Mixed Waste Management Facility Preliminary Safety Analysis Report

September, 1994

Prepared by: Roy F. Weston, Inc./Vectra Government Services Inc. under Master Task Agreement B147902 for Lawrence Livermore National Laboratory

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Preface

The Preliminary Safety Analysis Report was prepared for the Mixed Waste Management Project to reflect the activities as presented in the April 29, 1994 Conceptual Design Report. Activities evaluated in this document are the upgrade of an existing facility, Building 494, to house the primary technologies (mediated electrochemical oxidation, molten salt oxidation, wet oxidation and UV photolysis) and support systems needed to demonstrate a fully integrated pilot-scale mixed waste treatment system. Should major changes occur, this document will be reevaluated and modified to reflect the changes as appropriate.

R. Streit, MWMP Project Manager

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Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapters 1 to 20

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

%	percent
A	ampere
ACGIH	American Conference of Governmental Industrial Hygienists
ACI	American Concrete Institute
AD	Associate Director
AEMC	Alternate Emergency Management Center
AGA	American Gas Association
AIHA	American Industrial Hygiene Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALARA	As Low As Reasonably Achievable
ALOHA	Areal Locations Of Hazardous Atmospheres
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOE	Abnormal Operational Event
ARF	Airborne Release Fraction
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATS	Automatic Transfer Switch
AWS	American Welding Society
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
Btu	British thermal unit
CAM	Continuous Air Monitor
CCR	California Code of Regulations
CCTV	Closed-circuit television
CDR	Conceptual Design Report
CEDE	Committed Effective Dose Equivalent
CEGL	Continuous Exposure Guidance Level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
Ci	curie
Ci/cm ³	curies per cubic centimeter
cm	centimeter
cm ²	square centimeter
cm ² /sec	square centimeters per second
cm ³	cubic centimeter
cm ³ /sec	cubic centimeters per second
CO	carbon monoxide

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

DAC	Derived Air Concentration
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBFI	Design Basis Flood
DBW	Design Basis Wind
dc	direct current
DEM	Deputy Emergency Manager
DOD	Department of Defense
DOE	Department of Energy
DOE-HQ	Department of Energy Headquarters
DOE-OAK	Department of Energy Oakland
DOE-STD	Department of Energy Standard
DOE-TIC	Department of Energy Technical Information Center
DOT	Department of Transportation
DTSC	Department of Toxic Substances Control
e.g.	<i>exempli gratia</i> (for example)
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EEGL	Emergency Exposure Guidance Level
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
EM	Emergency Manager
EMAD	Environmental Monitoring and Analysis Division
EMC	Emergency Management Commander
EP&RP	Emergency Preparedness and Response Program
EPA	Environmental Protection Agency
EPAP	Emergency Preparedness Administrative Procedure
EPD	Environmental Protection Department
EPiP	Emergency Plan Implementing Procedure
ERO	Emergency Response Organization
ERPG	Emergency Response Planning Guideline
ES&H	Environmental, Safety, and Health
et al.	<i>et alia</i> (and others)
etc.	<i>et cetera</i> (and so forth)
FEMA	Federal Emergency Management Agency
FONSI	Finding Of No Significant Impact
FSAR	Final Safety Analysis Report
FSP	Facility Safety Procedure
ft	foot
ft ²	square foot
FY	Fiscal Year
g	acceleration due to gravity
g	gram

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

g/hr	grams per hour
g/sec	grams per second
gal.	gallon
gpm	gallons per minute
HAZOP	Hazard and Operability
HEPA	High-Efficiency Particulate Air
hr	hour
HVAC	Heating, Ventilation and Air Conditioning
HWM	Hazardous Waste Management
I&C	Instrumentation and Control
i.e.	<i>id est</i> (that is)
IC	Incident Commander
ICR	Incremental Cancer Risk
ICRP	International Commission on Radiological Protection
ID	Identification
IDLH	Immediately Dangerous to Life and Health
IRIS	Integrated Risk Information System
ISCST	Industrial Source Complex-Short Term
kA	kiloampere
kg	kilogram
kg/hr	kilograms per hour
kg/L	kilograms per liter
km	kilometer
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
L	liter
lb	pound
lb/hr	pounds per hour
LCO	Limiting Condition for Operation
LCS	Limiting Control Setting
LCWS	Low Conductivity Water Supply
LEDO	Laboratory Emergency Duty Officer
LFP	Liquids Feed Preparation
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level Waste
LWRP	Livermore Water Reclamation Plant
M	molar
m	meter
M&TE	Measuring and Test Equipment
m/sec	meters per second
m ²	square meter
MCC	Motor Control Center

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

MEO	Mediated Electrochemical Oxidation
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m ³	milligrams per cubic meter
mg/sec	milligrams per second
MP	Management Plan
mph	miles per hour
MPI	Management Performance Indicator
MSDS	Material Safety Data Sheet
msl	mean sea level
MSO	Molten Salt Oxidation
MWM	Mixed Waste Management
NACE	National Association of Corrosion Engineers
NAS	National Academy of Sciences
nCi/g	nanocuries per gram
NDE	Nondestructive Evaluation
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NGVD	National Geodetic Vertical Datum
NIOSH	National Institute for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NSC	National Safety Council
NTS	Nevada Test Site
OERO	On-site Emergency Response Organization
OJT	On-the-Job Training
ORO	Occurrence Reporting Office
ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Administration
OSP	Operational Safety Procedure
OSR	Operational Safety Requirement
PAD	Personal Alarming Dosimeter
PCE	tetrachloroethylene
PEL	Permissible Exposure Limit
PHA	Preliminary Hazards Analysis
PID	Photo-Ionization Detector
PMFI	Probable Maximum Flood
ppm	parts per million
PSAR	Preliminary Safety Analysis Report
psi	pounds per square inch
psig	pounds per square inch, gage
PSO	Program Secretarial Officer
PT&S	Process Transport and Storage

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

QA	Quality Assurance
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
rem	roentgen equivalent, man
RF	Radio Frequency
RQ	Reportable Quantity
SAD	Safety Analysis Document
SAR	Safety Analysis Report
SBC	Standard Building Code
SDR	System Design Requirement
sec	second
sec/m ³	seconds per cubic meter
SFP	Solids Feed Preparation
SL	Safety Limit
SNL	Sandia National Laboratories
SPEGL	Short-Term Public Emergency Guidance Level
SR	Surveillance Requirement
SRF	Source Release Factor
SRS	Savannah River Site
STEL	Short-Term Exposure Limit
STP	Standard Temperature and Pressure
TBD	To Be Determined
TCE	trichloroethylene
TLD	Thermoluminescent Dosimeter
TLV	Threshold Limit Value
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity
TRU	transuranic
TSC	Technical Support Center
TSCA	Toxic Substances Control Act
TSR	Technical Safety Requirement
TWA	Time-Weighted Average
UBC	Uniform Building Code
UC	University of California
UCRL	University of California Research Laboratory
UPS	Uninterruptible Power Supply
UVP	Ultraviolet Photolysis
V	volt
VOC	Volatile Organic Compound
WAA	Waste Accumulation Area
WG	water gage
wk	week

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

WOX	Wet Oxidation
wt%	weight percent
yr	year
°C	degrees Celsius
°F	degrees Fahrenheit
°K	degrees Kelvin

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 1 Executive Summary

September 1994

Lawrence Livermore National Laboratory
University of California Livermore, California 94551

Chapter 1. Executive Summary

This chapter provides a summary of the Preliminary Safety Analysis Report (PSAR) for the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL). The PSAR was prepared in accordance with Department of Energy (DOE) Order 5480.23, *Nuclear Safety Analysis Reports* (DOE 1992c).

This PSAR demonstrates that the MWM Facility can be operated without posing an undue risk to the health and safety of the facility worker and the public. This PSAR also demonstrates that the safety features of the MWM Facility adequately mitigate the potential impact of MWM operations on the environment. Additionally, this PSAR identifies how the generic safety requirements of applicable statutes, federal rules, and DOE directives apply specifically to the MWM Facility and proposes commitments that LLNL has undertaken or will undertake to design, build, operate, and maintain the MWM Facility to be in compliance with these safety requirements.

DOE will use this PSAR as the principal safety basis for its decision to authorize procurement, construction, and preoperational testing of the MWM Facility. DOE may decide to impose conditions of approval or alternatives to other commitments.

Table 1-1 lists the titles of each PSAR chapter and provides a brief description of the contents of each chapter.

1.1 General Facility Description and Location

The MWM Facility is a single-story structure with a concrete floor, structural steel framing, and sheet metal sides and roof. The MWM Facility is a national demonstration test bed that will be used to evaluate, at pilot scale, emerging technologies for the effective treatment of low-level radioactive organic mixed waste; these technologies represent alternatives to incineration.

LLNL is located about 40 miles east of San Francisco at the southeast end of Livermore Valley in Alameda County, California. The MWM Facility is located in Building 494, near the north fence of the LLNL site. The distance to the nearest point of unrestricted public access (security fence) is 575 feet (175 meters), due north.

Design, construction, operation, and decontamination and decommissioning functions at LLNL are the responsibility of LLNL. The MWM Facility is operated

under the responsibility of the LLNL Associate Director for Environmental Programs.

1.2 Hazard Classification

Chapter 5 of this PSAR identifies the inventory of materials used and processed in the MWM Facility including radioactive material and hazardous chemicals. The MWM Facility has been determined to be a nonnuclear facility and to have a facility hazard classification of Radiological Facility for the radionuclide inventory in accordance with DOE-STD-1027-92 (DOE 1992b). In addition, the MWM Facility has been determined to have a Low Hazard classification for the reagent and chemical inventory in accordance with DOE Orders 5481.1B (DOE 1987) and 5480.23 (DOE 1992c).

It is important to note that, even though the MWM Facility was determined to be a nonnuclear facility, DOE Order 5480.23 was used in the preparation of this PSAR for several reasons. Initial planning had assumed the MWM Facility to be a nuclear facility, and the development of the PSAR began using DOE Order 5480.23. When the hazards analysis and classification of the MWM Facility were performed for Chapter 5 of the PSAR, based on the 90 percent Conceptual Design Report (CDR) (LLNL 1994), the MWM Facility was determined to be a nonnuclear facility. Since the PSAR was 50 percent complete at that time, the decision was made to continue to develop the PSAR in accordance with DOE Order 5480.23. This decision is considered acceptable since the level of detail required by DOE Order 5480.23 is more extensive than that required by DOE Order 5481.1B and since this document meets all of the requirements of DOE Order 5481.1B.

1.3 Graded Approach

In response to DOE Order 5480.23 (DOE 1992c), a graded approach was used in the preparation of this PSAR. In general, a graded approach dictates a more rigorous and more thoroughly documented analysis and evaluation for higher hazard facilities than lower hazard facilities, given the potential for more widespread and severe consequences if a higher hazard facility fails to meet its safety basis requirements. In all cases, however, this PSAR provides adequate safety analysis, evaluation, and supporting documentation. The level of effort, sophistication of analysis, and the thoroughness of documentation have been graded commensurate with the following considerations:

- The magnitude of the hazards being addressed.

- The complexity of the facility and the safety systems relied upon to maintain an acceptable level of risk.
- The stage or stages of the facility life cycle.

As recommended in DOE-STD-1027-92 (DOE 1992b) for a Hazard Category 3 facility, a simple, qualitative consequence analysis for the safety analysis should be used. The graded approach was applied in this PSAR.

1.4 Summary of Safety Analysis

The analysis of operations was performed for three areas of operation:

- Normal Operations
- Abnormal Operations
- Accidents.

The analysis was systematic and demonstrates that all radiological and chemical hazards are identified and that a broad scope of initiators is considered. The analysis shows that the MWM Facility can be operated without posing undue risk to the health and safety of facility workers, other on-site employees, or individuals at the site boundary.

1.4.1 Normal Operations

Aspects of normal operations that have a potential impact on facility workers or the on-site and off-site populations were identified and analyzed to determine what controls and mitigators are in place to maintain the impact within acceptable levels.

During normal operations, the MWM Facility workers could receive a radiation dose from in-process radioactive material. For comparison purposes, there were six personnel exposures at the Hazardous Waste Management (HWM) facilities based on data from 1990-1992 (LLNL 1992c). The maximum exposure to an HWM facility worker was 54 mrem, while the average exposure was 22 mrem (LLNL 1992b). These values are well below the occupational worker exposure level set at 5 rem.

The MWM Facility workers also could be exposed to chemical hazards during normal MWM operations. Based on LLNL waste treatment and storage emissions, the worst-case risk of incurring a cancerous health effect was calculated to be $8.90\text{E-}07$ (8.9 chances in 10,000,000) to the facility worker during the 70-year lifetime of the worker (LLNL 1992a).

The safety and health hazards associated with the operations at the MWM Facility are typical of those found for light industrial operations and include injuries such as electrical shock and back strain. Occupational safety records, summarized for the LLNL site for the five-year period ending in 1990, reported an average accident rate of 2.1 per 200,000 hours worked.

Potential radiological and chemical consequences to on-site and off-site populations and to on-site and off-site individuals during normal operation in the MWM Facility are negligible. Nonfacility workers would not be exposed to safety and health hazards associated with the MWM Facility.

1.4.2 Abnormal Operations

An Abnormal Operational Event (AOE) is defined as any unplanned loss of function of a safety or support system with the worst-case consequence resulting in a shutdown of the facility or in limited personnel exposure to contamination or hazardous chemicals. Based on MWM operations, the risk associated with the loss of function of any MWM system is estimated to be low and acceptable. This conclusion is based upon the moderate frequency and extremely low consequences associated with the various events in question and upon the fact that risk is a product of these two parameters.

1.4.3 Accidents

Accidents are those events initiated by unplanned internal or external occurrences that have the potential to produce measurable consequences. The events that potentially could result in a release of radionuclides and/or hazardous material analyzed in this PSAR are as follows:

- Earthquake
- Extreme wind or tornado
- Flood
- Fire
- Leaks and spills
- Pressurized release
- Criticality
- Explosion
- Aircraft crash
- Uncontrolled chemical reactions
- Bounding Accidents
- Beyond Design Basis Accidents.

The radiological risk of all the event scenarios considered credible is bounded by the Bounding Fire and is summarized in the following paragraphs.

The Bounding Fire scenario involving radionuclides is a fire in the liquids feed preparation area or the solids feed preparation area where containers are opened and contents are removed. The combustible liquids or combustible solids in the containers are ignited and burn releasing radionuclides from the containers.

To conservatively model the consequence of the Bounding Fire, the maximum radiological inventory of 0.052 Ci of Pu-239 is assumed to be released to the air during the Bounding Fire. The dose to the facility worker during the Bounding Fire is estimated to be 0.29 rem. The Committed Effective Dose Equivalent (CEDE) to the maximally exposed individual at the nearest site boundary (175 meters) is 0.4 rem. The dose to the maximally exposed individual at 100 meters is 1.1 rem. These consequences are judged to be acceptable based on comparisons to Environmental Impact Statement/Environmental Impact Report (EIS/EIR) criteria, Environmental Protection Agency (EPA) criteria, and DOE criteria.

The nonradiological risk of all the event scenarios considered credible is bounded by a hydrogen peroxide spill. It was conservatively assumed that the entire inventory of 3,000 gallons of 50 percent hydrogen peroxide is spilled from a storage tank to the ground and is released to the air by evaporation. The consequence to the maximally exposed individual at the site boundary (175 meters) is less than 20 ppm, which is less than Emergency Response Planning Guideline 2 (ERPG-2) or equivalent (25 ppm), and is therefore judged to be acceptable. The consequence to the maximally exposed individual at 100 meters is less than 50 ppm, which is less than ERPG-3 or equivalent (50 ppm), and is therefore judged to be acceptable.

The mitigating features that are applied at the MWM Facility include the following:

- Fire detection and suppression systems
- High-Efficiency Particulate Air (HEPA) filters and ventilation systems
- Offgas stacks
- Administrative controls (i.e., procedures and worker training).

No credit was taken for mitigating features for the radionuclide analysis. However, for the nonradiological chemical hazard analysis, berms were assumed to be in place to contain and limit the size of the chemical spills.

1.5 Items Requiring Further Development

No additional information is needed for completion of this PSAR.

1.6 Preliminary Commitments to DOE Orders and LLNL Policies

This section summarizes the preliminary commitments yet to be fulfilled by the MWM Facility to be in compliance with DOE Orders and LLNL policies and procedures. These preliminary commitments are presented in this PSAR to demonstrate that safe operation of the MWM Facility is feasible if these commitments are put in place. These commitments also demonstrate that safety issues involving the operation of the MWM Facility have been anticipated and that appropriate efforts have been made to develop the design with operational constraints and problems in mind. This section summarizes the preliminary commitments of this PSAR by chapter, as necessary.

PSAR Chapter 9 - Radiation Protection

The *Health & Safety Manual* (LLNL 1992b) will be the reference document for isotope source handling and use and for radiation safety system operation, and will provide safety procedures for administrative controls to prevent excessive radiation exposure. In addition, a Facility Safety Procedure (FSP) will be developed which will implement and supplement the *Health & Safety Manual*.

Procedures written for operation of the MWM Facility will be required to comply with Supplement 33.011 of the *Health & Safety Manual* with respect to As Low As Reasonably Achievable (ALARA) guidelines.

Airborne radioactivity areas will be established where airborne concentrations of radioactive material exceed or are likely to exceed one-tenth of the appropriate Derived Air Concentration (DAC) as required by DOE Order 5480.11 (DOE 1992e). Respiratory protection devices will be available in these areas.

Radiological areas will be identified and maintained in accordance with the *Health & Safety Manual*.

Access control to Building 494 will be maintained in accordance with the *Health & Safety Manual*.

PSAR Chapter 10 - Hazardous Material Protection

The MWM Facility Operations Section Leader will implement the Health Hazard Communication Program for operations in the facility in accordance with the

Health & Safety Manual (LLNL 1992b). Implementation of the program will be discussed in the FSP.

PSAR Chapter 13 - Procedures and Training

The development, verification, and validation of the technical content and form of all procedures will be in accordance with the requirements of DOE Order 5480.19 (DOE 1992a) and the applicable sections and supplements of the *Health & Safety Manual* (LLNL 1992b).

The development, verification, and validation of the technical content and form of training procedures will be in accordance with the requirements of the *LLNL Training Program Manual* (LLNL 1991).

PSAR Chapter 17 - Operational Safety

The Conduct of Operations Program will be developed in accordance with the requirements of DOE Order 5480.19 (DOE 1992a) and Supplement 2.19 of the *Health & Safety Manual* (LLNL 1992b).

An FSP is required for any facility having a SAR. The FSP lists the Technical Safety Requirements (TSRs) and Operational Safety Requirements (OSRs). Supplemental Operational Safety Procedures (OSPs) for the MWM Facility will be prepared in accordance with the requirements of the *Health & Safety Manual*.

PSAR Chapter 19 - Emergency Preparedness

Classification and notification of accidents will be in accordance with the requirements of DOE Order 5500.3A (DOE 1992d) and the *LLNL Draft Emergency Plan* (LLNL 1993).

A description of the MWM emergency facilities and equipment will be provided in the Facility Contingency Plan.

A description of the Evacuation Plan will be provided in the Facility Contingency Plan.

PSAR Chapter 20 - Provisions for Decontamination and Decommissioning

The decontamination and decommissioning plan for the MWM Facility will be developed in accordance with DOE Order 5820.2A (DOE 1988).

1.7 References

- Department of Energy (1987), *Safety Analysis and Review Systems*, U.S. Department of Energy, Washington, DC, DOE Order 5481.1B, Change 1, May 19, 1987.
- Department of Energy (1988), *Radioactive Waste Management*, U.S. Department of Energy, Washington, DC, DOE Order 5820.2A, September 26, 1988.
- Department of Energy (1992a), *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, DC, DOE Order 5480.19, Change 1, May 18, 1992.
- Department of Energy (1992b), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, DOE-STD-1027-92, December 1992.
- Department of Energy (1992c), *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, DOE Order 5480.23, April 10, 1992.
- Department of Energy (1992d), *Planning and Preparedness for Operational Emergencies*, U.S. Department of Energy, Washington, DC, DOE Order 5500.3A, Change 1, February 27, 1992.
- Department of Energy (1992e), *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, DC, DOE Order 5480.11, Change 3, June 17, 1992.
- Lawrence Livermore National Laboratory (1991), *LLNL Training Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-106166, February 1, 1991.
- Lawrence Livermore National Laboratory (1992a), *Chemical Health Risk Assessment for Hazardous and Mixed Waste Management Units at Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-CR-109772, September 1992.
- Lawrence Livermore National Laboratory (1992b), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.
- Lawrence Livermore National Laboratory (1992c), *Summary Report of HWM Personnel Exposures 1990-1992*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-CR-109772, September 1992.

1.7 References (continued)

Lawrence Livermore National Laboratory (1993), *LLNL Draft Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-113311, Revision 3, September 1993.

Lawrence Livermore National Laboratory (1994), *Mixed Waste Management Facility Conceptual Design Report*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-PROP-116761, 1994.

Table 1-1. Contents of the MWM Facility PSAR

DOE 5480.23 Ch. No.	PSAR Ch. No.	Title	Description of Contents
1	1	Executive Summary	Provides a brief summary of the PSAR.
2	2	Applicable Statutes, Rules, and Departmental Orders	Identifies the applicable statutes, rules, and DOE Orders binding upon the safety basis and operation of the facility.
3	3	Site Characteristics	Provides LLNL site characteristics as they relate to the MWM Facility.
4	4	Facility Description and Operation, Including Design of Principal Structures, Components, Systems, Engineered Safety Features, and Processes	Provides a description of the MWM Facility and the principal equipment, processes, and controls provided to fulfill the mission of the facility.
5	5	Hazard Analysis and Classification of the Facility	Identifies the hazard classification.
6	6	Principal Health and Safety Criteria	Identifies safety criteria for structures, systems, components, equipment, and processes contained in the MWM Facility.
7	7	Radioactive and Hazardous Material Waste Management	Describes the management of radioactive, hazardous, and mixed wastes.
8	8	Inadvertent Criticality Protection	Discusses criticality prevention.
9	9	Radiation Protection	Discusses the radiation protection programs.
10	10	Hazardous Material Protection	Discusses the hazardous material protection program.
11	11	Analysis of Normal, Abnormal, and Accident Conditions, Including Design Basis Accidents	Presents the methodology, assumptions, and results of the systematic evaluation of hazards associated with the operation of the MWM Facility.
12	12	Management, Organization, and the Institutional Safety Provisions	Discusses the responsibilities and methods of safe operation.
13	13	Procedures and Training	Describes the training and procedure control program.
14	14	Human Factors	As a below Hazard Category 3 facility, there were no human factors analyses to be performed.
15	15	Initial Testing, Inservice Surveillance, and Maintenance	Discusses the testing program.

Table 1-1. Contents of the MWM Facility PSAR (continued)

DOE 5480.23 Ch. No.	PSAR Ch. No.	Title	Description of Contents
16	16	Derivation of Operational Safety Requirements	Defines operational limits that protect the safety envelope defined in the PSAR.
17	17	Operational Safety	Discusses the requirements and guidelines for operational safety based on conduct of operations requirements.
18	18	Quality Assurance	Provides a description of the QA Program being implemented for the design, construction, operation, and maintenance of the MWM Facility.
19	19	Emergency Preparedness	Provides a description of the Emergency Preparedness Program.
20	20	Provisions for Decontamination and Decommissioning	Provides brief requirements for the decontamination and decommissioning plan for the MWM Facility, which will be developed prior to facility closure.

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 2

Applicable Statutes, Rules, and Departmental Orders

September 1994

Lawrence Livermore National Laboratory
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Chapter 2. Applicable Statutes, Rules, and Departmental Orders

This chapter of the Preliminary Safety Analysis Report identifies the Department of Energy (DOE) Orders binding upon the safety basis and operation of the Mixed Waste Management (MWM) Facility at Lawrence Livermore National Laboratory (LLNL).

Appendix G, "Treatment of DOE Orders," to contract W-74508-ENG-48 between DOE and the University of California (UC) identifies the DOE Orders that are applicable to LLNL. Appendix G is revised frequently upon the mutual agreement of UC, DOE, and LLNL. The MWM facilities will comply with all applicable provisions of these Orders. A listing of these Orders from a 1992 contract revision, as well as the Orders affecting the safety requirements of the MWM facilities, is provided in Table 2-1 as an example.

Implementation of the individual Orders at LLNL is in one of the following stages: (1) implementation is complete; (2) implementation is in progress; (3) an implementation plan is under development; (4) negotiations between DOE and UC are in progress to determine the Order's applicability to LLNL; or (5) written justification has been provided to DOE for not implementing the Order.

The Directives Management System is an LLNL database that tracks DOE Orders in Appendix G and records each Order's implementation status. Information concerning the implementation status of DOE Orders at LLNL is available from the Office of Contract Management. A review of the implementation status indicates that the Orders most directly applicable to safety and safety analysis (i.e., the 5400 series Orders) have been implemented fully.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Table 2-1. Extant DOE Orders that DOE and UC Agree Are Applicable to Contract W-74508-ENG-48^a

DOE Order #	Title	Safety Orders Affecting MWM Facility
1130.7A	Departmental Conference Activity	
1200.1A	Policy and Procedures for Departmental News Media Activities	
1240.2A	Unclassified Visits and Assignments by Foreign Nationals	
1300.2A	DOE Technical Standards Program	
1300.3	Policy on the Protection of Human Subjects	
1322.2C	Forms Management	
1322.3C	Directory of Departmental Forms	
1322.4B	Directory Standard, Optional and Other Agency Forms	
1324.2A	Records Disposition	
1324.4	Micrographic Management	
1324.5A	Records Management Program	
1324.6	Automatic Office Electronic Recordkeeping	
1324.7	Departmental History Program	
1324.8	Rights and Interests Records Protection Program	
1330.1C	Computer Software Management	
1322.1A	Uniform Reporting System	
4300.1B	Real Property Management	
4300.2B	Non-DOE Funded Work (Work for Others)	
4320.1B	Site Development Planning	
4320.2	Capital Assets Management Program	
4330.2C	In-House Energy Management	
4300.4A	Maintenance Management Program	
4440.1	Acquisition of Fuel-Efficient Passenger Automobiles by the DOE	
4540.1B	Utilities Acquisition and Management	
4700.1	Project Management System	
4700.3	General Plant Projects	
5000.1B	Institutional Planning by Multiprogram Laboratories	
5000.3A	Occurrence Reporting and Processing of Operations Information	X
5000.4A	Laboratory Directed Research and Development	
5100.3	Field Budget Process	
5300.1B	Telecommunications	
5300.2D	Telecommunications: Emission Security (TEMPEST)	
5300.3B	Telecommunications: Communications Security	
5300.4B	Telecommunications: Protected Distribution	
5400.1	General Environmental Protection Program	X
5400.2A	Environmental Compliance Issue Coordination	
5400.3	Hazardous and Radioactive Mixed Waste Program	X
5400.4	CERCLA Requirements	
5400.5	Radiation Protection of the Public and the Environment	X
5440.1D	NEPA Compliance Program	X
5480.1B	Environment, Safety, and Health Program	X

Table 2-1. Extant DOE Orders that the DOE and the UC Agree are Applicable to Contract W-74508-ENG-48^a (continued)

DOE Order #	Title	Safety Orders Affecting MWM Facility
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials	X
5480.4	Environmental Protection, Safety and Health Standards	X
5480.5	Safety of Nuclear Facilities	
5480.7	Fire Protection	X
5480.8	Contractor Occupational Medicine Program	X
5480.9	Construction Safety and Health Program	X
5480.10	Contractor Industrial Hygiene Program	X
5480.11	Radiation Protection for Occupational Workers	X
5480.13	Aviation Safety	
5480.15	DOE Laboratory Accreditation Program for Personnel Dosimetry	
5480.16	Firearms Safety	
5480.18A	Accreditation of Performance-Based Training	
5480.19	Conduct of Operations Requirements for DOE Facilities	X
5480.20	Personnel Selection, Qualification, Training and Staffing Requirements at DOE Nuclear Facilities	
5480.21	Unreviewed Safety Questions	
5480.22	Technical Safety Requirements	
5480.23	Nuclear Safety Analysis Reports	
5481.1B	Safety Analysis and Review System	X
5482.1B	Environment, Safety, and Health Appraisal Program	X
5483.1A	Occupational Safety and Health Program for Contractor Employees at GOCO Facilities	X
5484.1	ES&H Information Reporting Requirements	X
5500.1B	Emergency Management System	X
5500.2B	Emergency Categories, Classes and Notification and Reporting Requirements	
5500.3A	Planning and Preparedness for Operational Emergencies	
5500.4	Public Affairs Policy and Planning Requirements for Emergencies	
5500.7B	Emergency Operating Records Protection Program	
5500.9	Emergency Planning, Preparedness, and Response to Continuity of Government Emergencies	
5500.10	Emergency Readiness Assurance Program	
5530.1A	Accident Response Group	
5530.2	Nuclear Emergency Search Team	
5530.3	Radiological Assistance Program	
5560.1A	Priorities and Allocations Program	
5600.1	Management of DOE Weapon Program and Weapon Complex	
5610.1	Packaging and Transporting of Nuclear Explosives, Nuclear Components	
5610.2	Control of Weapons Data	
5610.10	Nuclear Explosive and Weapon Safety Program	

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Table 2-1. Extant DOE Orders that the DOE and the UC Agree are Applicable to Contract W-74508-ENG-48^a (continued)

DOE Order #	Title	Safety Orders Affecting MWM Facility
5610.11	Nuclear Explosive Safety	
5610.13	Joint DOE/DOD Nuclear Weapon System Safety	
5630.11	Safeguards and Security Program	
5630.12A	Safeguards and Security Inspection and Evaluation Program	
5630.13	Master Safeguards and Security Agreements	
5630.14	Safeguards and Security Program Planning	
5631.1B	Security Education Briefing and Awareness Program	
5631.2B	Personnel Security Program	
5631.4	Control of Classified Visits	
5631.5	Violations of Laws, Losses, and Incidents of Security Concern	
5631.6	Personnel Security Assurance Program	
5632.1A	Protection Program Operations	
5632.2A	Physical Protection of Special Nuclear Material and Vital Equipment	
5632.5	Physical Protection of Classified Matter	
5632.6	Physical Protection of DOE Property and Unclassified Facilities	
5632.7	Protective Forces	
5632.8	Protective Programs Operations - Systems Performance Tests	
5632.9	Issuance, Control, and Use of Badges, Passes, and Credentials	
5632.10	Safeguards and Security Equipment Standardization	
5633.3	Control and Accountability of Nuclear Material	
5633.4	Nuclear Materials Transactions: Documentation and Reporting	
5633.5	Nuclear Materials Reporting and Data Submission Procedures	
5634.1A	Facility Approval, Security Survey, and Nuclear Materials Surveys	
5635.1A	Control of Classified Documents and Information	
5635.2B	Protection of Classified National Security Council Information	
5635.3	Hand-Carrying Classified Matter on Air Carriers	
5635.4	Protection of Unclassified Controlled Nuclear Information	
5636.1	Prohibition on Wiretapping and Eavesdropping	
5636.3A	Technical Surveillance Countermeasures Program	
5637.1	Classified Computer Security Program	
5639.7	Operations Security Program	
5650.2B	Identification of Classified Information	
5650.3	Identification of Unclassified Controlled Nuclear Information	
5660.1	Management of Nuclear Materials	
5670.1A	Management and Control of Foreign Intelligence	
5670.2	Security of Foreign Intelligence Information and Sensitive Compartmented Information	
5700.2D	Cost Estimating, Analysis, and Standardization	
5700.6C	Quality Assurance	X
5700.7C	Work Authorization System	

Table 2-1. Extant DOE Orders that the DOE and the UC Agree are Applicable to Contract W-74508-ENG-48^a (continued)

DOE Order #	Title	Safety Orders Affecting MWM Facility
5800.1A	Research and Development Laboratory Technology Transfer Program	
5820.2A	Radioactive Waste Management	X
5900.2A	Use of the Metric System of Measurement	
6430.1A	General Design Criteria	X
N4700.4A	Baseline Change Control Process at the Executive Level	
SEN 30-91	Setting the Course for Technology Transfer in the DOE	

^a This list of DOE Orders was taken from the 1992 revision of contract W-74508-ENG-48; many Orders have been superseded since that revision.

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Chapter 3 Site Characteristics

September 1994

Lawrence Livermore National Laboratory
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Chapter 3. Site Characteristics

This chapter of the Preliminary Safety Analysis Report (PSAR) addresses the site characteristics of Lawrence Livermore National Laboratory (LLNL) as they relate to the Mixed Waste Management (MWM) Facility (Building 494).

3.1 Site Description

LLNL, occupying a total area of approximately 1.3 square miles (821 acres), is located about 64 kilometers (40 miles) east of San Francisco at the southeast end of Livermore Valley in Alameda County, California. The city of Livermore's central business district is located approximately 5 kilometers (3 miles) to the west of the LLNL site. Figure 3-1 shows the regional location of LLNL with respect to the San Francisco Bay and San Joaquin River area. LLNL is bordered on the east by Greenville Road, on the north by Patterson Pass Road, on the west by Vasco Road, and on the south by East Avenue. Regional access to LLNL is primarily from Interstate 580 by the Vasco Road and Greenville Road interchanges. The LLNL site is accessed by security gates along Vasco Road (West Gate), East Avenue (South Gate), and Greenville Road (East Gate).

The Livermore Valley is surrounded by hills that define the region and open space around the development on the valley floor. The terrain in the vicinity of the site ranges from relatively flat land to gently rolling hills. The hills east and south of LLNL gradually become steeper as they trend eastward to form the Altamont Hills of the Diablo Range.

The area surrounding the LLNL site is generally rural and pastoral because of the surrounding hillsides. Rural residences and grazing land are the primary land uses to the south and east of the site. The rural character continues to the southwest, where large vineyards are located. West of the LLNL site, existing and newly constructed residential areas of the city of Livermore provide a more suburban area. The area extending north from the LLNL site to Interstate 580 is industrial and includes research, business, and industrial sites. Primary features in this area are one- and two-story industrial buildings, business parks, and the Union Pacific and Southern Pacific railroad lines that traverse the area. Figure 3-2 shows the LLNL site relative to surrounding land uses.

The LLNL Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992) provides additional information on the physical and geological setting in and around LLNL.

3.2 Location of the MWM Facility on LLNL Site

The MWM Facility is located in Building 494, near the north fence of the LLNL complex, as shown in Figure 3-3. The distance to the nearest point of unrestricted public access (security fence) is 175 meters (575 feet), due north. The nearest public road is 191 meters (627 feet), due north. Building 494 is located in an area of LLNL that has no additional access restrictions for persons authorized to be unescorted within the basic LLNL fenced area. The MWM Facility is accessed from the south by the North Outer Loop as shown in Figure 3-3.

The MWM Facility floor plan is shown in Chapter 4 of this PSAR.

3.3 Site Characteristics

LLNL is located at the east end of the Livermore Valley groundwater basin. Recharge to the basin is largely from arroyos that originate in the foothills, including Arroyo Seco and Arroyo Las Positas, which cross the LLNL site. Arroyo Las Positas is the only potential source of flooding on the LLNL site (DOE and UC 1992).

Potentially strong earthquake ground motion sources at LLNL include the major regional fault zones and local faults. A major seismic event could result in adverse impacts to some structures and equipment leading to a hazardous material release and/or the structural failure of buildings and facilities (DOE and UC 1992). Potential accidents resulting from natural phenomena are discussed in Chapter 11 of this PSAR.

The area around Building 494 slopes gradually away from the building to drain water from the structure. On the west and southwest sides of the building, asphalt covers the ground and diverts precipitation runoff west to storm water collection areas associated with the Waste Accumulation Area, Building 495. Storm water runoff from the areas around the building either flows naturally or is collected and discharged to a small canal (Arroyo Las Positas) that runs east to west, north of Building 494 (LLNL 1993).

Complete discussions of geology, seismology, demography, local and regional meteorology, climatology, regional land and water use patterns, and hydrology are presented in Volume I, Section 4 of the EIS/EIR (DOE and UC 1992).

3.4 References

Department of Energy and University of California (1992), *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*, U.S. Department of Energy and University of California, Livermore, CA, DOE/EIS-0157, August 1992.

Lawrence Livermore National Laboratory (1993), *Preliminary Hazards Analysis for Building 494 Mixed Waste Management Facility*, Draft, Lawrence Livermore National Laboratory, Livermore, CA, February 12, 1993.

Figure 3-1. Regional Location of the LLNL Site

Figure 3-2. Location of the LLNL Site Relative to Surrounding Land Uses

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Chapter 4

Facility Description and Operation, Including Design of Principal Structures, Components, Systems, Engineered Safety Features, and Processes

September 1994

Lawrence Livermore National Laboratory
University of California Livermore, California 94551

Chapter 4. Facility Description and Operation, Including Design of Principal Structures, Components, Systems, Engineered Safety Features, and Processes

4.1 Introduction

This chapter describes the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL) and the principal equipment, processes, and controls provided to fulfill the mission of the facility. The operations to be conducted at the MWM Facility include demonstration of technologies for the handling, treatment, packaging, and short-term storage of low-level mixed wastes.

