16E-03 Ci
^{236}U	—	3.34E-05 Ci	^{238}U	—	1.82E-03 Ci
^{228}Th	—	3.53E-04 Ci	^{232}Th	—	3.53E-04 Ci
^{244}Pu	—	4.05E-09 Ci			

(Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory)

Table A-6. Preliminary Hazards Identification Listing for Tank W-10

HAZARD TYPE	DESCRIPTION
Toxic/Corrosive/Reactive materials	1. Approximately 24,400 gallons of sludge containing:
	RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Pb at 9.20E+02 mg/kg.
	Process metals — Al, B, Be, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Al at 3.40E+04 mg/kg.
	Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is NO_3^-, at 6.27E+03 mg/kg.
	Organic compounds — Total Organic Compounds (TOC) is 4.90E+03 mg/kg.
	Carcinogens — Hexachlorobenzene — 9.0E-01 mg/kg, Benzene — 1.0E+00 mg/kg, Vinyl Chloride — 1.0E+00 mg/kg, Carbon Tetrachloride — 1.0E+00 mg/kg.
	2. Approximately 105,860 gallons of supernate containing:
	RCRA metals — Ag, As, Ba, Cd, Cr, Ni, Pb, Se, Hg, Ti: Highest concentration is Cr at 3.86E+00 mg/l.
	Process metals — Al, B, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Sb, Si, Sr, Th, U, V, Zn: Highest concentration is Na at 2.80E+03 mg/l.
	Anions — Br^-, Cl^-, F^-, NO_3^-, PO_4^-, SO_4^-: Highest concentration is NO_3^- at 4.14E+03 mg/l.
	Organic compounds — Total Organic Compounds (TOC)is 2.0E+00 mg/l.
	Carcinogens — Benzene — 3.8E-02 mg/l, Vinyl Chloride — 5.0E-03 mg/l, Carbon Tetrachloride — 5.0E-03 mg/l.
Flammable materials	1. Approximately 24,400 gallons of sludge containing:
	Toluene — 1.0E+00 mg/kg Chlorobenzene — 1.0E+00 mg/kg Methanol — 1.0E+01 mg/kg Acetone — 1.0E+01 mg/kg Isobutanol — 1.0E+01 mg/kg n-Butyl Alcohol — 1.0E+01 mg/kg Benzene — 1.0E+00 mg/kg Cyclohexane — 1.0E+00 mg/kg Ethyl Ether — 1.0E+01 mg/kg 1,1 Dichloroethylene — 2.1E+00 mg/kg Carbon Disulfide — 1.0E+00 mg/kg 1,2 Dichloroethane 1.0E+00 mg/kg Trichloroethylene — 1.0E+00 mg/kg Methylene Chloride — 1.0E+00 mg/kg Methyl Ethyl Ketone - 1.0E+01 mg/kg Pyridine — 1.0E+01 mg/kg Ethylbenzene — 1.0E+00 mg/kg Nitropropane — 1.0E+00 mg/kg Vinyl Choloride — 1.0E+00 mg/kg

Table A-6. Preliminary Hazards Identification Listing for Tank W-10

HAZARD TYPE	DESCRIPTION
	2. Approximately 105,860 gallons of supernate containing: Toluene — 2.6E - 02 mg/l Chlorobenzene — 5.0E - 03 mg/l Acetone — 3.0E+00 mg/l Methanol — 4.1E+01 mg/l Benzene — 3.8E - 02 mg/l Ethyl Ether — 1.0E+01 mg/l Ethanol — 1.0E+00 mg/l Methyl Isobutyl Ketone — 2.3E - 02 mg/l Vinyl chloride — 5.0E - 03 mg/l 2 Nitropropane — 5.0E - 03 mg/l Carbon disulfide — 5.0E - 03 mg/l Trichloroethylene — 8.1E - 02 mg/l Methylene Chloride — 1.9E - 02 mg/l Methyl Ethyl Ketone — 1.0E+01 mg/l n-Butyl Alcohol — 1.0E+00 mg/l Cyclohexane — 5.0E - 03 mg/l Ethyl Alcohol — 1.0E+00 mg/l Ethybenzene — 5.0E - 03 mg/l Isobutanol — 1.0E+01 mg/l 1,1 Dichloroethylene — 3.1E - 02 mg/l 1,2 Dichloroethane — 5.0E - 03 mg/l
Explosive/Pyrophoric Materials	Hydrogen gas continuously generated by radiolysis of sludge and supernate
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac throughout
Thermal energy source	1. Small amount of heat generated from radioactive decay of radiation sources in the supernate, sludge, and tank walls and floor. 2. During planned activities, welding units or torches may be used for repair work or instrumentation installation activities.
Kinetic energy source	Cranes or hoists may be used to install or suspend within a tank a pump for planned tank pump-out campaigns, suspend test equipment, or suspend replacement equipment.
Potential energy source	Crane or lift truck payloads in suspended or elevated lift positions. Elevated tank service equipment on work platforms built over tanks during planned pump-out activities.
Lasers	Lasers may be used for tank testing and inspections.
Accelerators	N/A
X-ray machines	N/A

Table A-7. Preliminary Hazards Identification Listing for Combined Inventory in Tank W-8 and/or W-9

HAZARD TYPE	DESCRIPTION
Fissionable materials	1. Approximately 81,200 gallons of sludge containing up to the following quantities of fissionable radionuclides: ^{233}U — 6.84E+00 Ci; ^{235}U — 2.16E-01 Ci ^{238}Pu — 6,10E+01 Ci; ^{239}Pu — 3.38E+01 Ci ^{240}Pu — 7.11E+00 Ci; ^{241}Pu — 6.80E+01 Ci ^{242}Pu — 1.48E-02 Ci; ^{241}Am — 3.17E+01 Ci ^{244}Cm — 2.82E+02 Ci; ^{237}Np — NC
	2. Approximately 334,507* gallons of supernate containing up to the following quantities of fissionable radionuclides: ^{233}U — 1.29E+00 Ci; ^{235}U — 9.67E-03 Ci ^{238}Pu — 5.25E-02 Ci; ^{244}Cm — 4.42E-01 Ci
	3. Inventory of fissionable radionuclides in approximately 1540 ft^3 of Gunite removed from the tank wall and floor by scarification process: ^{233}U — 3.09E-02 Ci; ^{235}U — 9.29E-04 Ci ^{238}Pu — 5.02E+00 Ci; ^{239}Pu — 1.62E-01 Ci ^{240}Pu — 3.57E-02 Ci; ^{241}Pu — 4.82E+00 Ci ^{242}Pu — 1.08E-02 Ci; ^{241}Am — 1.83E-01 Ci
Radiation source	1. Approximately 81,200 gallons of sludge containing up to the following quantities of nonfissionable radionuclides: ^{3}H — 5.39E-01 Ci; ^{60}Co — 5.51E+01 Ci ^{134}Cs — 4.46E+00 Ci; ^{137}Cs — 3.12E+04 Ci ^{152}Eu — 2.27E+01 Ci; ^{154}Eu — 3.36E+01 Ci ^{155}Eu — 6.12E-02 Ci; ^{90}Sr — 3.07E+04 Ci ^{234}U — 6.30E+00 Ci; ^{236}U — 2.66E - 02 Ci ^{238}U — 5.39E+00 Ci; ^{244}Pu — 2.50E-06 Ci ^{228}Th — 3.16E-01 Ci; ^{230}Th — 6.88E-02 Ci ^{232}Th — 3.16E-01 Ci; ^{252}Cf — 4.05E-02 Ci
	2. Approximately 334,507* gallons of supernate containing up to the following quantities of nonfissionable radionuclides: ^{3}H — 1.51E+00 Ci; ^{60}Co — 8.09E+00 Ci ^{134}Cs — 4.01E-01 Ci; ^{137}Cs — 7.42E+03 Ci ^{90}Sr — 3.99E+01 Ci; ^{234}U — 2.50E-01 Ci ^{236}U — 1.05E-03 Ci; ^{238}U — 2.46E-01 Ci ^{228}Th — 3.16E-02 Ci; ^{230}Th — 3.68E-01 Ci ^{232}Th — 3.16E-02 Ci

Table A-7. Preliminary Hazards Identification Listing for Combined Inventory in Tank W-8 and/or W-9

HAZARD TYPE	DESCRIPTION
Radiation Source (continued)	3. Inventory of nonfissionable radionuclides in approximately 1540 ft^3 of Gunite removed from the tank wall and floor by scarification process: ^{3}H — 4.71E-02 Ci; ^{60}Co — 4.06E+00 Ci ^{134}Cs — 2.06E-01 Ci; ^{137}Cs — 1.73E+03 Ci ^{152}Eu — 1.69E+00 Ci; ^{154}Eu — 2.35E+00 Ci ^{155}Eu — 6.92E-03 Ci; ^{90}Sr — 2.00E+03 Ci ^{234}U — 2.72E-02 Ci; ^{236}U — 1.13E-04 Ci ^{238}U — 2.32E-02 Ci; ^{228}Th — 2.45E-03 Ci ^{230}Th — 1.87E-03 Ci; ^{232}Th — 2.45E-03 Ci ^{244}Pu — 1.17E-08 Ci; ^{252}Cf — 3.00E-04 Ci (Note: The fissionable radionuclides listed for the gunite are also part of the gunite radiation source inventory) (Note: Radioactive material inventory includes inventory from Tanks W-3 and W-4 that will be transferred from the NTF to the STF before or during the STF Remediation Project.) * Supernate will be transferred from each tank to Tank W-8 or W-9 to achieve and maintain a liquid level in the tank sufficiently low to facilitate the remediation activities. As supernate accumulates in Tank W-8 or W-9, some will be periodically transferred to the LLLW system in batch operations to maintain the level in the tank below the administrative limit and to work off STF inventory when the LLLW System can accept additional material.