Chapter 5 of this Preliminary Safety Analysis Report (PSAR) shows only the potential for localized consequences based on the inventory of nuclear and hazardous materials in the MWM Facility. Therefore, the MWM Facility has been classified as a Radiological/Low Hazard facility. As a Radiological/Low Hazard facility, all of the topics listed in paragraph 8b(3) of Department of Energy (DOE) Order 5480.23 (DOE 1992a) are not necessary for this chapter of the PSAR; therefore, a graded approach has been utilized for the preparation of this PSAR.

Information pertaining to the design and operation of the MWM Facility is provided to the level of detail warranted by existing documentation (e.g., DOE and UC 1992; LLNL 1993a,b,c; Keller and Gannon 1993a,b; DOE 1994) that supports the Radiological/Low Hazard facility classification. Information on the design of principal structures, components, and systems of the MWM Facility is provided to the level of detail needed to support the safety analysis of this facility. The majority of the information for the facility descriptions and requirements has been obtained from the draft *Supplemental Conceptual Design Report for Subproject B Building 494 Upgrade* (Keller and Gannon 1993b), draft *Mixed Waste Management Facility Conceptual Design Report* (LLNL 1994), draft *System Design Requirements for MWMF* (LLNL 1993c), and draft *Mixed Waste Management Facility Functional Requirements and Design Criteria* (LLNL 1993a). Where additional detail is required, references to appropriate technical documents are provided.

4.1.1 Comparison to DOE Design Requirements

Various sections of this chapter discuss the principal health and safety criteria invoked by Chapter 6 of this PSAR and how the MWM Facility meets the criteria through facility design. Table 4-1 summarizes the criteria discussed in Chapter 6

of this PSAR and indicates the section of Chapter 4 that demonstrates whether the MWM Facility is in compliance with the associated criteria.

4.2 Process Buildings/Structures

The MWM Facility is composed of Building 494 and the immediately adjacent areas used for ancillary facilities and service access. The layout of the MWM Facility complex is shown in Figure 4-1.

Building 494 is a 30,000-ft² (120 feet by 250 feet) single-story structure with a concrete floor, structural steel framing, and sheet metal sides and roof (DOE 1994). The eve height is 30 feet with a peak roof height of 32.5 feet. Prior to becoming the MWM Facility, Building 494 has only been used as a shop for laser systems assembly and for related storage. The building floor plan, before alterations necessary for use as the MWM Facility, is shown in Figure 4-2. The building was categorized as a "General Use"(Excluded) facility, as described in UCRL-15910 (Kennedy et al. 1990), and was designed in compliance with the 1985 Uniform Building Code (UBC) except where LLNL specified more rigorous design requirements.

The areas immediately adjacent to Building 494 are to be developed specifically for support of the MWM Facility. Currently, only standard asphalt paving surrounds the facility. As shown in Figure 4-1, a tank farm, a new electrical service including a backup power diesel generator, and a free-standing exhaust stack will be located on the north side of Building 494.

Containerized solid and liquid mixed wastes will be brought to the MWM Facility receiving areas by forklifts, manual and electric lifts, trucks, or other similar equipment approved for such transportation purposes by LLNL's Hazardous Waste Management (HWM) Division. Except for those materials properly released to the sanitary sewer or to the building exhaust stack, all wastes, or products from the MWM Facility final forms process, are similarly transported from the MWM Facility shipping area.

4.2.1 Building 494

4.2.1.1 Function

Building 494 will initially house four demonstration primary process systems: Wet Oxidation (WOX), Ultraviolet Photolysis (UVP), Mediated Electrochemical Oxidation (MEO), and Molten Salt Oxidation (MSO). These systems will be used to demonstrate processing of mixed waste materials. The building will also

house other systems that directly support the operation of those primary systems or otherwise support the overall mission of the MWM Facility. A key function of the building shell is to provide the envelope within which confinement zones and negative pressure gradients can be established around the MWM Facility processes. Maintaining these zones and pressure gradients minimizes the threat of potential backflows or other airborne spread of contamination within and to the outside of the building.

Building 494 will house areas for in-process storage, shipping, and receiving; offices; showers; rest rooms; and a public reception and/or display area.

4.2.1.2 Process Building Description and Plans

Building 494 will undergo modifications from its existing condition before its use as the MWM Facility. The building floor plan will be increased by approximately 1,250 ft² to a total of 31,250 ft² due to the addition of office/conference/display space on the south side of the building (Keller and Gannon 1993b). Modifications to the building are being made to increase its resistance to natural phenomena hazards (e.g., seismic forces), consistent with UCRL-15910 (Kennedy et al. 1990), LLNL's seismic safety committee recommendations, and the building's classification as a Radiological/Low Hazard facility, in accordance with Chapter 5 of this PSAR. The details of these structural modifications are discussed in Section 4.2.1.4. Other modifications are being made to the interior of Building 494 as necessitated by the planned function of the MWM Facility. Figure 4-2 illustrates the floor plan of Building 494 before its modification. As shown, the existing Building 494 contains almost no interior walls or other structures. Figure 4-3 illustrates the floor plan of Building 494 after modifications have been completed. A comparison of the two figures demonstrates the nature and extent of added interior walls, partitions, office space, and separated process areas. The building configuration provides for the approximate square footage by area given in Table 4-2.

The modified building will provide the necessary space to install fully integrated mixed waste processes on a pilot scale. The mixed waste process areas include Solids Feed Preparation (SFP) and Liquids Feed Preparation (LFP) areas, a waste treatment (WOX, UVP, MEO, and MSO) process area with interim storage, a water treatment area, an analytical laboratory, and final forms packaging areas. In addition, process support areas include receiving and shipping, equipment staging, facility offgas, refurbishment, and decontamination. Building 494 utilities include Heating, Ventilation and Air Conditioning (HVAC) (this provides conditioned air to building occupants and is separate from the MWM Facility offgas system), sanitary sewer, lighting and electrical, water, hot water and steam, fire protection, and communication/alarm systems (Keller and Gannon 1993b).

The floor of the building is a 7-inch-thick reinforced concrete slab supported at the building perimeter by a reinforced concrete grade beam of 12- by 17-inch nominal cross section. Interior and exterior columns are supported by reinforced concrete spread footings measuring 7 feet square and 5 feet square, respectively, and 2 feet 7 inches deep. The foundations and floor slab will be modified as part of the Building 494 upgrade (see Section 4.2.1.4).

Mixed waste processing areas will have curbed concrete floors and/or sumps to contain spillage and potential water from the sprinkler system. Special coatings (epoxy) will seal the inside surfaces and provide easier decontamination. Existing floor drains to the sanitary sewer will be sealed.

The structure above the foundation is a prefabricated structural steel frame sheathed with preformed sheet metal siding bolted vertically on z-girts and preformed sheet metal roofing bolted on z-purlins. It is totally enclosed on all four sides with the roof covering the full extent of the structure. Lateral resistance in the north-south (transverse) direction is provided by rigid frames (bents) on 25-foot centers. Lateral resistance in the east-west (longitudinal) direction is provided by braced frames in the plane of the two exterior perimeter walls. Z-purlins are supported on the built-up structural steel beams of the rigid frames. Built-up, tapered, structural steel columns form the exterior vertical elements of the rigid frames and support the z-girts. Straight, structural steel interior columns are located at third-points of the rigid frames. A roof bracing system acts to transfer the roof's longitudinal lateral forces to the braced frames. In the transverse direction, the metal roofing panels, stiffened by their attachment to the roof purlins, act as diaphragms to transfer the roof's lateral forces to the rigid frames (Keller and Gannon 1993a).

The building structure will be used as a tertiary confinement boundary within which negative pressure zones will be maintained. Access to the waste processing areas will be via air locks as depicted in Figure 4-3. By using air locks, the ventilation system, and the building structure, proper pressure differentials can be maintained to ensure that building air flow is directed from areas of potentially lesser contamination to areas of potentially higher contamination.

4.2.1.3 Major Components

The major components of Building 494 will initially be the four demonstration primary process systems: WOX, UVP, MEO, and MSO. These process systems are discussed in Section 4.5.

Several of the process auxiliary support systems, while not considered major components, are nevertheless very significant because they handle or process waste components or products at elevated temperatures or pressures, or in ways

that if some failure occurred, localized radiological consequences or on-site hazardous material consequences could occur. As a minimum, the final forms, facility offgas, and waste feed preparation systems would be included in this category. These components are discussed in Section 4.6.

4.2.1.4 Structural Specifications and Safety Design Basis

Building 494 was engineered and fabricated in 1988 in accordance with construction specification No. 880400 (LLNL 1988). The structural specifications of specification No. 880400 required adherence to design requirements listed therein or the requirements of the UBC (UBC 1985), whichever were greater. All construction materials and methods were required to conform to industry standards, such as the American Society for Testing and Materials (ASTM), the American Welding Society (AWS), the American Iron and Steel Institute (AISI), the American Institute for Steel Construction (AISC), and the American Concrete Institute (ACI).

Although Building 494 is being classified as a Radiological/Low Hazard facility in its role as the MWM Facility, its structural components will be strengthened and modified so as to comply with all requirements of DOE Order 6430.1A (DOE 1989), UCRL-15910 (Kennedy et al. 1990), and UBC 1991 for a Moderate Hazard facility to provide flexibility in future operations. An evaluation (Keller and Gannon 1993a) of the facility was made in which it was determined that upgrading the facility to meet the requirements for a Moderate Hazard facility in accordance with UCRL guidelines would necessitate the following construction:

- Adding structural tube braces to the roof framing system.
- Adding structural tube braces to the wall framing system.
- Replacing interior columns with larger size members.
- Increasing flexural capacity of transverse bents by welding on flange cover plates and web doubler plates.
- Constructing grade beams between each pair of interior columns in the transverse bents.
- Constructing grade beams under each set of wall braces (four grade beams, each about 75 feet long).

Since the requirements for a Moderate Hazard facility exceed the requirements for a Low Hazard facility, the design and analysis loads used in the evaluation (Keller and Gannon 1993a) meet the requirements of all applicable local codes

and DOE requirements for a Radiological/Low Hazard facility. The design wind and seismic evaluations are in accordance with the requirements invoked by Chapter 6 of this PSAR, as are the resulting member stresses and forces, assuming the retrofit actions described above are incorporated in the structure.

Building 494 is located below the Design Basis Flood (DBFI) elevation invoked by Chapter 6 of this PSAR. To minimize the effects of local flooding, the building has been designed and/or upgraded with the following run-on controls:

- The roof, wall panels, and closed doors prevent precipitation from entering the structure.
- Gutter and downspout systems divert storm water to local drainage systems within the MWM Facility.
- Perimeter curbing and MWM Facility drainage features prevent surface water run-on during and following a storm event.

4.2.2 Building 494 Utility Area

4.2.2.1 Function

The treatment processes located in Building 494 require a storage area for process reagents and process output water. A new tank farm, consisting of tankage for both process reagents (hydrogen peroxide, H_2O_2 , and HNO_3) and process output water treatment tanks, will be constructed exterior to Building 494. Additional process reagents, such as sodium hydroxide and sulfuric acid, will be contained in 55-gallon drums and stored in this area. Incompatible chemicals will be separated appropriately. A new electrical service consisting of a new substation and a new standby generator will also be located exterior to Building 494.

4.2.2.2 Area Descriptions and Plans

The tank farm will be located on the north side of Building 494 at the west end, separated from the building a distance of approximately 35 feet.

The hydrogen peroxide reagent tank will be constructed of passivated aluminum or stainless steel. The hydrogen peroxide (50%) tank capacity of 3,000 gallons will be sufficient to supply the WOX and UVP process systems with the required reagent. The nitric acid (15M) reagent tank will have a capacity of approximately 20 gallons. Nitric acid will be used as a reagent in the MEO process.

The water treatment tanks provide storage for wastewater recycled from the various treatment processes. The wastewater is collected in the tanks for final sampling before reuse in the treatment processes or discharge to the sanitary sewer.

The reagent and water treatment tanks will be located on a concrete pad, which will be sloped and provided with concrete curbing and/or sumps.

The electric substation and standby generator will be located at the northeast corner of Building 494. The new electric substation will provide the necessary levels of electric power to operate the various primary process, auxiliary process, and other MWM Facility systems such as lighting, HVAC, and basic building electrical items. The new electric service substation will provide 3,000-kVA power to the MWM Facility in normal operation (Keller and Gannon 1993b).

A 350-kW diesel generator will be provided for important loads. Standby power will be supplied to emergency lighting, important HVAC equipment, control room Uninterruptible Power Supply (UPS) loads, and the fire alarm panel. The standby generator will be provided with a 12-hour day tank fuel supply located in the generator skid base (Keller and Gannon 1993b).

4.2.2.3 Major Components

The major components of the Building 494 Utility Area are the reagent tanks, the water treatment tanks, sump pumps, associated piping and instrumentation control items, and the standby diesel generator system. Section 4.9.2 provides detailed information concerning the electrical power systems.

4.2.2.4 Structural Specification and Safety Design Basis

The seismic and wind structural design requirements of DOE Order 6430.1A (DOE 1989), UCRL-15910 (Kennedy et al. 1990), LLNL seismic safety committee recommendations, and UBC 1991 will be met in the design of the tanks and their support structures. Support structures for the standby diesel generator (and supporting equipment, tanks, etc.), the substation, and the free-standing exhaust stack will also be designed in accordance with those requirements.

Consequently, the design wind and seismic requirements invoked by Chapter 6 of this PSAR for these components will be met.

All of the Area 494 tank farm, utility service, and access areas are below the DBFI elevation invoked by Chapter 6 of this PSAR. To minimize the effects of local flooding, the area will be designed and/or will be upgraded with the following run-on controls:

- Gutter and downspout systems divert storm water to local drainage systems within the MWM Facility.
- Perimeter curbing and MWM Facility drainage features prevent surface water run-on during and following a storm event.

4.3 Safety Design Features

Due to the MWM Facility being classified as a Radiological/Low Hazard facility, there are no MWM Facility items or systems requiring special consideration in the design of safety protection systems (see Chapter 6 of this PSAR). However, to maintain personnel and environmental exposures from radioactive and hazardous materials to As Low As Reasonably Achievable (ALARA), certain design features and controls have been incorporated into the design of the facility.

This section discusses radiological and hazardous sources and the safety design features provided to prevent any unnecessary exposure to the worker and/or the environment.

4.3.1 Radiation Sources

The MWM Facility will handle, store, and process solid and liquid low-level mixed wastes. The low-level mixed wastes are sources of radiation, which exist primarily as contained sources. Airborne sources resulting from the processing of these contained sources are also possible. The following sections address both types of sources and define the radiation protection design features to be provided at the MWM Facility. Chapter 5 of this PSAR provides a detailed description of the isotopic contents of the waste stored or processed in the MWM Facility.

Monitoring as required by facility administrative controls and Operational Safety Requirements (OSRs) will be employed to limit the radionuclide inventories at the facility.

4.3.1.1 Contained Sources

Contained radiation sources within the MWM Facility will consist of the radioactive materials associated with the low-level radioactive organic mixed waste managed at this facility.

The MWM Facility will receive low-level mixed waste at the receiving and shipping area. The mixed waste is contained in a variety of storage containers. The types of containers that will be received include steel cans, steel and cardboard type barrels, cardboard boxes holding vials or bottles, plastic and steel carboys, and overpacks. The containers are constructed of various materials and range in capacity (see Section 4.6.1 for storage capacities and maximum receiving rates). During waste treatment, radioactive sources will be contained by process equipment (i.e., piping, treatment units, and storage tanks) and/or process system enclosures.

4.3.1.2 Airborne Sources

The sources for airborne contamination are the radioactive constituents of mixed waste being processed in the facility. During operations in the waste process areas (i.e., feed preparation, waste treatment [WOX, UVP, MEO, and MSO], water treatment, analytical laboratory, and final forms packaging), the potential exists for a release of radioactive contamination. Particularly, whenever waste containers are opened (feed preparation) or waste is received or handled in final forms (as a powder) prior to final processing, it is possible for radioactive contamination to become airborne. All waste treatment process vessels, tanks, piping, offgas systems, and associated equipment are potential sources of airborne radioactive contamination. Airborne radioactivity is confined by the MWM Facility offgas treatment system as discussed in Section 4.3.2.2.

4.3.2 Radiation Protection Design Features

4.3.2.1 Design Considerations

DOE Order 5480.11 (DOE 1992b) prescribes limits for worker radiation exposure. The Order also stipulates that exposure at any facility should be kept ALARA. Facility design provides the primary method for ensuring that radiation exposure to on-site and off-site personnel is maintained ALARA.

It is LLNL's policy that the radiation protection standards of DOE Order 5480.11 be met and that facilities be designed to prevent intakes of radioactive materials and to minimize exposure to ionizing radiation to the extent reasonably achievable (LLNL 1992).

The overall radiological safety objective for a radiological facility is to ensure that the facility can be operated and decommissioned without undue risk to the general public or to on-site personnel. Several radiological safety concerns that need to be considered are as follows:

- Protection against an uncontrolled release of radioactive material to the environment.
- Prevention and mitigation of the spread of contamination within the facility.
- Radiation protection for workers.

Inventory controls on the type of waste accepted at the MWM Facility are the primary means of controlling radioactive materials in the facility. In addition, design features (i.e., sealed containers, secondary confinement, personnel access controls, Continuous Air Monitors [CAMs], offgas systems, and High-Efficiency Particulate Air [HEPA]-filtered exhaust systems) will be provided to maintain radiation doses and contamination ALARA (LLNL 1992).

It should be noted that the design considerations, as described above, provided in DOE Orders 6430.1A (DOE 1989), 5480.11 (DOE 1992b), and other pertinent DOE Orders as identified in Chapter 6 of this PSAR, have been followed. Chapter 6 of this PSAR provides additional details on the safety criteria invoked on the MWM Facility, and Chapter 9 of this PSAR provides further information on radiation protection. The issue of decommissioning is addressed in Chapter 20 of this PSAR.

4.3.2.2 Description

The primary methods of confinement for the mixed waste processed and/or stored at the MWM Facility involve the use of sealed waste containers, process system equipment, process enclosures, ventilation control, pressure differentials, and offgas systems. The types of containers used to contain the waste are the same as those discussed in Section 4.3.1.1. Waste containers are always kept closed, except when wastes are being transferred from containers or when waste is being processed. When waste containers are received into the MWM Facility, bungs are tightened and rings are bolted; can lids are taped shut; and boxes are taped, stapled, clamped, or nailed shut. The containers are constructed of various materials, such as metals, cardboard, and plastics.

The information on the containers is organized (on the container) by the specific waste types stored in the containers. The container information includes container composition and specifications (i.e., container type, capacity, and description). Information on the compatibility of containers with waste types is also provided. Facility administrative controls provide waste acceptance limits for waste containers received at the facility. Waste characterization data are identified by the original generator and shown on the container label and waste requisition forms. This information is screened to ensure that there are no

criticality safety concerns and that radiation and surface contamination levels are adequate for safely handling the containers.

MWM Facility process equipment is designed to be leak free. However, to protect against spills, process areas will be provided with adequate secondary containment capacity through the use of concrete curbing. Epoxy sealants are used to maintain a leaktight, chemically compatible secondary containment system. Accumulated liquids in the secondary containment system are visually detected, either pumped out or absorbed, placed into an appropriate container, and then sampled and analyzed (if the identification of the material or its origin is questionable). An on-site or off-site analytical laboratory certified by the California Department of Health Services will be used for analysis of any accumulated liquids.

To confine radioactive airborne sources, the MWM Facility will be provided with ventilation and offgas treatment systems. By using supply and exhaust fans with appropriate design flow rates, proper pressure differentials are maintained between building confinement zones. Multiple confinement zones will be provided, with air pressure gradients across confinement barriers such that the air flows from the lowest to highest level of potential contamination. All confinement zones are below atmospheric pressure (LLNL 1993a).

To prevent the release of radioactive contamination to the atmosphere and to minimize the potential exposure of Operations personnel, process areas and equipment will be equipped with offgas system enclosures and exhaust hoods. Gases evacuated from volumes within processing and storage vessels, tanks, and other confinement barriers will be treated prior to being released to the environment. Offgas treatment will include serial use of HEPA filters and activated carbon getter (adsorption) as appropriate for the possible offgas contents (LLNL 1993a). Section 4.6.4 provides additional details of the offgas treatment systems to be used in the MWM Facility.

Access control at the MWM Facility is maintained in accordance with the *Health & Safety Manual* (LLNL 1992). Access to all LLNL waste management areas is strictly controlled. Only those personnel approved by MWM Facility Supervision will be authorized to enter and/or to work in the MWM Facility. All visitors will be required to log in and out and to be escorted by trained personnel. Instrumentation to detect surface contamination on personnel and equipment will be available for use at the exits of potentially contaminated areas to prevent contaminated items and clothing from leaving the controlled areas.

Radiological control areas will be identified and maintained in accordance with the *Health & Safety Manual*. Barriers and signs are utilized to alert personnel of hazards. To determine possible internal contamination or exposure, all personnel working in areas where radioactive materials are handled must be

monitored. All employees are required to wear at a minimum a Thermoluminescent Dosimeter (TLD) to record the external radiation exposure received (LLNL 1992). In addition, each employee working in the MWM Facility will submit periodic bioassay samples and receive a whole-body count in accordance with the direction of the Hazards Control Health Physicist assigned to the area. The frequency and need for testing are determined by MWM Facility Supervision and the Health Physicist, based on the nature and duration of the work to be performed.

Portable radiation monitors and CAMs will be used to detect radiation and airborne contamination and to warn Operations personnel. The LLNL Hazards Control Department maintains programs for monitoring the work environment to ensure that doses remain below applicable radiation protection standards. The *Health & Safety Manual* discusses monitoring requirements, maintenance, and calibration of monitoring equipment.

4.3.3 Hazardous Material Sources

The sources of hazardous material in the MWM Facility will consist of the mixed wastes managed at these facilities and the chemicals (reagents) used to treat this waste. The following sections address both types of sources and define the hazardous material protection design features provided. Chapter 5 of this PSAR provides a detailed description of the hazardous materials to be stored or processed in the MWM Facility.

4.3.3.1 Contained Sources

The MWM Facility will handle, store, and process hazardous material in the form of mixed waste and reagents. Hazardous material is any solid, liquid, or gaseous material that is toxic, explosive, flammable, corrosive, or otherwise physically or biologically threatening to health (DOE 1992a).

Hazardous waste is waste that is designated hazardous by the U.S. Environmental Protection Agency (EPA) regulations found in Title 40 Code of Federal Regulations (CFR) Part 261 and/or by the state of California regulations found in Title 22, California Code of Regulations (CCR). The term *hazardous waste* refers to nonradioactive hazardous waste. *Mixed waste* refers to waste containing both radionuclides and hazardous components.

The mixed waste and reagents located within the MWM Facility may contain such items as carcinogenic, toxic, corrosive, reactive, pyrophoric, combustible, and flammable materials.

Hazardous reagents located within the MWM Facility will be contained in storage drums, process equipment (i.e., piping, treatment units, and storage tanks), and process system enclosures.

4.3.3.2 Airborne Sources

There are no expected airborne sources in the MWM Facility waste container storage areas since all waste containers are maintained tightly closed. However, during waste segregation when containers are open, the potential exists for a release of hazardous gases, vapors, and/or particulates. In addition, the four primary treatment processes (WOX, UVP, MSO, and MEO) generate the following air pollutants: volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and acid vapors.

The sources of airborne contamination are the reagents and the constituents of the mixed wastes being processed in the facility. All waste treatment process vessels, tanks, piping, offgas systems, and associated equipment are potential sources of airborne hazardous vapors and gases.

4.3.4 Hazardous Material Protection Design Features

4.3.4.1 Design Considerations

It is LLNL's policy to meet DOE Health and Safety Orders and to comply with the prescribed standards and local, state, federal, and University of California regulations. The LLNL Health and Safety Policy, which includes hazardous material, is defined in the *Health & Safety Manual* (LLNL 1992).

It is LLNL's policy that facilities be designed to minimize personnel exposure to hazardous materials to ALARA. At a minimum, exposures to hazardous materials are maintained below exposure limits (i.e., the lower of the Occupational Safety and Health Administration [OSHA] Permissible Exposure Limits or American Conference of Governmental Industrial Hygienists [ACGIH] Threshold Limit Values) as defined by DOE Order 5480.4 (DOE 1993).

Engineering and administrative controls are implemented to control exposures. Facility administrative procedures are followed during any process (e.g., transfer, treatment, and maintenance activities) that involve hazardous materials.

Chapter 6 of this PSAR provides the safety protection system criteria invoked on the MWM Facility to ensure safe facility operation. It should be noted that the design considerations provided in DOE Order 6430.1A (DOE 1989) and other pertinent DOE Orders as identified in Chapter 6 of this PSAR have been

followed. Chapter 10 of this PSAR provides further information on hazardous material protection.

4.3.4.2 Description

The primary methods of controlling hazardous material exposures at the MWM Facility involve the use of sealed storage containers, process system equipment, process enclosures, and offgas systems. Hazardous and mixed wastes are stored in the same containers discussed in Section 4.3.1.1. Container information includes container composition and specifications (i.e., container type, capacity, and description). Information on the compatibility of containers with waste types is also provided.

Reagents such as sodium hydroxide and sulfuric acid are stored in 55-gallon drums. Nitric acid and hydrogen peroxide are stored in 20- and 3,000-gallon tanks, respectively. The nitric acid tank is hard-piped directly to the MEO system while the hydrogen peroxide tank is piped to the WOX and UVP systems.

MWM Facility process equipment is designed to be leak free; however, to protect against spills, process areas will be provided with secondary containment as discussed in Section 4.3.2.2.

To confine hazardous airborne sources, the MWM Facility will be provided with ventilation and offgas treatment systems. By using supply and exhaust fans with appropriate design flow rates, proper pressure differentials are maintained between building confinement zones. Negative air flows sweep away any hazardous vapors from the process unit and from Operations personnel. To prevent the release of hazardous gases to the atmosphere and to minimize the potential exposure of Operations personnel, offgas treatment systems will be utilized. Section 4.6.4 provides additional details of the offgas treatment systems to be used in the MWM Facility.

Access control at the MWM Facility is maintained in accordance with the *Health & Safety Manual* (LLNL 1992) as described in Section 4.3.2.2.

4.4 Description of Facility Process

4.4.1 Facility Purpose

The MWM Facility is designed to demonstrate different emergent technologies that are alternatives to incineration for processing low-level organic mixed waste into forms acceptable at a low-level disposal site such as the Nevada Test Site

(NTS), or forms that can be more readily treated and/or disposed of in conventional ways. Hazardous waste facilities designed for experimental purposes are eligible to apply for a Research, Development, and Demonstration (RD&D) Permit. This permit program is administered by the California EPA, Department of Toxic Substances Control (DTSC) since California has been delegated authority by the U.S. EPA to implement the federal Resource Conservation and Recovery Act (RCRA) program.

The DTSC, Alternative Technology Division, is responsible for evaluating and permitting RD&D facilities in accordance with 22 CCR 66270.65. LLNL is seeking an RD&D permit and has submitted a "Request for Eligibility Determination" to the Alternative Technology Division of the DTSC in November 1992. The response from the state to this request in March 1993 determined the suitability of the MWM Facility to qualify for an RD&D permit. LLNL will proceed with the RD&D application process in accordance with federal and state requirements.

The MWM Facility would operate under all the conditions of an RD&D permit granted by the California DTSC (DOE 1994).

4.4.2 Narrative Description of Facility Processes

The MWM Facility will conduct operations using low-level mixed wastes brought to the facility from LLNL's HWM facilities. Wastes will be both newly generated waste and previously stored and characterized waste. All of these wastes will be generated at LLNL but will be representative of wastes produced at other DOE sites. The MWM Facility would receive containers of liquid and solid mixed wastes that would potentially contain those wastes listed in Table 4-3 that are defined by DOE waste codes. The integrated flowsheet schematic shown in Figure 4-4 provides an overview of the waste process at the MWM Facility.

Waste characterization data provided on waste requisition forms will be reviewed to determine if each container of waste meets the MWM Facility waste acceptance criteria prior to receipt at the MWM Facility.

The receiving and shipping area will accept waste containers to be off-loaded by HWM personnel. Limited storage is provided in the receiving area.

Wastes accepted for treatment at the MWM Facility would be transferred from interim storage in the waste receiving area to the SFP area of the MWM Facility. Wastes would be segregated, prepared, and batched in these areas for subsequent transfer to specific treatment systems. Sorting, shredding, grinding, blending, filtering, precipitation, and centrifugal separation of wastes, for example, would be conducted as necessary in the SFP and LFP areas.

Once sufficient waste feed is accumulated in a feed queue, that waste is then fed into one of the primary demonstration treatment systems designed to process the waste. The primary initial demonstration process systems that may be used in the MWM Facility are as follows:

- Wet Oxidation (WOX) with Ultraviolet Photolysis (UVP).
- Molten Salt Oxidation (MSO) with salt recycle.
- Mediated Electrochemical Oxidation (MEO) with acid recycle and silver recovery.

These systems are discussed in greater detail in Section 4.5.

The output solids, liquids, and gases from these primary demonstration processes require further processing before they can be released to the environment or sent to the HWM Division for storage or off-site disposal. However, these additional processes use standard off-the-shelf technologies that are fully tested, operational, and no longer considered "experimental." These additional processes are discussed in more detail in Sections 4.6.4, 4.6.5, and 4.6.7.

The removal efficiency of the MWM Facility offgas system will be designed to meet Bay Area Air Quality Management District (BAAQMD) requirements. Prototype experimental process offgas systems will be installed in the MWM Facility. Process offgas will be diverted into an experimental system. Experimental systems include NO_x selective catalytic reduction, NO_x advanced wet scrubbing, and metal HEPA filter designs. The effluent from these experimental systems will be backed up by the MWM process offgas systems.

The major output of the water treatment system is a clean water stream that may be recycled for reuse to treatment units within the MWM Facility or discharged to the sanitary sewer. Recycled water would be collected in tanks for final sampling before reuse or discharge to the sanitary sewer. Any off-specification water would be routed back through the polishing steps of the water treatment process. The purpose of the polishing step is to ensure that water, reused or recycled within the facility or discharged to the environment, meets the "minimal contaminant discharge" philosophy as well as regulatory requirements. Resulting solids would be transferred to final forms for immobilization; offgas effluents would be sent to the offgas treatment system.

The principal objective of the final forms treatment is to stabilize and solidify the outputs from primary and secondary waste treatment processes, and residues from offgas treatment systems, into (1) final forms that will meet the requirements for disposal as low-level radioactive waste at an approved DOE

disposal site such as the NTS or (2) forms that can be more readily stored or disposed of in conventional ways.

Packaging, transport, and shipping of hazardous, radioactive, and mixed wastes are managed by the HWM Division of the Environmental Protection Department (EPD) of LLNL. Hazardous and radioactive wastes are currently transported off site in compliance with DOE Orders, U.S. Department of Transportation (DOT) regulations, California DOT requirements, 22 CCR, and 40 CFR. Compliance with these regulations provides protection to workers and to the public. The Building 494 staff would repackage low-level waste and other treatment-limited inorganic solid mixed wastes and return these materials to appropriate HWM facilities.

4.5 Primary Process Systems

The following sections provide the functional requirements, major components, and design descriptions for the major demonstration process systems associated with the MWM Facility: WOX, UVP, MSO, and MEO.

These primary processes, along with the principal process auxiliary support systems discussed in Section 4.6, bound the operational parameters, hazards, and potential impacts of treating mixed wastes.

All of the major demonstration process systems are contained within the envelope of Building 494. Some of the reagent feed for these systems is stored outside in the tank farm as described in Section 4.2.2. As shown in Figure 4-3, all the major demonstration process systems are located within a negative pressure confinement zone of Building 494.

Table 4-3 lists the waste streams to be processed and which experimental treatment process is proposed for each waste stream. Specific chemicals and radionuclides present in the waste are discussed in Chapter 5 of this PSAR. Information in the following sections is provided to the level of detail that supports the Radiological/Low Hazard facility classification. More detailed information on these process systems is provided in the System Design Requirements (SDRs) and the Conceptual Design Report (CDR). Chapters 15, 16, and 17 of this PSAR discuss maintenance and surveillance, OSRs, and conduct of operations, respectively.

Due to the Radiological/Low Hazard classification of this facility, no safety class components or systems are required. However, the instrumentation and controls do provide personnel and process-related safety controls.

The equipment and ancillary systems of the primary processes will be designed and fabricated in compliance with all applicable federal, state, and local regulations pertaining to the health and safety of the public, employees, and the environment. These designs are also governed by the LLNL Quality Assurance Plan for the MWM Facility project. Component materials of construction/fabrication will be designed to be compatible with the materials being processed and the process environment.

4.5.1 Wet Oxidation Process System (LLNL 1993c, LLNL 1994)

WOX is an aqueous process to treat mixed wastes, oxidizing the organic components of the waste into carbon dioxide and water. The WOX process consists of oxidizing the organic material in mixed wastes with hydrogen peroxide in the presence of a suitable catalyst (e.g., iron, nickel, and copper). The process proceeds by the initial breakdown of the hydrogen peroxide and formation of free radicals (HO_2 and OH or R) that react to oxidize and fragment organic material, eventually leading to the formation of carbon dioxide and water as the major products. The major competing reaction is the self-decomposition reaction of the hydrogen peroxide, leading to the formation of oxygen and water.

4.5.1.1 Functional Requirements

WOX will receive certain LLNL waste streams after those wastes have been prepared to meet the WOX requirements. WOX is well suited for destroying high-water, high-ash streams of cellulose and most organic wastes. Table 4-3 lists the waste streams to be processed by WOX.

Inputs to the system other than wastes would be hydrogen peroxide, transition metal catalysts (e.g., iron and copper), alkali (e.g., sodium hydroxide), mineral acid (e.g., nitric, sulfuric, and hydrochloric), and water to provide an aqueous medium for the oxidation process. For certain wastes, anti-foaming agents are also fed to control excess foaming. For certain wastes, an organic cosolvent (e.g., ethanol) may be fed to promote miscibility. For ion exchange resins containing amine groups, caustic soda is added to the system to convert the amines to ammonia. Hydrogen peroxide will be supplied (hard-piped) from a 3,000-gallon tank located in the exterior tank farm area. The remaining reagents discussed above will be stored within the facility in drums provided with metering pumps and piping for transfer to WOX.

The WOX functional requirements are summarized below:

- Store input waste feed and reagents.
- Feed wastes and reagents to treatment unit.
- Treat the wastes by oxidizing organic components.
- Transfer offgas continuously to offgas treatment.
- Transfer the condensate water continuously to UVP.
- Transfer the batch residual periodically to water treatment.
- Maintain the wastes in an aqueous dispersion.
- Feed reagents; add or remove heat.
- Oxidize organic components in the waste.
- Condense the evaporated water and organics.
- Separate organics from condensate water; recycle organics back to the reactor or purge untreatable materials to LFP; or repackage for shipping to HWM.
- Collect ash, salt, metals, and radionuclides in batch residual.

4.5.1.2 Major Components

WOX consists of two major components: the reactor and the condensate processing systems.

WOX is a chemical process which operates at moderate temperature and low pressures (i.e., approximately the boiling point of water and nominally ambient pressure, respectively). In this process the oxidizer, hydrogen peroxide, is fed to the reactor which also contains the waste stream. The reactor is the vessel within which the primary oxidation process occurs and where the by-products of the reaction are generated. The condensate processing system condenses the vapors that boil off from the reactor, separates the vapors, recycles some back into the reactor, and removes some from the system. The vapors result from water of dilution fed to the reactor, decomposed hydrogen peroxide, and destroyed organic material.

Details of the major components are provided in the CDR (LLNL 1994).

4.5.1.3 Design Description

The system will be designed to maintain confinement under Design Basis Accident (DBA) conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

WOX will be a modular configuration design so it can be easily removed and relocated as the process or facility requires. All parts will be designed to be maintainable in place except in the case of a major failure. The designs will emphasize easy disassembly and reassembly. Minimization of exposure to toxic chemical and radioactive hazards during normal operating and maintenance activities will be a primary design objective.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-5 and 4-6, respectively.

4.5.1.4 Instrumentation and Control Systems

WOX will be controlled from a single integrated local control system that permits independent operation from other processes under test in the facility. The local control system will interface with the MWM Facility supervisory Instrumentation and Control (I&C) system (see Section 4.6). The system will have the capability to operate WOX autonomously as well as in concert with the other systems in the MWM Facility through the supervisory I&C system. System performance will be monitored by a central computer-based system, which has alarms to alert operators of off-normal conditions warranting corrective action. Control interfaces will present a consistent interface to both local and remote operators. Man-machine interfaces will be designed to incorporate human factors considerations. The control system will provide for automatic start-up, automatic shutdown, parameter adjustment control, and fluid and gas sampling. There will be a redundant interlock system implemented with electromechanical relays in areas where safety or equipment damage is an issue. Additional details of the WOX I&C systems are provided in the CDR (LLNL 1994).

4.5.2 Ultraviolet Photolysis (LLNL 1993c, LLNL 1994)

The UVP system will treat the aqueous liquid condensate discharged from the WOX condensate processing system. The UVP system may also treat aqueous liquid sent to it by the water treatment system and/or LFP system. The objective of the UVP system is to destroy organics in these streams to meet the MWM Facility water effluent requirements for organics.

It is expected that the WOX system will not completely destroy the organics in its feed or the organic reaction products. The aqueous liquid from the WOX condenser is expected to contain up to 2,000 ppm of organics. The UVP system can be described as an organic polishing system to help the WOX system achieve acceptably low organic concentrations.

Some of the water that is to be treated in the water treatment system will contain organic contaminants in excess of the allowable discharge concentrations. The UVP treatment units will receive some of this water and destroy the organic constituents in the water. When the UVP system receives these streams, the UVP treatment units serve as conditioning units available to the water treatment system.

4.5.2.1 Functional Requirements

The UVP process functional requirements are summarized below:

- Store a campaign of WOX system condensate or other UVP feed
- Feed waste continuously during normal working hours
- Feed reagents, remove heat, and convert electricity to ultraviolet (UV)
- Destroy organic components in the waste
- Accumulate and store treated water
- Transfer offgas continuously to the offgas treatment system.

The composition and rate of the input streams will depend on the feed waste and operating conditions of WOX. Inputs to the system other than the waste streams would be hydrogen peroxide, a proprietary reduction reagent, alkali (e.g., sodium hydroxide), and mineral acid (e.g., sulfuric acid).

4.5.2.2 Major Components

The major components of the UVP system consist of the treatment units and storage units.

The UVP treatment units utilize UV light for the destruction of dilute dissolved organics in aqueous streams under ambient temperature and pressure. In one type of unit, UV oxidation, UV light dissociates hydrogen peroxide to form hydroxyl free radicals. These free radicals are strong oxidants that, under ambient conditions, oxidize many organics to form carbon dioxide, water, and dilute mineral acids such as hydrochloric acid. In another type of unit, UV reduction, UV light interacts with a proprietary reagent to produce hydrated electrons which are effective at removing halogen atoms from organic molecules. The UVP system will consist of one or more of these treatment units designed to meet the process objectives.

The UVP input storage unit for WOX water will be the same as the WOX output storage unit and will collect water from the WOX condenser. The UVP output storage unit will collect water that has been treated by UVP.

Details of the major components are provided in the CDR (LLNL 1994).

4.5.2.3 Design Description

The system will be designed to maintain confinement under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-7 and 4-8, respectively.

4.5.2.4 Instrumentation and Control Systems

The UVP I&C systems will be similar to the ones discussed in Section 4.5.1.4. Additional details of the UVP I&C systems are provided in the CDR (LLNL 1994).

4.5.3 Molten Salt Oxidation with Salt Recycle (LLNL 1993c, LLNL 1994)

MSO is an advanced thermal process for the treatment of mixed wastes in molten salt media and is intended to operate at temperatures in the range of 700°C to 950°C. Molten salt provides a heat transfer and reaction medium, catalyzes oxidation of organics, prevents thermal surges, and functions as an *in situ* scrubber to prevent the formation of acidic gases, such as hydrochloric (HCl),

sulfur dioxide (SO_2), and phosphorous pent-oxide (P_2O_5), by forming neutral salts, such as sodium chloride (NaCl), sodium sulfate (Na_2SO_4), and sodium phosphate (Na_3PO_4), that are retained in the melt. A massive melt provides thermal inertia to resist fluctuations in temperature and pressure resulting from potential feed errors. The melt also retains the potentially fugitive radioactive particulates and molecular species by a combination of particle wetting, encapsulation, and dissolution with complex formation. The MSO process was originally developed by Rockwell International who employed a one-stage unit operated at 900°C to 980°C (LLNL 1993b).

4.5.3.1 Functional Requirements

The MSO process functional requirements are summarized below:

- MSO Primary Unit
 - Receives waste from SFP and LFP
 - Destroys organic constituents in waste
 - Traps metals, ash, and acid gases in salt.
- MSO Salt Recycle Support
 - Receives spent salt from MSO unit
 - Separates ash and metals for final forms
 - Recycles carbonate salt.

The process will be designed to operate continuously for a week or more without shutdown in the event extended experimental runs are required. The organic components of the waste to be treated will comprise halogenated organic liquids, nonhalogenated organic liquids, combustible or heterogeneous debris, and scintillation cocktails as presented in Table 4-3.

4.5.3.2 Major Components

The MSO process has two major components: an MSO unit and a salt recycling unit. The MSO unit consists of a waste feed system, a single-stage reactor where complete oxidation occurs, a feed salt system, a condensate liquid and waste treatment system, an offgas treatment system, and a system for transferring expended salts to the salt recycling component. Salt recycling involves dissolving expended salts in water, removing and centrifuging the solids to final forms, removing sodium carbonate (Na_2CO_3) and sodium chloride (NaCl) slurries, drying salt slurries and recycling to the MSO unit, and treating condensate liquids. The offgas and water treatment systems will be part of the overall MWM Facility design, which will treat offgas and wastewater from all major processes, including the MSO process.

Details of the major components are provided in the CDR (LLNL 1994).

4.5.3.3 Design Description

The process will be designed to maintain confinement under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations of the system will cease and equipment not performing a safety function will be automatically or passively shut down. Safety interlocks will be provided for such a shutdown to occur immediately.

The MSO process will be designed as a modular system to allow easy removal or relocation as process or facility requirements change. The design will emphasize easy disassembly and reassembly of the MSO system components, piping, valves, and associated hardware. All parts will be designed to be maintainable in place at the MWM Facility. A primary design objective of the MSO system will be to minimize exposure of Operations personnel to toxic chemical and radioactive hazards during normal operating and maintenance activities.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-9 and 4-10, respectively.

4.5.3.4 Instrumentation and Control System

The MSO I&C systems will be similar to the ones discussed in Section 4.5.1.4. Additional details of the MSO I&C systems are provided in the CDR (LLNL 1994).

4.5.4 Mediated Electrochemical Oxidation (LLNL 1993c, LLNL 1994)

MEO is an aqueous electrochemical process that utilizes mediating ions to oxidize the organic components of mixed waste into carbon dioxide and water. The process is ideally suited for destroying organic liquids and some organic solids which can be finely ground or shredded. The inorganic residues of the waste will be passed to the final forms process for conversion to ceramics. In addition to destroying organics, the MEO process is also capable of oxidizing and dissolving radioactive materials.

In the MEO process, a mediator is oxidized at the anode in an electrolytic cell. The mediator in turn oxidizes and eventually destroys organics dispersed in the bulk of the electrolyte. The mediator electrolyte combination that would be used

in LLNL's MEO process is silver in nitric acid. The silver, which is initially in its lower valence state as Ag(I), is oxidized at the anode to its higher valence state Ag(II). Ag(II) is a powerful oxidizer and reacts with waste, producing intermediate OH radicals which facilitate the decomposition of organics. This process eventually results in the near-complete conversion of carbon atoms in the organic molecules to carbon dioxide, nitrogen to nitrates, sulfur to sulfates, etc. Ag(II) also oxidizes radioactive materials that are otherwise insoluble in the electrolyte, such as TRU oxides, and converts them to a soluble ionic form. During the oxidation process, Ag(II) is reduced back to Ag(I). It is then regenerated at the anode so that the process continuously repeats itself. Nitric acid and sodium hydroxide are used to maintain the proper pH for the process.

4.5.4.1 Functional Requirements

The MEO system will be designed to receive certain LLNL waste streams after these materials have been prepared to meet the MEO feed requirements. Table 4-3 lists the waste streams to be processed by the MEO system.

Inputs to the process include waste in liquid or solids in shredded form, nitric acid solution, silver nitrate, oxygen or air, cooling water for heat exchangers, sodium hydroxide, and hydrogen peroxide or ammonium thiosulfate. Outputs include carbon dioxide, trace quantities of NO_x, sodium chloride, water, and nitric acid still bottoms. Sulfates, phosphates, etc., will be present in the still bottoms if organic compounds in the wastes contain sulfur, phosphorous, etc. There is a potential for hydrogen generation (see Chapter 11 of this PSAR). The still bottoms will also contain nitrate salts of metals (including radioactive materials) carried into the system with the mixed waste feed streams. Recycled streams will include water, nitric acid, and silver nitrate. Gaseous products from the process (NO_x and CO₂) will be transferred to the MEO process offgas treatment system; excess water will be recycled; and nitric acid will be transferred to the acid recovery still. Acidic still bottoms will be transferred to final forms.

4.5.4.2 Major Components

The MEO system consists of two major subsystems: the MEO primary system and the MEO support system. The MEO primary system destroys organic wastes by electrochemical oxidation. The MEO support system maintains the MEO electrolyte within specified chemical composition limits.

The MEO primary system comprises an electrochemical process which operates at low temperatures and pressures. MEO processes would be operated at 70°C and 1 atmosphere pressure with the exception of the distillation process, where

the operation temperatures would be to the boiling point of nitric acid. The MEO system receives and processes the selected mixed wastes, provides the capability to vary process parameters to optimize the destruction process, collects data as required to monitor the MEO process, and provides storage capacity for the selected mixed wastes which are to be processed.

The MEO support system performs the following basic functions:

- Removes water introduced into the electrolyte as a result of the destruction of organic compounds.
- Recovers and redissolves into the electrolyte any silver that has been removed from solution by precipitation as AgCl when the incoming feed contains chlorinated hydrocarbons.
- Removes any inorganic material introduced with the feed to the MEO system.
- Regenerates nitrous acid back into nitric acid.
- Provides storage capacity for both fresh and spent electrolyte.
- Provides a means to add make-up electrolyte, remove fouled electrolyte, and remove residual solids.

To reconstitute nitric acid and recycle water, distillation stills will be provided.

Details of the major components are provided in the CDR (LLNL 1994).

4.5.4.3 Design Description

The system will be designed to maintain confinement under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

The MEO system will be designed as a modular system to allow easy removal or relocation as process or facility requirements change. All parts will be designed to be maintainable in place except in the case of a major failure. The system design will emphasize easy disassembly and reassembly. Minimization of exposure to toxic chemical and radioactive hazards during normal operating and maintenance activities will be a primary design objective.

To contain nitric acid in case of a spill, three berms will be constructed to contain leaks from the MEO process. The largest berm will be 7.9 meters by 1.4 meters (see Chapter 11 of this PSAR).

The MEO process has been demonstrated at the PNL, Savannah River Site (SRS), AEA (Dounreay, UK), and LLNL. At LLNL, the process has been demonstrated using a large commercial electrochemical cell to destroy 200 g/hr of pure Trimsol, a commercially available machining oil composed of several organic oils. The LLNL system has two pairs of electrodes capable of passing 3,000 amps at 3 volts and of destroying 200 g/hr of pure Trimsol. The pilot scale system planned for installation in the MWM Facility would contain similar cells. A plant-scale system would contain many such cells (each with eight pairs of electrodes) arranged electrically in series.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface flow diagram are shown in Figures 4-11 and 4-12, respectively.

4.5.4.4 Instrumentation and Control Systems

The MEO I&C systems will be similar to the ones discussed in Section 4.5.1.4. Additional details of the MEO I&C systems are provided in the CDR (LLNL 1994).

4.6 Process Auxiliary (Support) Systems

4.6.1 Receiving and Shipping Systems (LLNL 1993c, LLNL 1994)

Receiving provides an area where all of the mixed waste containers, surrogate waste containers, and reagent containers are inspected and prepared before entering the feed preparation treatment areas.

Shipping provides an area where radioactive, hazardous, or mixed waste containers rejected by receiving or output from decontamination are inspected and prepared for shipment to HWM.

4.6.1.1 Functional Requirements

Receiving and shipping area functional requirements are summarized below:

- Receive and inspect all the mixed waste containers, surrogate waste containers, and reagent containers entering the MWM Facility.
- Inspect waste containers nonintrusively to
 - Determine if the containers meet the MWM Facility Waste Acceptance Criteria (WAC).
 - Identify hazards within the containers as possible.
 - Determine the waste composition of the containers for proper routing.
- Prepare containers for handling by the feed preparation and transport systems.
- Store containers before transfer into the contaminated area.
- Prepare and inspect containers going to HWM.

The receiving and shipping area will have the capability of processing the following containers at the indicated input and output maximum rates:

- Maximum throughput of containers input to the facility
 - Waste
 - Two DOT 7A (4- by 4- by 7-foot) containers per shift (DOT 7A containers will not be accepted during initial operations), or
 - Sixteen drums per shift (110-gallon maximum), or
 - Sixteen cardboard boxes per shift, or
 - Thirty-two 19-L (5-gallon) carboys per shift.
 - Reagents
 - Four 208-L (55-gallon) drum per week.
- Maximum throughput of waste containers output from the facility
 - Two DOT 7A containers per shift, or
 - Twenty-four drums per shift (eight new drums plus empty containers).

- Maximum weights of containers
 - DOT 7A (4 by 4 by 7 feet) 4,091 kg (9,000 lb)
 - Drums 545 kg (1,200 lb).

The total surface dose rate for containers to be received by the MWM Facility or released to the feed preparation areas is less than 200 mR/hr.

Initial capability to receive waste may involve manual operations in the receiving area; the system, however, should be compatible with future growth to a capability that does not require routine human operations (aside from operating delivery and pick-up vehicles) in the reception area. The waste containers will not be opened in the receiving and shipping area.

4.6.1.2 Major Components

The major components of receiving and shipping consist of container handling equipment. A counterbalance truck and side loader truck will be used.

Details of the major components are provided in the CDR (LLNL 1994).

4.6.1.3 Design Description

The system will be designed to maintain containment under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

The receiving and shipping system will be designed with flexibility to allow its use in the initial and potential future configurations of the various facility systems and for testing and evaluating alternative equipment, technologies, sequences and combinations of operations, and waste and container variations. System component modularity, and commonality in interfaces for material reception or issuance, is desirable.

Modular components will be used to facilitate maintenance and to minimize the mean time to repair. Appropriate redundancy in support systems will be provided so that a single component failure will not result in an extended delay in operations. The designs will emphasize easy disassembly and reassembly to minimize equipment downtime. Minimization of exposure to toxic chemical and radioactive hazards during normal operations and maintenance activities will be a primary design objective to allow extrapolation of MWM Facility exposure data to future full-scale waste facilities under normal operating conditions.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-13 and 4-14, respectively.

4.6.1.4 Instrumentation and Control Systems

A local control system will handle all normal process calibration, control, and measurement. This system will be structured to communicate and receive commands from and override the supervisory I&C system. The local control system will have the capability to operate the receiving and shipping system autonomously as well as in concert with the other systems in the MWM Facility. The control system will provide for automatic start-up, automatic shutdown, parameter adjustment control, and sampling. A single control station will be used for the receiving and shipping system. This control system may have more than one console to facilitate operations of ancillary subsystems.

Instrumentation will control and monitor the following parameters:

- Container identification (ID) (bar code reader).
- Container weight.
- Individual process equipment operating status (temperature, radiation, amperage, pressure, etc.).
- Container storage status (position/weight sensors).

System performance will be monitored by a central computer-based system. This system has alarms to alert operators of off-normal conditions warranting corrective action. Control interfaces will present a consistent interface to both local and remote operators. Man-machine interfaces will be designed to incorporate human factors considerations.

4.6.2 Liquid Feed (LLNL 1993c, LLNL 1994)

The LFP system provides for the receipt, verification of contents, preparation for processing, and handling of homogeneous liquids and solid/liquid mixtures received from the SFP system, including identifying and segregating the entering waste stream into one of the following categories:

- Aqueous with Trimsol
- Halogenated organic liquids
- Oils
- Scintillation cocktails
- Solvents.

Included within the aforementioned liquid categories will be the solids/sludges, which in turn will be separated from their corresponding liquid and transported to the SFP system. Emptied containers will also be returned to the SFP system to be decontaminated. Those containers with liquids confirmed to be beyond the scope of the facility will be returned to their place of origin (HWM) via SFP (for decontamination) and Shipping. For the scope of the initial test phase, the LFP system will be designed to handle drums, carboys, and flasks, and to appropriately segregate and store their contents in preparation for transport to the appropriate destination.

4.6.2.1 Functional Requirements

The LFP system will be capable of processing a maximum of 480 kg/day of liquid waste.

The LFP system functional requirements are summarized below:

- Receive and sample containers
- Open and empty containers of their liquid contents
- Separate solids from the liquid phase
- Separate organic and aqueous phases in emulsions
- Store prepared liquids for process use.

The input storage queue will provide for one day's storage of individual components. The output storage queue will be capable of storing one week's treatment process throughput.

4.6.2.2 Major Components

Major components of the LFP system will consist of the following:

- Measuring and sampling equipment
- Container emptying equipment
- Liquid/solid separation equipment
- Liquid/liquid separation equipment
- Storage tanks
- Container conveyance equipment.

Details of the major components are provided in the CDR (LLNL 1994).

4.6.2.3 Design Description

The system will be designed to maintain confinement under DBA conditions. Component materials of construction/fabrication will be designed to be compatible with the materials being processed and the process environment.

The LFP system will consist of modular units that can easily be removed and relocated as the preparation process requires. Modular components will also be used to facilitate maintenance and to minimize the mean time to repair. Each unit must be maintainable in place, and the design has to consider disassembly and decontamination.

The system and enclosure will be configured to allow for the collection and disposition of liquids potentially free within containers as well as spills within the process. Equipment for handling and processing the sludges/solids recovered from liquid wastes will be provided.

Appropriate redundancy in support systems will be provided so that a single component failure will not result in an extended delay in operations. The designs will emphasize easy disassembly and reassembly to minimize equipment downtime. Minimization of exposure to toxic chemical and radioactive hazards during normal operations and maintenance activities will be a primary design objective to allow extrapolation of MWM Facility exposure data to future full-scale waste facilities under normal operating conditions.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-15 and 4-16, respectively.

4.6.2.4 Instrumentation and Control Systems

A local control system will handle all normal process calibration, control, and measurement. This system will be structured to communicate and receive commands from and override the supervisory I&C system. The local control system will have the capability to operate the LFP system autonomously as well as in concert with the other systems in the MWM Facility. The control system will provide for automatic or manual start-up, automatic shutdown, parameter adjustment control, and sampling. A single control station will be used for the

LFP system. This control station may have more than one console to facilitate operations of ancillary subsystems.

Typical parameters requiring instrumentation or control include, but are not limited to, the following:

- Container ID (bar code reader).
- Container weight.
- Individual process equipment operating status (temperature, radiation, amperage, pressure, etc.).
- Feed rates of process equipment input and output streams (mass and volumetric rates).
- Vented gas status (composition, temperature, pressure, etc.).
- Container storage status (position/weight sensors).

System performance will be monitored by a central computer-based system. This system has alarms to alert operators of off-normal conditions warranting corrective action. Control interfaces will present a consistent interface to both local and remote operators. Man-machine interfaces will be designed to incorporate human factors considerations.

4.6.3 Solid Feed (LLNL 1993c, LLNL 1994)

The SFP system provides for the receipt, characterization, preparation for processing, and handling of homogeneous and heterogeneous organic solids received from storage and other processes in the treatment system. This system segregates the incoming waste stream into combustible solids, heterogeneous solids, homogeneous inorganic solids and metals, and containerized liquids. Containerized liquids are transferred to the LFP area for processing. The SFP system also decontaminates containers and equipment to be handled in the MWM Facility. For the scope of the initial test phase, this system will be designed to handle drums, boxes smaller than drums, and flasks. The initial installation will have the capability to treat combustible solids and heterogeneous solids.

4.6.3.1 Functional Requirements

The SFP system functional requirements are summarized below:

- Receive, characterize, and prepare waste for treatment.
- Handle waste containers from overpacks to cans and individual waste items.
- Process homogeneous and heterogeneous solids.
- Decontaminate containers to be handled in the MWM Facility.

The SFP system segregates the incoming waste stream into the following:

- Combustible solids
- Heterogeneous solids
- Homogeneous inorganic solids and metals
- Liquids that were not identified previously
- Others
- Maximum sizes and weights of containers to be handled:
 - 545 kg (1,200 lb) in a 208-L (55-gallon) drum
 - 4,091 kg (9,000 lb) in a DOT 7A type container (4 by 4 by 7 feet).

4.6.3.2 Major Components

The major components of the SFP system will consist of container handling and conditioning units. Details of the major components are provided in the CDR (LLNL 1994).

4.6.3.3 Design Description

The design characteristics of the SFP system will be similar to those of the LFP system (see Section 4.6.2.3).

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-17 and 4-18, respectively.

4.6.3.4 Instrumentation and Control Systems

A local control system will handle all normal process calibration, control, and measurement. This system will be structured to communicate and receive commands from and override the supervisory I&C system. The local control system will have the capability to operate the SFP system autonomously as well as in concert with the other systems in the MWM Facility. The control system will provide for automatic start-up, automatic shutdown, parameter adjustment control, and sampling. A single control station will be used for the SFP system. This control station may have more than one console to facilitate operations of ancillary subsystems.

Typical parameters requiring instrumentation or control include, but are not limited to, the following:

- Container ID (bar code reader).
- Container weight.
- Individual process equipment operating status (temperature, radiation, amperage, pressure, etc.).
- Feed rates of process equipment input and output streams (mass and volumetric rates).
- Vented gas status (composition, temperature, pressure, etc.).
- Container storage status (position/weight sensors).

System performance will be monitored by a central computer-based system. This system has alarms to alert operators of off-normal conditions warranting corrective action. Control interfaces will present a consistent interface to both local and remote operators. Man-machine interfaces will be designed to incorporate human factors considerations.

4.6.4 Offgas Treatment (LLNL 1993c, Keller and Gannon 1993b, LLNL 1994)

The MWM Facility offgas treatment system will consist of facility, process, and experimental offgas systems. Offgas treatment systems will be provided to prevent potential releases of air pollutants, such as VOCs, NO_x, CO, acid vapors, and radionuclides, into the environment and to ensure the health and safety of facility personnel and the public.

Building 494 will consist of multiple confinement zones, with air pressure gradients across confinement barriers such that the area in which containers are opened and wastes are treated will be at the lowest pressure, and all confinement zones are below atmospheric pressure. Operation of the ventilation supply fans and the offgas system exhaust fans will provide sufficient differential pressures to maintain proper pressure gradients.

At the end of the offgas treatment train, the facility HEPA filters ensure that no radionuclides escape into the environment by filtering the entire facility exhaust, which consists of treated process offgas (enclosures and process equipment offgas), the enclosure gas (typically air), and the room air. These filters are redundant to the process offgas treatment HEPA filters, and air pollution control devices protect the equipment and personnel from contamination. An emergency charcoal adsorption unit provides additional protection against a sudden increase in the concentration of VOCs in the facility exhaust caused by spills in areas (such as SFP) where normally concentration is below the treatment level.

Upstream of the facility offgas system, air pollution control devices (collectively known as the process offgas treatment system) are determined by the scope of contaminants in the process offgas. While treatment at the source is usually the most economical treatment method, few offgas sources at the MWM Facility are large enough for even minimum size commercial treatment units. Therefore, the sources are grouped such that reduction of NO_x would be required for one and oxidation of VOCs and/or CO for another. Catalytic processes are employed in either case, and caustic scrubbing is provided for acid gases formed in the oxidation of halogenated VOCs.

The experimental offgas treatment system is upstream of the process offgas treatment system. The overall objective of the experimental offgas treatment system is to demonstrate advanced, innovative technologies that minimize secondary waste, as well as demonstrate the feasibility and effectiveness of treatment at or near the source of the effluent. The primary area of interest is the destruction of NO_x. The specific concepts being proposed for evaluation are selective catalytic reduction and advanced wet scrubbing. Another area of interest is to evaluate state-of-the-art methods for removing particulates from the process offgas. The method being considered is the use of metal HEPA filters.

4.6.4.1 Functional Requirements

The process and facility offgas systems will operate continuously to maintain proper pressure differentials for Building 494 confinement zones.

The removal efficiency of the MWM Facility offgas system will meet BAAQMD requirements.

The experimental offgas system will be capable of handling up to 10 m³ of offgas per hour at Standard Temperature and Pressure (STP) for at least an 8-hour period. Since this system is for experimental evaluation only, it has no requirements for normal operation of the MWM Facility.

4.6.4.2 Major Components

Major components of the MWM Facility offgas treatment system will consist of enclosures, exhaust fans, catalytic NO_x removal systems, wet scrubbers, HEPA filters, activated carbon adsorption beds, condensers, and inorganic absorbers as required. Details of the major components are provided in the CDR (LLNL 1994).

4.6.4.3 Design Description

The offgas treatment system will be designed to maintain confinement under DBA conditions. Component materials of construction/fabrication will be compatible with materials being processed and the process environment.

Modular components will be used to facilitate maintenance and to minimize the mean time to repair. Appropriate redundancy in support systems will be provided so that a single component failure will not result in any adverse impact to human health or the environment, or in an extended delay in operations. The designs will emphasize easy disassembly and reassembly to minimize equipment downtime. Minimization of exposure to hazardous chemical and radiological hazards during normal operations and maintenance activities will be a primary design objective.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-19 and 4-20, respectively.

Figure 4-21 provides a system flow diagram of the process and facility offgas systems.

4.6.4.4 Instrumentation and Control Systems

The offgas treatment system will be controlled remotely and locally. The local control system will interface with the supervisory I&C system. Details of the I&C systems were not available at the time that this PSAR was written.

4.6.5 Water Treatment (LLNL 1993c, LLNL 1994)

The water treatment system will consist of the management of aqueous liquids produced within the contained area of the MWM Facility by waste processing systems, process support systems, and facility operations. The goal of water treatment is to meet the regulatory and LLNL requirements for the management, treatment, and discharge of MWM Facility wastewater. Water will be recycled within the MWM Facility to the extent practical as to minimize discharged wastewater. Water treatment will separate the solids contained in the liquids and prepare them to be acceptable to the final forms system.

Some of the incoming aqueous streams will be transferred directly to discharge storage units if their source and composition allow. The other incoming aqueous waste streams will be stored, analyzed, and treated as needed to make the water acceptable for either recycle or discharge. Water to be discharged will be analyzed and certified acceptable before being released to the LLNL sewer system. Salt and ash solids separated from treated water will be transferred to the final forms system.

4.6.5.1 Functional Requirements

Wastewater discharged from the LLNL site will meet the local limits specified in a Permit to Discharge issued by the City of Livermore Water Reclamation Plant. The LLNL EPD issues guidelines for individual facilities within LLNL that ensure LLNL compliance with these local limits and any other requirements of the LLNL wastewater outfall. Water discharged from the output discharge storage units (retention tanks) of the MWM Facility must meet these guidelines using a protocol of retain, analyze, certify, and release.

In addition, EPA Categorical Standards for waste treatment facilities are being prepared and due to come into effect in 1996. It is expected that, as an RD&D permitted facility, the MWM Facility will not be regulated under these standards. However as a facility for demonstrating how a stand-alone treatment facility would operate, the design will address the EPA Categorical Standards by segregating streams by source.

Solid streams must be segregated by source stream and waste campaign and must meet the following final forms acceptance criteria:

Ash solids

- < 1% salts
- < 50% water
- < 1% total organics.

Salt solids

- < 3% water.
- < 1% total organics.
- < Land Disposal Restriction (LDR) concentrations of RCRA organics (see CDR).
- < LDR concentrations of RCRA metals (see CDR).

4.6.5.2 Major Components

The major components of the water treatment system consist of the treatment units and their respective storage units. The types of treatment units may include the following:

- Precipitation tank
- Filter
- Submerged-tube evaporator
- Wiped-film evaporator
- Spray dryer
- Neutralization tank
- Organic adsorption beds.

Details of the major components are provided in the CDR (LLNL 1994).

Figure 4-22 provides a flow diagram of the water treatment units.

4.6.5.3 Design Description

The system will be designed to maintain containment under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

The water treatment system will facilitate safe and efficient maintenance. Modular components will be used to facilitate maintenance and to minimize the mean time to repair. Designs will emphasize easy disassembly and reassembly to minimize equipment downtime. Appropriate redundancy will be provided so that a single component failure will not result in an extended delay in operations. Minimization of exposure to toxic chemical and radioactive hazards during normal operating and maintenance activities will be a primary design objective.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-23 and 4-24, respectively.

4.6.5.4 Instrumentation and Control Systems

The water treatment system will be controlled from a single integrated local control system that permits independent operation from other processes under test in the facility. The local control system will interface with the MWM Facility supervisory I&C system and will have the capability to operate the water treatment system autonomously as well as in concert with the other systems in the MWM Facility through the supervisory I&C system. The control system will provide for automatic start-up upon local command and automatic shutdown upon either local or central command. Both an immediate shutdown sequence and a normal shutdown sequence will be provided. Manual override of automatic control will also be provided. The control system will provide for parameter adjustment control and stream sampling. There will be a redundant interlock system implemented with electromechanical relays in areas where safety or equipment damage is an issue.

System performance will be monitored by a central computer-based system. This system has alarms to alert operators of off-normal conditions warranting corrective action. Control interfaces will present a consistent interface to both local and remote operators. Man-machine interfaces will be designed to incorporate human factors considerations.

Details of the water treatment I&C systems were not available at the time that this PSAR was written.

4.6.6 Process Transport and Storage (LLNL 1993c, LLNL 1994)

The Process Transport and Storage (PT&S) system provides candidate equipment suited for collection, transfer, deposit, and handling of containers, discrete items, dry and wet bulk materials, slurries, and liquids as required by various process

operations. The PT&S system also provides an interim storage area with access to/from the receiving area, process areas, and the treatment areas capable of accepting barrels, drums, and transport containers.

4.6.6.1 Functional Requirements

The PT&S system functional requirements are summarized below:

- Provide material transport and monitoring
 - Throughput quantity per period will support feed rates for all areas of the MWM Facility.
 - Maximum rates by containers (i.e., container types, weights, or volumes of waste) will support individual process operations.
- Provide interim storage for process feed and reagents.
- All operations will be monitored providing failure detection and notification for operator corrective action.

4.6.6.2 Major Components

Major components of the PT&S system consist of identification and monitoring equipment, material transport equipment, and interim storage.

Details of the major components are provided in the CDR (LLNL 1994).

4.6.6.3 Design Description

The system will be designed to maintain confinement under DBA conditions. Component materials of construction/fabrication will be compatible with materials being processed and the process environment.

The PT&S system will facilitate safe and efficient maintenance. Modular components will be used to facilitate maintenance and to minimize the mean time to repair. Designs will emphasize easy disassembly and reassembly to minimize equipment downtime. Appropriate redundancy will be provided so that a single component failure will not result in an extended delay in operations. Minimization of exposure to toxic chemical and radioactive hazards during normal operating and maintenance activities will be a primary design objective.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-25 and 4-26, respectively.

4.6.6.4 Instrumentation and Control Systems

A local control system will handle all normal process calibration, control, and measurement. This system will be structured to communicate and receive commands from and override the supervisory I&C system. The local control system will have the capability to operate the PT&S system autonomously as well as in concert with the other systems in the MWM Facility. The control system will provide for automatic start-up, automatic shutdown, parameter adjustment control, and sampling. A single control station will be used for the PT&S system. This control station may have more than one console to facilitate operations of ancillary subsystems.

Typical parameters requiring instrumentation or control include, but are not limited to, the following:

- Container ID (bar code reader).
- Container weight.
- Individual process equipment operating status (temperature, radiation, amperage, pressure, etc.).
- Container storage status (position/weight sensors).
- Maintenance of an operation record which tracks the containers to maintain legal chain of custody of the wastes.

Details of the PT&S I&C systems were not available at the time that this PSAR was written.

4.6.7 Final Forms (LLNL 1993c, LLNL 1994)

The final forms system will produce a final waste form for the residues from the primary treatment processes of the MWM Facility. The system will also produce final waste forms for any of the secondary waste streams generated by recycling of reagents from the primary treatment processes. The final waste forms for the treatment process residues will be required to be acceptable for disposal as low-

level radioactive waste at the NTS under the requirements of NVO-325 (Rev. 1, 1992).

4.6.7.1 Functional Requirements

The final forms functional requirements are summarized below:

- Receive and sample residues from primary processes.
- Convert ash to ceramic waste form:
 - Blend and mill ash with mineralizers
 - Dry, calcine, and granulate the mixture
 - Press to form pellets
 - Sinter to convert pellets to a durable ceramic waste form.
- Receive and immobilize (or have immobilized by others) volatiles as sulfur-polymer cement.
- Process salt
 - Receive and store salt (via water treatment system)
 - Immobilize by polymer encapsulation.
- Condition final forms secondary waste streams (offgas, water).
- Evaluate samples.

The final forms system must be capable of maintaining the records that accompany each container of residue coming from the primary process systems, and adding the appropriate information from the final forms processing such that the final documentation package demonstrates the sampling and characterization requirements of NVO-325.

Inputs to the final forms process include the residues from the primary and secondary facility systems; nitric acid; phosphoric acid; gas mixtures of argon or nitrogen containing 4 percent hydrogen; organic binders; additives such as Al_2O_3 , Y_2O_3 , CeO_2 , Fe_2O_3 , La_2O_3 , AlPO_4 , CaO , or MgO ; and small amounts of pyrite or other sulfides.

The outputs of the final forms process include low-level radioactive waste forms; offgas potentially containing N_2 , H_2 , O_2 , H_2O , CO_2 , CO , NH_3 , NO_x , SO_2 , H_2S , or Ar; Hg (if present); and wash waters.

4.6.7.2 Major Components

The final forms system consists of three major subsystems:

- Ceramic waste form production system (for ash)
- Sulfur-polymer cement system (for volatiles)
- Polymer encapsulation system (for salt).

Details of the major components are provided in the CDR (LLNL 1994).

4.6.7.3 Design Description

The system will be designed to maintain confinement under DBA conditions. System equipment will be designed such that, during emergency conditions, normal operations will cease and equipment not performing a safety function will be automatically or passively shut down.

The final forms system will be designed as a modular system to allow easy removal or relocation as process or facility requirements change. All parts will be designed to be maintainable in place except in the case of a major failure. The system design will emphasize easy disassembly and reassembly. Minimization of exposure to toxic chemical and radioactive hazards during normal operating and maintenance activities will be a primary design objective.

The system design assumes that transfers of material from one step in the process to the next will be accomplished manually and in batch mode. Transfers to and from other facility systems, with the exception of facility and process offgas systems, will be handled similarly. The design will provide enclosed areas or laminar flow work stations for processing steps involving crushing, grinding, etc., which could result in the dispersion of powders. The design will also include appropriate mechanical shields and guards for mixers and crushing equipment.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-27 and 4-28, respectively.

4.6.7.4 Instrumentation and Control Systems

The equipment in the final forms system will be controlled by a local computer system and by the operator of the equipment. Man-machine interfaces will incorporate human factors considerations. Control interfaces will present a

consistent interface to both local and remote operations. All unit operations, with the possible exception of the sintering furnace, will be active only when the operator is present.

The final forms system will interface with the MWM Facility supervisory I&C system (see Section 4.7) to maintain chain of custody for the waste materials and to allow for monitoring of waste processing schedules.

4.7 Supervisory Instrumentation and Control System (LLNL 1993c, LLNL 1994)

The supervisory I&C system will provide the means of centrally monitoring the MWM Facility to determine the status of operations from a global view and to carry out analyses and reporting on the following observations:

- Provide the means of remotely controlling local operations of the individual processes from the central control room.
- As conditions demand, provide an integrated control of the processes and supporting operations comprising the entire facility.

4.7.1 Functional Requirements

Functions of the supervisory I&C system are summarized below:

- Central monitoring and control functions include three major elements:
 - Facility Health Management
 - Safety systems monitoring and alarms
 - Environmental monitoring and alarms
 - Workcell and process equipment monitoring and alarms
 - Process Database Management
 - Material tracking and accounting
 - Analysis and reporting
 - Process effectiveness and permitting database
 - Network communications link
 - Remote monitoring and control
 - Safety control systems
 - Message handling and other network interactions.
- Safety control systems protect personnel and the environment by providing the elements necessary to address facilitywide issues.

- Ancillary systems and equipment:
 - Intercom communications
 - Closed-Circuit Television (CCTV) surveillance
 - Facility cable distribution and instrumentation grounding
 - Central control facilities - Control Room and Equipment Room
 - Facility monitoring and supervisory control system
 - Instrumentation and equipment database.
- Process I&C standards will include the basic building blocks ("rules and tools") and subsystem elements of the control system:
 - Building blocks provide basic services
 - Message handling and other communication services
 - Process interface
 - Baseline set of instruments, sensors, and effectors
 - Documentation conventions for Functional Requirements documents, system design descriptions, interface control documents, electrical schematics, instrument, equipment and cabling identification, etc.
 - Human factors standards communicate information
 - Process control icons
 - Man-machine interface color scheme
 - Message and alarming responses
 - Data entry syntax.

Each process will require multiple inputs, outputs, and operator screens depending on the complexity of the process. The I&C systems will manage approximately 2,233 input/output points (see Table 4-4).

The supervisory I&C system need not perform any functions in the event of any emergency conditions. All process equipment will be designed to shut down in a safe manner in an emergency situation without relying on the supervisory I&C system. The supervisory I&C system will remain operational to facilitate remote monitoring, operation, and repair functions as required if the system is undamaged by the emergency condition.

4.7.2 Major Components

The major components of the supervisory I&C system will consist of the following:

- Each local control station will require electronic cabinets adjacent to the center of the main process system equipment areas.