Table A-8 Preliminary Hazards Identification Listing for Support Systems

HAZARD TYPE		DESCRIPTION
Fissionable materials	1.	Process Water Supply System — Small quantities of contamination on in-tank equipment including the CSEE.
	2.	Compressed Air Supply System — None Identified
	3.	Electrical Supply System — None Identified
	4.	Ventilation System — Exhaust air from tanks results in contamination of system ductwork and filters for Tanks W-5 through W-10. (See Tables A.1 through A.7 for fissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
	5.	Instrument Air Supply System — None Identified
Radiation source	1.	Process Water Supply System — Small quantities of contamination on in-tank equipment including the CSEE.
	2.	Compressed Air Supply System — None Identified
	3.	Electrical Supply System — None Identified
	4.	Ventilation System — Exhaust air from tanks results in contamination of system ductwork and filters for Tanks W-5 through W-10. (See Tables A.1 through A.7 for nonfissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
	5.	Instrument Air Supply System — None Identified
Toxic/Corrosive/Reactive materials	1.	Process Water Supply System — Small quantities of contamination on in-tank equipment including the CSEE.
	2.	Compressed Air Supply System — None Identified
	3.	Electrical Supply System — None Identified
	4.	Ventilation System — Exhaust air from tanks results in contamination of system ductwork and filters for Tanks W-5 through W-10. (See Tables A.1 through A.7 for hazardous material concentrations in supernate, sludge, and scarified Gunite.)
	5.	Instrument Air Supply System — None Identified

Table A-8 Preliminary Hazards Identification Listing for Support Systems

HAZARD TYPE	DESCRIPTION
Flammable materials	1. Process Water Supply System — None Identified 2. Compressed Air Supply System — None Identified 3. Electrical Supply System — None Identified 4. Ventilation System — None Identified 5. Instrument Air Supply System — None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Electrical power supply — 120 Vac, 240 Vac, and 3-phase 480 Vac
Thermal energy source	None Identified
Kinetic energy source	Pumps for CSEE high pressure water supply system.
Potential energy source	1. Process Water Supply System — 100 psig pressure to feed tank 7000 psig pressure to CSEE 2. Compressed Air Supply System — 175 psig pressure 3. Electrical Supply System — None Identified 4. Ventilation System — 2 in. H_2O vacuum pressure 5. Instrument Air Supply System — 100 psig pressure
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-9. Preliminary Hazards Identification Listing for the WD&C System

HAZARD TYPE	DESCRIPTION
Fissionable materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for fissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Radiation source	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for nonfissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Toxic/Corrosive/Reactive materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for hazardous material concentrations in supernate, sludge, and scarified Gunite.)
Flammable materials	None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase 480 Vac.
Thermal energy source	None Identified
Kinetic energy source	Movement of in-tank equipment and suspended loads.
Potential energy source	Weight of suspended equipment load
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-10. Preliminary Hazards Identification Listing for the MLDUA System

HAZARD TYPE	DESCRIPTION
Fissionable materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for fissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Radiation source	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for nonfissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Toxic/Corrosive/Reactive materials	1. Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A7. for hazardous material concentrations in supernate, sludge, and scarified Gunite.) 2. Hydraulic oil for MLDUA operation 3. Freon-22 used in oil cooler.
Flammable materials	None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-phase Vac.
Thermal energy source	None Identified
Kinetic energy source	1. Pumps provide a soure of rotational energy. 2. Remote arm when in operation.
Potential energy source	1. Pressurized hydraulic fluids for MLDUA operations. 2. MLDUA containment structure in the raised position. 4. Remote arm when raised and in service.
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-11. Preliminary Hazards Identification Listing for Decontamination Spray Ring

HAZARD TYPE	DESCRIPTION
Fissionable materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for fissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Radiation source	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for nonfissionable radioactive material concentrations in supernate, sludge, and scarified Gunite.)
Toxic/Corrosive/Reactive materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on in-tank equipment for Tanks W-5 through W-10. (See Tables A.1 through A.7 for hazardous material concentrations in supernate, sludge, and scarified Gunite.)
Flammable materials	None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Standard electrical circuits of 120 Vac, 240 Vac, and 3-Phase 480 Vac.
Thermal energy source	None Identified
Kinetic energy source	High pressure water spray (2,050 psig)
Potential energy source	1) Weight of suspended equipment load 2) High pressure water supply (2,050 psig)
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-12. Preliminary Hazards Identification Listing for the Decontamination Tent

HAZARD TYPE	DESCRIPTION
Fissionable materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on equipment removed from Tanks W-5 through W-10. (See Tables A.1 through A.7 for fissionable material concentrations in supernate, sludge, and scarified Gunite.)
Radiation source	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on equipment removed from Tanks W-5 through W-10. (See Tables A.1 through A.7 for nonfissionable material concentrations in supernate, sludge, and scarified Gunite.)
Toxic/Corrosive/Reactive materials	Equipment will be rinsed by Decontamination Spray Ring System prior to removal from the tank. Contamination on equipment removed from Tanks W-5 through W-10. (See Tables A.1 through A.7 for hazardous material concentrations in supernate, sludge, and scarified Gunite.)
Flammable materials	None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Up to 480 volts to operate lights and equipment.
Thermal energy source	None Identified
Kinetic energy source	None Identified
Potential energy source	None Identified
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-13. Preliminary Hazards Identification Listing for the Scarifier System

HAZARD TYPE	DESCRIPTION
Fissionable materials	Small quantities of contamination on in-tank scarifier equipment. (See Tables A.1 through A.7 for fissionable material concentrations in supernate, sludge, and scarified gunite.)
Radiation source	Small quantities of contamination on in-tank scarifier equipment. (See Tables A.1 through A.7 for nonfissionable material concentrations in supernate, slude, and scarified gunite.)
Toxic/Corrosive/Reactive materials	Small quantities of contamination on in-tank scarifier equipment. (See Tables A.1 through A.7 for hazardous material concentrations in supernate and sludge.)
Flammable materials	1. Small quantities of contamination on in-tank scarifier equipment. (See Tables A.1 through A.7 for flammable material concentrations in supernate and sludge). 2. Diesel fuel for scarifier high pressure water pump.
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Standard electrical service for instrumentation and equipment.
Thermal energy source	None Identified
Kinetic energy source	1. Diesel motor for scarifier high pressure water pump. 2. High pressure water pump. 3. High pressure scarifier spray in tank.
Potential energy source	High pressure water supply (30,000 psig).
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-14. Preliminary Hazards Identification Listing for the Remote Operated Vehicle

HAZARD TYPE	DESCRIPTION
Fissionable materials	Small quantities of contamination on Remote Operated Vehicle. (See Tables A.1 through A.7 for fissionable material concentrations in supernate, sludge, and scarified gunite.)
Radiation source	Small quantities of contamination on Remote Operated Vehicle. (See Tables A.1 through A.7 for nonfissionable material concentrations in supernate, sludge, and scarified gunite.)
Toxic/Corrosive/Reactive materials	1. Small quantities of contamination on Remote Operated Vehicle. (See Tables A.1 through A.7 for hazardous material concentrations in supernate and sludge.) 2. Hydraulic oil
Flammable materials	None Identified
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Up to 480 volts to operate pumps, hydraulic controls, and instrumentation.
Thermal energy source	None Identified
Kinetic energy source	1. Pumps provide a source of rotational energy. 2. Vehicle movement when in operation.
Potential energy source	1. Pressurized hydraulic fluids for vehicle operations. 2. Raising and lowering vehicle in tank.
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

Table A-15. Preliminary Hazards Identification Listing for the Sludge Conditioning System

HAZARD TYPE	DESCRIPTION
Fissionable materials	Sludge/supernate slurry in transfer through the sludge conditioning system. (See Tables A.1 through A.7 for fissionable material concentrations in supernate, sludge, and scarified gunite.)
Radiation source	Sludge/supernate slurry in transfer through the sludge conditioning system. (See Tables A.1 through A.7 for non-fissionable material concentrations in supernate, sludge, and scarified gunite.)
Toxic/Corrosive/Reactive materials	Sludge/supernate slurry in transfer through the sludge conditioning system. (See Tables A.1 through A.7 for toxic/corrosive/reactive material characteristics of the supernate and sludge.
Flammable materials	Sludge/supernate slurry in transfer through sludge conditioning system (see Tables A-1 through A-7 for flammable material concentrations of the supernate and sludge).
Explosive/Pyrophoric Materials	None Identified
Electrical energy source	Electrical power for pump and instrumentation.
Thermal energy source	None Identified
Kinetic energy source	Rotational kinetic energy associated with pump operation.
Potential energy source	Up to 300 psig pressure generated by pump.
Lasers	N/A
Accelerators	N/A
X-ray machines	N/A

APPENDIX B

GUNITE AND ASSOCIATED TANKS PROJECT REMEDIATION OF THE SOUTH TANK FARM PRELIMINARY HAZARDS ANALYSIS

PRELIMINARY HAZARDS ANALYSIS

DATA SHEET

AREA OF OPERATIONS: South Tank Farm (STF)

PROCESS/OPERATION: Mobilize and transfer sludges between STF tanks W-5,W-6,W-7,W-8, W-9, and W-10. Transfer waste from North Tank Farm (NTF) tanks W-3 and W-4 to a STF tank.