- The central control room will require areas for the teleoperator consoles and central control console.
- The CCTV system will provide the central control room with surveillance.
- The system will require a high-speed computer communication network linking the central control room consoles with the local control cabinets for each process system.
- The system will require a dedicated high-speed communication link between each robot controller in the process system and the central control room teleoperator consoles.

Details of the major components are provided in the CDR (LLNL 1994).

4.7.3 Design Description

The supervisory I&C system will be designed for flexibility appropriate to its use in the initial and potential future configurations of the various MWM Facility systems. This design will include testing and evaluating alternative equipment, technologies, sequences and combinations of operations, and waste and container variations. Component modularity, and commonalty in interfaces for material reception or issuance, is desirable. The control room HVAC should be capable of operating continuously at computer room temperatures including the electronic heat load and the heat generated by operators.

CCTV cameras will be located so as to cover all process systems from at least one vantage point. These cameras will be linked to an ensemble of TV monitors in the central control room by way of a video switch by which the operators can select any combination of the camera images for viewing. Similarly, microphones will be located for complete coverage of sound conditions local to each of the process systems with an intercom switch and speakers by which the operators can select listening stations.

Modular components will be used to facilitate maintenance and to minimize the mean time to repair. Appropriate redundancy in support systems will be provided so that a single component failure will not result in an extended delay in operations. The designs will emphasize easy disassembly and reassembly to minimize equipment downtime.

Details of system design requirements are provided in the CDR (LLNL 1994).

The process flow diagram and interface diagram are shown in Figures 4-29 and 4-30, respectively.

4.7.4 Instrumentation and Control Systems

The supervisory I&C system will be networked to all the other process I&C systems (local process I&C systems) and will provide two modes of interacting with these process I&C systems: remote display connect and client-server messaging. The I&C systems will have the capability of operating autonomously as well as in concert with the supervisory I&C system and other systems in the MWM Facility using these modes of operation.

4.8 Sampling Systems and Analytical Laboratory

The MWM Facility will be capable of performing a variety of chemical analyses within the facility. Laboratory capabilities will be provided by the analytical laboratory. Analysis beyond the capabilities of the analytical laboratory will be performed at other LLNL laboratories. The analytical laboratory will provide chemical measurement and characterization support to the MWM Facility as required for process development, process characterization, process control, and regulatory compliance. The objectives of the principal laboratory-type functions required to support the MWM Facility are as follows (LLNL 1994):

- Radiochemical characterization (certified and noncertified)
- Organic characterization (certified and noncertified)
- Inorganic characterization (certified and noncertified)
- Refrigerated and nonrefrigerated sample storage
- Support process sampling
- Offgas monitoring and calibration
- Sample/result tracking and reporting
- Performance verification and calibration of process sensors.

4.9 Service and Utility Systems

The service and utility systems in this section are classified as nonsafety class systems or components. The level of detail provided reflects this classification.

4.9.1 Facility Ventilation (Keller and Gannon 1993b)

The Building 494 ventilation systems consist of process area HVAC, nonprocess area HVAC, and building exhaust/offgas systems. The building supply air is provided by the process area HVAC and nonprocess area HVAC systems. The Building 494 exhaust systems include the offgas treatment systems as previously discussed in Section 4.6.4.

Figure 4-21 provides a layout of the building ventilation system.

4.9.1.1 Building 494 HVAC Systems

Process Area HVAC

The process area HVAC system consists of two 30,000-cfm air handling units: AC-3A and AC-3B. These units will be equipped with a filter, heat-recovery coil, heating coil, cooling coil, and supply fan with adjustable-speed drive fans. AC-3A and AC-3B will be operated together as a single unit. Each process area zone will have temperature and pressure control. Supply air to the zone is variable, set to maintain a preprogrammed, fixed differential between total exhaust and total supply into a zone. By coordinating supply and exhaust air flows, the proper differential pressures can be maintained.

Nonprocess Area HVAC

The nonprocess area HVAC system consists of two 4,000-cfm air handling units: AC-1 and AC-2. These units will be equipped with a filter, cooling coil, and supply fan with adjustable-speed drive fans.

4.9.1.2 Building 494 Exhaust and Offgas Systems

The Building 494 exhaust system is divided into three offgas systems: process offgas, facility offgas, and experimental offgas. Process offgas systems provide the primary treatment of emissions from waste treatment process enclosures and equipment. The facility offgas systems would be installed and operated as a secondary treatment system treating facility process area and room air. The offgas treatment units used for the process and facility offgas systems would be designed for those emissions unique to the process for which they operate, including catalytic NO_x removal systems, wet scrubbers, HEPA filters, activated carbon adsorption beds, condensers, and inorganic absorbers as required.

The purpose of the experimental offgas system is to demonstrate the feasibility and effectiveness of offgas treatment at or near the source of the gas. The experimental offgas system will use experimental technologies to evaluate filtering methods.

The process, facility, and experimental offgas systems will be vented to the atmosphere via the building exhaust stack. To control the stack exhaust velocity, an air flow measuring station and flow control damper is provided. An air flow measuring station is mounted in the main building exhaust stack to measure total pressure and static pressure, which then converts this signal to velocity pressure

and exhaust air flow in cubic feet per minute. During balancing, the exhaust flow rate is 60,000 cfm (assuming both process and building exhaust fans are operating), and the stack exit velocity from the flow control damper is 3,000 fpm.

Process Offgas System

The analytical laboratory, decontamination area, and process waste treatment areas will be provided with fume hoods and enclosures. Exhaust from local HEPA filters and offgas treatment units such as scrubbers and NO₂ abatement will be routed through a 30,000-cfm HEPA filtration bank by exhaust fans prior to being released to the environment.

The process offgas system consists of two 30,000-cfm exhaust fans (EF-1A and EF-1B), offgas treatment units, enclosures and hoods, and a building exhaust stack. The process exhaust fans will be variable flow, controlled by LLNL building operators to required flow rates through a flow monitoring station.

Facility Offgas System

Facility process areas and room air will be exhausted and treated via the facility offgas system. Room exhaust from local mounted HEPA filters and offgas treatment units will be routed through a 30,000-cfm HEPA filtration bank by exhaust fans prior to being released to the environment.

The facility offgas system consists of two 30,000-cfm exhaust fans (EF-2A and EF-2B), offgas treatment units, enclosures and hoods, and a building exhaust stack. The facility exhaust fans will be constant flow, controlled by LLNL building operators to required flow rates through a flow monitoring station.

Experimental Offgas System

The experimental offgas system will use selective catalytic reduction, advanced wet scrubbing, and metal HEPA filtering methods. Since the experimental offgas system is being used for research, it will be backed up by the process offgas system.

4.9.2 Electrical Power (Keller and Gannon 1993b)

Normal electrical power is provided to the MWM Facility from the LLNL electrical power distribution system. The power supplies facility process equipment, lighting, ventilation and offgas systems, and instrumentation.

Normal primary power will be supplied from an existing feeder cable in manhole MH-P491. This cable will be tapped in MH-P491 and routed through a new duct

bank to two new pad-mounted, exterior 1,500-kVA substations located on the north side of Building 494. The exterior substations will be connected by bus to the building in the Electrical Room, and 480/277 volts will be distributed to panels located throughout the facility.

Standby power will be provided by a 350-kW diesel generator. Standby power will supply loads such as building emergency lighting, process area ventilation loads, UPS for the Control Room, and a fire alarm panel. On a loss of normal power, standby power will be supplied via the diesel generator through the automatic transfer switch to the emergency distribution panel. The standby generator will be provided with a 12-hour day tank fuel supply located in the generator skid base.

4.9.3 Compressed Air and Gases (Keller and Gannon 1993b)

Compressed air is used in a number of treatment processes (e.g., MSO and MEO). Compressed air is provided from the LLNL plant air system. Compressed air lines will be extended from the existing air lines along Outer Loop Road and distributed within the building.

4.9.4 Water Supply Systems (Keller and Gannon 1993b)

The Uniform Plumbing Code, as adopted by the State of California, will be used to design the plumbing systems in this building. The sanitary water system and domestic water system serving the existing building will be modified to accommodate the new rest rooms and janitor area.

The Low-Conductivity Water Supply (LCWS) and demineralized water used for cooling water in process treatment and ventilation cooling systems will be provided by existing water systems at LLNL.

4.9.5 Safety Communications and Alarms (Keller and Gannon 1993b)

4.9.5.1 Fire Alarms and Communications

A fire detection and alarm system will be provided for the MWM Facility, and telephones will be located throughout the MWM Facility. During emergencies, these phones can be used to notify the Area Facility Supervisor (or alternate), the LLNL Dispatcher, and other key personnel. These individuals can help summon additional responders and/or initiate evacuation procedures. In addition, an evacuation voice alarm and paging system will be provided for the MWM

Facility. This system can be used to notify personnel of existing hazards during an emergency or to communicate an evacuation order.

4.9.5.2 Radiation Protection and Warning System

The radiation protection monitoring systems for the MWM Facility consist of CAMs and area radiation monitors. Section 4.3.2.2 discusses these monitors in more detail.

4.9.6 Fire Protection System (Keller and Gannon 1993b)

Building 494 is currently equipped with a wet-sprinkler fire protection system. The existing sprinkler system is tied into the LLNL water distribution system, which draws from the Outer Loop Road through an 8-inch-diameter polyvinyl chloride (PVC) line. Final connection to Building 494 is via a 6-inch-diameter line, butterfly valve, and fire department connections. This water supply system is to be upgraded to the requirements of DOE Order 6430.1A (DOE 1989) and NFPA-13 for a Low Hazard facility. The existing wet-sprinkler system will be analyzed to determine suitability to these new requirements, and modifications will be made as necessary.

In addition, each exit door will be provided with floor drains to drain the fire protection water discharge. Drains will be sized for the design discharge rate from the wet-sprinkler system. To collect this water drainage, two 15,000-gallon retention tanks (one on each side of the building) will be installed underground on the west and east sides of the building. The 15,000-gallon tank size is based on a 20-minute discharge time at 750 gpm.

4.9.7 Maintenance Systems

Maintenance systems (programs and requirements) are provided in Chapter 15 of this PSAR.

4.9.8 Miscellaneous Systems

Natural gas is supplied to Building 494 via an underground natural gas pipeline. The connection to the pipeline occurs at the southwest corner of Building 494.

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Table 4-1. Criteria Summary

Sections, Chapter 6	CRITERIA Criteria	Sections, Chapter 4	CONFORMANCE	
			Mixed Waste Management Building/Structures Status ^a	
			Building 494	Building 494 Utility Area
6.1.1	Wind Loadings	4.2.1.4/4.2.2.4	C	C
6.1.2	Tornado Loadings	NR	NR	NR
6.1.3	Water Level (Flood) Design	4.2.1.4/4.2.2.4	N	N
6.1.4	Missile and Blast Protection	4.2.1.4/4.2.2.4	C	C
6.1.5	Seismic Design	4.2.1.4/4.2.2.4	C	C
6.1.6	Snow and Rain-On-Snow Loadings	4.2.1.4/4.2.2.4	C	C
6.1.7	Process and Equipment Derived Loads	4.2.1.4/4.2.2.4	C	C
6.1.8	Combined Loads	4.2.1.4/4.2.2.4	C	C
6.1.9	Subsurface Hydrostatic Loadings	4.2.1.4/4.2.2.4	C	C
6.2.2.1	Solid Confinement Barriers	4.3.2.1, 4.3.2.2	C	C
6.2.2.2	Liquid Confinement Barriers	4.3.2.1, 4.3.2.2	C	C
6.2.2.3	Ventilation and Offgas Systems	4.9.1	C	C
6.2.2.4	Liquid Effluent System	4.3.2.1	C	C
6.2.3.1	Equipment	4.5	C	C
6.2.3.2	Instrumentation	4.5	C	C
6.2.4.1	Radiological Access Control	4.3.2.1, 4.3.2.2	C	C
6.2.4.2	Radiological Shielding	4.3.2.1, 4.3.2.2	C	C
6.2.4.3	Radiation Alarm Systems	4.9.5.2	C	C
6.2.5	Fire and Explosion Protection	4.9.6	I	I
6.2.6	Protection from Industrial Accidents	4.5	C	C
6.2.7	Protection from Hazardous Materials	4.3.4.1, 4.3.4.2	C	C
6.2.8	Robotic Systems	4.6	C	C

a C - Compliance: The MWM Facility complies with the requirements invoked by Chapter 6 of this PSAR.

I - Indeterminate: The compliance status cannot be determined definitively due to the lack of available information or analysis.

N - Noncompliance: The MWM Facility does not comply with the requirements invoked by Chapter 6 of this PSAR.

NR - Not Required

Table 4-2. Approximate Square Footage by Area of Building 494 (Keller and Gannon 1993b)

Space	Approximate Floor Area (ft ²)
Analytical laboratory	675
Final forms	550
Refurbishment	775
Decontamination	750
Air lock 3	125
Shipping	375
Certification	125
Process support/water treatment	500
Waste treatment	8,000
Solids feed preparation	1,500
Liquids feed preparation	750
In-process storage	750
Air lock 1	500
HVAC equipment	750
Boiler	250
Electrical equipment	500
Technical area	1,000
Shop area	500
Process equipment and staging	4,000
Receiving and storage	2,375
NDE	500
Women's lockers	250
Women's rest room 1	235
Gowning	265
Men's lockers	250
Men's rest room 1	235
Air lock 2	125
Men's rest room 2	285
Women's rest room 2	285
Janitor	130
Control	990
Operations Manager/Office	710
Conference	375
Reception and display	875
Corridors	—
Total	31,250

Table 4-3. LLNL Waste Streams Treated by Process

Waste Description (DOE Waste Code)	Primary Treatment Process
Aqueous/Halogenated Organic Liquids (2110)	MEO WOX
Halogenated Organic Liquids (2210)	MSO MEO WOX
Nonhalogenated Organic Liquids (2220)	MSO MEO WOX
Combustible Debris/Heterogeneous Debris	MSO
Scintillation Cocktails	MEO MSO WOX
Cellulose Waste	WOX MEO
Aqueous Liquid and Slurries	Water treatment

Table 4-4. I&C System I/O Points

System	Approximate Count
Receiving and Shipping	50
Solids Feed Preparation	300
Liquids Feed Preparation	150
MEO	440
MSO	157
WOX	148
UVP	80
Experimental Offgas	42
Transport and Storage	50
Analytical Laboratory	*
Water Treatment	250
Final Forms	41
Facility Monitoring	79
Estimated subtotal	1,787
25% growth and spares	446
Total estimated I/O points managed	2,233

- I/O is performed via communication links with instruments.

Figure 4-1. Layout of MWM Facility Complex at LLNL

Figure 4-2. Building 494 Existing Layout

LLMHHBB3

Figure 4-3. Building 494 Modified Floor Plan

Figure 4-4. Integrated Flowsheet Schematic

Figure 4-5. WOX Process Flow Diagram

Figure 4-6. WOX Interface Diagram

Figure 4-7. UVP Process Flow Diagram

Figure 4-8. UVP Interface Diagram

Figure 4-9. MSO Process Flow Diagram

Figure 4-10. MSO Interface Diagram

Figure 4-11. MEO Process Flow Diagram

Figure 4-12. MEO Interface Diagram

Figure 4-13. Receiving and Shipping Process Flow Diagram

Figure 4-14. Receiving and Shipping Interface Diagram

Figure 4-15. LFP Process Flow Diagram

Figure 4-16. LFP Interface Diagram

Figure 4-17. SFP Process Flow Diagram

Figure 4-18. SFP Interface Diagram

Figure 4-19. Process and Experimental Offgas Process Flow Diagram

Figure 4-20. Process and Experimental Offgas Interface Diagram

NG EXHAUST

FIGURE 4-21

PROCESS AND FACILITY OFFGAS
SYSTEM FLOW DIAGRAM

SCALE:

NONE

LLMWM021

Figure 4-22. Water Treatment Units Flow Diagram

Figure 4-23. Water Treatment System Process Flow Diagram

Figure 4-24. Water Treatment System Interface Diagram

Figure 4-25. Process Transport and Storage System Process Flow Diagram

Figure 4-26. Process Transport and Storage System Interface Diagram

Figure 4-27. Final Forms Process Flow Diagram

Figure 4-28. Final Forms Interface Diagram

Figure 4-29. Supervisory Instrumentation and Control Process Flow Diagram LLHWM029

Figure 4-30. Supervisory Instrumentation and Control Interface Diagram

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 5

Hazard Analysis and Classification of the Facility

September 1994

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Chapter 5. Hazard Analysis and Classification of the Facility

This chapter of the Preliminary Safety Analysis Report (PSAR) analyzes the Mixed Waste Management (MWM) Facility (Building 494) in accordance with Department of Energy (DOE) Order 5480.23 (DOE 1992b), DOE-STD-1027-92 (DOE 1992a), DOE Order 5481.1B (DOE 1987), and WSRC-MS-92-206 (Craig et al. 1993) and provides a classification based on the radiological and chemical hazards associated with the facility.

As part of the safety analysis procedure set forth by DOE, a hazards analysis must be performed for the MWM Facility at Lawrence Livermore National Laboratory (LLNL) to characterize the level of intrinsic potential hazards associated with the facility (DOE 1992b). The hazards analysis provides a basis for hazard classification, which in turn determines the level of safety documentation required for the facility and the level of review and approval required for the safety documentation.

The MWM Facility operation has been determined to have a facility hazard classification of Radiological Facility for the radionuclide inventory in accordance with DOE-STD-1027-92, and a Low Hazard classification for the reagent and chemical inventory in accordance with WSRC-MS-92-206.

5.1 Hazard Classification Methodology

The hazards associated with the MWM Facility are both radiological and chemical in nature. To comply with DOE guidance, the hazard classification is based upon comparing facility inventories against criteria quantities of radionuclides and hazardous airborne chemical concentrations at various distances as set forth in DOE-STD-1027-92 (DOE 1992a) and WSRC-MS-92-206 (Craig et al. 1993).

The analysis to determine the hazard classification is performed without credit taken for engineered features or administrative controls except controls on inventory limits discussed within this analysis. Examples of engineered features and administrative controls are those specific facility features (not including site location), such as building containment, stacks, equipment, systems, actions, or operating conditions, that are established to control risk. This approach allows credit to be taken for the existing location and the physics of material release and dispersion, but not for containment, confinement, shielding, protective systems, administrative controls, or human activities.

5.1.1 Radiological Methodology and Criteria for Facility Hazard Classification

The radiological evaluation is accomplished by comparing the inventory of each radionuclide to the threshold quantities provided in Table A.1 of DOE-STD-1027-92 (DOE 1992a). The results of this comparison are evaluated in accordance with criteria defined in DOE Order 5480.23 (DOE 1992b). In DOE Order 5480.23, three hazard categories are defined. A facility is classified as Hazard Category 1 if the hazards analysis shows the potential for significant off-site consequences, Hazard Category 2 if the hazards analysis shows the potential for significant on-site consequences, and Hazard Category 3 if the hazards analysis shows the potential for significant localized consequences only.

The radiological criteria for performing a facility hazard classification are as follows:

Hazard Category 1

- The facility has the potential for significant off-site consequences based on total curie content, potential material forms, and maximum energy source available for dispersion of the radioactive material. Only Category A Reactors or facilities designated by the Program Secretarial Officer (PSO) are designated as Hazard Category 1 in accordance with the directions of DOE-STD-1027-92.

Hazard Category 2

- The quantity of any radionuclide exceeds the Hazard Category 2 threshold quantity provided in Table A.1 of DOE-STD-1027-92. This quantity is based on 1 rem at 100 meters as determined in Title 10 Code of Federal Regulations (CFR) Part 30 (CFR 1989) and as modified by DOE.
- The minimum critical mass limit for any fissile material, as specified in ANSI/ANS-8.1 (ANS 1983), is exceeded.
- The total quantity of mixed fission products, where the individual radionuclides have not been determined, is greater than 1,000 curies.
- Where there are combinations of radioactive materials, the sum of the ratios of the quantity of each radionuclide to the respective Hazard Category 2 threshold quantity exceeds one.

Hazard Category 3

- The quantity of any radionuclide exceeds the Hazard Category 3 threshold quantity provided in Table A.1 of DOE-STD-1027-92. This quantity is based on 10 rem at 30 meters based on a 24-hour exposure.
- Where there are combinations of radioactive materials, the sum of the ratios of the quantity of each radionuclide to the respective Hazard Category 3 threshold quantity exceeds one.

A facility with a quantity of radionuclides less than the Hazard Category 3 threshold quantity provided in Table A.1 of DOE-STD-1027-92 will be classified as a Radiological Facility.

5.1.2 Chemical Methodology and Criteria for Facility Hazard Classification

The analysis of the chemical inventory begins with a comparison of each chemical to the Reportable Quantities (RQs) of 40 CFR 302.4 (CFR 1992b), the Threshold Planning Quantities (TPQs) of 40 CFR 355 (CFR 1992c), and the Threshold Quantities (TQs) of 29 CFR 1910.119 (CFR 1992a). Chemicals in quantities less than the RQs, TPQs, and TQs are designated as Excluded and do not require further evaluation because such chemicals are generally accepted by the public. Similarly, chemicals with less than 1 pound of inventory are considered Excluded and are not evaluated further.

Following the initial screening process, the hazard classification is determined by calculating the airborne chemical concentrations for the local, on-site, and off-site individuals for all identified hazardous chemicals (i.e., those exceeding the screening thresholds) and by comparing these values to specific criteria. The airborne chemical concentrations can be calculated using an approved chemical modeling program such as Areal Locations Of Hazardous Atmospheres (ALOHA) (National Safety Council 1991). The chemical concentrations are compared to two sets of criteria.

The first set of criteria for determining the chemical hazard classification of Building 494 is based on the criteria provided in WSRC-MS-92-206 (Craig et al. 1993) (Table 5-1). A facility is classified as High Hazard if the hazards analysis shows the potential for on-site or off-site impacts to large numbers of persons or for major impacts to the environment; Moderate Hazard if the hazards analysis shows the potential for on-site impacts to people or the environment but, at most, only minor off-site impacts; and Low Hazard if the hazards analysis shows the potential for minor on-site and negligible off-site impacts to people or the environment. In addition, a facility that does not meet or exceed the Low Hazard criteria but still possesses some amount of hazardous material is considered an

Excluded Facility. Such facilities are excluded from the requirements of safety analyses. The first set of criteria for determining the hazard classification is described below:

High Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its Emergency Response Planning Guideline 3 (ERPG-3) value at the site boundary (off site) (175 meters).

Moderate Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its ERPG-3 value on site (100 meters), or an airborne concentration greater than or equal to its ERPG-2 value off site.

Low Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its ERPG-2 value on site, or an airborne concentration greater than or equal to its ERPG-1 value off site.

Excluded

- A postulated release of any hazardous chemical results in an airborne concentration less than its ERPG-2 value on site, and an airborne concentration less than its ERPG-1 value off site.

These criteria are summarized in Table 5-1.

The second set of criteria for determining the chemical hazard classification of Building 494 is based on the criteria provided in WSRC-MS-92-206 (Craig et al. 1993) (Table 5-2). A facility is classified as High Hazard if the hazards analysis shows the potential for significant off-site consequences, Moderate Hazard if the hazards analysis shows the potential for significant on-site consequences, and Low Hazard if the hazards analysis shows the potential for significant localized consequences only. In this analysis, a facility that does not meet or exceed the Low Hazard threshold criteria but still possesses some amount of hazardous material is considered an Excluded Facility. The second set of criteria for determining the hazard classification is described below:

High Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its ERPG-3 value off site.

Moderate Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its ERPG-3 value on site.

Low Hazard

- A postulated release of any hazardous chemical results in an airborne concentration greater than or equal to its ERPG-3 value locally (30 meters) at the facility.

These criteria are summarized in Table 5-2.

5.2 Facility Segments

In determining the facility classification, flexibility is allowed in defining facility segments since many DOE facilities conduct a wide variety of activities in one facility. Segmentation is used to avoid placing excessive requirements on simple co-located operations. The concept of independent facility segments is applied where facility features would preclude bringing material together or causing harmful interaction from a common severe phenomenon. The MWM Facility was evaluated to determine a method of segmenting the facility in order to avoid placing restrictive inventory limits on the facility as a whole. This evaluation determined that the MWM Facility is to be considered a single segment.

5.3 Hazard Evaluation

5.3.1 Introduction

This evaluation assumes that normal operation is as described in Chapter 4 of this PSAR. In addition, it is assumed that administrative controls and Operational Safety Requirements (OSRs) will be employed to limit the radionuclide and hazardous chemical inventories at the facility to levels specified throughout the remainder of this section. If there are operational changes or changes in the potential maximum inventories of radionuclides or hazardous chemicals, the MWM Facility must be reevaluated.

5.3.2 Inventories

5.3.2.1 Radionuclide Inventory

An accident in the MWM Facility can involve any and all of the radionuclides present as waste in the facility. This evaluation is based on the total mixed waste inventory generated at LLNL between January 1991 and June 1992 initially considered for treatment demonstrations at the MWM Facility (LLNL 1993a). The radionuclide inventory was calculated by multiplying the mean concentration by the mean mass or volume. This number was then multiplied by the number of containers. The calculations are shown in Appendix 5C, and the results are shown in Table 5-3.

Any sealed sources needed for instrument calibration will be certified by the American National Standards Institute (ANSI) or the U.S. Department of Transportation (DOT), so their inventory was not included for the purpose of hazard classification.

5.3.2.2 Chemical Inventory

An accident in the MWM Facility can involve any and all of the chemicals present as waste, reagents, or process area by-product material. This evaluation is based on the total mixed waste inventory generated at LLNL between January 1991 and June 1992 initially considered for treatment demonstrations at the MWM Facility (LLNL 1993a, 1993b). The sludge and waste oil stream chemical inventories were calculated by multiplying the mean concentration by the mean mass or volume. This number was then multiplied by the number of containers. Table 5-4 provides the total chemical inventory during this period. In addition to the mixed waste inventory, the chemical inventory of reagents that will be used in the MWM Facility was evaluated. Table 5-5 provides the total reagent chemical inventory (Steenhoven 1994b). The chemical inventory of process area by-product material is evaluated also. Table 5-6 provides the total by-product material chemical inventory. At this time, the plans for the wastewater treatment process are not finalized; therefore, no chemical inventories for this process were analyzed.

5.3.3 Hazard Analysis and Classification

5.3.3.1 Radionuclide Analysis

The radionuclide analysis involved an evaluation of the total radionuclide waste inventory present in the MWM Facility. These radionuclide quantities were compared to the threshold quantities from Table A.1 of DOE-STD-1027-92 (DOE 1992a) and were found to be below the Hazard Category 3 limit in all cases (Table 5-3). The sum of the ratios of the total inventory of each radionuclide to the Table A.1 threshold quantities was calculated and found to be less than 1.0 (Table 5-3). The MWM Facility will not, at any time, contain any significant fraction of the quantity of LLNL mixed waste evaluated; therefore, this analysis is conservative.

To accommodate potential management intentions to use the facility in later applications for waste which may contain radionuclides in greater quantities, the maximum radionuclide inventory is assumed to be 10 percent of the Hazard Category 3 threshold limit. Table 5-7 provides the maximum inventory for each radionuclide. The Hazard Category 3 threshold values for radionuclides not listed in Table 5-7 are listed in DOE-STD-1027-92. The sum of the ratios of the quantity of each radionuclide to 10 percent of the Hazard Category 3 threshold quantities must be less than 1.0.

These limits are approximately a factor of 2 larger than the one-year mixed waste inventory. Therefore, 10 percent of the Hazard Category 3 threshold quantities conservatively models the expected inventory at the MWM Facility.

For further information, the total waste stream inventory and 10 percent of the Hazard Category 3 threshold values were compared to the RQs listed in Appendix B of 40 CFR 302 (CFR 1992b). The comparison indicated that all values in the total waste stream inventory are less than their respective RQ. The comparison also indicated that, for each nuclide, 10 percent of the Hazard Category 3 threshold value is greater than or equal to the RQ (the tritium threshold value was the only amount equal to the RQ).

Based on this information, the MWM Facility is classified as a Radiological Facility in terms of the radionuclide inventory.

5.3.3.2 Chemical Analysis

The MWM Facility chemical inventory includes the total mixed waste inventory at LLNL between January 1991 and June 1992 (LLNL 1993b) plus the sludge and waste oil streams (LLNL 1993a), the reagent inventory (Steenhoven 1994b), and

the process by-product material inventory. In accordance with the methodology of Section 5.1, the inventory was initially compared to the threshold limits. The comparison shows that the mixed waste inventory of lead, tetrachloroethylene (PCE), trichloroethylene (TCE), and vinyl chloride exceeded the RQs of 40 CFR 302.4 (CFR 1992b). The mixed waste inventories of barium, hexanone (2-), freon 113, manganese, and trichlorofluoromethane have no listed threshold limits and are above the 1-pound limit criterion discussed in Section 5.1.2. This comparison also shows that the reagent inventory of hydrogen peroxide exceeded the RQ and TPQ of 40 CFR 355 (CFR 1992c) and the TQ of 29 CFR 1910 (CFR 1992a). Hydrogen peroxide does not have a listed RQ in 40 CFR 302.4. The reagent inventory of sodium hydroxide and silver nitrate exceeded the RQ of 40 CFR 302.4, and nitric acid exceeded the RQ of CFR 302.4 (CFR 1992b). Tables 5-4, 5-5, and 5-6 summarize the comparison.

The evaluations to determine the chemical concentrations for the identified hazardous chemicals were performed using the approved chemical modeling program ALOHA and various other standard evaporation models. The calculations indicate that these concentrations should be bounding, based on the energy sources and release mechanisms that would be available at the facility. The models and concentration calculations are discussed in detail in Appendix 5A. Table 5-8 summarizes the concentrations for the local (30 meters), on-site (100 meters), and off-site (175 meters) individuals. Note that the concentrations of several chemicals at 30 meters and 100 meters are different by a factor of 10. This difference is based on the average X/Q values discussed in Appendix 5A and is just a coincidence.

These values were compared to their respective ERPG or equivalent values. WSRC-MS-92-206 (Craig et al. 1993) provides recommended alternative concentration criteria for chemicals that do not have ERPG criteria as shown in Table 5-9. The associated ERPG values for each hazardous chemical are listed in Table 5-10. Tables 5-11, 5-12, and 5-13 show the results of the comparison.

5.3.4 Summary of Results

The radionuclide analysis resulted in a hazard classification of Radiological Facility. This classification was based on the assumptions that the inventory amounts would be maintained below 10 percent of the Hazard Category 3 threshold values and that the sum of the ratios of the quantity of each radionuclide to 10 percent of the Hazard Category 3 threshold quantity would be maintained below 1.0 (Table 5-7). These assumptions are supported by administrative controls and OSRs.

As shown in Tables 5-11, 5-12, and 5-13, the hazardous chemical analysis resulted in a hazard classification of Low Hazard. This result is based on each of the

hazardous chemical analyses. The hazardous chemical inventory will be maintained within the limits specified in the OSRs.

An additional scoping analysis was performed for hydrogen peroxide and nitric acid to identify the maximum inventory that would allow a Low Hazard classification to be maintained at the facility. The results of the analysis indicate that the maximum quantity of nitric acid is 36,000 pounds at 13M and the maximum quantity of hydrogen peroxide is 16,600 gallons at 50 wt%. The analysis is provided in Appendix 5B.

5.4 References

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- Code of Federal Regulations (1992c), *Protection of Environment*, 40 CFR 355, Appendix A, "List of Extremely Hazardous Substances and Their Threshold Planning Quantities," National Archives and Records Administration, July 1, 1992.
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5.4 References (continued)

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National Safety Council (1991), *Areal Locations of Hazardous Atmospheres, Version 5.1*, National Safety Council, Washington, DC, September 1991.

Steenhoven, J. (1994a), "DOE-STD-1027-92 Category 3 Threshold Limits," Memorandum to File, Lawrence Livermore National Laboratory, Livermore, CA, MWMF-94-089, June 1994.

Steenhoven, J. (1994b), "MWMF Inventory Limits for Hazardous and Radioactive Materials," MWMF-94-076 Rev. 1, Interoffice Memorandum to R. Streit, Lawrence Livermore National Laboratory, Livermore, CA, March 9, 1994.

**Table 5-1. Recommended Nonradiological Hazard Classification Guidelines
Criterion 1 (Craig et al. 1993)**

Hazard Class	Primary Concentration / Cancer Risk Guidelines	
	On Site (100 m)	Off Site (175 m)
High	—	≥ ERPG-3
Moderate	≥ ERPG-3	≥ ERPG-2
Low	≥ ERPG-2	≥ ERPG-1
Excluded	< ERPG-2	< ERPG-1

**Table 5-2. Recommended Nonradiological Hazard Classification Guidelines
Criterion 2 (Craig et al. 1993)**

Hazard Category	Receptor Location	Recommended Guidelines
High	Off Site (175 m)	$\geq$ ERPG-3
Moderate	On Site (100 m)	$\geq$ ERPG-3
Low	Local (30 m)	$\geq$ ERPG-3

Table 5-3. Hazard Evaluation of the Total Mass of Radioactive Constituents Present in Mixed Waste Streams Generated at LLNL During 1991-1992, Initially Considered for Treatment Demonstrations at the MWM Facility

Radionuclide	Total Waste Stream Inventory (Ci) ^a	Hazard Classification Criteria (Ci)		Hazard Classification
		Category 3 Threshold	Ratio to Category 3 Threshold	
H-3	2.31E-02	1.00E+03	2.31E-05	Radiological ^b
Be-7	3.71E-06	1.40E+04 ^c	2.65E-10	Radiological ^b
C-14	5.32E-04	4.20E+02	1.27E-06	Radiological ^b
S-35	2.50E-03	7.80E+01	3.21E-05	Radiological ^b
K-40	1.58E-03	1.70E+02	9.29E-06	Radiological ^b
Sc-46	1.21E-06	3.60E+02	3.36E-09	Radiological ^b
Mn-54	6.40E-05	8.80E+02 ^c	7.27E-08	Radiological ^b
Co-57	4.03E-06	6.00E+03 ^c	6.72E-10	Radiological ^b
Co-58	4.04E-07	9.00E+02 ^c	4.49E-10	Radiological ^b
Co-60	3.98E-05	2.80E+02	1.42E-07	Radiological ^b
Y-88	4.03E-07	2.80E+02 ^c	1.44E-09	Radiological ^b
Sr-90	2.70E-06	1.60E+01	1.69E-07	Radiological ^b
Nb-95	3.41E-04	9.60E+02 ^c	3.55E-07	Radiological ^b
Zr-95	1.65E-04	7.00E+02	2.36E-07	Radiological ^b
Rh-102m	6.07E-07	6.20E+02 ^c	9.79E-10	Radiological ^b
Rh-106	1.34E-05	1.96E+03 ^c	6.84E-09	Radiological ^b
Ru-106	1.34E-05	1.00E+02	1.34E-07	Radiological ^b
Cd-109	4.75E-05	1.80E+02	2.64E-07	Radiological ^b
Sb-120m	1.89E-07	3.20E+02 ^c	5.91E-10	Radiological ^b
Sb-125	3.03E-05	1.20E+03 ^c	2.53E-08	Radiological ^b
Ba-133	3.99E-08	1.10E+03	3.63E-11	Radiological ^b
Cs-134	3.71E-06	4.20E+01	8.83E-08	Radiological ^b
Cs-137	5.08E-05	6.00E+01	8.47E-07	Radiological ^b
Ce-141	1.74E-05	1.00E+03	1.74E-08	Radiological ^b
Ce-144	6.61E-04	1.00E+02	6.61E-06	Radiological ^b
Pm-144	3.99E-08	4.80E+02 ^c	8.31E-11	Radiological ^b
Nd-147	3.99E-08	1.20E+03 ^c	3.33E-11	Radiological ^b
Eu-152	9.48E-06	2.00E+02	4.74E-08	Radiological ^b
Eu-154	1.31E-05	2.00E+02	6.55E-08	Radiological ^b
Eu-155	1.11E-05	9.40E+02	1.18E-08	Radiological ^b
Tm-168	5.04E-07	NL	NL	Radiological ^d
Ta-182	2.40E-06	6.20E+02 ^c	3.87E-09	Radiological ^b
Re-183	2.78E-08	NL	NL	Radiological ^d
Re-184	2.78E-08	9.00E+02 ^c	3.09E-11	Radiological ^b

Table 5-3. Hazard Evaluation of the Total Mass of Radioactive Constituents Present in Mixed Waste Streams Generated at LLNL During 1991-1992, Initially Considered for Treatment Demonstrations at the MWM Facility (continued)

Radionuclide	Total Waste Stream Inventory (Ci) ^a	Hazard Classification Criteria (Ci)		Hazard Classification
		Category 3 Threshold	Ratio to Category 3 Threshold	
W-188	7.81E-04	2.80E+02 ^c	2.79E-06	Radiological ^b
Au-195	9.06E-04	3.20E+03 ^c	2.83E-07	Radiological ^b
Pt-195m	1.47E-05	5.00E+03 ^c	2.94E-09	Radiological ^b
Hg-203	9.76E-08	3.60E+02	2.71E-10	Radiological ^b
Bi-205	3.30E-07	8.80E+02 ^c	3.75E-10	Radiological ^b
Th-228	2.37E-08	1.00E+00	2.37E-08	Radiological ^b
Th-232	6.61E-10	1.00E-01	6.61E-09	Radiological ^b
U-235	7.36E-05	1.47E-03 ^e	5.01E-02	Radiological ^b
U-238	5.15E-02	4.20E+00	1.23E-02	Radiological ^b
Np-239	1.62E-05	7.80E+03 ^c	2.08E-09	Radiological ^b
Pu-239	2.12E-05	5.20E-01	4.08E-05	Radiological ^b
Am-241	2.54E-04	5.20E-01	4.88E-04	Radiological ^b
Pu-242	2.54E-09	6.20E-01 ^c	4.10E-09	Radiological ^b
Am-243	2.01E-09	5.20E-01	3.87E-09	Radiological ^b
Cm-244	2.40E-06	1.04E+00 ^c	2.31E-06	Radiological ^b
Cf-249	9.02E-06	5.20E-01 ^c	1.73E-05	Radiological ^b
Sum of Ratios = 6.30E-02				Radiological ^f

^a Mixed Waste Inventory (LLNL 1993b)

^b Less than the Hazard Category 3 threshold value

^c Steenhoven 1994a

^d The lowest Hazard Category 3 threshold value listed in Table A.1 of DOE-STD-1027-92 is 4.20E-01 Ci for Np-237. The waste stream inventory for Tm-168 and Re-183 is considerably lower than this value; therefore, a hazard classification of Radiological is assigned.

^e The fissile material limit of 700 grams is conservatively used.

^f Less than 1.0

NL - No Limit has been determined (Steenhoven 1994a)

Table 5-4. Hazard Evaluation of Hazardous Constituents Present in the LLNL Mixed Waste Streams Generated During 1991-1992, Initially Considered for Treatment Demonstrations at the MWM Facility

Chemical	Total Waste Stream Mass ^a (lb)	Reportable Quantity ^b (lb)	Threshold Planning Quantity ^c (lb)	Threshold Quantity ^d (lb)	Further Evaluation Performed ^e
Acetone	1.12E+01	5.00E+03	NL	NL	No
Acrolein	6.20E-01	1.00E+00	5.00E+02	NL	No
Acrylonitrile	1.20E+00	1.00E+02	1.00E+05	NL	No
Antimony	3.44E+00	5.00E+03	NL	NL	No
Aroclor (PCB)	7.54E-01	1.00E+00	NL	NL	No
Arsenic	2.78E-04	1.00E+00	NL	NL	No
Barium	8.08E+00	NL	NL	NL	Yes
Benzene	7.24E+00	1.00E+01	NL	NL	No
Beryllium	6.51E-01	1.00E+01	NL	NL	No
Bromoform	2.20E-03	1.00E+02	NL	NL	No
Butanone (2) (Methyl ethyl ketone)	3.10E+00	5.00E+03	NL	NL	No
Cadmium	1.28E-01	1.00E+01	NL	NL	No
Carbon tetrachloride	4.90E-01	1.00E+01	NL	NL	No
Chlorobenzene	5.50E+00	1.00E+02	NL	NL	No
Chloroform	5.51E+00	1.00E+01	1.00E+05	NL	No
Chromium	8.21E-01	5.00E+03	NL	NL	No
Cobalt	4.04E-01	NL	NL	NL	No
Copper	5.40E+00	5.00E+03	NL	NL	No
Cyanide	1.32E+00	1.00E+01	NL	NL	No
Dichlorobenzene (1,2-)	2.20E-03	1.00E+02	NL	NL	No
Dichlorodifluoromethane	9.22E-02	5.00E+03	NL	NL	No
Dichloroethane (1,1-)	5.16E+00	1.00E+03	NL	NL	No
Dichloroethane (1,2-)	1.07E+00	1.00E+02	NL	NL	No
Dichloroethene (1,2-) (total)	1.10E-03	NL	NL	NL	No
Dichloroethylene (1,1-)	4.00E+01	1.00E+02	NL	NL	No
Dichloropropane (1,2-)	1.10E-03	1.00E+03	NL	NL	No
Dichloropropene (1,3-) Cis	1.10E-03	1.00E+02	NL	NL	No
Dichloropropene (1,3-) Trans	1.10E-03	1.00E+02	NL	NL	No
Ethylbenzene	4.68E+00	1.00E+03	NL	NL	No
Freon 113	1.81E+01	NL	NL	NL	Yes ^f
Hexanone (2-)	1.11E+00	NL	NL	NL	Yes ^f
Lead	1.13E+00	1.00E+00	NL	NL	Yes
Manganese	2.03E+00	NL	NL	NL	Yes ^f
Mercury	2.33E-02	1.00E+00	NL	NL	No

Table 5-4. Hazard Evaluation of Hazardous Constituents Present in the LLNL Mixed Waste Streams Generated During 1991-1992, Initially Considered for Treatment Demonstrations at the MWM Facility (continued)

Chemical	Total Waste Stream Mass ^a (lb)	Reportable Quantity ^b (lb)	Threshold Planning Quantity ^c (lb)	Threshold Quantity ^d (lb)	Further Evaluation Performed ^e
Methanol	1.21E+00	5.00E+03	NL	NL	No
Methyl (4)-Pentanone (2-)	1.27E+00	5.00E+03	NL	NL	No
Methylene chloride	2.46E+02	1.00E+03	NL	NL	No
Molybdenum	3.95E-01	NL	NL	NL	No
Napthalene	6.80E-01	1.00E+02	NL	NL	No
Nickel	8.54E-01	1.00E+02	NL	NL	No
Silver	1.85E+00	1.00E+03	NL	NL	No
Sodium hydroxide (NaOH)	6.00E+00	1.00E+03	NL	NL	Yes
Styrene	7.27E-01	1.00E+03	NL	NL	No
Tetrachloroethane (1,1,2,2-)	1.10E-03	1.00E+02	NL	NL	No
Tetrachloroethylene (PCE)	3.76E+02	1.00E+02	NL	NL	Yes
Thallium	4.58E-02	1.00E+03	NL	NL	No
Toluene	1.24E+01	1.00E+03	NL	NL	No
Trichloroethane (1,1,1-) (TCA)	6.65E+02	1.00E+03	NL	NL	No
Trichloroethane (1,1,2-)	2.40E+00	1.00E+02	NL	NL	No
Trichloroethylene (TCE)	3.11E+02	1.00E+02	NL	NL	Yes
Trichlorofluoromethane	5.40E+00	NL	NL	NL	Yes ^f
Vanadium	2.20E-01	NL	NL	NL	No
Vinyl chloride	1.40E+00	1.00E+00	NL	NL	Yes
Xylene (total)	6.57E+00	1.00E+03	NL	NL	No
Zinc	5.19E+00	1.00E+03	NL	NL	No

^a Mixed Waste Inventory (LLNL 1993a, 1993b)

^b Reportable Quantity as given in 40 CFR 302.4 (CFR 1992b)

^c Threshold Planning Quantity as given in 40 CFR 355 (CFR 1992c)

^d Threshold Quantity as given in 29 CFR 1910.119 (CFR 1992a)

^e Chemical to be evaluated against ERPG values if one or more of the RQ, TPQ, or TQ values are exceeded.

^f No established RQ, TPQ, or TQ value but chemical mass exceeds 1 pound and must be evaluated against ERPG values.

NL - Not Listed in the associated CFR

Table 5-5. Hazard Evaluation of Chemical Inventory of Waste Treatment Reagents

Chemical	Total Waste Treatment Reagents ^a (lb)	Reportable Quantity ^b (lb)	Threshold Planning Quantity ^c (lb)	Threshold Quantity ^d (lb)	Further Evaluation Performed ⁱ
Ammonia	7.70E+01	1.00E+02	5.00E+02	1.50E+04	No
Hydrogen Peroxide	1.53E+04 ^e	1.00E+00 ^f	1.00E+03	7.50E+03	Yes
Sodium Hydroxide	3.00E+03	1.00E+03	NL	NL	Yes
Nitric Acid	1.70E+03 ^g	1.00E+03	1.00E+03	5.00E+02	Yes
Silver Nitrate	4.00E+02	1.00E+00	NL	NL	Yes
Ferric Nitrate	2.55E+01	1.00E+03	NL	NL	No
"Proprietary Reagent" ^h	No	No	No	No	No
Hydrochloric Acid	6.60E+00	5.00E+03	NL	5.00E+03	No

^a Steenhoven 1994b

^b Reportable Quantity as given in 40 CFR 302.4 (CFR 1992b)

^c Threshold Planning Quantity as given in 40 CFR 355 (CFR 1992c)

^d Threshold Quantity as given in 29 CFR 1910.119 (CFR 1992a)

^e Quantity of hydrogen peroxide in 3,050 gallons of 50 wt % hydrogen peroxide solution

^f Reportable Quantity as given in 40 CFR 355 (CFR 1992c)

^g Quantity of nitric acid in 2,500 pounds of 13M nitric acid solution plus 299 pounds of 15M nitric acid solution

^h The Ultraviolet Photolysis (UVP) process will use a reagent that is currently proprietary. No information concerning the reagent is available at this time, but the reagent will be assessed further as part of the FSAR.

ⁱ Chemical to be evaluated against ERPG values if one or more of the RQ, TPQ, or TQ values are exceeded.

NL - Not Listed in the associated CFR

Table 5-6. Hazard Evaluation of Chemical Inventory of By-Product Material from Process Areas

Chemical	Total By-Product Material ^a (lb)	Reportable Quantity ^b (lb)	Threshold Planning Quantity ^c (lb)	Threshold Quantity ^d (lb)	Further Evaluation Performed ^f
Hydrochloric Acid	1.73E+02	5.00E+03	NL	5.00E+03	No
Carbon Monoxide	trace ^e	NL	NL	NL	No
Silver Chloride	trace ^e	1.00E+00	NL	NL	No
Sodium Chloride	trace ^e	NL	NL	NL	No
Silver	<1.00E+03	1.00E+03	NL	NL	No

^a Estimates based on discussions with LLNL personnel.

^b Reportable Quantity as given in 40 CFR 302.4 (CFR 1992b)

^c Threshold Planning Quantity as given in 40 CFR 355 (CFR 1992c)

^d Threshold Quantity as given in 29 CFR 1910.119 (CFR 1992a)

^e Negligible amounts

^f Chemical to be evaluated against ERPG values if one or more of the RQ, TPQ, or TQ values are exceeded.

NL - Not Listed in the associated CFR

Table 5-7. MWM Maximum Radionuclide Inventory and Comparison to Waste Inventory

Radionuclide	Total Waste Stream Inventory (Ci) ^a	Hazard Classification Criteria (Ci)		Ratio of Waste Inventory to 10% of Category 3 Threshold
		Category 3 Threshold	10% of Category 3 Threshold	
H-3	2.31E-02	1.00E+03	1.00E+02	2.31E-04
Be-7	3.71E-06	1.40E+04 ^b	1.40E+03	2.65E-09
C-14	5.32E-04	4.20E+02	4.20E+01	1.27E-05
S-35	2.50E-03	7.80E+01	7.80E+00	3.21E-04
K-40	1.58E-03	1.70E+02	1.70E+01	9.29E-05
Sc-46	1.21E-06	3.60E+02	3.60E+01	3.36E-08
Mn-54	6.40E-05	8.80E+02 ^b	8.80E+01	7.27E-07
Co-57	4.03E-06	6.00E+03 ^b	6.00E+02	6.72E-09
Co-58	4.04E-07	9.00E+02 ^b	9.00E+01	4.49E-09
Co-60	3.98E-05	2.80E+02	2.80E+01	1.42E-06
Y-88	4.03E-07	2.80E+02 ^b	2.80E+01	1.44E-08
Sr-90	2.70E-06	1.60E+01	1.60E+00	1.69E-06
Nb-95	3.41E-04	9.60E+02 ^b	9.60E+01	3.55E-06
Zr-95	1.65E-04	7.00E+02	7.00E+01	2.36E-06
Rh-102m	6.07E-07	6.20E+02 ^b	6.20E+01	9.79E-09
Rh-106	1.34E-05	1.96E+03 ^b	1.96E+02	6.84E-08
Ru-106	1.34E-05	1.00E+02	1.00E+01	1.34E-06
Cd-109	4.75E-05	1.80E+02	1.80E+01	2.64E-06
Sb-120m	1.89E-07	3.20E+02 ^b	3.20E+01	5.91E-09
Sb-125	3.03E-05	1.20E+03 ^b	1.20E+02	2.53E-07
Ba-133	3.99E-08	1.10E+03	1.10E+02	3.63E-10
Cs-134	3.71E-06	4.20E+01	4.20E+00	8.83E-07
Cs-137	5.08E-05	6.00E+01	6.00E+00	8.47E-06
Ce-141	1.74E-05	1.00E+03	1.00E+02	1.74E-07
Ce-144	6.61E-04	1.00E+02	1.00E+01	6.61E-05
Pm-144	3.99E-08	4.80E+02 ^b	4.80E+01	8.31E-10
Nd-147	3.99E-08	1.20E+03 ^b	1.20E+02	3.33E-10
Eu-152	9.48E-06	2.00E+02	2.00E+01	4.74E-07
Eu-154	1.31E-05	2.00E+02	2.00E+01	6.55E-07
Eu-155	1.11E-05	9.40E+02	9.40E+01	1.18E-07
Tm-168	5.04E-07	NL	4.20E-02 ^c	1.20E-05
Ta-182	2.40E-06	6.20E+02 ^b	6.20E+01	3.87E-08
Re-183	2.78E-08	NL	4.20E-02 ^c	6.62E-07
Re-184	2.78E-08	9.00E+02 ^b	9.00E+01	3.09E-10
W-188	7.81E-04	2.80E+02 ^b	2.80E+01	2.79E-05

Table 5-7. MWM Maximum Radionuclide Inventory and Comparison to Waste Inventory (continued)

Radionuclide	Total Waste Stream Inventory (Ci) ^a	Hazard Classification Criteria (Ci)		Ratio of Waste Inventory to 10% of Category 3 Threshold
		Category 3 Threshold	10% of Category 3 Threshold	
Au-195	9.06E-04	3.20E+03 ^b	3.20E+02	2.83E-06
Pt-195m	1.47E-05	5.00E+03 ^b	5.00E+02	2.94E-08
Hg-203	9.76E-08	3.60E+02	3.60E+01	2.71E-09
Bi-205	3.30E-07	8.80E+02 ^b	8.80E+01	3.75E-09
Th-228	2.37E-08	1.00E+00	1.00E-01	2.37E-07
Th-232	6.61E-10	1.00E-01	1.00E-02	6.61E-08
U-235	7.36E-05	1.47E-03 ^d	1.47E-04	5.01E-01
U-238	5.15E-02	4.20E+00	4.20E-01	1.23E-01
Np-239	1.62E-05	7.80E+03 ^b	7.80E+02	2.08E-08
Pu-239	2.12E-05	5.20E-01	5.20E-02	4.08E-04
Am-241	2.54E-04	5.20E-01	5.20E-02	4.88E-03
Pu-242	2.54E-09	6.20E-01 ^b	6.20E-02	4.10E-08
Am-243	2.01E-09	5.20E-01	5.20E-02	3.87E-08
Cm-244	2.40E-06	1.04E+00 ^b	1.04E-01	2.31E-05
Cf-249	9.02E-06	5.20E-01 ^b	5.20E-02	1.73E-04
Sum of Ratios 6.30E-01				Radiological ^e

^a Mixed Waste Inventory (LLNL 1993b)

^b Steenhoven 1994a

^c 10 percent of Np-237 (4.20E-01 Ci) Hazard Category 3 threshold value

^d The fissile material limit of 700 grams is conservatively used

^e Less than 1.0

NL - No Limit has been determined (Steenhoven 1994a)

Table 5-8. Airborne Concentrations at Various Distances for Hazardous Chemicals that Required Further Evaluation

Chemical ^a	Local (30 m) Concentration (ppm)	On-Site (100 m) Concentration (ppm)	Off-Site (175 m) Concentration (ppm)
Barium ^b	1.69E-02 ^c	1.70E-03 ^c	5.86E-04 ^c
Freon 113 ^b	8.35E+01	8.40E+00	2.89E+00
Hexanone (2-) ^b	3.10E-01	2.93E-02	1.01E-02
Hydrogen Peroxide	1.38E+02	1.39E+01	4.77E+00
Lead	2.37E-03 ^c	2.38E-04 ^c	8.19E-05 ^c
Manganese ^b	4.25E-03 ^c	4.27E-04 ^c	1.47E-04 ^c
Nitric Acid	4.38E+01	4.40E+00	1.52E+00
Silver Nitrate	8.37E-01 ^c	8.42E-02 ^c	2.90E-02 ^c
Sodium Hydroxide	6.29E+00 ^c	6.33E-01 ^c	2.18E-01 ^c
Tetrachloroethylene (PCE)	5.05E+01	5.42E+00	1.88E+00
Trichloroethylene (TCE)	1.54E+02	1.64E+01	5.67E+00
Trichlorofluoromethane ^b	1.95E+01	1.90E+00	6.61E-01
Vinyl Chloride	4.79E+00	4.53E-01	1.56E-01

^a Obtained from Tables 5-4, 5-5, and 5-6

^b Have no listed threshold limits

^c mg/m³

Table 5-9. Recommended Hierarchy of Alternative Concentration-Limit Parameters (Craig et al. 1993)

Primary Guideline	Hierarchy Group	Hierarchy of Alternative Guidelines	Source of Concentration Parameter
ERPG-3	1	EEGL (30 min) IDLH	AIHA 1991 NAS 1985 NIOSH 1990
ERPG-2	2	EEGL (60 min) LOC PEL-C TLV-C TLV-TWA x 5*	AIHA 1991 NAS 1985 EPA 1987 29 CFR 1910.1000 ACGIH 1993-94 ACGIH 1993-94
ERPG-1	3	PEL-STEEL TLV-STEEL TLV-TWA x 3*	AIHA 1991 29 CFR 1910.1000 ACGIH 1993-94 ACGIH 1993-94
PEL-TWA	4	TLV-TWA SPEGL (60 min) CEGL	29 CFR 1910.1000 ACGIH 1993-94 NAS 1985 NAS 1985

Notes: * Applicable only to chemicals whose effects are dose-dependent.

The protocol is to use the primary guidelines first and then the alternative guidelines in the order presented for each hazard level when the primary guideline does not exist.

If application of this hierarchy to a particular chemical gives rise to a value for a lower hazard class that is higher than the value for the next higher hazard class (e.g., ERPG-1-equivalent value greater than ERPG-2-equivalent value), then that value should be adjusted downwards to match that of the next higher hazard class.

Table 5-10. Chemicals Evaluated with their Associated ERPG Values

Chemical	ERPG-1 (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)
Barium	1.50E+00 ^{a,b}	2.50E+00 ^{b,c}	1.10E+03 ^{b,d}
Freon 113	1.25E+03	1.50E+03	4.50E+03
Hexanone (2-)	1.50E+01 ^a	2.50E+01 ^c	5.00E+03 ^d
Hydrogen Peroxide	3.00E+00	2.50E+01 ^e	5.00E+01 ^e
Lead	4.50E-01 ^{a,b}	7.50E-01 ^{b,c}	7.00E+02 ^{b,d}
Manganese	1.50E+01 ^{a,b}	5.00E+00 ^{b,f}	NA
Nitric Acid	2.00E+00 ^e	1.50E+01 ^e	3.00E+01 ^e
Silver Nitrate	3.00E-02 ^{a,b}	5.00E-02 ^{b,c}	NA
Sodium Hydroxide	2.00E+00 ^{b,e}	4.00E+01 ^{b,e}	1.00E+02 ^{b,e}
Tetrachloroethylene (PCE)	1.00E+02 ^e	2.00E+02 ^e	5.00E+02 ^e
Trichloroethylene (TCE)	1.00E+02 ^e	5.00E+02 ^e	1.00E+03 ^e
Trichlorofluoromethane	NA	1.50E+03	1.00E+04
Vinyl Chloride	5.00E+00 ^f	5.00E+00 ^g	NA

a (TLV-TWA) x 3

b mg/m³

c (TLV-TWA) x 5

d IDLH

e Draft ERPG values (Craig et al. 1993)

f PEL-STEEL

g PEL-C

NA - Not Available

Table 5-11. On-Site Evaluation of Chemical Analysis

Chemical	On-Site (100 m) Concentration (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)	Hazard Classification
Barium	1.70E-03a	2.50E+00a,b	1.10E+03a,c	Excluded ^d
Freon 113	8.40E+00	1.50E+03	4.50E+03	Excluded ^d
Hexanone (2-)	2.93E-02	2.50E+01b	5.00E+03c	Excluded ^d
Hydrogen Peroxide	1.39E+01	2.50E+01	5.00E+01	Excluded ^d
Lead	2.38E-04a	7.50E-01a,b	7.00E+02a,c	Excluded ^d
Manganese	4.27E-04a	5.00E+00a,e	NA	Excluded ^d
Nitric Acid	4.40E+00	1.50E+01f	3.00E+01f	Excluded ^d
Silver Nitrate	8.42E-02a	5.00E-02a,b	NA	Low Hazard ^g
Sodium Hydroxide	6.33E-01a	4.00E+01a,f	1.00E+02a,f	Excluded ^d
Tetrachloroethylene (PCE)	5.42E+00	2.00E+02f	5.00E+02f	Excluded ^d
Trichloroethylene (TCE)	1.64E+01	5.00E+02f	1.00E+03f	Excluded ^d
Trichlorofluoromethane	1.90E+00	1.50E+03	1.00E+04	Excluded ^d
Vinyl Chloride	4.53E-01	5.00E+00e	NA	Excluded ^d

a mg/m³

b (TLV-TWA) × 5

c IDLH

d Less than the ERPG-2 value

e PEL-C

f Draft ERPG values (Craig et al. 1993)

g ERPG-3 value is not available; therefore, a Low Hazard classification is assigned.

NA - Not Available

Table 5-12. Off-Site Evaluation of Chemical Analysis

Chemical	Off-Site (175 m) Concentration (ppm)	ERPG-1 (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)	Hazard Classification
Barium	5.86E-04 ^a	1.50E+00 ^{a,b}	2.50E+00 ^{a,c}	1.10E+03 ^{a,d}	Excluded ^e
Freon 113	2.89E+00	1.25E+03	1.50E+03	4.50E+03	Excluded ^e
Hexanone (2-)	1.01E-02	1.50E+01 ^{a,b}	2.50E+01 ^{a,c}	5.00E+03 ^{a,d}	Excluded ^e
Hydrogen Peroxide	4.77E+00	3.00E+00	2.50E+01	5.00E+01	Low Hazard ^f
Lead	8.19E-05 ^a	4.50E-01 ^{a,b}	7.50E-01 ^{a,c}	7.00E+02 ^{a,d}	Excluded ^e
Manganese	1.47E-04 ^a	1.50E+01 ^{a,b}	5.00E+00 ^{a,g}	NA	Excluded ^e
Nitric Acid	1.52E+00	2.00E+00 ^h	1.50E+01 ^h	3.00E+01 ^h	Excluded ^e
Silver Nitrate	2.90E-02 ^a	3.00E-02 ^{a,b}	5.00E-02 ^{a,c}	NA	Excluded ^e
Sodium Hydroxide	2.18E-01 ^a	2.00E+00 ^{a,h}	4.00E+01 ^{a,h}	1.00E+02 ^{a,h}	Excluded ^e
Tetrachloroethylene (PCE)	1.88E+00	1.00E+02 ^h	2.00E+02 ^h	5.00E+02 ^h	Excluded ^e
Trichloroethylene (TCE)	5.67E+00	1.00E+02 ^h	5.00E+02 ^h	1.00E+03 ^h	Excluded ^e
Trichlorofluoromethane	6.61E-01	NA	1.50E+03	1.00E+04	Low Hazard ⁱ
Vinyl Chloride	1.56E-01	5.00E+00 ^j	5.00E+00 ^g	NA	Excluded ^e

^a mg/m³

^b (TLV-TWA) x 3

^c (TLV-TWA) x 5

^d IDLH

^e Less than the ERPG-1 value

^f Less than the ERPG-2 value and greater than the ERPG-1 value

^g PEL-C

^h Draft ERPG values (Craig et al. 1993)

ⁱ ERPG-1 value is not available; therefore, a Low Hazard classification is assigned.

^j PEL-STEL

NA - Not Available

Table 5-13. ERPG-3 Evaluation of Chemical Analysis

Chemical	Local (30 m) Concentration (ppm)	On-Site (100 m) Concentration (ppm)	ERPG-3 (ppm)	Hazard Classification
Barium	1.69E-02 ^a	1.70E-03 ^a	1.10E+03 ^{a,b}	Excluded ^c
Freon 113	8.35E+01	8.40E+00	4.50E+03	Excluded ^c
Hexanone (2-)	3.10E-01	2.93E-02	5.00E+03 ^b	Excluded ^c
Hydrogen Peroxide	1.38E+02	1.39E+01	5.00E+01	Low Hazard ^d
Lead	2.37E-03 ^a	2.38E-04 ^a	7.00E+02 ^{a,b}	Excluded ^c
Manganese	4.25E-03 ^a	4.27E-04 ^a	NA	ND
Nitric Acid	4.38E+01	4.40E+00	3.00E+01 ^e	Low Hazard ^d
Silver Nitrate	8.37E-01 ^a	8.42E-02 ^a	NA	ND
Sodium Hydroxide	6.29E+00 ^a	6.33E-01 ^a	1.00E+02 ^{a,e}	Excluded ^c
Tetrachloroethylene (PCE)	5.05E+01	5.42E+00	5.00E+02 ^e	Excluded ^c
Trichloroethylene (TCE)	1.54E+02	1.64E+01	1.00E+03 ^e	Excluded ^c
Trichlorofluoromethane	1.95E+01	1.90E+00	1.00E+04	Excluded ^c
Vinyl Chloride	4.79E+00	4.53E-01	NA	ND

^a mg/m³

^b IDLH (NIOSH 1990)

^c Less than the ERPG-3 value at 30 meters

^d Less than the ERPG-3 value at 100 meters and greater than the ERPG-3 value at 30 meters

^e Draft ERPG values (Craig et al. 1993)

NA - Not Available

ND - Not Determined

APPENDIX 5A

AMBIENT CHEMICAL CONCENTRATION CALCULATIONS

5A.1 Introduction

This appendix documents the results of the analysis conducted to determine the ambient chemical concentrations resulting from the postulated releases of chemical wastes and chemical reagents at the Mixed Waste Management (MWM) Facility. These ambient chemical concentrations were calculated at three receptor locations: 30 meters from the point of release (local receptor), 100 meters from the point of release (on-site receptor), and 175 meters from the point of release (facility fence line, off-site receptor).

5A.2 Input Data

The National Safety Council's Areal Locations Of Hazardous Atmospheres (ALOHA) model (Version 5.1) (National Safety Council 1991), produced as a joint effort by the Hazardous Materials Response Branch of the National Oceanic and Atmospheric Administration and the Chemical Emergency Preparedness and Prevention Office of the Environmental Protection Agency (EPA), is the atmospheric dispersion model used in this analysis to calculate the ambient chemical concentrations. Using air quality modeling assumptions commonly used in risk assessment evaluations of ambient air quality standards and air quality permitting studies, the ALOHA model was utilized to calculate the ambient concentrations of chemical vapors resulting from the release of the selected inventories of chemicals contained in waste processed, used, or stored at the MWM Facility.

The input data for these calculations consist of the specific input data required by the ALOHA model or the alternative methodology used to calculate ambient chemical concentrations. The input data include several categories of data. In this analysis, a puddle or pool was chosen as the source of the chemical emissions for the liquid chemicals chosen for analysis. A pool depth of 1 cm was used with each pool size analyzed. This depth is consistent with guidelines established by the EPA for screening model applications (FEMA 1990). In addition, information is required detailing where the ambient chemical concentrations are to be calculated (the downwind and crosswind location of the receptor). Three receptor locations were used in this analysis: 30 meters from the point of release (local receptor), 100 meters from the point of release (on-site receptor), and 175 meters from the point of release (facility fence line, off-site receptor).

The prevailing meteorological conditions to be used in each calculation must also be input into the ALOHA model. The information required includes the time of day, ambient air and ground temperature, atmospheric stability category, wind speed, percentage of cloud cover, relative humidity, and ground roughness type. These parameters were selected according to guidelines built into the ALOHA

model, which is menu-driven. The meteorological conditions used in this analysis were conservatively assumed to occur at 5 p.m. on an evening in July, with an ambient air and ground temperature of 35°C (95°F), D stability category, wind speed of 4.5 m/sec, 90% cloud cover, 50% relative humidity, over open country. Although unlikely to occur, these conditions were selected to provide for a conservative calculation of the ambient chemical concentrations that could be expected following a release of the chemical inventories analyzed.

Chemical physical data must be input into the ALOHA model for each chemical analyzed. The ALOHA database contains physical data for approximately 700 chemicals. However, the information is supplied only for pure forms of the chemicals (not for solutions or mixtures).

The EPA Open Dump Model (EPA 1987) was used to calculate the emission rates for the liquid chemicals and chemical solutions not included in the ALOHA database. The inputs required for the Open Dump Model include the physical data specific to the chemical and the quantity released, including the chemical molecular weight, vapor pressure, diffusivity in air, spill area information, and the ambient air temperature.

The chemicals and amounts analyzed are shown in Table 5A-1.

5A.3 Assumptions

The following assumptions were made in this analysis:

- The pools formed by the releases of the chemicals analyzed were conservatively assumed to be circular in shape and to have an average depth of 1 cm (FEMA 1990).
- As a spill of nitric acid solution evaporates, the nitric acid solution will form an azeotrope. At the azeotrope, the nitric acid emission rate remains unchanged, even if further evaporation occurs. The azeotrope for nitric acid occurs at 67 wt% (Weast 1991). When the 13M (60 wt%) nitric acid solution is spilled, water will preferentially evaporate from the solution causing the nitric acid concentration in the solution to rise until the solution reaches the azeotrope concentration of 67 wt%. This concentration remains constant until the spill is completely evaporated. The 15M nitric acid solution is at the azeotrope concentration of 67 wt%. In this analysis, it was conservatively assumed that the 60 wt% nitric acid solution instantaneously reaches the azeotrope concentration of 67 wt% as soon as it is released. This assumption provides for conservative calculations of ambient nitric acid concentrations resulting from the release of these nitric acid solutions.

- Vinyl chloride and trichlorofluoromethane are both components of waste to be processed at the MWM Facility. In their pure state, however, these chemicals are both gases at the ambient temperature assumed in this analysis (95°F). In this analysis, the ambient chemical concentrations resulting from the release of the inventories of these chemicals were calculated under the conservative assumption that the total inventories of these chemicals were released directly as gases. The release duration is assumed to be 15 minutes (Craig et al. 1993).
- The release duration for all nonvolatile solids released from solutions is assumed to be 60 minutes (Craig et al. 1993).
- The Release Fraction (RF) for gases is 1.0 (DOE 1992).
- An RF of 1.00E-03 is conservatively used for nonvolatile solids released from solutions (DOE 1992).

5A.4 Analytical Methods and Calculations

To determine the ambient chemical concentrations, the following steps were performed:

1. Determine the concentration calculation method to be used for each evaluated chemical.
2. Determine the nitric acid weight percent.
3. Calculate the pool areas for input to the ALOHA model or for use in the evaporation rate calculations.
4. Calculate the emission rates for chemicals not included in the ALOHA database.
5. Calculate the ambient concentrations for chemicals included in the ALOHA database.
6. Determine the X/Q values to be applied to chemicals not included in the ALOHA database.
7. Calculate the ambient concentrations for chemicals not included in the ALOHA database.

These steps are detailed in the following sections.

5A.4.1 Determination of Concentration Calculation Method

The ambient concentration calculations require two basic parameters: emission rate and atmospheric dispersion factor (χ/Q). Due to the variety of chemicals evaluated in this analysis, four methods were required to calculate the ambient chemical concentrations.

First, for pure liquid chemicals included in the ALOHA database, pool sizes were calculated based on the amount of chemical released and the density of the chemical. These data were then input into the ALOHA model, and the emission rates and χ/Q values were calculated directly by ALOHA. Trichloroethylene (TCE), tetrachloroethylene (PCE), and hexanone (2-) were evaluated using this method.

Second, for gases included in the ALOHA database, the emission rates were calculated by releasing the entire inventory over 15 minutes and using this value as input data to the ALOHA model. The χ/Q values for the gases were calculated by ALOHA. Trichlorofluoromethane and vinyl chloride were evaluated using this method.

Third, the EPA Open Dump Model (EPA 1987) was used to calculate the emission rates for the chemical solutions and liquid chemicals not included in the ALOHA database. The χ/Q values were obtained from an evaluation of results calculated with the ALOHA model. This method of analysis was used for the hydrogen peroxide solution, the nitric acid solutions, and 1,1,2-trichloro, 1,2,2-trifluoroethane (freon 113), a liquid at ambient temperature.

Fourth, for solid chemicals or nonvolatile solutions not included in the ALOHA database, ambient chemical concentrations were obtained by multiplying a calculated emission rate by atmospheric dispersion factors. The χ/Q values were obtained from an evaluation of results calculated with the ALOHA model. Barium, manganese, lead, sodium hydroxide, and silver nitrate were evaluated with this method.

Table 5A-1 summarizes the methods used to evaluate each chemical.

5A.4.2 Determination of Nitric Acid Weight Percent

The inventory of nitric acid solutions considered in this analysis consists of 2,500 pounds of 13M nitric acid solution and 299 pounds of 15M nitric acid solution. To evaluate the release of these solutions, it was necessary to determine the weight percent of the nitric acid in these solutions. Molarity (abbreviated M) is defined as the number of moles of solute in a liter of solution:

$$\text{Molarity} = \frac{\text{moles solute}}{\text{volume solution in liters}}$$

To find the weight percent of nitric acid in a 13M solution of nitric acid, it is first assumed that the volume of the solution is 1 liter. Therefore, the number of moles of nitric acid (HNO_3) in this liter of solution is calculated as follows:

$$\begin{aligned}\text{Moles HNO}_3 &= 1.0 \text{ liters of solution} \times \frac{13 \text{ moles HNO}_3}{\text{liter solution}} \\ &= 13 \text{ moles HNO}_3\end{aligned}$$

Converting this quantity of moles to grams yields the following:

$$x \text{ g} = 13 \text{ moles HNO}_3 \times \frac{63.02 \text{ g}}{1 \text{ mole HNO}_3}$$

$$\text{or } x = 819.3 \text{ g}$$

Therefore, in 1 liter of 13M nitric acid solution, there are 819.3 grams of nitric acid. To find the equivalent weight percent for a solution with this density (819.3 grams of nitric acid per liter of solution), a reference table of densities of nitric acid solutions (as found in *Perry's Chemical Engineers' Handbook* [Perry et al. 1984]) was consulted. At 20°C, this density corresponds to an approximately 60 wt% nitric acid solution. In the same manner, a 15M nitric acid solution corresponds to an approximately 67 wt% nitric acid solution at 20°C.

5A.4.3 Calculation of Pool Areas

Pool areas are required for input to the ALOHA model or for use in the evaporation rate calculations. In this analysis, for each of the liquid chemicals analyzed, it was conservatively assumed that the inventories of the reagents and waste chemicals are released and each forms a circular pool, where width equals length and the spill height or depth equals 1 cm (FEMA 1990). Pool areas and corresponding pool diameters were calculated as follows:

Pool Area

$$\text{inventory (lb)} \times \frac{0.45359 \text{ kg}}{\text{lb}} \times \text{density} \frac{\text{L}}{\text{kg}} \times \frac{1000 \text{ cm}^3}{\text{L}} \times \frac{1}{1 \text{ cm}} = \text{cm}^2$$

or

$$\text{inventory (gal)} \times \frac{3.785 \text{ L}}{\text{gal}} \times \frac{1000 \text{ cm}^3}{\text{L}} \times \frac{1}{1 \text{ cm}} = \text{cm}^2$$

$$\text{Pool Area} = \pi r^2$$

$$= \pi (d/2)^2$$

$$\text{so} \quad \pi \frac{d^2}{4} = \text{Pool area}$$

$$\text{or} \quad d = \sqrt{\frac{\text{Pool area} \times 4}{\pi}}$$

where

r = radius of pool,

d = diameter of pool.

The pool areas and diameters calculated for the evaluated chemicals are provided in Tables 5A-2 and 5A-3.

5A.4.4 Calculation of Emission Rates for Chemicals Not Included in ALOHA Database

The EPA's Open Dump Model (EPA 1987) was used to determine the evaporation rate of liquid chemicals and chemical solutions not included in the ALOHA database. Table 5A-3 contains the release rate calculations for all the chemicals in the MWM Facility which were calculated using the EPA model. The steps used to calculate the release rates are described below. Each step is shown in Table 5A-3.

The Open Dump Model is as follows (EPA 1987):

$$E_i = \frac{2 P_O MW_i y_i^* w}{R T} \sqrt{\frac{D_i l u}{\pi F_v}}$$

where

E_i = emission rate of constituent i (g/sec),

P_O = atmospheric pressure (760 mm Hg),

MW_i = molecular weight of constituent i (g/gmole),

y_i^* = equilibrium mole fraction of constituent i in the gaseous phase,

w = width of spill in direction perpendicular to wind flow (cm),

R = universal gas constant (62,300 mm Hg cm³/gmole °K),
T = temperature, 308°K (conservatively assumed to be 35°C),
D_i = diffusion coefficient of constituent i in air (cm²/sec),
l = length of spill in the direction of the wind flow (cm),
u = wind speed (450 cm/sec),
π = 3.1416,
F_v = Fick's law correction factor (a function of y_i^{*}).