HAZARDS OF INTEREST:

See hazard identification tables in Appendix A.

SYSTEMS:

1. Tanks W-5,W-6,W-7,W-8, W-9, and W-10 (level monitoring and dry well monitoring).
2. Modified Light Duty Utility Arm (MLDUA).
3. Remotely Operated Vehicle (ROV).
4. Waste Dislodging and Conveyance (WD&C) system.
5. Sludge Conditioning System (SCS) and confinement enclosures
6. Transfer piping skid.
7. Tank wall and floor scarifying system.
8. Ventilation system.
9. Process water (high and low pressure).
10. Compressed air.
11. Electrical system.
12. Decontamination spray system.
13. Control/administrative trailers.
14. Maintenance/decon area (temporary tents).
15. Closed circuit TV system.
16. Gripper end effector (GEE), characterization end effector (CEE), and additional sampling and monitoring end effectors.

ENERGY SOURCES:

1. Electrical energy associated with pumps, air compressor, lights, and instrumentation.
2. Kinetic energy associated with the process water pumps; SCS pump; air compressor; MLDUA, ROV, and WD&C System movement, and high pressure water in confined sluicing end effector (CSEE), Gunite scarifying end effector (GSEE), jet pump, and decontamination spray.
3. Potential energy associated with the high pressure process water to CSEE, GSEE, jet pump, and decontamination spray; elevated structures; operations platforms, MLDUA enclosure, and WD&C enclosure; support cranes.

OPERATIONS/PROCESSES/ACTIVITIES:

1. Inserting, removing, and operating the MLDUA, WD&C, and ROV.
2. Changing end effectors on MLDUA, ROV, and WD&C.

3. Transferring supernate between tanks and to the LLLW System without mobilizing sludges.
4. Mobilizing and transferring sludges between tanks.
5. Conditioning sludges during transfer (operating the SCS)
6. Operating and maintaining closed circuit TV system.
7. Removing solid materials from the tanks.
8. Scarifying tank walls and bottoms.
9. Sampling and monitoring of waste and tank structures.
10. Maintenance/testing/modification.
11. Operating support systems (compressed air, process water, ventilation, etc.).

STF REMEDIATION MODES:

1) Operation Mode	Inventory above Category 3 limits present and process water to CSEE, GSEE, or jet pump (when in tank) is not isolated.
2) Warm Standby Mode	Inventory above Category 3 limits present and process water isolated to CSEE, GSEE, or jet pump (when in tank). MLDUA, ROV and WD&C System powered up and process water which can cause tank to overflow not isolated.
3) Cold Standby Mode	Inventory above Category 3 limits present and (1) process water isolated to CSEE, GSEE, or jet pump (when in tank) is isolated and (2) MLDUA, ROV and WD&C System powered down and (3) all process water which can cause tank to overflow isolated.

COMMENTS:

The following release paths (RPs) are considered in this analysis:

RP-1: through cracks/penetrations/openings in the WD&C process waste piping (primary confinement) into the process waste piping secondary confinement (WD&C confinement box) and from the process waste transfer piping secondary confinement to the outside environment through cracks/penetrations/openings in the secondary confinement,

RP-2: through cracks/penetrations/openings in the SCS process waste piping (primary confinement) and in-line components (pump, valves, instrumentation and connections) into the SCS secondary confinement (SCS enclosure, hose/hose flange secondary confinement system) and from the SCS secondary confinement to the outside environment through cracks/penetrations/ openings in the secondary confinement,

RP-3: through cracks/penetrations/openings in the tank to the outside environment,

RP-4: from overfill of tanks to the outside environment,

RP-5: from the primary confinement tanks from aerosols from sluicing or primary confinement leaks to the outside environment through the ventilation system,

RP-6: from the primary confinement tanks from aerosols from sluicing or primary confinement leaks into the WD&C, tank riser isolation and confinement (TRIC), and/or ROV confinement box or from contaminated equipment in the confinement box and through cracks/penetrations/openings in the confinement box to the outside environment,

RP-7: from the WD&C process waste transfer piping through interfacing systems piping (process water) or instrumentation interfacing with the WD&C transfer piping to the outside environment,

RP-8: from the SCS process waste piping through interfacing systems piping (process water) or instrumentation interfacing with the SCS process piping to the outside environment.

Frequency of sludge transfer operations:

Sludge transfers are the single critical operation during which a release could result in significant consequences. However, it is important to note that these transfers are infrequent, which limits the risk from them. Transfers will periodically take place as batch operations. At the maximum sludge transfer rate, it takes ~12 h to transfer the "combined" inventory of sludge in all tanks to a single tank. Consequences are determined for this maximum flow rate case. The 12 hours of cumulative exposure to this event over the several months duration of the project is the conditional probability that sludge (at maximum pumping rate) is in the piping when a random initiating event occurs. The effect of this required coincidence of events is to reduce the accident frequency by one category over what it would otherwise be if the sludge transfers were continuous during the tank remediation. Unlikely occurrence of a random component failure causing a leak is further reduced to extremely unlikely by the event requirement that the failure must occur during a sludge transfer.

Table B.1 Preliminary Hazards Analysis for the South Tank Farm Remediation Project

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel: Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
STF Tanks						
1 Leak from tank (Modes 1, 2, or 3)	Random failure	1b, 1c, 3b, 3c, 3d, 3g, 3l, 5b, 6a	Unlikely	On-site Consequence: Up to a hundred and fifty thousand gallons of supernate, forty five thousand gallons of suspended sludges, and fifteen thousand gallons of scarified gunite could be released. (Note: No on-site or off-site airborne release consequences are evaluated for this scenario. Only a very small airborne release is considered possible due to the below surface leak location. The exposure of project personnel and co-located workers to this type of release is expected to be minimal.) On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **« 5 rem**		If the collection and drain system functions, the leaking liquid could enter process waste station #1 at a rate exceeding the station's pump capacity. The overflow would discharge into an outdoor overflow basin. The spillway to the basin is approximately 5 feet long. Some airborne particulate would be generated as the spillway surface drys and the residue particulate is suspended and entrained in the air. This source is expected to be a very small fraction of the leaked inventory. The liquid reaching the basin will mix with the basin inventory and the particulate will settle out.

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		Action Items/Comments
				Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	
				Off-site Consequence: Liquid contaminants migrate to White Oak Lake and are ingested downstream. A leak from Tank W-8 or W-9 containing the combined inventory from all STF tanks (including inventories transferred from Tanks W-3 and W-4) was evaluated to bound the potential off-site consequence. Ingestion — **High** Inhalation — **Negligible**	 I IV	The off-site consequence evaluation did not take credit for the basin containing the leaked LLLW, all the LLLW enters White Oak Creek. No credit was taken for retention of sludge in the tank. The tank sludge is the residue that remained following the 1982-84 sluicing operation that used a slurry jet to impinge on and resuspend the sludge. Sludge remained in areas where the jet action was not strong enough to mobilize it, indicating that it is not likely to readily flow out through a leak in the wall or floor of the tank. [Note: The majority of the radionuclide inventory is in the less mobile sludge.]

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
2. Leak from tank (Modes 1 or 2)	2.a MLDUA, ROV, WD&C, or other large component dropped into tank, impacting the tank floor:1) spontaneous equipment failure causes dropped load: crane drops load (failure of cable brake, cable/rigging, component lifting attachment, etc.) 2) operator error: lifting equipment positioned in an out-of balance configuration causing tip over and dropped load; operator inadvertently releases load.	1b, 1c, 3b, 2j, 3c, 3d, 3g, 3k, 3l, 5b, 6a, 7a, 7b	Unlikely	The tank contents are slowly released through a crack or hole in the tank wall or floor. Up to a hundred and fifty thousand gallons of supernate, forty five thousand gallons of suspended sludges, and fifteen thousand gallons of scarified gunite could be released. The consequences of this event are the same as for Event 1. <u>On-site Consequence</u>: Exposure of project personnel and co-located workers to a below-ground leak is expected to be minimal. Project Personnel — **Negligible** Co-located Worker — « **5 rem**		Most of the supernate in the tank will be removed before sludge removal activities start. Supernate and/or sludge in a tank at levels exceeding several feet will absorb a significant portion of the impact energy from dropped large components. The tanks are structurally robust and it is believed a dropped or misguided piece of equipment would have to generate a large amount of impact energy to cause failure of the tank structure. The initiating event for this accident requires the movement of equipment near or in a tank when operators are present (either physically at the tank or monitoring the operation with video cameras. Operations personnel should immediately notice such an event and take action to shut down the operation and initiate mitigative measures. Because the tanks are not very deep when compared to the MLDUA extension capability, the arm will not be fully extended but will be held in place by the hoist system.
				<u>Off-site Consequence:</u> Ingestion consequence same as for Event 1 with ingestion of liquid contaminants that reach a downstream intake location along the Clinch River the dominant exposure pathway. Ingestion - **High** Inhalation - **Negligible**	I IV	