The equilibrium mole fraction of each chemical in the gaseous phase (y_i^{*}) is determined as follows (EPA 1987):

$$y_i^* = X_i \times P_i^*/P_O$$

where

P_i^{*} = pure component vapor pressure (or partial pressure of a component in a solution, if data are available) at temperature T (mm Hg),

P_O = atmospheric pressure (760 mm Hg),

X_i = mole fraction of the component,

= 1 for pure components if the partial pressure of the component in a solution is used for P_i^{*},

= (C_i/MW_i) / [(C_i/MW_i + C_{water}/18] for components in solutions; used if partial pressure data for the component in the solution are unavailable.

Here

C_i = weight fraction of constituent i in the solution,
MW_i = molecular weight of constituent i (g/gmole),
C_{water} = weight fraction of water in the solution.

Fick's law correction factor (F_v) is a function of y_i^{*}. Interpolation of Table 5A-4 (EPA 1987) produced the F_v values used in this analysis.

The diffusion coefficient (D_i) is determined as follows (EPA 1987):

$$D_i = 0.0067 \times (T^{1.5}) \times (0.034 + M^{-1})^{0.5} \times (M^{-0.17}) \times [(M/2.5d)^{0.33} + 1.81]^{-2}$$

where

D_i = diffusivity of a chemical in air (cm^2/sec),
 T = ambient air temperature ($^\circ\text{K}$),
 M = molecular weight of the liquid (g/gmole),
 d = density of the liquid chemical (kg/L).

$$\text{Factor 1, g/cm}^2 = \frac{2 \times 760 \times MW_i \times Y_i \times \text{spill diameter}}{62300 \times 308}$$

$$\text{Factor 2, cm}^2/\text{sec} = \sqrt{\frac{D_i \times \text{spill diameter} \times 450}{3.1416 \times F_v}}$$

$$\text{Release rate (g/sec)} = \text{Factor 1} \times \text{Factor 2}$$

The release rates calculated using this methodology are summarized in Table 5A-3.

5A.4.5 Calculation of Ambient Concentrations for Chemicals Included in ALOHA Database

The ambient concentrations for chemicals included in the ALOHA database were analyzed using the ALOHA model. The input data for chemicals analyzed with the ALOHA model are summarized in Table 5A-2. For the liquid chemicals (TCE, PCE, and hexanone [2-]), pool sizes were calculated based on the amount of each chemical released and the density of the chemical, as discussed in Section 5A.4.3. These data were then input into the ALOHA model, and ambient concentrations were calculated at the downwind receptor locations. Emission rates for trichlorofluoromethane and vinyl chloride, which are gases in pure form at ambient temperature, were calculated by assuming that the total quantity of each chemical is released over a 15-minute period (Craig et al. 1993). These emission rates, as reported in Table 5A-2, were input into the ALOHA model, and ambient concentrations were calculated at the downwind receptor locations. The ambient chemical concentrations are listed in Table 5A-5.

5A.4.6 Calculation of X/Q Values for Chemicals Not Included in ALOHA Database

The atmospheric dispersion factor (X/Q) values required to calculate the ambient chemical concentrations for the chemical solids (barium, lead, manganese, sodium hydroxide, and silver nitrate) and liquids (nitric acid solutions, hydrogen peroxide solution, and freon 113) selected for analysis but not included in the

ALOHA database were obtained from results calculated by the ALOHA model from the analysis of TCE, PCE, hexanone (2-), and vinyl chloride.

The equation used to calculate ambient chemical concentrations (Kim and Waltz 1990) can be rewritten as follows:

$$\chi/Q = C/E$$

where

χ/Q = atmospheric dispersion factor (sec/m³),

C = ambient air concentration (mg/m³),

E = effective source emission rate (mg/sec).

The ALOHA model can be programmed to use either the heavy gas plume-spreading algorithm or the gaussian plume-spreading algorithm, or the model can evaluate the input parameters and select either the heavy gas plume-spreading algorithm or the gaussian plume-spreading algorithm. In this analysis, the model chose the gaussian plume-spreading algorithm to calculate the ambient chemical concentrations for TCE, PCE, hexanone (2-), and vinyl chloride. These concentrations were used to calculate the atmospheric dispersion factors to be used in this analysis.

The 30-, 100-, and 175-meter concentrations for all chemicals were divided by the release rates to obtain the respective χ/Q values shown in Table 5A-6. Using these results, the average χ/Q values were calculated:

<u>Receptor Location</u>	<u>χ/Q</u>
30 meters	1.66E-02 sec/m ³
100 meters	1.67E-03 sec/m ³
175 meters	5.75E-04 sec/m ³

5A.4.7 Calculations of Ambient Concentrations for Chemicals Not Included in ALOHA Database

The airborne chemical concentrations resulting from the release of solutions containing chemicals not included in the ALOHA database were calculated using the following equation (Kim and Waltz 1990):

$$C = E \times (\chi/Q)$$

where

$$\begin{aligned}C &= \text{ambient air concentration (mg/m}^3\text{),} \\E &= \text{effective source emission rate (mg/sec),} \\X/Q &= \text{atmospheric dispersion factor (sec/m}^3\text{).}\end{aligned}$$

The ambient concentrations of sodium hydroxide, manganese, lead, barium, silver nitrate, nitric acid solutions, hydrogen peroxide solution, and freon were calculated in this manner.

The atmospheric dispersion factors (X/Q) were obtained from the ALOHA model results, as explained in Section 5A.4.6.

For sodium hydroxide, manganese, lead, barium, and silver nitrate, the effective source emission rate is calculated as follows:

$$E = \frac{I \times RF}{T}$$

where

$$\begin{aligned}E &= \text{effective source emission rate (mg/sec),} \\I &= \text{total inventory (mg),} \\RF &= \text{release fraction} = 1.00\text{E-}03 \text{ (DOE 1992),} \\T &= \text{averaging time} = 60 \text{ min (3,600 sec) (Craig et al. 1993).}\end{aligned}$$

Using this methodology, the following ambient concentrations of sodium hydroxide (inventory of 3.00E+03 lb or 1.36E+09 mg) were calculated:

30-meter sodium hydroxide concentration:

$$\begin{aligned}C &= (1.36\text{E}+09 \text{ mg})(1.00\text{E-}03)(2.78\text{E-}04 \text{ sec}^{-1})(1.66\text{E-}02 \text{ sec/m}^3) \\&= 6.29\text{E}+00 \text{ mg/m}^3\end{aligned}$$

100-meter sodium hydroxide concentration:

$$\begin{aligned}C &= (1.36\text{E}+09 \text{ mg})(1.00\text{E-}03)(2.78\text{E-}04 \text{ sec}^{-1})(1.67\text{E-}03 \text{ sec/m}^3) \\&= 6.33\text{E-}01 \text{ mg/m}^3\end{aligned}$$

175-meter sodium hydroxide concentration:

$$\begin{aligned}C &= (1.36\text{E}+09 \text{ mg})(1.00\text{E-}03)(2.78\text{E-}04 \text{ sec}^{-1})(5.75\text{E-}04 \text{ sec/m}^3) \\&= 2.18\text{E-}01 \text{ mg/m}^3\end{aligned}$$

Similar calculations were made to obtain ambient concentrations of barium (total inventory of 8.08 pounds), lead (total inventory of 1.13 pounds), manganese (total inventory of 2.03 pounds), and silver nitrate (total inventory of 400 pounds). These results are summarized in Table 5A-7.

For freon 113, the nitric acid solutions, and the hydrogen peroxide solution, the Open Dump Model was used to calculate the emission rate (see Section 5A.4.4). Ambient chemical concentrations resulting from the release of the inventories of these chemicals were calculated using the same ambient chemical concentration calculation mentioned above. Thus, using the calculated emission rate of 39.2 g/sec (3.92E+04 mg/sec), for freon 113, the following concentrations were calculated:

30-meter freon-113 concentration:

$$\begin{aligned} C &= (3.92\text{E}+04 \text{ mg/sec})(1.66\text{E}-02 \text{ sec/m}^3) \\ &= 6.51\text{E}+02 \text{ mg/m}^3 \times \frac{1 \text{ ppm}}{7.79 \text{ mg/m}^3} \\ &= 8.35\text{E}+01 \text{ ppm} \end{aligned}$$

100-meter freon-113 concentration:

$$\begin{aligned} C &= (3.92\text{E}+04 \text{ mg/sec})(1.67\text{E}-03 \text{ sec/m}^3) \\ &= 6.55\text{E}+01 \text{ mg/m}^3 \times \frac{1 \text{ ppm}}{7.79 \text{ mg/m}^3} \\ &= 8.40\text{E}+00 \text{ ppm} \end{aligned}$$

175-meter freon-113 concentration:

$$\begin{aligned} C &= (3.92\text{E}+04 \text{ mg/sec})(5.75\text{E}-04 \text{ sec/m}^3) \\ &= 2.25\text{E}+01 \text{ mg/m}^3 \times \frac{1 \text{ ppm}}{7.79 \text{ mg/m}^3} \\ &= 2.89\text{E}+00 \text{ ppm} \end{aligned}$$

Similar calculations were performed for the nitric acid solutions (1 ppm = 2.62 mg/m³) and the hydrogen peroxide solution (1 ppm = 1.41 mg/m³), because even though these solutions are included in the ALOHA database as pure chemicals, they are not included as the solutions in which they are used or stored at the MWM Facility. The ambient chemical concentrations are listed in Table 5A-7.

5A.5 Results

The calculated ambient chemical concentration results from this analysis are summarized in Tables 5A-5 and 5A-7. The ALOHA model was run in the computational mode, which allowed the model to evaluate the input parameters and select either the heavy gas plume-spreading algorithm or the gaussian plume-spreading algorithm. After evaluating the input parameters, the ALOHA model selected the gaussian plume-spreading algorithm to calculate the ambient chemical concentrations for all of the chemicals, except trichlorofluoromethane, evaluated by the ALOHA model in this analysis (TCE, PCE, hexanone [2-], and vinyl chloride). As previously discussed, the ambient chemical concentrations for barium, lead, manganese, sodium hydroxide, nitric acid solutions, hydrogen peroxide solution, and freon 113 were conservatively calculated using release rates and gaussian plume-spreading algorithm atmospheric dispersion factors calculated from ALOHA model results.

5A.6 Computer Program Listings

Input listings for the chemicals evaluated with the ALOHA model are included in Attachment 5A-1.

5A.7 Computer Program Documentation

Program documentation for the ALOHA model is included in *Areal Locations of Hazardous Atmospheres* (National Safety Council 1991).

5A.8 References

- Craig, D.K., J.S. Davis, L.G. Lee, P.J. Lein, and P. Hoffman (1993), *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities*, Westinghouse Savannah River Company, Aiken, SC, WSRC-MS-92-206, Rev. 1 (April 1993 Recommendations of the Westinghouse M&O Subcommittee on Nonradiological Risk Acceptance Guideline Development), April 1993.
- Department of Energy (1992), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, DOE-STD-1027-92, December 1992.
- Environmental Protection Agency (1987), *Hazardous Waste Treatment, Storage And Disposal Facilities (TSDF) - Air Emission Models*, U.S. Environmental Protection Agency, Washington, DC, EPA-450/3-87-026, December 1987.
- Federal Emergency Management Agency (1990), *Handbook of Chemical Hazard Analysis Procedures*, Federal Emergency Management Agency, Washington, DC, 1990.
- Kim, K.S. and W.R. Waltz (1990), *Interim Hazards Classification Guide for Non-Reactor Facilities at Savannah River Site*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, July 1990.
- National Institute for Occupational Safety and Health (1990), *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, Washington, DC, June 1990.
- National Safety Council (1991), *Areal Locations of Hazardous Atmospheres, Version 5.1*, National Safety Council, Washington, DC, September 1991.
- Perry, R.H., D.W. Green, and J.O. Maloney (eds.) (1984), *Perry's Chemical Engineers' Handbook*, Fifth Edition, McGraw Hill Book Co., New York, NY, 1984.
- Weast, R.C. (1991), *CRC Handbook of Chemistry and Physics*, 72ND Edition, CRC Press, Inc., Boca Raton, FL, 1991-1992.

Table 5A-1. Chemical Inventories Evaluated and Methodologies Used

Chemical	Inventory (lb)	Emission Rate Calculations			Dispersion Calculations	
		ALOHA	EPA	Inventory × SRF	ALOHA	%/Q × Emission Rate
Tetrachloroethylene (PCE)	3.76E+02	X			X	
Trichloroethylene (TCE)	3.11E+02	X			X	
Vinyl Chloride	1.40E+00			X	X	
Barium	8.08E+00			X		X
Freon 113	1.81E+01		X			X
Hexanone (2-)	1.11E+00	X			X	
Lead	1.13E+00			X		X
Manganese	2.03E+00			X		X
Trichlorofluoromethane	5.40E+00			X	X	
Hydrogen Peroxide	1.53E+04 ^a		X			X
Sodium Hydroxide	3.00E+03			X		X
Silver Nitrate	4.00E+02			X		X
Nitric Acid	1.70E+03 ^b		X			X

^a Quantity of hydrogen peroxide in 3,050 gallons of 50 wt% hydrogen peroxide solution

^b Quantity of nitric acid in 2,500 pounds of 13M nitric acid solution plus 299 pounds of 15M nitric acid solution

Table 5A-2. ALOHA Model Input Data for Pure Chemicals

Chemical	Release Quantity (lb)	Chemical Density (kg/L)	Pool Area (m ²)	Release Rate (g/sec)
Trichloroethylene (TCE)	311.0	1.46	9.60	54.17 ^a
Tetrachloroethylene (PCE)	376.0	1.62	10.50	22.67 ^a
Hexanone (2-)	1.11	0.81	0.062	0.073 ^a
Trichlorofluoromethane	5.40	N/A ^b	N/A ^b	2.72 ^c
Vinyl Chloride	1.40	N/A ^b	N/A ^b	0.71 ^c

^a Release rate calculated by ALOHA model

^b Not Applicable; chemical released as a gas at the ambient temperature (95°F)

^c Release rate calculated assuming a 15-minute averaging time (Craig et al. 1993)

Table 5A-3. EPA Dump Model Release Rate Calculations

Chemical	Component Density (kg/L)	Pool Area (cm ²)	Pool Diameter (cm)	MWl (g/gmole)	Vapor pressure (mm Hg)	X _l	Y _l ^a	Diffusivity (cm ² /sec)	F _v	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)
Nitric Acid (67%)	1.40E+00 ^a	9.07E+05	1.07E+03	6.30E+01	5.48E+00 ^a	1.00E+00	7.21E-03	2.06E-01	9.95E-01	3.87E-02	1.79E+02	6.91E+00
Hydrogen Peroxide (50%)	1.20E+00 ^a	1.15E+07	3.83E+03	3.40E+01	6.05E+00 ^b	3.46E-01	2.76E-03	3.07E-01	9.98E-01	2.85E-02	4.11E+02	1.17E+01
Freon 113	1.56E+00 ^c	5.27E+03	8.19E+01	1.87E+02	4.99E+02 ^a	1.00E+00	6.57E-01	1.01E-01	4.92E-01	7.98E-01	4.92E+01	3.92E+01

^a Perry et al. 1984

^b Weast 1991

^c NIOSH 1990

Table 5A-4. Fick's Law Correction Factor as a Function of y_i^* (EPA 1987)

y_i^*	F_v
0.00	1.0000
0.05	0.9635
0.10	0.9268
0.15	0.8900
0.20	0.8527
0.25	0.8152
0.30	0.7774
0.35	0.7391
0.40	0.7004
0.45	0.6613
0.50	0.6215
0.55	0.5810
0.60	0.5398
0.65	0.4976
0.70	0.4540
0.75	0.4088
0.80	0.3616
0.85	0.3112
0.90	0.2456
0.95	0.1893
1.00	0.0000

**Table 5A-5. Calculated Ambient Chemical Concentrations for Chemicals
Listed in the ALOHA Database**

Chemical	30-m Concentration (ppm)	100-m Concentration (ppm)	175-m Concentration (ppm)
Trichloroethylene (TCE)	1.54E+02	1.64E+01	5.67E+00
Tetrachloroethylene (PCE)	5.05E+01	5.42E+00	1.88E+00
Hexanone (2-)	3.10E-01	2.93E-02	1.01E-02
Vinyl Chloride	4.79E+00	4.53E-01	1.56E-01
Trichlorofluoromethane	1.95E+01	1.90E+00	6.61E-01

Table 5A-6. ALOHA Gaussian Plume-Spreading Algorithm c/Q Values for Select Chemicals

Chemical	Release Rate (mg/sec)	30-meter Conc. (mg/m ³)	100-meter Conc. (mg/m ³)	175-meter Conc. (mg/m ³)	30-meter c/Q (sec/m ³)	100-meter c/Q (sec/m ³)	175-meter c/Q (sec/m ³)
Hexanone (2-)	7.32E+01	1.30E+00	1.23E-01	4.21E-02	1.77E-02	1.68E-03	5.76E-04
Trichloroethylene	5.42E+04	8.46E+02	8.95E+01	3.11E+01	1.56E-02	1.65E-03	5.74E-04
Tetrachloroethylene	2.27E+04	3.50E+02	3.76E+01	1.30E+01	1.54E-02	1.66E-03	5.75E-04
Vinyl Chloride	7.05E+02	1.25E+01	1.18E+00	4.06E-01	1.77E-02	1.67E-03	5.75E-04
Average					1.66E-02	1.67E-03	5.75E-04

Table 5A-7. Calculated Ambient Concentrations of Chemicals Not Included in the ALOHA Database

Chemical	30-m Concentration (mg/m ³)	100-m Concentration (mg/m ³)	175-m Concentration (mg/m ³)
Barium	1.69E-02	1.70E-03	5.86E-04
Lead	2.37E-03	2.38E-04	8.19E-05
Manganese	4.25E-03	4.27E-04	1.47E-04
Sodium Hydroxide	6.29E+00	6.33E-01	2.18E-01
Silver Nitrate	8.37E-01	8.42E-02	2.90E-02
Nitric Acid	4.38E+01 ^a	4.40E+00 ^a	1.52E+00 ^a
Freon 113	8.35E+01 ^a	8.40E+00 ^a	2.89E+00 ^a
Hydrogen Peroxide	1.38E+02 ^a	1.39E+01 ^a	4.77E+00 ^a

^a ppm

Attachment 5A-1

ALOHA COMPUTER PROGRAM INPUT LISTINGS

ALOHA INPUT DECKS

<u>CHEMICAL</u>	<u>PAGE</u>
Trichloroethylene receptor distance = 30 m	5-51
Trichloroethylene receptor distance = 100 m	5-52
Trichloroethylene receptor distance = 175 m	5-53
Tetrachloroethylene, receptor distance = 30 m	5-54
Tetrachloroethylene, receptor distance = 100 m	5-55
Tetrachloroethylene, receptor distance = 175 m	5-56
Hexanone (2-) (Methyl Butyl Ketone), receptor distance = 30 m	5-57
Hexanone (2-) (Methyl Butyl Ketone), receptor distance = 100 m	5-58
Hexanone (2-) (Methyl Butyl Ketone), receptor distance = 175 m	5-59
Vinyl Chloride, receptor distance = 30 m	5-60
Vinyl Chloride, receptor distance = 100 m	5-61
Vinyl Chloride, receptor distance = 175 m	5-62
Trichlorofluoromethane, receptor distance = 30 m	5-63
Trichlorofluoromethane, receptor distance = 100 m	5-64
Trichlorofluoromethane, receptor distance = 175 m	5-65

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035403

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROETHYLENE Molecular Weight: 131.39 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 1000.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1000 ppm
Boiling Point: 86.95° C
Vapor Pressure at Ambient Temperature: 0.15 atm
Ambient Saturation Concentration: 154,552 ppm or 15.5%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 9.6 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: 51 minutes
Max Computed Release Rate: 4.15 kilograms/min
Max Average Sustained Release Rate: 3.25 kilograms/min
(averaged over a minute or more)
Total Amount Released: 138 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 30 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 154 ppm
Indoor: 74.6 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035445

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROETHYLENE Molecular Weight: 131.39 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 1000.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1000 ppm
Boiling Point: 86.95° C
Vapor Pressure at Ambient Temperature: 0.15 atm
Ambient Saturation Concentration: 154,552 ppm or 15.5%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 9.6 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: 51 minutes
Max Computed Release Rate: 4.15 kilograms/min
Max Average Sustained Release Rate: 3.25 kilograms/min
(averaged over a minute or more)
Total Amount Released: 138 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 16.4 ppm
 Indoor: 7.94 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035464

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROETHYLENE Molecular Weight: 131.39 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 1000.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1000 ppm
Boiling Point: 86.95° C
Vapor Pressure at Ambient Temperature: 0.15 atm
Ambient Saturation Concentration: 154,552 ppm or 15.5%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 9.6 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: 51 minutes
Max Computed Release Rate: 4.15 kilograms/min
Max Average Sustained Release Rate: 3.25 kilograms/min
(averaged over a minute or more)
Total Amount Released: 138 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 5.67 ppm
Indoor: 2.76 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035572

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TETRACHLOROETHYLENE Molecular Weight: 165.83 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 500.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 500 ppm
Boiling Point: 121.25° C
Vapor Pressure at Ambient Temperature: 0.041 atm
Ambient Saturation Concentration: 41,374 ppm or 4.14%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 10.5 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 1.46 kilograms/min
Max Average Sustained Release Rate: 1.36 kilograms/min
(averaged over a minute or more)
Total Amount Released: 77.0 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 30 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 50.5 ppm
Indoor: 31 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035590

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TETRACHLOROETHYLENE Molecular Weight: 165.83 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 500.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 500 ppm
Boiling Point: 121.25° C
Vapor Pressure at Ambient Temperature: 0.041 atm
Ambient Saturation Concentration: 41,374 ppm or 4.14%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 10.5 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 1.46 kilograms/min
Max Average Sustained Release Rate: 1.36 kilograms/min
(averaged over a minute or more)
Total Amount Released: 77.0 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 5.42 ppm
Indoor: 3.33 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035616

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TETRACHLOROETHYLENE Molecular Weight: 165.83 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 500.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 500 ppm
Boiling Point: 121.25° C
Vapor Pressure at Ambient Temperature: 0.041 atm
Ambient Saturation Concentration: 41,374 ppm or 4.14%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 10.5 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 1.46 kilograms/min
Max Average Sustained Release Rate: 1.36 kilograms/min
(averaged over a minute or more)
Total Amount Released: 77.0 kilograms

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 1.88 ppm
 Indoor: 1.15 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035227

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours .

CHEMICAL INFORMATION:

Chemical Name: METHYL BUTYL KETONE	Molecular Weight: 100.16 kg/kmol
TLV-TWA: 5.00 ppm	IDLH: 5000.00 ppm
Footprint Level of Concern: 5000 ppm	
Boiling Point: 127.70° C	
Vapor Pressure at Ambient Temperature: 0.025 atm	
Ambient Saturation Concentration: 25,072 ppm or 2.51%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s	No Inversion Height
Stability Class: D	Air Temperature: 95° F
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 9 tenths	

SOURCE STRENGTH INFORMATION:

Puddle Area: 6.22E-02 square meters	
Average Puddle Depth: 1 centimeters	
Soil Type: Default	Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature	
Release Duration: ALOHA limited the duration to 1 hour	
Max Computed Release Rate: 4.74 grams/min	
Max Average Sustained Release Rate: 4.39 grams/min	
(averaged over a minute or more)	
Total Amount Released: 248 grams	

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 30 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 0.31 ppm
Indoor: 0.19 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035257

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: METHYL BUTYL KETONE	Molecular Weight: 100.16 kg/kmol
TLV-TWA: 5.00 ppm	IDLH: 5000.00 ppm
Footprint Level of Concern: 5000 ppm	
Boiling Point: 127.70° C	
Vapor Pressure at Ambient Temperature: 0.025 atm	
Ambient Saturation Concentration: 25,072 ppm or 2.51%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s	No Inversion Height
Stability Class: D	Air Temperature: 95° F
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 9 tenths	

SOURCE STRENGTH INFORMATION:

Puddle Area: 6.22E-02 square meters	
Average Puddle Depth: 1 centimeters	
Soil Type: Default	Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature	
Release Duration: ALOHA limited the duration to 1 hour	
Max Computed Release Rate: 4.74 grams/min	
Max Average Sustained Release Rate: 4.39 grams/min	
(averaged over a minute or more)	
Total Amount Released: 248 grams	

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:

Downwind:	100 meters
Off Centerline:	0 meters

Max Concentration:

Outdoor:	0.0293 ppm
Indoor:	0.018 ppm

Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

2848035285

Text Summary

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: METHYL BUTYL KETONE Molecular Weight: 100.16 kg/kmol
TLV-TWA: 5.00 ppm IDLH: 5000.00 ppm
Footprint Level of Concern: 5000 ppm
Boiling Point: 127.70° C
Vapor Pressure at Ambient Temperature: 0.025 atm
Ambient Saturation Concentration: 25,072 ppm or 2.51%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 6.22E-02 square meters
Average Puddle Depth: 1 centimeters
Soil Type: Default Ground Temperature: 95° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 4.74 grams/min
Max Average Sustained Release Rate: 4.39 grams/min
 (averaged over a minute or more)
Total Amount Released: 248 grams

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 0.0101 ppm
 Indoor: 0.00619 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035771

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: VINYL CHLORIDE Molecular Weight: 62.50 kg/kmol
TLV-TWA: -unavail- IDLH: 1.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1 ppm
Boiling Point: -13.37° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: .7056 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 42.3 grams/min
Total Amount Released: 2.54 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 30 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 4.79 ppm
 Indoor: 3.14 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

2848035795

Text Summary

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: VINYL CHLORIDE Molecular Weight: 62.50 kg/kmol
TLV-TWA: -unavail- IDLH: 1.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1 ppm
Boiling Point: -13.37° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: .7056 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 42.3 grams/min
Total Amount Released: 2.54 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 0.453 ppm
 Indoor: 0.298 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035818

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: VINYL CHLORIDE Molecular Weight: 62.50 kg/kmol
TLV-TWA: -unavail- IDLH: 1.00 ppm
Note: Potential or confirmed human carcinogen.
Footprint Level of Concern: 1 ppm
Boiling Point: -13.37° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: .7056 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 42.3 grams/min
Total Amount Released: 2.54 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 0.156 ppm
 Indoor: 0.102 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848035931

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROFLUOROMETHANE Molecular Weight: 137.37 kg/kmol
TLV-TWA: 1000.00 ppm IDLH: 10000.00 ppm
Footprint Level of Concern: 10000 ppm
Boiling Point: 23.82° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: 2.72 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 163 grams/min
Total Amount Released: 9.79 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (10000 ppm)
Max Threat Zone for LOC: 11 meters
Note: Footprint wasn't drawn because effects of
near-field patchiness make plume presentation
unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 30 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 19.5 ppm
Indoor: 12.8 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2848036331

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROFLUOROMETHANE	Molecular Weight: 137.37 kg/kmol
TLV-TWA: 1000.00 ppm	IDLH: 10000.00 ppm
Footprint Level of Concern: 10000 ppm	
Boiling Point: 23.82° C	
Vapor Pressure at Ambient Temperature: greater than 1 atm	
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s	No Inversion Height
Stability Class: D	Air Temperature: 95° F
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 9 tenths	

SOURCE STRENGTH INFORMATION:

Direct Source: 2.72 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 163 grams/min
Total Amount Released: 9.79 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (10000 ppm)
Max Threat Zone for LOC: 11 meters
Note: Footprint wasn't drawn because effects of
near-field patchiness make plume presentation
unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 1.9 ppm
Indoor: 1.24 ppm
Note: Indoor graph is shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

2848036015

Text Summary

SITE DATA INFORMATION:

Location: LIVERMORE, CALIFORNIA
Building Air Exchanges Per Hour: 1.08 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1994 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROFLUOROMETHANE Molecular Weight: 137.37 kg/kmol
TLV-TWA: 1000.00 ppm IDLH: 10000.00 ppm
Footprint Level of Concern: 10000 ppm
Boiling Point: 23.82° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 4.5 meters/sec from s No Inversion Height
Stability Class: D Air Temperature: 95° F
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 9 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: 2.72 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 163 grams/min
Total Amount Released: 9.79 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (10000 ppm)
Max Threat Zone for LOC: 11 meters
Note: Footprint wasn't drawn because effects of near-field patchiness make plume presentation unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 0.661 ppm
Indoor: 0.43 ppm
Note: Indoor graph is shown with a dotted line.

APPENDIX 5B

SCOPING CHEMICAL CONCENTRATION CALCULATIONS

5B.1 Introduction

This appendix documents the results of the analysis conducted to determine the maximum inventory of hydrogen peroxide and nitric acid that would allow a Low Hazard classification to be maintained in the Mixed Waste Management (MWM) Facility. Ambient chemical concentrations resulting from the postulated releases of these chemicals were calculated at three receptor locations: 30 meters from the point of release (local receptor), 100 meters from the point of release (on-site receptor), and 175 meters from the point of release (facility fence line, off-site receptor).

5B.2 Input Data

The Environmental Protection Agency (EPA) Open Dump Model (EPA 1987) was used to calculate the emission rates for the hydrogen peroxide and nitric acid solutions. The inputs required for the Open Dump Model include the physical data specific to the chemical and the quantity released, including the chemical molecular weight, vapor pressure, diffusivity in air, spill area information, and the ambient air temperature.

The National Safety Council's Areal Locations Of Hazardous Atmospheres (ALOHA) model (Version 5.1) (National Safety Council 1991), produced as a joint effort by the Hazardous Materials Response Branch of the National Oceanic and Atmospheric Administration and the Chemical Emergency Preparedness and Prevention Office of the EPA, is the atmospheric dispersion model used in this analysis to calculate the χ/Q values. The inputs to the model are the same inputs used to calculate the χ/Q values in Appendix 5A.

5B.3 Assumptions

The following assumptions were made in this analysis:

- The pools formed by the releases of the chemicals analyzed were conservatively assumed to be circular in shape and to have an average depth of 1 cm (FEMA 1990).
- As a spill of nitric acid solution evaporates, the nitric acid solution will form an azeotrope. At the azeotrope, the nitric acid emission rate remains unchanged, even if further evaporation occurs. The azeotrope for nitric acid occurs at 67 wt% (Weast 1991). When the 13M (60 wt%) nitric acid solution is spilled, water will preferentially evaporate from the solution causing the nitric acid concentration in the solution to rise until the solution reaches the azeotrope concentration of 67 wt%. This

concentration remains constant until the spill is evaporated completely. In this analysis, it was conservatively assumed that the 60 wt% nitric acid solution instantaneously reaches the azeotrope concentration of 67 wt% as soon as it is released. This assumption will provide for conservative calculations of ambient nitric acid concentrations resulting from the release of this nitric acid solution.

5B.4 Analytical Methods and Calculations

To determine the ambient chemical concentrations, the following steps were performed:

1. Determine the nitric acid weight percent.
2. Calculate the pool areas for use in the evaporation rate calculations.
3. Calculate the emission rates of the chemical solutions.
4. Determine the χ/Q values to be applied to the chemicals.
5. Calculate the ambient concentrations of hydrogen peroxide and nitric acid.

These steps are detailed in the following sections.

5B.4.1 Determination of Nitric Acid Weight Percent

The maximum inventory of nitric acid solution considered in this analysis consists of 36,000 pounds of a 13M nitric acid solution. To evaluate the release of this solution, it was necessary to determine the weight percent of the nitric acid in this solution. Molarity (abbreviated M) is defined as the number of moles of solute in a liter of solution:

$$\text{Molarity} = \frac{\text{moles solute}}{\text{volume solution in liters}}$$

To find the weight percent of nitric acid in a 15M solution of nitric acid, it is first assumed that the volume of the solution is 1 liter. Therefore, the number of moles of nitric acid (HNO_3) in this liter of solution is calculated as follows:

$$\begin{aligned}\text{Moles HNO}_3 &= 1.0 \text{ liters of solution} \times \frac{13 \text{ moles HNO}_3}{\text{liter solution}} \\ &= 13 \text{ moles HNO}_3\end{aligned}$$

Converting this quantity of moles to grams yields the following:

$$x \text{ g} = 13 \text{ moles HNO}_3 \times \frac{63.02 \text{ g}}{1 \text{ mole HNO}_3}$$

or

$$x = 819.3 \text{ g}$$

Therefore, in 1 liter of 13M nitric acid solution, there are 819.3 grams of nitric acid. To find the equivalent weight percent for a solution with this density (819.3 grams of nitric acid per liter of solution), a reference table of densities of nitric acid solutions (as found in *Perry's Chemical Engineers' Handbook* [Perry et al. 1984]) was consulted. At 20°C, this density corresponds to an approximately 60 wt% nitric acid solution.

5B.4.2 Calculation of Pool Areas

Pool areas are required for use in the evaporation rate calculations. In this analysis, for each of the liquid chemicals analyzed, it was conservatively assumed that the inventories of the reagents are released and each forms a circular pool, where width equals length and the spill height or depth equals 1 cm (FEMA 1990). The pool area and corresponding pool diameter equations used are shown in Appendix 5A, Section 5A.4.3. The pool areas and corresponding pool diameter calculations for hydrogen peroxide and nitric acid are shown in Table 5B-1.

5B.4.3 Calculation of Emission Rates

The EPA's Open Dump Model (EPA 1987) was used to determine the evaporation rate for hydrogen peroxide and nitric acid. Table 5B-1 contains the release rate calculations for both chemicals. The steps used to calculate the release rates are described in Appendix 5A, Section 5A.4.4. Each step is shown in Table 5B-1. Various quantities of hydrogen peroxide and nitric acid were input into the spreadsheet calculations to determine the maximum allowed inventories.

5B.4.4 Calculation of χ/Q Values

The atmospheric dispersion factor (χ/Q) values required to calculate the ambient chemical concentrations for the hydrogen peroxide and nitric acid solutions are described in Appendix 5A, Section 5A.4.6. The χ/Q values used are listed below:

<u>Receptor Location</u>	<u>χ/Q</u>
30 meters	1.66E-02 sec/m ³
100 meters	1.67E-03 sec/m ³
175 meters	5.75E-04 sec/m ³

5B.4.5 Calculation of Ambient Concentrations of Hydrogen Peroxide and Nitric Acid

The airborne chemical concentrations resulting from the release of the hydrogen peroxide and nitric acid solutions were calculated using the following equation (Kim and Waltz 1990):

$$C = E \times (\chi/Q)$$

where

- C = ambient air concentration (mg/m³),
- E = effective source emission rate (mg/sec),
- χ/Q = atmospheric dispersion factor (sec/m³).

The ambient chemical concentrations are listed in Table 5B-2. These concentrations were compared to their respective Emergency Response Planning Guideline (ERPG) or equivalent values. The associated ERPG values for each chemical are listed in Table 5B-3. Tables 5B-4, 5B-5, and 5B-6 show the results of the comparison. The chemical criteria used to determine the hazard classifications are listed in Tables 5-1 and 5-2 of this chapter.

5B.5 Results

As shown in Tables 5B-4, 5B-5, and 5B-6, a maximum inventory of 36,000 pounds of 15M nitric solution and 16,600 gallons of a 50 wt% hydrogen peroxide solution results in the MWM Facility remaining Low Hazard.

5B.6 References

- Environmental Protection Agency (1987), *Hazardous Waste Treatment, Storage And Disposal Facilities (TSDF) - Air Emission Models*, U.S. Environmental Protection Agency, Washington, DC, EPA-450/3-87-026, December 1987.
- Federal Emergency Management Agency (1990), *Handbook of Chemical Hazard Analysis Procedures*, Federal Emergency Management Agency, Washington, DC, 1990.
- Kim, K.S., and W.R. Waltz (1990), *Interim Hazards Classification Guide for Non-Reactor Facilities at Savannah River Site*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, July 1990.
- National Safety Council (1991), *Areal Locations of Hazardous Atmospheres, Version 5.1*, National Safety Council, Washington, DC, September 1991.
- Perry, R.H., D.W. Green, and J.O. Maloney (eds.) (1984), *Perry's Chemical Engineers' Handbook*, Fifth Edition, McGraw Hill Book Co., New York, NY, 1984.
- Weast, R.C. (1991), *CRC Handbook of Chemistry and Physics*, 72ND Edition, CRC Press, Inc., Boca Raton, FL, 1991-1992.