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel / Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
2. Leak from tank (Modes 1 and 2) (continued)	2.b During operations to remove sludge or scarify the gunite, the MLDUA, ROV, or WD&C impacts the tank wall or the scarifier makes hole in gunite tank wall: 1) Spontaneous equipment failure causes inability to control movement. 2) Operator steers/remotely drives equipment into tank wall. 3) Scarifier operated in same section of tank wall or floor for too long.	1b, 1c, 3b, 2j, 3c, 3d, 3g, 3k , 3l, 5b, 6a, 7a, 7b	Unlikely	The tank contents are slowly released through a crack or hole in the tank wall or floor. Up to a hundred and fifty thousand gallons of supernate, forty five thousand gallons of suspended sludges, and fifteen thousand gallons of scarified gunite could be released. The consequences of this event are the same as for Event 1. On-site Consequence: Exposure of project personnel and co-located workers to a below-ground leak is expected to be minimal. Project Personnel — **Negligible** Co-located Worker — « **5 rem**		Most of the supernate in the tank will be removed before sludge removal activities start. Supernate and/or sludge in a tank at levels exceeding several feet will absorb a significant portion of the impact energy from dropped large components. The tanks are structurally robust and it is believed a dropped or misguided piece of equipment would have to generate a large amount of impact energy to cause failure of the tank structure. The initiating event for this accident requires the movement of equipment near or in a tank when operators are present (either physically at the tank or monitoring the operation with video cameras. Operations personnel should immediately notice such an event and take action to shut down the operation and initiate mitigative measures. Because the tanks are not very deep when compared to the MLDUA extension capability, the arm will not be fully extended but will be held in place by the hoist system.
				Off-site Consequence: Ingestion consequence same as for Event 1 with ingestion of liquid contaminants that reach a downstream intake location along the Clinch River the dominant exposure pathway. Ingestion — **High** Inhalation — **Negligible**	I IV	

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
2. Leak from Tank (Modes 2 and 3) (Continued)	2.c MLDUA or WD&C mast housing, etc. falls onto tank from random failure, operator error	1b, 1c, 2h, 2j, 3b, 3c, 3d, 3g, 3h, 3k, 3l, 6a, 7a, 7b	Unlikely	Falling mast crushes/collapses the tank dome, dome structure and overburden/backfill fall into tank cavity, covering the supernate and sludge inventory. An initial "puff" of aerosol is generated from the agitation of the inventory by the collapse of the dome. No significant continuation of the aerosol release is expected as the dome collapse effectively buries tank inventory, preventing resuspension and entrainment in the air above. A large leak results from cracking/collapse of the tank walls and/or cracking/puncture of the tank floor. On-site Consequence: Inhalation exposure of project personnel and co-located workers from a dome collapse will not be significant because the aerosol release is an initial "puff" of a small fraction of the supernate/sludge inventory. On-site exposures from the below-ground tank leak are negligible. Project Personnel — **Negligible** Co-located Worker — **« 5 rem**		The platforms will reduce the impact loads on the tank domes.
				Off-site Consequence: Ingestion exposure is the same as for Event 1. Liquid contaminants migrate to White Oak Lake and are ingested downstream. The combined tank inventory is evaluated to bound the potential off-site consequence. Ingestion — **High** Inhalation — **Low**	II III	

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
3. Tank overfill (Modes 1, 2, and 3)	Operator Errors: Isolation valve left open; process water flows un-checked into tank from flushing; decontamination ring spray left on; supernate or sludge transfer operation not terminated, etc. Random Component Failures: Isolation valve failure and leak-through	3b, 3c, 3d, 3g, 3l, 3n, 5b, 6a, 7a, 7b, 7c	Unlikely	Introduction of liquids into a tank fills it beyond capacity and (1) pushes the LLLW inventory out tank openings (i.e., open standpipe risers, breather, leaks at tank penetrations) directly to the environment, and/or (2), pushes the LLLW inventory into tank ventilation ducts and out openings in the ducts or (3) continue back flooding LLLW into the central off-gas system and leak out openings there. On-site Consequence: Exposure of project personnel and co-located workers is not high due to the much lower radionuclide concentration in the supernate. Project Personnel — **Negligible** Co-located Worker — **< 5 rem** [Based on exposure (at 30 m) to a spill or spray release of the supernate inventory with the highest inhalation hazard.]		Tank overflow will likely go to the dry wells. If the flow of liquid into the tank continues, the LLLW could backup into the off-gas system. The site will be graded and sloped to a storm sewer. The exposed compacted fill/sub-grade will be covered with a layer of geotextile fabric and a 12-in.-thick gravel pad. Much of the material released from the will go to the tank drain system and to pump station #1.
				Off-site Consequence: Supernate spill-over released directly into White Oak Lake. Same pathway as for the tank leak events. Ingestion — **Moderate** Inhalation — **Low**	 II III	The material releases will be diluted supernate with small amounts of suspended sludge. Tank W-7 has the highest supernate radionuclide concentration. Tank W-10 has the highest sludge radionuclide concentration and its inventory is used to bound the consequence of a release from a single tank.

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
4. Tank leak from a construction activity accident (Modes 1, 2, or 3)	Tank is damaged during an on-site construction accident: large piece of equipment or platform structural member dropped on the ground above the tank.	1b, 1c, 3d, 3g, 4b, 7a, 7b, 3r	Unlikely	On-site Consequence: Exposure of project personnel and co-located workers to a dome collapse is not expected to be significant due to the fact that the sludges are the most hazardous. (Consequence is the same as that for Event 2.c) Project Personnel — **Negligible** Co-located Worker — **« 5 rem**		The platform and soil overburden above each buried tank provide protection against tank failure. The soil overburden will absorb much of the impact energy of a dropped piece of construction equipment. The tank operations platforms, once installed, cover almost the entire footprint of the tank. The platforms are substantial steel structures that will act as barriers against driveovers by construction vehicles and other equipment (see Event 27). The platform support structure, decking, and installed equipment will protect the tank from most dropped loads (except loads suspended over the access ports while installing or retrieving equipment from the tanks). Impact loads to the platform would be transmitted through support piers to footings centered outside the circle defining the vertical projection of the tank wall (loads are not transmitted over the tank dome). (Note: Each of the six STF tanks slated for clean up will be remediated in sequence. One operations platform will be installed over the tank to be cleaned-up and one over the sludge receiving tank. When a tank clean-up is complete, the platform is removed and set up over the next tank. Tanks awaiting sludge removal will not be protected by overhead platforms. Once sludge is removed, the tank is no longer a hazard source.
				Off-site Consequence: Same consequence as for Event 2.c with ingestion of liquid contaminants that reach a downstream intake location along the Clinch River the dominant exposure pathway. Ingestion — **High** Inhalation —**Low**	 I III	

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
5. Fire in tank (Modes 1, 2, or 3)	Combustible material introduced into tank. (Note: There are only a few potentially significant sources of combustible materials, fuel for the diesel driven high pressure water pump and fuel in vehicles and mobile construction equipment. There are no adjacent fuel storage tanks that could be confused with the STF tanks.)	2d, 3a, 4d	Extremely Unlikely	During fire, HEPA filter may plug and negative pressure may be lost. Release of airborne contamination suspended and entrained in the combustion gases. Hot combustion gases generate positive pressure in the tank, the driving force for an airborne release through tank penetrations, the tank breather, tank penetrations (including the risers), and/or leaks in the ventilation system ducts. <u>On-site Consequence:</u> Project Personnel - **Negligible** Co-located Worker - **~ 5 rem**		Material in tanks is not combustible. Flammable organic liquids in the sludge and supernate are not in concentrations sufficient to fuel a fire in a tank. Sustained combustion would be required to generate an airborne release of a magnitude comparable to the bounding liquid spray and spill scenarios (the fire scenario has a similar release fraction). The depletion of the air in the tank will limit the duration of combustion. Hot combustion gases push the entire aerosol volume out tank openings, then the fire extinguishes preventing newly generated aerosols from adding to the release. The on-site worker is expected to be closer to the release and could receive a larger dose. An estimate of exposure to an operator 10 m from the release is approximately four times the exposure of the co-located worker. A fire in the tank is not likely to generate a new source of aerosols (by vaporization or boiling supernate). A fire of short duration would not cause a rupture of the tank, therefore, off-site ingestion exposure would be negligible. *The STF site will be enclosed within a fence* with gated vehicle and equipment access that will help prevent the inadvertent placement of combustible materials near the tanks. Off-site inhalation dose is bounded by the estimate for Events 16.a and 16.b