Table 5B-1. EPA Dump Model Release Rate Calculations

Chemical	Component Density (kg/L)	Pool Area (cm ²)	Pool Diameter (cm)	MWl (g/gmole)	Vapor pressure (mm Hg)	X _i	Y _i *	Diffusivity (cm ² /sec)	F _v	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)
Nitric Acid (67%)	1.40E+00 ^a	1.17E+07	3.85E+03	6.30E+01	5.48E+00 ^a	1.00E+00	7.21E-03	2.06E-01	9.95E-01	1.39E-01	3.38E+02	4.69E+01
Hydrogen Peroxide (50%)	1.20E+00 ^a	6.28E+07	8.94E+03	3.40E+01	6.05E+00 ^b	3.46E-01	2.76E-03	3.07E-01	9.98E-01	6.64E-02	6.28E+02	4.17E+01

^a Perry et al. 1984

^b Weast 1991

Table 5B-2. Airborne Concentrations for Hydrogen Peroxide and Nitric Acid at Various Distances

Chemical	Local (30 m) Concentration (ppm)	On-Site (100 m) Concentration (ppm)	Off-Site (175 m) Concentration (ppm)
Hydrogen Peroxide	4.91E+02	4.94E+01	1.70E+01
Nitric Acid	2.97E+02	2.99E+01	1.03E+01

Table 5B-3. Hydrogen Peroxide and Nitric Acid Associated ERPG Values

Chemical	ERPG-1 (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)
Hydrogen Peroxide	3.00E+00	2.50E+01	5.00E+01
Nitric Acid	2.00E+00	1.50E+01	3.00E+01

Table 5B-4. On-Site Evaluation of Chemical Analysis

Chemical	On-Site (100 m) Concentration (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)	Hazard Classification
Hydrogen Peroxide	4.94E+01	2.50E+01	5.00E+01	Low Hazard
Nitric Acid	2.99E+01	1.50E+01	3.00E+01	Low Hazard

Table 5B-5. Off-Site Evaluation of Chemical Analysis

Chemical	Off-Site (175 m) Concentration (ppm)	ERPG-1 (ppm)	ERPG-2 (ppm)	Hazard Classification
Hydrogen Peroxide	1.70E+01	3.00E+00	2.50E+01	Low Hazard
Nitric Acid	1.03E+01	2.00E+00	1.50E+01	Low Hazard

Table 5B-6. ERPG-3 Evaluation of Chemical Analysis

Chemical	Local (30 m) Concentration (ppm)	On-Site (100 m) Concentration (ppm)	ERPG-3 (ppm)	Hazard Classification
Hydrogen Peroxide	4.91E+02	4.94E+01	5.00E+01	Low Hazard
Nitric Acid	2.97E+02	2.99E+01	3.00E+01	Low Hazard

APPENDIX 5C
CALCULATION OF RADIONUCLIDE INVENTORY

5C.1 Introduction

The radionuclide inventory for the Mixed Waste Management (MWM) Facility was prepared using the Lawrence Livermore National Laboratory (LLNL) waste stream data from the MWM Facility Waste Stream Characterization Results (LLNL 1993). The waste streams used in the compilation of data include trimsol waste, chlorinated solvent waste, oils waste, plating solution waste, solvents waste, combustible solids waste, sludges, and scintillation cocktails. For these waste streams, data on the mean concentration of radionuclides, mean volume of container, and number of containers are provided in the MWM Facility Waste Stream Characterization Results. The calculation method for determining the amount of radionuclides is discussed in Section 5C.2. The calculations are performed in Section 5C.3 and the results are reported in Section 5C.4.

5B.2 Methodology

The amount of radionuclide in each waste stream is calculated using the information provided in the Waste Stream Characterization Results (LLNL 1993). The information used in the calculation include:

- number of containers
- mean volume of container (gal)
- concentration of radionuclide ($\mu\text{Ci}/\text{mL}$)
- density (g/cc)
- mean waste mass in container (lbs)

The following formulas were used in the calculation of the radionuclide inventory in each waste stream:

Case 1: When the mean volume of a waste container is given

Amount of radionuclide in a waste stream (C_i) =

number of containers x mean volume of container (gal) x 3.785 L/gal x
concentration of radionuclide ($\mu\text{Ci}/\text{mL}$) x $C_i/10^6 \mu\text{Ci} \times 10^3 \text{ mL/L}$

Case 2: When the mean waste mass of a container and the density of the waste are given:

Amount of radionuclide in a waste stream (C_i) =

number of containers x mean mass of container (lb) x 453.6 g/lb x
concentration of radionuclide ($\mu\text{Ci}/\text{mL}$) x $C_i/10^6 \mu\text{Ci} / \text{density (g/cc)}$

5C.3 Calculation

The calculation was performed using the Microsoft EXCEL spread sheet. The formulas used to compute the value within each cell of the spread sheet are given below:

Trimsol

H-3 = C3 = $8.15\text{E-}05 = 0.0000212 \times 34 \times 50.55 \times 0.001 + 4.094 \times 11 \times 0.000001$
Sr-90 = C6 = $4.58\text{E-}07 = 0.04167 \times 11 \times 0.000001$
Th-228 = C18 = $2.00\text{E-}08 = 0.02 \times 1 \times 0.000001$
U-235 = C20 = $1.59\text{E-}07 = 0.046 \times 2 \times 0.000001 + 0.00000035 \times 50.55 \times 3.785 \times 0.001$
U-238 = C21 = $5.07\text{E-}04 = 0.203 \times 49 \times 50.55 \times 0.000001 + 0.0000075 \times 3 \times 50.55 \times 3.785 \times 0.001$
K-40 = C28 = $1.13\text{E-}05 = 0.215 \times 51 \times 0.000001 + 0.0000018 \times 50.55 \times 3.785 \times 0.001$

Chlorinated Solvent Waste

H-3 = D2 = $7.11\text{E-}06 = 0.0000123 \times 6 \times 25.46 \times 3.785 \times 0.001$
C-14 = D3 = $3.78\text{E-}05 = 0.000098 \times 4 \times 25.46 \times 3.785 \times 0.001$
Sr-90 = D6 = $3.10\text{E-}08 = 0.000000161 \times 2 \times 25.46 \times 3.785 \times 0.001$
U-238 = D21 = $1.66\text{E-}06 = 0.00000191 \times 9 \times 25.46 \times 3.785 \times 0.001$
K-40 = D28 = $1.30\text{E-}06 = 0.00000225 \times 6 \times 25.46 \times 3.285 \times 0.001$
Re-183 = D53 = $278\text{E-}08 = 0.0000002883 \times 25.46 \times 3.785 \times 0.001$
Re-184 = D54 = $2.78\text{E-}08 = 0.0000002883 \times 25.46 \times 3.785 \times 0.001$

Oils Waste

H-3 = E2 = $4.03\text{E-}03 = 0.0066 \times 17 \times 9.494 \times 3.785 \times 0.001$
Ba-133 = E12 = $3.99\text{E-}08 = 0.00000111 \times 9.494 \times 3.785 \times 0.001$
Cs-137 = E13 = $4.02\text{E-}09 = 0.000000112 \times 9.494 \times 3.785 \times 0.001$
U-235 = E20 = $4.74\text{E-}08 = 0.00000066 \times 2 \times 9.494 \times 3.785 \times 0.001$
U-238 = E21 = $1.03\text{E-}07 = 0.000000476 \times 6 \times 9.494 \times 3.785 \times 0.001$
K-40 = E28 = $4.38\text{E-}09 = 0.000000122 \times 9.494 \times 3.785 \times 0.001$
Nd-147 = E29 = $3.99\text{E-}08 = 0.00000111 \times 9.494 \times 3.785 \times 0.001$
Pm-144 = E30 = $3.99\text{E-}08 = 0.00000111 \times 9.494 \times 3.785 \times 0.001$

Plating Solutions Waste

H-3 = F2 = $3.24\text{E-}06 = 0.0000055 \times 155.6 \times 3.785 \times 0.001$
Sr-90 = F6 = $1.55\text{E-}08 = 0.0000000264 \times 155.6 \times 3.785 \times 0.001$
U-238 = F21 = $1.36\text{E-}06 = 0.000000769 \times 3 \times 155.6 \times 3.785 \times 0.001$

Solvents Waste

H-3 = G2 = $2.46\text{E-}05 = 0.00136 \times 2 \times 2.394 \times 3.785 \times 0.001$
C-14 = G3 = $1.75\text{E-}04 = 0.00242 \times 8 \times 2.394 \times 3.785 \times 0.001$
Co-60 = G4 = $1.18\text{E-}09 = 0.00000013 \times 2.394 \times 3.785 \times 0.001$
MFP = G5 = $9.06\text{E-}04 = 0.1 \times 2.394 \times 3.785 \times 0.001$
Sr-90 = G6 = $1.45\text{E-}15 = 1.6\text{E-}13 \times 2.394 \times 3.785 \times 0.001$

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Th-228 = G18 = 3.08E-09 = 0.00000034*2.394*3.785*0.001
U-235 = G20 = 1.11E-07 = 0.0000061*2*2.394*3.785*0.001
U-238 = G21 = 1.61E-13 = 1.78E-11*2.394*3.765*0.001
K-40 = G28 = 5.74E-07 = 0.0000634*2.394*3.785*0.001
Au-195 = G31 = 9.06E-04 = 0.1*2.394*3.785*0.001
Mn-54 = G32 = 2.36E-09 = 0.00000026*2.394*3.785*0.001

Combustible Solids Waste

Eu-152 = H17 = 2.99E-08 = 0.000000219*301.2*453.6*0.000001
Th-232 = H19 = 6.61E-10 = 4.84E-09*301.2*453.6*0.000001
U-238 = H21 = 4.96E-02 = 0.0242*15*301.2*453.6*0.000001
Pu-242 = H23 = 2.54E-09 = 9.28E-09*2*301.2*453.6*0.000001
Am-243 = H25 = 2.01E-09 = 1.47E-08*301.2*453.6*0.000001
Cm-244 = H26 = 2.40E-06 = 0.0000176*301.2*453.6*0.000001
Cf-249 = H27 = 9.02E-06 = 0.000066*301.2*453.6*0.000001
S-35 = H33 = 2.50E-03 = 0.0183*301.2*453.6*0.000001

Sludges

H-3 = I2 = 3.64E-03 = 0.00059*499*453.6*0.000001/1.43+0.00224*7*499*453.6*0.000001
Co-60 = I4 = 3.98E-05 = 3.2E-08*499*453.6*0.000001/1.43+0.000176*499*453.6*0.000001
Sr-90 = I6 = 2.20E-06 = 0.0000097*499*453.6*0.000001
Nb-95 = I7 = 3.28E-04 = 0.000027*499*453.6*0.000001/1.43+0.00143*499*453.6*0.000001
Zr-95 = I8 = 1.52E-04 = 0.000012*499*453.6*0.000001/1.43+0.000661*499*453.6*0.000001
Cs-137 = I13 = 3.46E-05 = 0.0000764*2*499*453.6*0.000001
Ce-141 = I14 = 4.03E-06 = 3.2E-07*499*453.6*0.000001/1.43+0.0000176*499*453.6*0.000001
Ce-144 = I15 = 6.47E-04 = 0.0000334*3*499*453.6*0.000001/1.43+0.00279*499*453.6*0.000001
Eu-152 = I17 = 9.45E-06 = 0.00000076*499*453.6*0.000001/1.43+0.0000412*499*453.6*0.000001
U-235 = I20 = 7.33E-05 = 9.78E-05*3*499*453.6*0.000001/1.43+3.95E-05*3*499*453.6*0.000001
U-238 = I21 = 1.36E-03 = 0.0043*2*499*453.6*0.000001/1.43
Pu-239 = I22 = 4.98E-06 = 0.000022*3*499*453.6*0.000001
Am-241 = I24 = 8.94E-06 = 5.82E-06*3*499*453.6*0.000001/1.43+6.82E-06*4*499*453.6*0.000001
K-40 = I28 = 8.94E-06 = 0.00000564*7*499*453.6*0.000001
Mn-54 = I32 = 6.40E-05 = 0.0000053*499*453.6*0.000001/1.43+0.000279*499*453.6*0.000001
Be-7 = I34 = 3.71E-06 = 0.0000003*499*453.6*0.000001/1.43+0.0000162*499*453.6*0.000001
Bi-205 = I35 = 3.30E-07 = 6.8E-07*2*499*453.6*0.000001/1.43+2.53E-07*2*499*453.6*0.000001
Cd-109 = I36 = 4.75E-05 = 9.7E-05*2*499*453.6*0.000001/1.43+3.7E-05*2*499*453.6*0.000001
Co-57 = I37 = 4.03E-06 = 3.1E-07*499*453.6*0.000001/1.43+1.76E-05*499*453.6*0.000001
Co-58 = I38 = 4.04E-07 = 3.4E-08*499*453.6*0.000001/1.43+1.76E-06*499*453.6*0.000001
Cs-134 = I39 = 3.71E-06 = 2.9E-07*499*453.6*0.000001/1.43+1.62E-05*499*453.6*0.000001
Eu-154 = I40 = 1.31E-05 = 1.1E-06*499*453.6*0.000001/1.43+5.73E-05*499*453.6*0.000001
Eu-155 = I41 = 1.11E-05 = 8.31E-06*3*499*453.6*0.000001/1.43+1.05E-05*3*499*453.6*0.000001
Hg-203 = I42 = 9.76E-08 = 2.0E-07*2*499*453.6*0.000001/1.43+7.58E-08*2*499*453.6*0.000001
Np-239 = I43 = 1.62E-05 = 1.3E-06*499*453.6*0.000001/1.43+7.05E-05*499*453.6*0.000001
Pt-195m = I44 = 1.47E-05 = 3.0E-05*2*499*453.6*0.000001/1.43+1.15E-05*2*499*453.6*0.000001
Rh-102m = I45 = 6.07E-07 = 4.8E-08*499*453.6*0.000001/1.43+2.65E-06*499*453.6*0.000001
Sb-120m = I46 = 1.89E-07 = 1.5E-08*499*453.6*0.000001/1.43+8.23E-07*499*453.6*0.000001
Sb-125 = I47 = 3.03E-05 = 2.5E-06*499*453.6*0.000001/1.43+1.32E-04*499*453.6*0.000001
Sc-46 = I48 = 1.21E-06 = 9.7E-08*499*453.6*0.000001/1.43+5.29E-06*499*453.6*0.000001
Ta-182 = I49 = 2.40E-06 = 1.7E-06*499*453.6*0.000001/1.43+9.41E-06*499*453.6*0.000001
Tm-168 = I50 = 5.04E-07 = 4.0E-08*499*453.6*0.000001/1.43+2.2E-06*499*453.6*0.000001

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W-188 = I51 = $7.81\text{E-}04 = 1.6\text{E-}03 \times 2 \times 499 \times 453.6 \times 0.000001 / 1.43 + 6.06\text{E-}04 \times 2 \times 499 \times 453.6 \times 0.000001$
Y-88 = I52 = $4.03\text{E-}07 = 3.2\text{E-}08 \times 499 \times 453.6 \times 0.000001 / 1.43 + 1.76\text{E-}06 \times 499 \times 453.6 \times 0.000001$

Scintillation Cocktails

H-3 = J2 = $1.53\text{E-}02 = 0.03609 \times 85 \times 4.99 \times 0.001$
C-14 = J3 = $3.18\text{E-}04 = 0.000862 \times 74 \times 4.99 \times 0.001$
Nb-95 = J7 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Zr-95 = J8 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Rh-106 = J9 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Ru-106 = J10 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Cs-137 = J13 = $1.62\text{E-}05 = 0.000649 \times 5 \times 4.99 \times 0.001$
Ce-141 = J14 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Ce-144 = J15 = $1.34\text{E-}05 = 0.000448 \times 6 \times 4.99 \times 0.001$
Th-228 = J18 = $6.49\text{E-}10 = 0.00000013 \times 4.99 \times 0.001$
U-238 = J21 = $1.95\text{E-}09 = 0.00000013 \times 3 \times 4.99 \times 0.01$
Pu-239 = J22 = $1.62\text{E-}05 = 0.000649 \times 5 \times 4.99 \times 0.001$
Am-241 = J24 = $2.45\text{E-}04 = 0.00614 \times 8 \times 4.99 \times 0.001$
K-40 = J28 = $1.56\text{E-}03 = 0.1042 \times 3 \times 4.99 \times 0.001$

5C.4 Results

The results of the calculations are shown in Table 5C-1. The total inventory of radionuclides for Fiscal Year (FY) 1991 was obtained by adding the radionuclides in eight waste streams, namely, trimsol, chlorinated solvent, oils waste, plating solutions, solvents, combustible solids waste, sludges, and scintillation cocktails.

5C.5 References

Lawrence Livermore National Laboratory (1993), *MWMF Waste Stream Characterization Results*, Lawrence Livermore National Laboratory, Livermore, CA, March 1993.

Table 5C-1. Calculation Results

Radionuclide	One Year (FY1991) Inventory (Ci)	Trimsol (Ci)	Chlorinated Solvent Waste (Ci)	Oils Waste (Ci)	Plating Solutions Waste (Ci)	Solvents Waste (Ci)	Combustible Solids Waste (Ci)	Sludges (Ci)	Scintillation Cocktails (Ci)
H-3	2.31E-02	8.15E-05	7.11E-06	4.03E-03	3.24E-06	2.46E-05		3.64E-03	1.53E-02
C-14	5.32E-04		3.78E-05			1.75E-04			3.18E-04
Co-60	3.98E-05					1.18E-09		3.98E-05	
MFP	9.06E-04					9.06E-04			
Sr-90	2.70E-06	4.58E-07	3.10E-08		1.55E-08	1.45E-15		2.20E-06	
Nb-95	3.41E-04							3.28E-04	1.34E-05
Zr-95	1.65E-04							1.52E-04	1.34E-05
Rh-106	1.34E-05								1.34E-05
Ru-106	1.34E-05								1.34E-05
Ba-133	3.99E-08			3.99E-08					
Cs-137	5.08E-05			4.02E-09				3.46E-05	1.62E-05
Ce-141	1.74E-05							4.03E-06	1.34E-05
Ce-144	6.61E-04							6.47E-04	1.34E-05
Eu-152	9.48E-06						2.99E-08	9.45E-06	
Th-228	2.37E-08	2.00E-08				3.08E-09			6.49E-10
Th-232	6.61E-10						6.61E-10		
U-235	7.36E-05	1.59E-07		4.74E-08		1.11E-07		7.33E-05	
U-238	5.15E-02	5.07E-04	1.66E-06	1.03E-07	1.36E-06	1.61E-13	4.96E-02	1.36E-03	1.95E-09
Pu-239	2.12E-05							4.98E-06	1.62E-05
Pu-242	2.54E-09						2.54E-09		
Am-241	2.54E-04							8.94E-06	2.45E-04
Am-243	2.01E-09						2.01E-09		
Cm-244	2.40E-06						2.40E-06		
Cf-249	9.02E-06						9.02E-06		
K-40	1.58E-03	1.13E-05	1.30E-06	4.38E-09		5.74E-07		8.94E-06	1.56E-03
Nd-147	3.99E-08			3.99E-08					
Pm-144	3.99E-08			3.99E-08					
Au-195	9.06E-04					9.06E-04			

Table 5C-1. Calculation Results

Radionuclide	One Year (FY1991) Inventory (Ci)	Trimsol (Ci)	Chlorinated Solvent Waste (Ci)	Oils Waste (Ci)	Plating Solutions Waste (Ci)	Solvents Waste (Ci)	Combustible Solids Waste (Ci)	Sludges (Ci)	Scintillation Cocktails (Ci)
Mn-54	6.40E-05					2.36E-09		6.40E-05	
S-35	2.50E-03						2.50E-03		
Be-7	3.71E-06							3.71E-06	
Bi-205	3.30E-07							3.30E-07	
Cd-109	4.75E-05							4.75E-05	
Co-57	4.03E-06							4.03E-06	
Co-58	4.04E-07							4.04E-07	
Cs-134	3.71E-06							3.71E-06	
Eu-154	1.31E-05							1.31E-05	
Eu-155	1.11E-05							1.11E-05	
Hg-203	9.76E-08							9.76E-08	
Np-239	1.62E-05							1.62E-05	
Pt-195m	1.47E-05							1.47E-05	
Rh-102m	6.07E-07							6.07E-07	
Sb-120m	1.89E-07							1.89E-07	
Sb-125	3.03E-05							3.03E-05	
Sc-46	1.21E-06							1.21E-06	
Ta-182	2.40E-06							2.40E-06	
Tm-168	5.04E-07							5.04E-07	
W-188	7.81E-04							7.81E-04	
Y-88	4.03E-07							4.03E-07	
Re-183	2.78E-08		2.78E-08						
Re-184	2.78E-08		2.78E-08						

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Preliminary Safety Analysis Report**

Chapter 6

Principal Health and Safety Criteria

September 1994

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Chapter 6. Principal Health and Safety Criteria

This chapter discusses safety (design) criteria for systems, components, equipment, and processes for the Mixed Waste Management (MWM) Facility through reference to published codes and standards and general design criteria from DOE Order 6430.1A (DOE 1989). Many criteria are dependent upon the category classification of the applicable facility and the safety classification of components, systems, and structures that comprise the facility. The usage category for the MWM Facility, as demonstrated in Chapter 5 of this Preliminary Safety Analysis Report (PSAR), is Radiological for the radionuclide inventory and Low Hazard for the reagent and chemical inventory. Table 6-1 provides a cross reference to other information sources based on facility categorization. The design criteria for the MWM Facility are obtained from DOE Order 6430.1A.

Based on the Low Hazard classification and in accordance with the criteria of DOE Order 6430.1A, the design criteria considered for the MWM Facility are those for nonsafety class systems and exclude design criteria for engineered safety feature systems. Additionally, since the MWM Facility is not required to prevent or mitigate the consequences of an uncontrolled release of radioactive material or to prevent an inadvertent criticality during or following a seismic event, the systems in the MWM Facility are designed in accordance with the Low Hazard Category requirements of DOE Order 6430.1A and UCRL-15910 (Kennedy et al. 1990).

To quantify the effectiveness of the design criteria with respect to natural phenomena hazards (i.e., floods, earthquakes, or high winds), UCRL-15910 defines overall performance goals.

6.1 Structural and Mechanical Safety Criteria

6.1.1 Wind Loadings

DOE Order 6430.1A (DOE 1989) states that wind load design criteria for Low Hazard facilities are determined by using procedures in American National Standards Institute (ANSI) A58.1 (ANSI 1982) with the basic wind speed obtained from UCRL-15910 (Kennedy et al. 1990). The design criteria should be sufficiently conservative to prevent failure from winds with a 2E-02 annual probability of occurrence. The recommended basic wind speed corresponding to this probability of occurrence is 72 mph at a height above ground of 10 meters (Kennedy et al. 1990). Structural design wind loadings shall be based on this wind speed.

The facility's main wind-force resisting structural systems should not collapse at design wind speeds. Complete integrity of the building envelope is not required because no significant quantities of toxic or radioactive materials are present. However, breach of the building envelope may not be acceptable if wind or water interferes with the facility function. If a loss of facility function is caused by water damage to sensitive equipment, collapsed interior partitions, or excessive damage to Heating, Ventilation and Air Conditioning (HVAC) ducts and equipment, then loss of cladding and missile perforation at the design wind speeds must be prevented (Kennedy et al. 1990). Section 3.2 of UCRL-15910 discusses the effects of missiles that are to be considered in the design of DOE facilities.

6.1.2 Tornado Loadings

Nonsafety class systems and structures that are exposed to the environment should be designed to withstand loadings resulting from tornadoes if, as determined from site-specific studies, the tornadoes are a viable threat to the site (Brynda et al. 1986). In accordance with UCRL-15910 (Kennedy et al. 1990), if the exceedance probability of the transition wind (wind-tornado) speed is less than $1\text{E-}05/\text{yr}$, straight winds are more likely and tornadoes are not a viable threat. At Lawrence Livermore National Laboratory (LLNL), the transition wind speed has an exceedance probability of less than $1\text{E-}06/\text{yr}$ (Kennedy et al. 1990), and the limiting wind speed is expected to result from extreme winds. Therefore, in accordance with UCRL-15910, Low Hazard facilities at LLNL do not have to be designed for tornadoes.

6.1.3 Water Level (Flood) Design

According to Section 0111-99.0.3 of DOE Order 6430.1A (DOE 1989), the design loads from flooding shall comply with UCRL-15910 (Kennedy et al. 1990). In calculating design loads from flooding, a conservative approach shall be taken to ensure that the loads used in the design are as follows:

- Greater than the maximum historic levels recorded for the site
- No less than the Probable Maximum Flood (PMF).

If a facility is above the Design Basis Flood (DBF) level, there is no requirement to include design loads from flooding. However, it is not always possible to provide margin in the flood design of a facility (Kennedy et al. 1990). For example, the fact that a site is inundated (even if structural damage does not occur) may cause significant disruption (e.g., downtime during the flood, cleanup). This may be an unacceptable risk in terms of the economic impact and disruption of the mission-dependent function of the site. In this case, there is no

margin, as used in the structural sense, that can be provided in the facility design. Therefore, the facility must be kept dry and operations must not be interrupted. As a result, the annual probability of the DBFI corresponds to the performance goal probability of damage, since any exceedance of the DBFI results in consequences that are unacceptable. For Low Hazard facilities such as the MWM Facility, the DBFI is equal to the flood whose probability of exceedance is $5E-04/\text{yr}$ plus the event combinations listed in Table 6-2 of UCRL-15910.

While a probabilistic flood hazard evaluation has been performed for Sandia National Laboratories (SNL), Livermore, one has not been performed for LLNL (Savy and Murray 1988). SNL, Livermore adjoins LLNL to the south and, according to the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992), both sites are subject to the same types of flooding, local precipitation, and arroyo overflow. The mean elevation of flooding at SNL, Livermore, corresponding to a probability of exceedance of $5E-04/\text{yr}$, is 643 feet National Geodetic Vertical Datum (NGVD).

According to UCRL-15910, facilities that are subject to flood loads should be designed according to provisions in DOE Order 6430.1A (DOE 1989) or governing local regulations (i.e., Uniform Building Code [UBC]). Design loads and load combinations are determined from the DBFI elevation. Load factors specified in DOE Order 6430.1A, ANSI A58.1 (ANSI 1982), or governing local regulations shall be used. For facilities located below the DBFI, an acceptable design can be achieved by performing the following (Kennedy et al. 1990):

- Providing flood protection for the site or the specific structure such that severe structural damage does not occur.
- Developing emergency procedures to mitigate the damage to mission-dependent components and systems and to provide adequate warning and evacuation capacity to provide safety for building occupants. These procedures must address installation of temporary flood barriers, removal of equipment to protected areas, anchoring of vulnerable items, or installation of sumps or emergency pumps.

For structures located below the DBFI elevation, mitigation measures can be designed that provide an acceptable margin of safety. In practice, a combination of structural and nonstructural measures (i.e., flood warning and emergency operation plans) is used. The flood design practice for these facilities is discussed in Section 6.4 of UCRL-15910.

6.1.4 Missile and Blast Protection

According to Section 3.5 of DOE/TIC-11603 (Brynda et al. 1986), nonsafety class structures, systems, and components do not require missile and blast protection above that afforded by the UBC and/or normal industrial standards.

6.1.5 Seismic Design

The MWM Facility is not required to prevent or mitigate the consequences of an uncontrolled release of radioactive material or to prevent an inadvertent criticality during or following a seismic event. Therefore, according to UCRL-15910 (Kennedy et al. 1990), the systems in the MWM Facility are designated Nonseismic Category I (versus Seismic Category I) and may be designed to normal industrial standards. Specifically, Nonseismic Category I systems and structures should be designed to withstand loadings resulting from earthquakes as determined from site-specific studies, the UBC (UBC 1988), ANSI A58.1 (ANSI 1982), or other appropriate earthquake data. Section 0111-2.7 of DOE Order 6430.1A (DOE 1989) invokes site-specific study UCRL-53582 (Coats and Murray 1984) for deriving basic seismic parameters and UCRL-15910 (Kennedy et al. 1990) for guidance on relating frequency of occurrence to facility hazard levels and earthquake load design for buildings and other structures. Earthquake load design for the MWM Facility is determined by using procedures in the UBC and UCRL-15910 and LLNL seismic safety committee recommendations.

Design or evaluation of Low Hazard facilities for earthquake hazards is based on normal building code seismic provisions (Kennedy et al. 1990). UCRL-15910 follows the 1988 edition of the UBC. All 1988 UBC provisions shall be followed for Low Hazard facilities with modifications as described in UCRL-15910. It should be noted that UCRL-15910 specifies that seismic loads should either be based on the UBC 1988 provisions or be derived from site-specific ground motion parameters, if available.

In the 1988 UBC provisions, the lateral force representing the earthquake loading on buildings is expressed in terms of the total base shear, V , given by the following equation:

$$V = ZICW/R_w$$

where

Z = a seismic zone factor equivalent to peak ground acceleration,

I = a factor accounting for the importance of the facility,

C = a spectral amplification factor,

W = the total weight of the facility,

R_w = a reduction factor to account for the energy absorption capability of the facility (1988 UBC values are shown in Table 4-2 of UCRL-15910).

For Low Hazard facilities, it is recommended that the 1988 UBC provisions be followed, with the exception that Z be evaluated from the hazard curves in UCRL-53582 or from updated site-specific geotechnical studies and that C be the amplification factor from 5 percent damped median response spectra. It is recommended that both new and existing facilities be evaluated for their adequacy to withstand earthquakes by the step-by-step procedure presented in Table 4-3 of UCRL-15910. If the response spectra and the resulting seismic loads are less than those determined by the UBC, the UBC loads should be used for design and evaluation.

Applying UCRL-15910, the specified probability of exceedance at which maximum ground accelerations are determined from seismic hazard curves is 1E-03/yr for Low Hazard facilities. Based upon this probability and the criteria specified in UCRL-JC-107649 (LLNL 1991), the maximum ground acceleration for the MWM Facility is 0.57g.

6.1.6 Snow and Rain-On-Snow Loadings

According to Section 0111-2.3.2 of DOE Order 6430.1A (DOE 1989), live loads on roofs shall be as stipulated in Sections 7 and 8 of ANSI A58.1 (ANSI 1982). The loads shall include the minimum roof live load, the snow loads and snow drifts, or possible rain loads stipulated therein, whichever produces the more severe effect.

According to Section 4.7.2 of the EIS/EIR (DOE and UC 1992), the average annual precipitation for the Livermore Valley region is 14.9 inches. The highest monthly precipitation recorded during the period 1980 to 1990 was 6.3 inches during January 1983. The annual snowfall in the Livermore and Tri-Valley area is minimal and therefore is not recorded. Consequently, rain loads should produce the most severe effect.

6.1.7 Process and Equipment Derived Loads

Design criteria for structures supporting process and equipment derived loads are addressed in Section 0111-2 of DOE Order 6430.1A (DOE 1989).

6.1.8 Combined Load Criteria

According to Section 0111-2 of DOE Order 6430.1A (DOE 1989), the combination of loads, allowable stresses, and strength requirements for buildings shall be as stipulated in the UBC (UBC 1988). Structural members shall be designed to resist the appropriate load combinations provided in UCRL-15910 (Kennedy et al. 1990).

6.1.9 Subsurface Hydrostatic Loadings

According to Section 0111-2 of DOE Order 6430.1A (DOE 1989), every foundation wall or other wall serving as a retaining structure shall be designed to resist, in addition to the vertical loads acting on it, the incidental lateral earth pressures and surcharges, plus hydrostatic pressures corresponding to the maximum probable groundwater level.

Section 4.11.2 of the EIS/EIR (DOE and UC 1992) states that depth to groundwater at the LLNL site varies from about 110 feet in the southeast corner to 30 feet in the northeast corner (the MWM Facility is located in the northeast quadrant of the site). The water table surface as of June 1991 is shown in Figure 4.11-6 of the EIS/EIR.

6.2 Safety Protection Systems

6.2.1 General

Chapter 5 of this PSAR indicates that the MWM Facility is classified as being less than a Hazard Category 3 (Radiological) facility in which no safety protection system is required to (1) prevent or mitigate the release of radioactive material, (2) prevent an inadvertent criticality, or (3) prevent dose exposure consequences in excess of those delineated by Section 1.2.3 of DOE/TIC-11603 (Brynda et al. 1986). There are no items in the MWM Facility that require special consideration in the design of safety protection systems because of site selection, process selection, or safe shutdown requirements.

6.2.2 Protection by Primary/Secondary Confinement Barriers

While not required, confinement features are employed at the MWM Facility to maintain dose and contamination As Low As Reasonably Achievable (ALARA). According to Section 1300-7 of DOE Order 6430.1A (DOE 1989), physical barriers should be provided to prevent an uncontrolled release of radioactive material to

the environment during normal operations or a Design Basis Accident (DBA) and to prevent or minimize the spread of contamination within the facility. Such physical barriers and their associated systems (e.g., ventilation and atmospheric cleanup) are referred to as confinement systems. Confinement system design is strongly influenced by many issues including the type of material confined, inventory of material confined, type of process within a confinement boundary, system interactions, and facility siting. Both solid and liquid wastes are handled by the MWM Facility and are classified as low-level mixed wastes. Section 1300-8 of DOE Order 6430.1A lists the documents that specify the requirements for identifying the type of waste handled.

Waste in a Low Hazard facility must be segregated by compatibility as required in Title 49 Code of Federal Regulations (CFR) Part 177.848 (CFR 1991a). Also, the waste must be inspected on a regular frequency in accordance with 40 CFR 264.174 (CFR 1991b).

6.2.2.1 Ventilation and Offgas Systems

Offgas treatment and ventilation systems are typically provided, as part of the radioactive waste management system, for removing radioactive material from a confinement atmosphere before exhausting it to the environment (Brynda et al. 1986). As previously noted, there is no requirement for the MWM Facility to have a confinement system. Therefore, there is no applicable design criteria from DOE/TIC-11603 or DOE Order 6430.1A (DOE 1989) for the MWM Facility to provide safety class offgas treatment and ventilation systems. However, as suggested in Section 6.2.2 of DOE/TIC-11603, some of the processes have an offgas ventilation system to control worker exposures, to maintain doses ALARA, and to minimize the spread of contamination.

Nonsafety class ventilation systems (i.e., those that are not essential for the confinement of airborne radioactive material or for offgas treatment and that are not otherwise required for ensuring the safety of off-site personnel) shall be designed in accordance with the general criteria of DOE Order 6430.1A.

6.2.2.2 Liquid Effluent System

According to Section 6.2 of DOE/TIC-11603 (Brynda et al. 1986), liquid waste treatment, storage, and solidification systems are provided, as part of the radioactive waste management system, to safely process a spectrum of liquid waste at a nuclear facility. The processes in the MWM Facility treat or combine liquid waste. These processes shall be built and operated in accordance with the requirements specified in Section 1323 of DOE Order 6430.1A (DOE 1989).

6.2.3 Protection by Equipment and Instrumentation Selection

6.2.3.1 Equipment

The following safety provisions will be incorporated into the design of the MWM Facility (systems and equipment) to protect both personnel and equipment:

- Radiation safety regulations
- Safety interlocks
- Emergency stop controls
- Electrical safety
- Physical personnel protection
- Seismic safety
- Warning devices
- Robotics operations.

General criteria for the design of these nonsafety class systems are found in DOE Order 6430.1A (DOE 1989) and DOE/TIC-11603 (Brynda et al. 1986).

6.2.3.2 Instrumentation

Instrumentation systems do not have a safety function, as defined by DOE/TIC-11603, unless they interface with a safety class system (Brynda et al. 1986). Since there are no safety class systems associated with the MWM Facility, the instrumentation need not meet safety class design criteria. However, the instrumentation is designed to satisfy the safety provisions listed in Section 6.2.3.1 of this chapter. The design criteria for nonsafety class instrumentation are specified in DOE Order 6430.1A (DOE 1989) and Section 5.1 of DOE/TIC-11603.

According to DOE/TIC-11603, nonsafety class instrumentation should be designed to facilitate periodic testing and calibration to ensure normal facility operation within the normal appropriate operating ranges. However, the instrumentation does not require seismic or environmental qualification in excess of that provided by designing it to normal industrial standards (Brynda et al. 1986).

6.2.4 Radiological Protection

Radiation protection design criteria are specified in Section 7.2 of DOE/TIC-11603 (Brynda et al. 1986), Section 1300-6 of DOE Order 6430.1A (DOE 1989), and DOE Order 5480.11 (DOE 1992c), which establishes radiation protection standards and program requirements to protect workers from ionizing radiation.

However, the waste in the MWM Facility is administratively controlled to preclude any uncontrolled release of radioactive material. Processes that have the potential to release radioactive material are required to be evaluated to determine if monitoring by a continuous air monitor and/or a portable radiation monitor to warn personnel of contamination or radiation is required.

6.2.4.1 Access Control

An appropriate entry control program shall be established for radiological areas (DOE 1992c). This program should include provisions for a buffer area prior to entry to a radiological area, where appropriate. The level of control should be consistent with the degree of hazard. Signs and barricades, control devices on entrances, conspicuous visual and/or audible alarms, locked entryways, and/or administrative procedures should be used as appropriate to ensure that personnel entry into radiological areas is controlled. Step-off pads and protective clothing shall be required for entry into contaminated areas.

A key is required to enter the MWM Facility, and the keys are only issued to personnel who need entry and who are appropriately trained. All visitors are required to log in and out and to be escorted by an authorized employee.

6.2.4.2 Shielding

According to Section 1300-6.2 of DOE Order 6430.1A (DOE 1989), the shielding design basis shall be to limit the maximum exposure to an individual worker to one-fifth of the annual occupational external exposure limits specified in DOE Order 5480.11 (DOE 1992c). Within this design basis, personnel exposures shall be maintained ALARA. Specifically, the shielding shall be designed with the objective of limiting extremity exposure to 10 rem/yr and the total Effective Dose Equivalent (EDE) to less than 1 rem/yr to workers, based on their predicted exposure time in the normally occupied area. Straight-line penetration of shield walls shall be avoided to prevent radiation streaming.