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		Action Items/Comments
				Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	
				Off-site Consequence: Ingestion exposure limited by the small radionuclide inventory from the aerosol release. No liquid release is postulated for this event. Ingestion — **N/A** Inhalation — **Low**	 IV IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
6. Deflagration in tank	Hydrogen buildup due to prolonged loss of forced ventilation.	3a	Extremely Unlikely	Hydrogen accumulates and reaches its lower flammability limit, resulting in a rapid burn or deflagration and a release of airborne contamination from the tank. (See the consequences for Events 16.a and 16.b) On-site Consequence: Project Personnel — **Negligible** Co-located Worker — ~ **5 rem**		A conservative scenario was used to evaluate the feasibility of reaching the lower flammability limit for hydrogen in the tanks. When all the sludges are combined in one tank and a minimum void volume is used (the tank is at 80% full—STF admin. limit) and no air flow (the tank ventilation system is not operating), it would take 1.5 years of H_2 generation for H_2 to reach the 4% limit (DAC PX495A02-SSE-001). This event is not dismissed as impossible within the time frame of the project. If hydrogen were to mix with tank air in a smaller volume than the assumed tank void volume, the lower flammability could be reached more quickly. Ventilation air flow patterns within the tank may not eliminate pockets of stagnant air in the tank. The presence of air in-leakage openings other than through the breather (in-leakage through tank dome penetrations) may actually improve in the sweep-out of the tank atmosphere.
				Off-site Consequence: Ingestion — **N/A** Inhalation — **Low** [Note: The off-site inhalation dose is bounded by the estimate for Events 16.a and 16.b .]	IV IV	

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Table B.1 (continued)

	Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		Action Items/Comments
					Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	
7.	Criticality accident (Modes 1, 2, or 3)	A sufficient amount of fissile material accumulates in a geometry favoring nuclear criticality.	1b, 2i, 4d	Beyond Extremely Unlikely	On-site Consequence: Project Personnel — **None** Co-located Worker — **None**		Sampling of the tanks contents indicate that a criticality accident is not possible with any of the individual tank inventories currently in the tanks or the combined inventory of all the tanks. See analysis results in Section 3.3.2.1, for nuclear criticality hazards for more details.
					Off-site Consequence: **None**	IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
Waste Dislodging and Conveyance System and Transfer Piping						
8. Leak from piping or valve inside the WD&C confinement box (Mode 1)	Random component failure, extreme freezing temperature	1e, 3a, 3c, 3e*, 7c (3e: Confinement box for piping)	Extremely Unlikely	On-site Consequence: The transfer line confinement box would collect most of the leakage and return it through a drain line to the tank. Project Personnel — **Moderate** Co-located Worker — **~30 rem** (Note: Credit not taken for termination of the release, however, project personnel at the tank platform are expected to quickly recognize the leak and take precautionary measures or leave the area quickly.)		The confinement box mitigates the on-site consequence by reducing both the total amount of the radioactive material released and the rate of release of the material compared to the unmitigated leak at full pumping capacity (70 gpm). A "liberal" confinement box leak rate of up to 5 gpm was used to calculate the on-site consequence. The release through the confinement box is 5/70ths or ~7% of the unmitigated release. The dose to a co-located worker at 30 m assumes the individual remains there for the duration of the release. The transfers will periodically take place as batch operations. It takes ~12 h to transfer the "combined" inventory of sludge to a single tank and another 12 h to sluice the sludge to the LLLW system, if transferred at the maximum sludge flow rate of 60 gpm plus 10 gpm process water. The 24 hours of exposure to this event over the several months duration of the project is the conditional probability that sludge is in the piping when a random component failure occurs. The unlikely occurrence of a random component failure causing a leak is further reduced to extremely unlikely by the event requirement that the failure must occur during a sludge transfer.
				Off-site Consequence: Unmitigated release to White Oak Creek. (Note: The off-site consequence does not take credit for the confinement box. The maximum consequence occurs when the entire "combined" inventory from either Tank W-8 or W-9 is released.) Ingestion — **High** Inhalation — **Moderate** The maximum off-site inhalation dose is determined assuming the receptor stays at a location 390 m downwind of the release. The dose received was bounded by using the tank inventory with the highest inhalation dose hazard in the consequence calculation (Tank W-10).	II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
9. Leak from piping, valve, or pump inside of tank (Mode 1).	Random component failure: Pipe ruptures, seal/connection leaks, rupture disk failure. (Note: Rupture disk vents into tank)	1h, 2c, 3a, 3k, 3m, 4f, 7c	Extremely Unlikely	On-site Consequence: With ventilation operating possible greater than expected exposure of project personnel from heavier radiation loading of the HEPA filters and build up of contamination in the ventilation ducts. Without ventilation, possible inhalation exposure from aerosol diffusing out tank openings. Project Personnel — **Low** Co-located Worker — **~10 rem**		Aerosols are generated within the tank either from the leaking LLLW process slurry or from agitation of the sludge/ supernate inventory by the leaking fluid (i.e., process water). Tank ventilation operating: The tank ventilation system continuously pulls air through the tanks and removes entrained particulate and deposits it on a HEPA filter. Any particulate not removed by the HEPA filter will go to the 250 foot 3039 stack. Tank ventilation unavailable: With ventilation off, the tank atmosphere will become stagnant. Airborne particulate contamination will diffuse at a slow rate through cracks and opening (most likely at the tank penetrations). Some aerosol particulate will diffuse into the tank ventilation duct. The diffusion rate of aerosol is conservatively bounded by using a measured ventilation flow rate for the release. On-site workers are assumed to be exposed to the release for an entire shift.
				Off-site Consequence: The off-site inhalation consequence assumes a continuous release of aerosol from within the tank to the environment. Aerosol is continually generated by the leak within the tank. Ingestion — **N/A** Inhalation — **Low**	 IV IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel / Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
10. Transfer line blockage (Mode 1)	Operator error: valve inadvertently closed, valve not opened when required Other cause: solids in LLLW slurry cause flow blockage and plug line	2e, 3a	Anticipated	On-site Consequence: Project Personnel — **None** Co-located Worker — **None**		The transfer line design pressure exceeds the maximum pressure generated by the pump.
				Off-site Consequence: **None**	IV	
11. WD&C transfer piping leak from a construction accident (Mode 1)	Random component failure: lifting device or load bearing device fails, heavy equipment control failures. Operator error: inadvertently drop load, impact WD&C confinement box with mechanized lifting/transporting equipment	3e, 3f, 3g, 4b, 7a, 7b, 7c*, 7e* (7c: Quick termination of operation) (7e: Terminate operations from more than one control point)	Extremely Unlikely	On-site Consequence: A large leak of LLLW slurry into the confinement box (damaged by the accident). Project Personnel — **Moderate** Co-located Worker — **<100 rem**		The event requires a prohibited action: "movement of heavy loads over the transfer line while an LLLW transfer is underway" and a construction activity accident. The unlikely occurrence of a rupture of the transfer line (two independent operator errors or a component failure and operator error) is further reduced to extremely unlikely by the need for the failure to occur during an LLLW sludge transfer.
				Off-site Consequence: Unmitigated release to White Oak Creek. Consequence is the same as that for Event 8. Ingestion — **High** Inhalation — **Moderate**	 II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
12. LLLW flows into WD&C interfacing system through an open line (Mode 1)	Backflow prevention failure <u>and</u> loss of normal operating pressure in interfacing system: <u>Equipment failure</u>: check valve failure <u>and</u> additional failure causing pressure loss. <u>Operator error</u>: backflow prevention inadvertently disabled incorrect interfacing system flow con-figuration (i.e., valve misalignment) causing system pressure loss and leak path.	2f, 2g*, 3c, 3j (2g: Interfacing system has a check valve in line to transfer piping)	Extremely Unlikely	<u>On-site Consequence</u>: (Note: Without a leak path from the interfacing system to the environment, there is only the minor risk of direct radiation exposure from the LLLW in a normally uncontaminated system.) Project Personnel — **Moderate** Co-located Worker — **~30 rem**		For a release to occur, the interfacing system must have an open line or develop a leak causing a loss of system pressure. This is considered a second failure in addition to the loss of backflow prevention (open isolation valve, failed check valve). As in event 8, the isolation devices can leak up to 5 gpm without the consequences exceeding the analysis guidelines. The probability of having these two events occur during a LLLW transfer or prior to a transfer and remain undetected is considered to be extremely unlikely. The maximum off-site inhalation dose is determined assuming the receptor is 390 m downwind of the release. The dose received was bounded by using the tank inventory with the highest inhalation dose hazard (Tank W-10).
				<u>Off-site Consequences</u>: Backflow of LLLW slurry into interfacing system line and out a leak in interfacing system. Unmitigated release to White Oak Creek. Consequence is same as for Event 8. Ingestion — **High** Inhalation — **Moderate**	II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
13. Spill of liquid from sample bottle (Modes 1 and 2)	Sample bottle dropped at containment box panel, operator error	7a, 7b	Anticipated	On-site Consequence: Spill of up to 500 ml of LLLW sludge or supernate on the ground adjacent to tank. Project Personnel — **Negligible** Co-located Worker — **~6 mrem**		The on-site consequence for the co-located worker is estimated by comparing the 500 ml spill to the bounding spill of the entire W-10 inventory (~9,300 gal). The sample bottle is assumed to contain W-10 sludge. The spill is over 5 orders-of-magnitude smaller than the bounding case. The off-site consequences from inhalation and ingestion are negligible due to the small volume of material involved. (~0.040 mrem from inhalation at 390 m).
				Off-site Consequences: Ingestion — **N/A** Inhalation — **Negligible**	IV IV	
Sludge Conditioning System						
14. Leak in SCS process component (including piping, pump hoses, connectors, couplings, valves, piping/hoses and branch piping up to first isolation point with interfacing system). (Mode 1)	Random component failure. Failure caused by high pressure: blocked line, plugged line, closed valve, extreme freezing temperature.	1e, 1h, 2e, 2k, 3c, 3e, 3o, 3s*, 4b, 7a, 7b, 7c, 7e (3s:Secondary confinement drains to a gunite tank.)	Extremely Unlikely	On-site Consequence: Leak with a release of LLLW supernate or sludge slurry into a SCS equipment enclosure or secondary confinement for the hoses. Project Personnel — **Moderate** Co-located Worker — **~30 rem**		The discharge line can withstand full discharge pump pressure. The pump discharge has a relief device to limit the pressure to design rating. The equipment enclosure drains are designed to direct all but 5 gpm of the released liquid back to a gunite tank. It is considered highly unlikely that a component failure will occur during the infrequent sludge or supernate transfers.
				Off-site Consequences: Unmitigated release of up to ~10% of the combined inventory to White Oak Creek. Inhalation —**High** Ingestion — **Moderate**	II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
15. SCS interfacing flush system line open. (Mode 1)	<u>Operator error</u>: Interfacing flush system is not isolated from the process system <u>and</u> random failure in the interfacing system creates a leak path.	2f, 2g, 2l*, 7a, 7b (2l : SCS flush system equipped with a check valve to prevent backflow of process liquids to the flush system)	Extremely Unlikely	<u>On-site Consequence</u>: Supernate and/or sludge backflows into an interfacing system through flush connections. No release to the environment occurs. Only the direct exposure consequences are estimated. Project Personnel — **Moderate** Co-located Worker — **~30 rem**		The probability of failure to disconnect the interfacing system coupled with the occurrence of a leak in the interfacing system during a sludge transfer is considered to be extremely unlikely. having these two events occur during a LLLW transfer is considered to be unlikely. The maximum off-site inhalation dose is determined assuming the receptor stays at a location 390 m downwind of the release. The dose received was bounded by using the tank inventory with the highest inhalation dose hazard (Tank W-10). The process transfer lines are not operated at pressures that would cause a rupture of the interfacing system in a backflow scenario. As in event 8, the isolation device can leak up to 5 gpm without the consequences exceeding the analysis guidelines.
				<u>Off-site Consequences</u>: Backflow of supernate or sludge into inter-facing system line and out a leak in the line to the environment. Unmitigated release to White Oak Creek. Consequence is same as that for Event 8. <u>Off-site Consequence</u>: Ingestion — **High** Inhalation — **Moderate**	 II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
Ventilation System						
16. Aerosols in tank leak to environment (Mode 1)	16a. Loss of air inflow when an access port is open to the outside environment (closed dampers, plugged filters, exhaust duct collapses, second access opened)	2c, 4c, 4f, 5a, 7c, 7f	Anticipated	Slow release of small amount of aerosol from a tank through an access port, no liquid or sludge is released with the aerosol. (Note: On-site/ off-site inhalation exposure calculated assuming the receptor is present for the entire release.) On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **~5 rem**		The access ports will be open directly to the environment very infrequently. The consequence estimate assumes all the aerosol in the tank void volume diffuses out before the problem is discovered. A conservative concentration for the aerosol present in the tank during normal operation was used. The aerosol released is conservatively estimated by using 217,000 gal for the tank void volume. The tank aerosol release dose is estimated by comparison with the bounding aerosol release (spray/spill of W-10 inventory) in DAC-PX495A02-SSE-003). The tank aerosol release equals the aerosol generated by the spray/spill of 141 gal of W-10 sludge. The release of 141 gal of W-10 sludge results in ~5 rem inhalation exposure at 30 m. The on-site worker is expected to be closer to the release and would receive a larger dose (~20 rem at 10 m). These doses assume the individual remains for the entire duration of the release. Off-site consequence at 390 m is ~ 80 mem. inhalation exposure. The amount of released aerosol that migrates to White Oak Lake is considered negligible, therefore, the ingestion exposure is considered negligible.
				Off-site Consequence: Ingestion — **N/A** Inhalation — **Low**	IV III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
16. Aerosols in tank leak to environment (continued)	16b. Vehicle accidents that impact, puncture, crush, or immerse in fire the above-ground portion of the ventilation system.	1f, 1g, 4i, 7c, 7e,	Anticipated	Release of aerosol from a tank and ventilation ducts. (Same consequences as for Event 16.a) On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **~5 rem**		
				Off-site Consequence: Ingestion — **N/A** Inhalation — **Low**	IV III	
	16c. Loss of negative pressure during normal operations, i.e, no access ports open directly to the outside environment (closed dampers, plugged filters, exhaust duct collapses-self plugging the system).	3h, 3i, 7c	Anticipated	Slow release of aerosol from a tank through openings/cracks around tank penetrations, remediation equipment confinement boxes, or ventilation ducts. On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **< 5 rem**		Used same conservative estimate of the aerosol concentration and release rate as in Event 9. (Note: No liquid or sludge is released with the aerosol.) Off-site inhalation dose is bounded by the estimate for Event 9.
				Off-site Consequence: The off-site inhalation consequence assumes a continuous release of aerosol from within the tank to the environment. The ingestion consequence assumes an unmitigated release to White Oak Creek. Ingestion — **N/A** Inhalation — **Low**	IV IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
16. Aerosols in tank leak to environment (continued)	16d. HEPA filters fail or are improperly installed	3a, 3i, 3m, 3q, 6a, 6b	Anticipated	On-site Consequence: Airborne contamination from the tank atmosphere is drawn into the main off-gas system (Bldg. 3039) and released out the 250 ft exhaust stack. There could be an increase in the exposure to project/facility personnel during change-out of a damaged or improperly installed HEPA filter. Project Personnel — **Negligible** Co-located Worker — **« 5 rem**		The ventilation exhaust from the STF mixes with other facility exhaust flows through another set of HEPA filters before it is released up the stack, however, credit is not taken for the second HEPA. Unfiltered exhaust will mix with large volumes of filtered exhaust from other ORNL facilities before it is released up the stack. Airborne concentrations that co-located workers and off-site individuals could receive are from the elevated release at the stack.
				Off-site Consequence: Ingestion — **Negligible** Inhalation — **Low**	IV IV	
17. Collected material on the HEPA filter released to environ- ment (Mode 3)	Dropped HEPA during change-out	6a, 7a, 7b	Anticipated	On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **<5 rem**		Based on operational history of HEPA filter change-outs for the STF and other similar facilities at ORNL, The contamination levels are low and only minor exposure to on-site workers would be expected.
				Off-site Consequence: Ingestion — **Negligible** Inhalation — **Negligible**	IV IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
All Systems: Natural Phenomena and Man-Made Hazards						
18. Tank leak (Modes 1, 2, or 3)	Earthquake	1a, 1c, 3c, 3d, 3g, 31	Unlikely	An initial "puff" of aerosol is released as tank dome collapses into tank. Dome collapse effectively buries tank inventory, preventing resuspension and entrainment as an aerosol. A large leak results from cracking/collapse of the tank walls and/or cracking/puncture of the tank floor. On-site Consequence: Inhalation dose from "puff" (See the consequences for Event 2) Project Personnel — **Negligible** Co-located Worker — **~5 rem**		Seismic evaluation of the tanks has determined that they should be able to withstand a PC-2 earthquake. This event is similar to Events 1 and 2.c. (See Events 1 and 2.c for additional discussion of event.) Puff release uses model developed for Event 2. Off-site inhalation dose from initial puff. Ingestion consequence is equivalent to other large leak events and is bounding.
				Off-site Consequence: Ingestion — **High** Inhalation — **Negligible**	I IV	

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Table B.1 (continued)

Event		Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		Action Items/Comments
					Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	
19.	Leak in WD&C transfer piping or SCS piping/hoses. (Mode 1)	Earthquake	1a, 3c, 3e, 4b, 7c*, 7e* (7c: Quick termination of operation.) (7e: Terminate operations from more than one control point)	Extremely Unlikely	Earthquake causes transfer line rupture with a large leak of LLLW slurry into secondary confinement. Secondary confinement also ruptured from the earthquake. On-site Consequence: Project Personnel — **Moderate** Co-located Worker — **<100 rem**		The event frequency is extremely unlikely because these systems will contain sludge for only a short amount time compared with the total time the remediation will be underway. The LLLW transfer lines can withstand up to a PC-2 level earthquake without failure (No credit taken for this feature because 7c and 7e are required for other events). It is expected that efforts to shut off the sludge flow will begin immediately following an earthquake because of the self-announcing nature of the event.
					Off-site Consequence: Unmitigated release to White Oak Creek. Consequence is same as that for Event 8. Ingestion — **High** Inhalation — **Moderate**	 II III	
20.	Leak in WD&C transfer piping or SCS piping/hoses. (Mode 1)	High wind	1a, 3c, 3e, 4b, 7c*, 7d, 7e* (7c: Quick termination of operation.) (7e: Terminate operations from more than one control point)	Extremely Unlikely	High wind causes rupture of the transfer line and its secondary confinement with a large leak of LLLW slurry into damaged secondary confinement and out to the environment. On-site Consequence: Project Personnel — **Moderate** Co-located Worker — **<100 rem**		The transfer lines can withstand a PC-2 level wind (No credit taken for this feature because 7c and 7e are required for other events). It would be extremely unlikely for a high wind condition to coincide with a sludge transfer operation. It is expected that shut off the sludge flow will begin immediately upon the start of a high wind event. It is likely that advance warning will be provided about approaching weather systems severe enough to produce damaging high winds.

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		
				Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
				Off-site Consequence: Unmitigated release to White Oak Creek. Consequence is same as that for Event 8. Ingestion — **High** Inhalation — **Moderate**	 II III	
21. Snow or ice accumulated on above ground equipment increasing the static loads on equipment. (Modes 1, 2, or 3)	Snow/Ice Loads	1a, 1b, 1c	Anticipated	On-site Consequence: Tanks and equipment can withstand expected loads without failure. Project Personnel — **None** Co-located Worker — **None**		Tanks are located below grade and are not considered vulnerable to snow/ice loads on soil above tank dome. Snow/ice load on above ground equipment not sufficient to cause failure.
				Off-site Consequence: **None**	IV	
22. Cold ambient conditions cause leak in the WD&C transfer piping or SCS piping/hoses. (Mode 1)	Low winter temperature causes pipe leak	N/A	N/A	Possible damage to piping due to freezing is addressed in release from primary confinement piping entries.		

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
23. Lightning strikes primary containment component vulnerable to damage from lightning (i.e.,SCS hoses) causing a leak/rupture of the component. (Mode 1)	Lightning	1b, 1c, 1e, 2b, 4b, 7c*, 7e* (7c: Quick termination of operation.) (7e: Terminate operations from more than one control point)	Extremely Unlikely	Lightning strikes a run of SCS hose during a sludge transfer causing a leak.. On-site Consequence: Project Personnel — **Moderate** Co-located Worker — **<100 rem**		Lightning strike will not likely cause failure of primary confinement system components located inside of equipment enclosures. If lightning damages a SCS LLLW transfer hose (primary containment) then the secondary confinement boundary has also been damaged and most likely breached. The on-site dose to the co-located worker is limited to <100 rem if the sludge transfer can be stopped in 40 min. Off-site consequence does not take credit for SCS secondary containment or quick shutdown of the transfer. The maximum consequence occurs when the entire "combined" inventory from either Tank W-8 or W-9 is released.)
				Off-site Consequence: Unmitigated release to White Oak Creek. Consequence is same as that for Event 8. Ingestion — **High** Inhalation — **Moderate**	 II III	

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Table B.1 (continued)

	Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
24.	Tank fails due to flood loadings (Modes 1, 2, or 3)	Local flooding from heavy rainfall	1d, 31	Unlikely	Flood causes tank failure and release of tank contents. On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **Negligible**		Local flooding in White Oak Creek up to the 799 ft. level is possible. Most equipment is located on platforms or skids well above the 800 ft level and several feet above the ground. The top ends of the tank access risers are at about the 807 ft level. Off-site ingestion dose is assumed to be 10% of a 100% tank release during non-flood conditions. The release scenario is not likely to release all material and the dilution flow rate is much higher than in normal conditions. The intake pumping station is likely to be submerged by flood. STF site is graded and sloped with a gravel cover to direct water run-off to a catch basin in the southeast corner.
					Off-site Consequence: Ingestion — **Moderate** Inhalation — **Negligible**	II IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
25. Tank fails due to flood loadings. (Modes 1, 2, or 3)	Flood waters from the failure of river dams exceed site grade.	2a	Extremely unlikely	Flood causes tank failure and release of tank contents. Consequences are the same as for Event 24. <u>On-site Consequence</u>: Project Personnel — **Negligible** Co-located Worker — **Negligible**		Flood level at mouth of White Oak Creek from Norris Dam failure is 799.4 ft. The flood water may fail the bottom of the tanks. Off-site ingestion dose is assumed to be 10% of a 100% tank release during non-flood conditions. The release scenario is not likely to release all material and the dilution flow rate is much higher than in normal conditions. The intake pumping station is likely to be submerged by flood.
				<u>Off-site Consequence</u>: Ingestion — **Moderate** Inhalation — **Negligible**	III IV	

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Table B.1 (continued)

Event		Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
26.	Personnel are unexpectedly forced to evacuate the STF site. (Modes 1 or 2)	Forced evacuation: smoke, toxic chemical releases, radiation emergencies, severe weather, etc.	4b, 7a, 4a, 7c, 7e, 7g	Unlikely	A site evacuation during a sludge transfer results in a tank overflow. A spill of supernate generates an airborne release of potential consequence to both on-site personnel and off-site individuals, however the evacuation will reduce and possibly eliminate potential for significant exposure of on-site workers by removing them from the vicinity of the spill. An overflow condition would take some time to come about. Tanks are kept below 80% of maximum capacity (not including the head space in the dome. Even a nominally full tank still has upwards of 50,000 gallons of space. At maximum pump capacity it would take ~14 h to completely flood the tank starting at nominally full. All on-site workers not involved with emergency response will have evacuated the site before a tank overfill occurs. <u>On-site Consequence</u>: Project Personnel — **None** Co-located Worker — **None**		The system is designed to allow quick termination of the transfer process. Several different ways to shut down the transfer are available to the project personnel: a pump kill switch, a site breaker switch, and a pump process water shut down switch. These ways to shut down the transfer are in addition to the normal computer controlled process shutdown. The operators will terminate operations prior to evacuation. If the transfer is not terminated before evacuation, the only release is from overfill of the receiving tank. (See the consequence discussion for Event 3)
					<u>Off-site Consequence</u>: Ingestion — **Moderate** Inhalation — **Low**	II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
27. Rupture/leak in the WD&C transfer piping and in-line components and interfacing system piping up to first isolation (including connectors, couplings, valves). (Mode 1)	Vehicle accidents that impact, puncture, crush, or immerse in fire the above-ground WD&C transfer piping: STF site sources: trucks, construction/ excavation equip. (cranes, bull-dozers, graders, etc.), personnel vehicles. Other ORNL site sources: tanker trucks (fuel, chemical, liquid nitrogen), bottled gas delivery trucks	1f, 1g, 3p, 4b, 4i, 7c*, 7e* (7c: Quick termination of operation.) (7e: Terminate operations from more than one control point)	Extremely Unlikely	Leak/spray of supernate or mobilized sludge directly to the environment. Airborne release from air entrainment of spray/splash droplets and aerodynamic entrainment (shear of wetted surfaces). Exposure of project personnel, co-located workers, and off-site individuals from inhalation of airborne contaminates. On-site Consequence: Project Personnel — **Moderate** Co-located Worker — ~ **100 rem**		The on-site dose to a co-located worker dose is limited to <100 rem assuming that the sludge transfer can be stopped within 40 min. following the event. It is expected that efforts to shut off the sludge flow will begin immediately following a vehicle accident because an event of this severity will itself provide an effective alarm for project personnel to initiate emergency shutdown action.
				Off-site Consequence: Unmitigated release to White Oak Creek. Consequence is same as that for other large leak events. Ingestion — **High** Inhalation — **Moderate**	 II III	
28. Rupture/leak in the SCS piping/ components/hoses and interfacing system piping up to first isolation (including hoses, connectors, and valves). (Modes 1)	Vehicle accidents (Same causes as for Event 27)	1f, 1g, 1i, 3p, 3j, 4b, 4i, 7c*, 7e*, 7g (See Event 27 for more details about these items.)	Extremely Unlikely	Same on-site and off-site consequences as for Event 27 On-site Consequence: Project Personnel — **Moderate** Co-located Worker — ~ **100 rem**		See comments for Event 27

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel		Action Items/Comments
				Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	
				Off-site Consequence: Ingestion — **High** Inhalation — **Moderate**	 II III	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
29. SCS LLLW process hoses rupture or leak from effects of a nearby fire or explosion. (Mode 1)	Fire in adjacent building/structure or from a nearby ruptured natural gas supply line sends burning materials (large coals, burning shards, heated projectiles, etc.) onto SCS hoses.	1b, 1e, 3e, 4a, 4b, 4h, 7a, 7c	Extremely Unlikely	Burning materials, lofted by fire up-draft or explosive energy, land on hoses and melt/degrade them. On-site Consequence: Project Personnel — **None** Co-located Worker — **None**		Other transfer equipment in the SCS enclosures, the WD&C transfer piping, and the below-grade tanks are not expected to be significantly effected by an adjacent fire. With an adjacent fire sufficient to threaten the hoses, operation will be terminated.
				Off-site Consequence: Ingestion — **None** Inhalation — **None**	IV IV	
30. Utilities are lost	Process water, electrical service, or instrument air service is lost due to events or conditions outside of the facility		Anticipated	On-site Consequence: The loss of the utility support systems will not cause failures leading to releases of radioactive materials. **No release.** Project Personnel — **None** Co-located Worker — **None**		Loss of utility services does not initiate a release of radioactive materials
				Off-site Consequence: **None**	IV	

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Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
31. WD&C or SCS transfer piping and components leak from a construction accident. (Mode 1)	Heavy equipment impacts, load drops	3d, 3e, 3f, 3g, 4b, 7a, 7b, 7c*, 7e* (7c: Quick termination of operation.) (7e: Terminate operations from more than one control point)	Extremely Unlikely	<u>On-site Consequence</u>: Same consequence as for Event 27. Project Personnel — **Moderate** Co-located Worker — **<100 rem** <u>Off-site Consequence</u>: Unmitigated release to White Oak Creek. Consequence is the same as that for Event 27. Ingestion — **High** Inhalation — **Moderate**	 II III	The event requires a prohibited action "movement of heavy loads over the transfer line while an LLLW transfer is underway" <u>and</u> an accident (operator error, component failure) causing rupture of the transfer line. The unlikely occurrence of a rupture of the SCS hoses (two independent operator errors or a component failure <u>and</u> operator error) is further reduced to extremely unlikely by the need for the failure to occur during an LLLW sludge transfer.

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at 30 m) and Project Personnel — Unprevented/Undetected/ Unmitigated Off-site Consequence	Off-site Screening Risk Category	Action Items/Comments
Decontamination Area						
32. Contaminated water released from containment during decontamination activities (Modes 1, 2, and 3)	Operator errors, random component failures	7a, 7b	Anticipated	Release of up to several gallons of contaminated water to the ground. On-site Consequence: Project Personnel — **Negligible** Co-located Worker — **300 mrem**		The release occurs as either a spill or a spray resulting in an airborne release similar to other accident events involving above ground releases of sludge or supernate. The consequence is bounded by using an equivalent volume of sludge with the highest radionuclide concentration, the inventory in Tank W-10. A spill volume of 8 gal is used for "several" gallons. (~4.5 mrem. from inhalation at 390 m, ~8 mrem. from ingestion)
				Off-site Consequence: Ingestion — **Negligible** Inhalation — **Negligible**	IV IV	
MLDUA (contains no unusual hazards)						
ROV (contains no unusual hazards)						
Process Water System (contains no unusual hazards)						
Compressed Air System (contains no unusual hazards)						
Electrical System (contains no unusual hazards)						
Chemical Addition System (contains no unusual hazards)						

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Table B.1 (continued)

Event	Cause	Prevention/ Detection/ Mitigation	Unprevented Frequency	On-site Consequence to Co-located Workers (at *30 m) and Project Personnel*		Action Items/Comments
				Unprevented/Undetected/ Unmitigated Off-site *Consequence*	Off-site Screening Risk Category	
Decontamination Spray System (contains no unusual hazards)						

"*" indicates prevention, detection, or mitigation feature or control for which credit is taken to prevent or minimize consequences to on-site personnel.

Facility Defense-in-Depth Features

1. Barriers

   a. System structural design can withstand the effects of internal and external loads without failure; mechanical loads (i.e., dead weight, pressure, impact, vibration, etc.) , thermal loads, and degradation mechanisms (i.e., corrosion, radiation damage, etc.).
   b. Tanks located below grade.
   c. Tanks are generally structurally sound.
   d. Site has a slight engineered grade that will divert rainwater, etc. run-off away from tanks without significant accumulation. White Oak Creek flooding will not cover the tanks.
   e. Double confinement of the process waste piping and in-line components (pumps, valves, flanges, instrumentation, and utility support system tie-ins) outside of the tanks.
   f. Existing concrete barriers and other structures (steam piping) along the Central Ave. side of the STF provide protection against vehicle run-off-road type accidents.
   g. Equipment platforms provide a structural barrier between sludge transfer piping/hoses and potential impact threats (i.e., moving vehicles, construction equipment)
   h. Supernate/sludge process waste piping is designed and fabricated to appropriate consensus national standards.
   i. Fence installed around STF site perimeter and gated access at site entry points provides site access controls.

2. Preventive Systems

   a. Transfer components are located above the elevation that is flooded from dam failure.
   b. WD&C and MLDUA systems have lightning protection.
   c. Ventilation system ensures air inflow at tank openings.
   d. MLDUA and ROV systems have only small quantities of hydraulic fluid and it is not highly combustible.
   e. Jet pump shutoff head not greater than the piping design pressure. Piping has a rupture disc for protection against overpressure.
   f. Operating pressure of interfacing systems is higher than the operating pressure of the WD&C transfer piping.
   g.* Interfacing systems have a check valve before connection to the WD&C transfer piping to prevent reverse flow.
   h. Tanks equipped with local vacuum breakers and pressure control to prevent damage to the radioactive material confinement boundary by high negative pressures caused by the central off-gas system.
   i. Sampling indicates that the material is not a criticality hazard.
   j. MLDUA system has a 9:1 margin for safety for the arm hoist strength to arm weight.
   k. SCS hose connections are type that is not likely to have a sudden complete failure.
   l.* SCS interfacing system connections are equipped with check valves to prevent contaminated process liquids from backflowing into the interfacing systems.

3. Detection/Mitigative Systems

a. Tank ventilation system normally operates and has a HEPA filter cleaning the discharge path.
b. Tanks have level instrumentation that provides indication and alarm in the control room and WOCC. When operating in either Mode 1 (operation) or Mode 2 (warm standby), project personnel in the control room will monitor tank levels and take emergency response action in the event of an alarm. When in cold standby and project personnel are not present, the responsibility for monitoring tank levels and responding to tank level alarms transfers to the WOCC.
c. Spill response prevents ingestion dose.
d. Tank dry wells are continuously monitored for leaks and leak detection alarms are provided in the control room and WOCC. (Monitoring and alarm response responsibility for Modes 1 and 2 assumed by project personnel, when in Mode 3, by WOCC personnel) Dry wells are sampled monthly.
e.* Transfer piping skids/enclosures and WD&C confinement box will collect leakage and direct it back to one of the tanks. The tank ventilation system provides negative pressure to the enclosures.
f. Sluicing and transfer operations can be terminated by more that one control point.
g. Dry wells drain to process waste pump station #1 for transfer into the process waste system. Pump in pump station #1 has a diesel generator backed power supply.
h. Modulating damper controls tank negative pressure (vacuum breaker is available for back-up if damper fails).
i. HEPA filters have differential pressure instrumentation; loss of back pressure will cause an alarm in the control room.
j. Process water system lines with tie-ins to waste process transfer line have a pressure instrument with an alarm.
k. Camera can allow visual monitoring of important components.
l. Portable pump is available to transfer liquid from tanks to other tanks or to the active LLLW system.
m. Ventilation exhaust is treated by the central off-gas system, which has additional HEPA filters.
n. Graded and gravel covered site surface will direct spilled liquids to a catch basin and reduce the amount of liquid in contact with surface air thereby reducing aerodynamic resuspension.
o.* SCS has hoses, piping, and components that are double contained such that all leakage from primary confinement will be directed back to a gunite tank.
p. SCS components located at central area of STF which is away from external hazards (i.e. vehicle impacts, etc.).
q. Tank ventilation system includes a demister for removing aerosols in the discharge path.
r. Visible indication of location of buried tanks as a precaution against driveovers or placement of heavy loads over a tank.
s.* Sludge conditioning system secondary confinement drains to a gunite tank.

Administrative Features

4. Procedural Restrictions or Limits Imposed

a. Process water normally isolated when operator not present.

b. Operator present at facility during operation in Modes 1 and 2.
c. Total area of tank openings is limited.
d. New waste from outside the STF tank farm is not being added to the tanks with the exception of the inventories from NTF Tanks W-3 and W-4. These tank inventories have been sampled and evaluated and do not present a nuclear criticality hazard or flammable hazard.
e. Deleted.
f. Sluicing and operation of the decontamination spray rings and wands will not be permitted when a tank access is open to the outside environment without compensatory measures for aerosol control. [Note: "access open" means — without an equipment confinement box (i.e., HMS glove box, WD&C confinement box) or other sealed enclosure in place over access opening.]
g. Item deleted.
h. Operations will be terminated if accidents in adjacent buildings threaten safe operations.
i. No heavy loads driven over tanks.
j. Heavy construction equipment not allowed within 5 ft of the Gunite tank walls without written permission from the Facility Manager.

5. Operator Monitoring of Critical Parameters

   a. Ventilation air inflow rate will be measured upon opening the access port, as deemed necessary, and periodically thereafter as necessary.
   b. Monitoring of the tank levels.

6. Equipment Support Functions (e.g., maintenance, calibration, etc.)

   a. Maintenance program.
   b. HEPA filters are tested for proper installation.

7. Operator Responses or Actions

   a. Operator training.
   b. Operating procedures.
   c.* System design will allow quick termination of operations.
   d. If the expected wind speed exceeds the limit for the MLDUA enclosure for the erected position, it will be lowered. If the MLDUA enclosure can not be lowered, then sludge transfers will be suspended for the duration of the high wind condition.
   e.* Sluicing and transfer operations can be terminated by more that one control point.
   f. Operating procedures will ensure ventilation system operation prior to opening large accesses.
   g. Operators will terminate operations prior to evacuating the site.

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