6.2.4.3 Radiation Alarm Systems

According to Section 1300-6 of DOE Order 6430.1A (DOE 1989), where ionizing radiation is present (due to process material, equipment, or operations), an area radiation monitoring and alarm system shall be provided to alert personnel of unexpected increases in ionizing radiation levels. The warning and alarm systems shall be designed, installed, and tested to ensure that they can be heard in the ambient conditions of the area they are intended to cover. Evacuation alarm systems should comply with ANSI N2.3 (DOE 1989).

According to Section 1300-6.5.3 of DOE Order 6430.1A, the use of devices to warn personnel of possible contamination or other hazardous materials shall be evaluated, and such devices shall be provided in accordance with this evaluation.

6.2.5 Fire and Explosion Protection

Explosive materials (e.g., those materials used in the fabrication of an explosive device) are not processed or stored in the MWM Facility; thus, explosion criteria are not applicable.

According to Section 0110-6 of DOE Order 6430.1A (DOE 1989), facilities shall comply with the following:

- DOE Order 5480.4 Attachment 2, Section 2.C (DOE 1993b)
- DOE Order 5480.7A (DOE 1993c)
- DOE Order 6430.1A, Section 1530.

Facilities shall comply with 29 CFR 1926 (CFR 1989) and 29 CFR 1910 (CFR 1992). Except where required by other sections of DOE Order 6430.1A, National Fire Protection Association (NFPA) 101 shall apply where 29 CFR 1926 and 29 CFR 1910 do not apply or where NFPA-101 exceeds the requirements of 29 CFR 1926 and 29 CFR 1910.

Definitions, fire resistance ratings, and types of construction shall be as defined in the UBC.

Fire protection design shall incorporate an "improved risk" level of fire protection as directed in DOE Order 5480.7A (DOE 1993c) and Section 0110-6 of DOE Order 6430.1A.

NFPA-13 specifies the requirements for the design and maintenance of wet-pipe sprinkler systems. NFPA-10 provides the requirements for the location and maintenance of various types of fire extinguishers used in facilities based on the types of waste handled.

6.2.6 Protection from Industrial Accidents

Industrial safety involves the detection, mitigation, management, and prevention of hazards in the workplace to protect against accidental death, injury, property damage, or interruption of production. DOE Order 5480.4 (DOE 1993b) lists the requirements that are applicable for occupational health protection and occupational safety to the design of the MWM Facility. The general guidelines for industrial accident prevention, which are invoked by DOE Order 5480.4, are

listed in 29 CFR 1910 (CFR 1992). These standards are enforced by the Occupational Safety and Health Administration (OSHA).

The MWM Facility shall be equipped with those interlocks and protective devices necessary to protect personnel from injury or death. Protective devices shall be designed to fail safe. The following are examples of hazards to be protected against:

- High voltage and other electrical hazards
- Pressurized gas or fluid hazards
- Noise hazards
- Moving equipment hazards
- Fire hazards
- Seismic-induced hazards
- Slip-trip-fall hazards
- Hazardous substances inherent in the MWM Facility equipment
- Thermal hazards
- UV exposure hazards
- Robotics hazards.

6.2.7 Protection from Hazardous Materials

According to Section 0110-7 of DOE Order 6430.1A (DOE 1989), the construction of all DOE facilities shall comply with the environmental protection and pollution control portions of the following DOE Orders:

- DOE Order 4700.1, *Project Management System*, Chapter V (DOE 1992b).
- DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards* (DOE 1993b).
- DOE Order 5480.1B, *Environment, Safety, and Health Program for Department of Energy Operations* (DOE 1993a).
- DOE Order 5440.1E, *National Environmental Policy Act Compliance Program* (DOE 1992a).

Radioactive and hazardous material waste management and hazardous material protection are described in Chapters 7 and 10, respectively, of this PSAR.

6.2.7.1 Access Control

For the MWM Facility, the DOE Orders listed in Section 6.2.7 do not invoke any access control criteria for protection from hazardous materials.

6.2.7.2 Alarm Systems

For the MWM Facility, the DOE Orders listed in Section 6.2.7 do not invoke any alarm system criteria for protection from hazardous materials.

6.2.8 Robotic Systems

For the MWM Facility, controls over robotic systems shall meet the requirements set forth in ANSI/RIA R15.06 (ANSI 1992) to guard against accident or injury due to automated operation of equipment.

6.3 References

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- Code of Federal Regulations (1991a), *Segregation and Separation Chart of Hazardous Materials*, 49 CFR 177.848, Office of the Federal Register, Washington, DC, July 1, 1991.
- Code of Federal Regulations (1991b), *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, 40 CFR 264.174, Office of the Federal Register, Washington, DC, July 1, 1991.
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- Department of Energy (1989), *General Design Criteria*, U.S. Department of Energy, Washington, DC, DOE Order 6430.1A, April 6, 1989.
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- Department of Energy (1993b), *Environmental Protection, Safety, and Health Protection Standards*, U.S. Department of Energy, Washington, DC, DOE Order 5480.4, Change 4, January 7, 1993.
- Department of Energy (1993c), *Fire Protection*, U.S. Department of Energy, Washington, DC, DOE Order 5480.7A, February 17, 1993.
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- Kennedy, R.P., S.A. Short, J.R. McDonald, M.W. McCann, R.C. Murray, and J.R. Hill (1990), *Design and Evaluation Guidelines for the Department of Energy Facilities Subjected to Natural Phenomena Hazards*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-15910, June 1990.
- Lawrence Livermore National Laboratory (1991), *Determination of Effective Acceleration for Use in Design at the LLNL Site*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-JC-107649, August 17, 1991.
- Savy, J.B., and R.C. Murray (1988), *Natural Phenomena Hazards Modeling Project: Flood Hazard Models for Department of Energy Sites*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-53851, May 1988.
- Uniform Building Code (1988), *Uniform Building Code*, 1988 Edition, International Conference of Building Officials, Whittier, CA, 1988.

Table 6-1. Comparison of Usage Categories

Source	Facility Categorization
UCRL-15910	Important or Low Hazard
1988 Uniform Building Code	Essential Facilities
DOD Tri-Service Manual for Seismic Design of Essential Buildings	None
IAEA-TECDOC-348, Nuclear Facilities with Limited Radioactive Inventory	Class C
DOE 5481.1B SAR System	Low Hazard
DOE 5480.23 SAR System	Hazard Category 3
NFPA 13	Ordinary Hazard (Group 1)
Nuclear Regulatory Commission	None

Source: Kennedy et al. 1990

**Mixed Waste Management Facility
Preliminary Safety Analysis Report**

Chapter 7

**Radioactive and Hazardous Material
Waste Management**

September 1994

Lawrence Livermore National Laboratory
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Chapter 7. Radioactive and Hazardous Material Waste Management

This chapter of the Preliminary Safety Analysis Report (PSAR) describes the management of radioactive, hazardous, and mixed wastes generated by the Mixed Waste Management (MWM) Facility to be located in Building 494 at Lawrence Livermore National Laboratory (LLNL).

For the purposes of this chapter, radioactive, hazardous, and mixed wastes are separated into three categories: facility-generated wastes, feed wastes, and product wastes.

Only facility-generated wastes are discussed in detail in this chapter. Facility-generated wastes are those wastes that result from routine and nonroutine MWM Facility operation and maintenance activities. These wastes include emissions of air pollutants and solid and liquid wastes containing radioactive and/or hazardous constituents. Air pollutants or air emissions as discussed in this chapter are not the same as gaseous waste. Gaseous waste is captured in cylinders and treated off site as hazardous, radioactive, or mixed waste. There are no plans to generate gaseous waste at the MWM Facility.

Feed and product wastes are considered in this chapter only as they relate to facility-generated wastes. A feed waste is any mixed waste received by the MWM Facility for use in demonstrating treatment technologies; feed wastes and chemical reagents used in the treatment demonstrations are the source for the mixed waste constituents in facility-generated wastes and product wastes. A product waste is a solid radioactive, hazardous, or mixed waste material that is a direct result of the MWM Facility final forms process. Feed and product wastes are primarily addressed in Chapter 4 of this PSAR.

7.1 Waste Management Programs

7.1.1 Philosophy and Objectives

7.1.1.1 General

Radioactive, hazardous, and mixed wastes generated at LLNL are managed under an extensive network of federal, state, and local laws and regulations and Department of Energy (DOE) Orders and requirements. The policy of LLNL is to comply with the letter and spirit of federal, state, and local requirements concerning environmental protection and waste management (LLNL 1990).

LLNL implements DOE's Environmental, Safety, and Health (ES&H) policies and programs through site policies and programs specified in the *Health & Safety Manual* (LLNL 1992a). Guidelines for safe disposal of waste are covered in the *Environmental Protection Handbook* (LLNL 1990).

Appendix B of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992) summarizes the applicable laws, regulations, and orders and provides an overview of the waste management practices at LLNL. In addition, Appendix B of the EIS/EIR presents the documents available at LLNL for providing guidance on waste management.

In the area of waste management, LLNL's primary objective is to minimize impacts to the public and the environment, keeping all impacts As Low As Reasonably Achievable (ALARA) below allowable limits. LLNL waste management operations are also conducted in a manner that minimizes the impact to workers (LLNL 1990).

The Hazards Control Department provides assistance to line managers for both radiological and nonradiological occupational safety. The Environmental Protection Department (EPD) is responsible for assisting the line managers in protecting the environment from operations at LLNL.

7.1.1.2 Requirements for Protection of the Public and the Environment

DOE Order 5440.1E (DOE 1992a) establishes the internal DOE responsibilities and procedures for implementing the National Environmental Policy Act (NEPA). DOE Order 5480.1B (DOE 1993a) establishes the Environment, Safety, and Health Program for DOE operations, with DOE Order 5400.1 (DOE 1990b) defining more specifically the environmental protection requirements. DOE Order 5480.4 (DOE 1993c) lists applicable environmental protection, safety, and health protection standards.

DOE Orders 5400.3 (DOE 1989b) and 5400.4 (DOE 1989a) implement the requirements of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), respectively. DOE Order 5400.5 (DOE 1993d) establishes the standards and requirements for DOE operations with respect to protection of the public and the environment against undue risk from radiation. DOE Order 5820.2A (DOE 1988) establishes policies, guidelines, and minimum requirements for ensuring that DOE manages its radioactive and mixed wastes in a manner that protects the health and safety of the public, the environment, and employees.

DOE Order 5400.2A (DOE 1993b) sets forth DOE policy, direction, and procedures for coordination of significant environmental compliance issues to ensure timely development and consistent application of DOE environmental policy and guidance. DOE Orders 5484.1 (DOE 1990a), 5482.1B (DOE 1991a), and 5700.6C (DOE 1991b) address associated reporting requirements, appraisal programs, and quality assurance, respectively.

7.1.1.3 Protection of Workers

DOE Order 5483.1A (DOE 1983) establishes the requirements and procedures to provide safety and health protection for DOE contractor employees at government-owned, contractor-operated facilities that is consistent with the protection afforded private industry employees by Occupational Safety and Health Administration (OSHA) standards. DOE Order 5480.10 (DOE 1985) establishes the requirements and guidelines applicable to DOE operations for maintaining an effective industrial hygiene program to preserve employee health and well-being. DOE Order 5480.11 (DOE 1992b) establishes DOE radiation protection standards and program requirements with respect to the protection of the worker from ionizing radiation.

7.1.2 Waste Management Processes

LLNL implements most DOE ES&H policies and programs through site policies and programs specified in the *Health & Safety Manual* (LLNL 1992a). The primary guidelines for the safe disposal of waste are covered in the *Environmental Protection Handbook* (LLNL 1990). Appendix B of the EIS/EIR (DOE and UC 1992) lists supporting documents that provide further guidance on managing radioactive, hazardous, and mixed wastes at LLNL.

Radioactive, hazardous, and mixed wastes are characterized by the generator to permit proper segregation, treatment, storage, and disposal. Acids, solvents, and other chemicals are segregated and stored in separate areas and disposed of in separate containers to prevent the mixture of incompatible chemicals that could cause violent or toxic reactions. The waste preparation portion of the *Environmental Protection Handbook* describes in detail the identification, separation, packaging, and transportation requirements for generators of hazardous chemicals and radioactive waste at LLNL. In general, all radioactive and hazardous wastes are placed only in containers approved by the Hazards Control Department and the Hazardous Waste Management (HWM) Division of the EPD (DOE and UC 1992). The types of containers in which the waste received at the MWM Facility will be stored are discussed in Chapter 4 of this PSAR.

A Facility Safety Procedure (FSP) will be developed for the MWM Facility to implement waste management processes specified in the *Health & Safety Manual*. Operational Safety Procedures (OSPs) will be written as required for special activities. FSPs and OSPs are discussed in more detail in Chapter 13 of this PSAR.

7.1.3 Waste Minimization Programs

DOE Order 5820.2A (DOE 1988) requires that facilities develop and implement waste minimization plans to ensure that the amount of waste generated at the facilities is minimized. The *Laser Programs Waste Minimization Plan* (LLNL 1992b) meets the requirements of this Order. This plan establishes policy and assigns responsibility for minimizing wastes generated from Laser Programs operations, including the MWM Facility. The plan also includes general guidance on waste minimization methods.

Appendix B of the EIS/EIR (DOE and UC 1992) describes the waste minimization policies and programs at LLNL.

7.2 Radioactive and Hazardous Air Pollutants

7.2.1 Identification

7.2.1.1 Sources

Radioactive and hazardous air pollutants result from normal operations at the MWM Facility. As discussed in Chapter 4 of this PSAR, the potential exists for a release of radioactive and hazardous gases during operations in the waste process areas (i.e., feed preparation, waste treatment, water treatment, analytical laboratory, and final forms packaging). Particularly, whenever waste containers are opened or waste is being packaged, a release of radioactive or hazardous gases could occur. In addition, the four primary treatment processes (WOX, UVP, MSO, and MEO) generate the following air pollutants: volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), and acid vapors.

The evaporation of spilled liquid waste and operating fluids (e.g., machine oil) is a secondary source of air emissions. The evaporation of small spills results in incidental amounts of air emissions. These vapors are dissipated before any impact to the public or environment occurs. Worker exposure to these vapors is addressed by the LLNL Health and Safety Policy in Chapters 1 and 21 and by the

Radiation Protection Standards in Chapter 33 of the *Health & Safety Manual* (LLNL 1992a). Spilled liquid waste that does not evaporate is discussed in Section 7.3 of this chapter.

Large spills could potentially vaporize to form significant amounts of radioactive and/or hazardous air pollutant emissions. Depending on the magnitude and frequency of the spill event, this type of situation is considered either an abnormal operational event or an accident. The abnormal operational events and accidents analyzed for the MWM Facility are addressed in Chapter 11 of this PSAR.

7.2.1.2 Characteristics

The radioactive and hazardous constituents present in air emissions originate from the feed wastes and reagents brought to the facility. Chapters 4 and 5 of this PSAR characterize the proposed incoming feed wastes.

7.2.1.3 Quantities

Based on Section 4.10 of the EIS/EIR (DOE and UC 1992) regarding air quality at LLNL, the quantities of air pollutants generated at LLNL are relatively insignificant. While this generalization will probably be true for the MWM Facility, an estimate of the quantity of air emissions to be generated (for inclusion into the Final Safety Analysis Report [FSAR]) will be postponed until the design details of the MWM Facility processes are finalized.

7.2.1.4 Effluent Streams

Effluents from the offgas treatment systems are discharged to the atmosphere via the building exhaust stack. The effluents meet Bay Area Air Quality Management District (BAAQMD) requirements for Best Available Control Technology (BACT). Additional details regarding gaseous effluents from the MWM Facility are provided in Chapter 4 of this PSAR.

7.2.2 Air Pollution Control Equipment and Systems

The MWM Facility has ventilation and offgas treatment systems to confine radioactive and hazardous airborne pollutants. The building ventilation system is designed such that proper pressure differentials are maintained between building confinement zones. Multiple confinement zones are provided with air pressure gradients across the confinement zones such that pressure is lower in

the areas in which containers are opened. All confinement zones are below atmospheric pressure.

The MWM Facility exhaust system is divided into three offgas systems: process offgas, building offgas, and experimental offgas. The process offgas system serves as the primary confinement system for waste treatment process enclosures and equipment. The building offgas system operates as a secondary confinement system treating facility process air and room air. The experimental offgas system uses experimental technologies to evaluate filtering methods.

The ventilation and offgas treatment systems are discussed in detail in Chapter 4 of this PSAR.

7.3 Liquid Radioactive, Hazardous, and Mixed Wastes

7.3.1 Waste Identification

7.3.1.1 Sources

Liquid radioactive, hazardous, and mixed wastes that result from normal operations at the MWM Facility consist primarily of filtered water (i.e., filtrate) resulting from the treatment of liquid waste, rinse water (i.e., rinsate) resulting from flushing operations, and rain water accumulated within bermed areas. These liquids have, at most, trace amounts of radioactive, hazardous, and mixed waste constituents. Two secondary sources of liquid waste are steam condensate and discarded operating fluids (e.g., machine oil).

In addition, an accident or abnormal operational event could lead to spillage of mixed wastes sent to the MWM Facility. Large spills are captured within bermed areas and/or sumps; small spills are captured by absorbent, resulting in the generation of solid waste (see Section 7.4). The abnormal operational events and accidents analyzed for the MWM Facility are addressed in Chapter 11 of this PSAR.

The required response for a spill is specified in Chapter 21 of the *Health & Safety Manual* (LLNL 1992a) and is also addressed in Section 4 of the *Environmental Protection Handbook* (LLNL 1990). Worker exposure to spilled liquid waste is addressed by the LLNL Health and Safety Policy in Chapters 1 and 21 and by the Radiation Protection Standards in Chapter 33 of the *Health & Safety Manual*.

7.3.1.2 Characteristics

The radioactive, hazardous, and mixed waste constituents present in liquid wastes generated by the MWM Facility originate from the feed wastes and reagents brought to the facility. Chapters 4 and 5 of this PSAR characterize the incoming feed wastes.

7.3.1.3 Quantities

The quantities of treated liquid waste, rinsate, and steam condensate depend on system capacities. Chapter 4 of this PSAR indicates system capacities for the various MWM Facility processes.

Quantities for discarded operating fluids such as machine oil depend on maintenance schedules for equipment. Chapter 15 of this PSAR addresses facility maintenance requirements.

Appendixes A and B of the EIS/EIR (DOE and UC 1992) quantify historical waste generation for LLNL. An estimate of the quantity of liquid waste to be generated by the MWM Facility (for inclusion into the FSAR) will be postponed until the design details of the MWM Facility processes are finalized.

7.3.1.4 Effluent Streams

Liquid effluents from the MWM Facility are discharged to the sewer via the water treatment system. Prior to discharge, the liquids are analyzed and certified acceptable to ensure that sewer release limits are met. Additional details regarding liquid effluents from the MWM Facility are provided in Chapter 4 of this PSAR.

7.3.2 Waste Treatment Equipment and Systems

The MWM Facility has a water treatment system to treat liquid wastes produced from facility operations as described in Section 7.3.1.4. The goal of the system is to meet the regulatory and LLNL requirements for the management, treatment, and discharge of MWM Facility wastewater. Water is recycled within the MWM Facility to the extent practical as to minimize discharged wastewater. Additional details regarding the water treatment system are provided in Chapter 4 of this PSAR.

7.4 Solid Radioactive, Hazardous, and Mixed Wastes

7.4.1 Waste Identification

7.4.1.1 Sources

The following wastes are representative of the solid radioactive, hazardous, and mixed wastes that are generated during normal operations at the MWM Facility:

- Filtration media that are discarded from the water treatment system.
- Solid materials such as swipes that result from MWM Facility decontamination operations.
- Absorbent materials that are used to capture spills (see Section 7.3).
- Contaminated equipment such as High-Efficiency Particulate Air (HEPA) filters that are discarded.

Liquid wastes that are solidified and solid wastes that are dismantled, compacted, or shredded are considered product wastes and are addressed in Chapter 4 of this PSAR.

Discarded filtration media and contaminated absorbents and swipes are introduced to the MWM Facility process as part of the incoming feed waste stream. Discarded equipment undergoes decontamination and volume reduction within the MWM Facility process and/or is sent off site for treatment and/or disposal, as necessary.

No solid radioactive, hazardous, or mixed wastes are released directly to the environment. Worker exposure to solid radioactive, hazardous, and mixed waste is addressed by the LLNL Health and Safety Policy in Chapters 1 and 21 and by the Radiation Protection Standards in Chapter 33 of the *Health & Safety Manual* (LLNL 1992a).

7.4.1.2 Characteristics

The radioactive, hazardous, and mixed waste constituents present in the solid wastes generated by the MWM Facility units originate from the feed wastes brought to the facility. Chapters 4 and 5 of this PSAR characterize the incoming feed wastes.

7.4.1.3 Quantities

Appendixes A and B of the EIS/EIR (DOE and UC 1992) quantify historical waste generation for LLNL. An estimate of the quantity of solid waste to be generated by the MWM Facility (for inclusion into the FSAR) will be postponed until the design details of the MWM Facility processes are finalized.

7.4.1.4 Effluent Streams

Facility-generated solid radioactive, hazardous, and mixed wastes are treated within the MWM Facility and/or sent off site for treatment and/or disposal, as necessary. Chapter 4 of this PSAR indicates the effluent streams for solid material that is considered product waste.

7.4.2 Waste Treatment Equipment and Systems

As stated in Section 7.4.1.4, facility-generated solid wastes are treated within the MWM Facility and sent off site for treatment or disposal. MWM Facility equipment for treating solid waste is discussed in detail in Chapter 4 of this PSAR.

7.5 References

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Lawrence Livermore National Laboratory (1990), *Environmental Protection Handbook*, Lawrence Livermore National Laboratory, Environmental Guidance Division, Livermore, CA, 1990.

Lawrence Livermore National Laboratory (1992a), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

Lawrence Livermore National Laboratory (1992b), *Laser Programs Waste Minimization Plan*, Lawrence Livermore National Laboratory, Livermore, CA, September 1992.

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Chapter 8

Inadvertent Criticality Protection

September 1994

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Chapter 8. Inadvertent Criticality Protection

This chapter of the Preliminary Safety Analysis Report (PSAR) addresses criticality prevention for the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL). Inventory controls are the primary means of preventing fissile material from reaching the facility in unacceptable quantities. Additional administrative controls prevent fissile material from being stored in such a manner as to cause or result in inadvertent criticality. Consequently, any criticality accident postulated for the MWM Facility would be incredible.

8.1 Criticality Safety Analysis

The Criticality Safety Group, which is part of the Special Projects Division of the Hazards Control Department, is responsible for performing criticality safety analyses and for resolving any questions related to the criticality safety of a proposed action that would not be clearly answered in applicable Operational Safety Procedures or the Facility Safety Procedure.

8.2 Criteria to Ensure Subcritical Limits

These inventory control limits are implemented by the Operational Safety Requirements contained in Chapter 16 of this PSAR. By following these limits, any criticality accident postulated for the MWM Facility would be incredible.

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 9 Radiation Protection

September 1994

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Chapter 9. Radiation Protection

This chapter of the Preliminary Safety Analysis Report (PSAR) addresses occupational radiation protection for the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL). The Facility Safety Procedure (FSP) for this facility will implement the site requirements for radiation protection specified in the *Health & Safety Manual* (LLNL 1992) and associated supplements.

9.1 Radiation Protection Systems

The principal occupational radiation safety consideration in the MWM Facility is to minimize radiation exposure and assimilation of radioactive materials to employees. To this end, LLNL complies with Department of Energy (DOE) Orders 5480.11 (DOE 1992) and 6430.1A (DOE 1989). These Orders are implemented via the *Health & Safety Manual* (LLNL 1992) and associated supplements.

9.1.1 Radiation Safety Design

The MWM Facility handles, stores, and processes solid and liquid low-level mixed wastes, which exist primarily as contained sources of radiation. Airborne sources resulting from the processing of these contained sources are also possible. The following sections address both types of sources and define the radiation protection design features to be provided at the MWM Facility.

The current design requirements for the MWM Facility ensure that engineered controls will provide primary radiation protection (e.g., sealed waste containers, process system equipment, process enclosures, offgas treatment system, ventilation systems, and safety interlocks). Secondary protection is provided by concrete curbing, personnel access controls, administrative controls, and protective clothing. As Low As Reasonably Achievable (ALARA) concepts are applied to minimize exposures (see Section 9.1.2). Facility design, along with administrative requirements, ensures that the DOE maximum dose rate requirements are not exceeded.

The MWM Facility is assigned to a Hazards Control (ES&H) Team who will design and administer the radiation protection program. During the design of the MWM Facility, the team provides input on ventilation systems, filtration, access control systems, radioactive materials workplace requirements, and radiation monitoring systems. This program is documented in the FSP and reviewed by the Team Health Physicist.

The Health & Safety Manual (LLNL 1992) provides information on isotope source handling and use, radiation safety system operation, and safety procedures that provide administrative controls to prevent excessive radiation exposure. The MWM Facility radiation protection design features are described in more detail in Section 4.3 of this PSAR.

9.1.2 ALARA Program

It is LLNL's policy that exposure of personnel to ionizing radiation associated with LLNL operations shall be maintained ALARA. A discussion of LLNL's detailed ALARA Program is provided in Supplement 33.011 of the *Health & Safety Manual* (LLNL 1992). This program is designed, in part, to comply with applicable radiation protection requirements contained in DOE Order 5480.11 (DOE 1992). Procedures written for operation of the MWM Facility will be required to comply with Supplement 33.011 of the *Health & Safety Manual*.

9.1.3 Radiological Protection Training

Any employee whose work assignment involves work with radioactive materials must receive adequate radiation safety training and be familiar with the processes and equipment to be used. This training and familiarization will permit the individual to perform the job safely. Work will be performed by employees who have satisfactorily completed the training and qualification requirements specified for MWM and the safety training mandated by the *Health & Safety Manual* (LLNL 1992). Training for MWM Facility personnel is also described in Chapter 13 of this PSAR.

9.1.4 Types of Ionizing Radiation

Ionizing radiation refers to gamma rays, x rays, neutron particles, beta particles, alpha particles, or other particles that are capable of producing ions. Gamma rays, x rays, and beta particles can result in either external or internal exposure, depending on the location of the radiation-emitting material. Alpha particles pose only an internal exposure concern. The types of ionizing radiation present in the MWM Facility are presented in Chapter 5 of this PSAR.

9.2 External Radiation Exposure Control

9.2.1 Maximum Levels

The policy of LLNL is to comply with the radiation protection standards of DOE Order 5480.11 (DOE 1992). This Order specifies an annual radiation dose limit of 5 rem for workers from both internal and external sources. The standards of this Order are implemented by Chapter 33 of the *Health & Safety Manual* (LLNL 1992). The total surface dose rate for containers to be received by the MWM Facility or released to the feed preparation areas is less than 200 mR/hr. Chapter 11 of this PSAR demonstrates that the worst-case worker accident exposure is less than 0.3 rem, which is well below the annual dose limit of 5 rem.

9.2.2 Dosimetry

DOE Order 5480.11 (DOE 1992) requires that the external radiation exposure of personnel be monitored where the potential exists for (1) the annual Effective Dose Equivalent (EDE) to exceed 0.1 rem, (2) the annual dose equivalent to the skin or to an extremity to exceed 5 rem, or (3) the annual dose equivalent to the lens of the eye to exceed 1.5 rem.

As required by Chapter 33 of the *Health & Safety Manual* (LLNL 1992), all personnel working in or visiting the MWM Facility are required to wear a Thermoluminescent Dosimeter (TLD) designed to measure external radiation exposure received on LLNL premises. If dosimeter analysis (to be evaluated monthly for facility personnel) reveals unexpected results, the cause will be investigated, corrective action will be taken, and additional controls will be implemented to reduce doses to ALARA. Self-reading gamma dosimeters will be worn by personnel in the MWM Facility where gamma dose rates have the potential to exceed 25 mR/hr in the work area. Personal Alarming Dosimeters (PADs) will be worn when deemed necessary by the Health Physicist.

Since a criticality accident is an incredible event, there are no criticality alarm systems in the MWM Facility. Therefore, nuclear accident dosimeters are not required.

9.3 Internal Radiation Exposure Control

9.3.1 Maximum Levels

Respiratory protection devices will be available in areas where unencapsulated radionuclides are handled. During routine operations, the combination of design and control procedures will ensure that the anticipated magnitude of the prospective Committed Effective Dose Equivalent (CEDE) from an intake plus any EDE from external exposures does not exceed 5 rem, and that the anticipated magnitude of the CEDE to any organ or tissue from an intake plus any EDE from external exposures will not exceed 50 rem. Derived Air Concentrations (DACs) for radionuclides in air are listed in Attachment 1 of DOE Order 5480.11 (DOE 1992).

As discussed in Chapter 11 of this PSAR, no routine uptake of radioactivity in the MWM Facility is expected. Under normal conditions, there will be no inhalation or ingestion of radioactive material. Thus, the above limits will not be exceeded.

9.3.2 Monitoring for Internal Exposure

Supplement 33.10 of the *Health & Safety Manual* (LLNL 1992) requires that all persons working in areas where unencapsulated radioactive materials are handled must be monitored to determine possible internal deposition. This supplement discusses monitoring requirements, selection of employees, selection of appropriate bioassay methods and frequencies, bioassay and dose data management, dose assessment procedures, and dose management policies. Any employee working in the MWM Facility is subject to submitting periodic bioassay samples or receiving whole-body counts, as determined by the Health Physicist, based on the nature and duration of the work performed by the employee.

9.4 Radiological Protection Instrumentation Program

The maintenance inspection and surveillance program applicable to the MWM Facility will be described in and implemented by MWM Facility safety procedures. Calibration standards are identified in calibration procedures. Instrument calibration procedures and records are maintained by the Hazards Control Department.

9.5 Respiratory Protection Program

Respiratory protection devices will be available in areas where unencapsulated radionuclides are handled. These devices will be used as protection from airborne radioactive material only when engineering controls, such as safety enclosures or proper ventilation, are not feasible or during emergency conditions.

Details of respirator usage are specified in Supplement 10.05 of the *Health & Safety Manual* (LLNL 1992).

9.6 Radiological Monitoring

The Hazards Control Department maintains the program for ensuring that exposures are below applicable radiation protection standards. This program includes (1) measuring ambient radiation fields, (2) monitoring for airborne contamination, and (3) surveying for surface contamination. The Hazards Control Department also selects, obtains, calibrates, distributes, and maintains radiation monitoring instruments as necessary.

The *Health & Safety Manual* (LLNL 1992) specifies radiation protection requirements. The manual also addresses inspection and maintenance requirements for portable radiation monitors and Continuous Air Monitors (CAMs). The MWM Facility units involved in the treatment or processing of radioactive and mixed wastes are provided with portable radiation monitors for measuring radiation fields and CAMs for detecting airborne contamination. Chapter 4 of this PSAR discusses the locations of all portable radiation monitors and CAMs in the MWM Facility.

9.6.1 Contamination Control

To prevent the contamination of personnel, LLNL provides protective apparel for individuals working with radioactive materials. At a minimum, anyone working with dispersible radioactive materials will wear laboratory coats and waterproof gloves. Additional clothing and shoes are specified by Hazards Control as needed.

To confine radioactive airborne sources, the MWM Facility is provided with ventilation and offgas treatment systems. By using supply and exhaust fans with appropriate design flow rates, proper pressure differentials are maintained between multiple building confinement zones with air pressure gradients. To prevent the release of radioactive contamination to the atmosphere and to minimize the potential exposure of Operations personnel, process areas and

equipment are equipped with offgas enclosures and exhaust hoods. Chapters 4 and 6 of this PSAR describe the offgas system and ventilation system in greater detail.

Radioactive contamination of surfaces outside work enclosures will be maintained ALARA. Articles or equipment to be used in nonradioactive work areas or outside LLNL will be decontaminated to levels which allow for unrestricted use as required by the *Health & Safety Manual* (LLNL 1992).

9.6.2 Radiological Protection Recordkeeping

Dosimeter readings are obtained and recorded, and a statement of accumulated external occupational radiation dose is provided annually to all employees as required by DOE Order 5480.11 (DOE 1992). Employees are notified of any positive radiation dose. Any radiation dose that exceeds the limits, as stated in the *Health & Safety Manual* (LLNL 1992), is reported to both the supervisor and the person involved as soon as the information is available. The cause of such doses is investigated by the Hazards Control Department. The Hazards Control Department maintains and stores the occupational radiation dose records for LLNL (LLNL 1992).

Supplement 33.10 of the *Health & Safety Manual* discusses internal exposure monitoring recordkeeping. Monitoring programs are specified by the area Health Physicist, in conjunction with appropriate facility personnel, using the guidelines of Supplement 33.10.

9.7 Radiological Area

9.7.1 Posting

Radiological areas will be identified and maintained in accordance with the *Health & Safety Manual* (LLNL 1992). All areas where radioactive materials will be present will be posted with warning signs and/or barricades containing applicable safety instructions and information on the radioactive materials present.

9.7.2 Entry and Exit Control

An appropriate entry control program will be established for radiological areas of the MWM Facility and will be maintained in accordance with the *Health & Safety Manual* (LLNL 1992). Only those personnel approved by the appropriate

supervisors will be authorized to work in the MWM Facility. Personnel not regularly assigned to the MWM Facility will be required to prearrange access to the facility and will be escorted while in the operational zones.

Airtight doors are located between some process areas and nonprocess areas as depicted in Figure 4-3 of this PSAR. Entrances to the facility are controlled by lock and key, and keys are only issued to personnel who need entry and who are appropriately trained. Entrances to the MWM Facility will be closed and locked at night and whenever they are unattended during the workday.

9.8 References

Department of Energy (1989), *General Design Criteria*, U.S. Department of Energy, Washington, DC, DOE Order 6430.1A, April 6, 1989.

Department of Energy (1992), *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, DC, DOE Order 5480.11, Change 3, June 1992.

Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

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Chapter 10 Hazardous Material Protection

September 1994

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Chapter 10. Hazardous Material Protection

This chapter of the Preliminary Safety Analysis Report (PSAR) addresses hazardous material protection for the Mixed Waste Management (MWM) Facility to be located in Building 494 at Lawrence Livermore National Laboratory (LLNL).

As stated in Chapter 4 of this PSAR, the MWM Facility will handle, store, and process hazardous material in the form of mixed waste and reagents (chemicals used for the treatment of waste). Department of Energy (DOE) Order 5480.23 (DOE 1992) defines hazardous material as any solid, liquid, or gaseous material that is toxic, explosive, flammable, corrosive, or otherwise physically or biologically threatening to health. The mixed waste and reagents located within the MWM Facility may contain items that are carcinogenic, toxic, corrosive, reactive, combustible, and flammable.

The principal hazardous material safety consideration in the MWM Facility will be to minimize the effects of hazardous materials on employees, the facility, and the environment. To this end, LLNL must comply with DOE Orders 5480.10 (DOE 1985) and 5483.1A (DOE 1983). These Orders are implemented via the *Health & Safety Manual* (LLNL 1992a) and associated supplements. In addition, the requirements specified in Title 29 Code of Federal Regulations (CFR) Part 1910.120, paragraph P, will also be implemented (CFR 1993).

10.1 Hazardous Material Policy

10.1.1 Policy and Directives

The LLNL Health and Safety Policy, which includes requirements for hazardous material protection, is defined in the *Health & Safety Manual* (LLNL 1992a). The policy is implemented through integrated management involvement, education and training, facility and equipment design, safety procedures, dosimetry, workplace monitoring, and work practice. The policy serves to maintain employee exposures As Low As Reasonably Achievable (ALARA). Procedures provide detailed requirements and responsibilities for implementing each part of the LLNL Health and Safety Policy. All management levels are responsible for developing and implementing procedures to protect workers against hazards in the workplace. In general, it is the policy of LLNL to comply with the extensive network of federal, state, and local laws and regulations and DOE Orders and requirements regarding hazardous material protection. A list of these requirements is presented in Table B-2 of Appendix B of the LLNL

Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992).

10.1.2 Hazards Control Department

The Hazards Control Department is one of the Environmental, Safety, and Health (ES&H) support organizations. The head of the Hazards Control Department reports to the Associate Director for Plant Operations.

The Hazards Control Department, through its ES&H Team, assists supervisors and employees in maintaining safe work areas by providing information on the hazardous properties of materials and on relevant regulations, by recommending methods for control, and by monitoring the work environment (LLNL 1992a). Hazards Control also maintains a file of Material Safety Data Sheets (MSDSs) and a library of current regulations and offers training courses regarding hazardous material protection. Other support services provided by Hazards Control are discussed in Chapter 1 of the *Health & Safety Manual* (LLNL 1992a).

10.1.3 Staff Qualifications

The Hazards Control Department includes a staff of qualified Industrial Hygienists. Most LLNL Industrial Hygienists are certified by the American Board of Industrial Hygiene and/or have graduate degrees in industrial hygiene or a closely related field (LLNL 1993). Ongoing training is provided for the Industrial Hygienists as described in the *LLNL Training Program Manual* (LLNL 1991).

10.2 Hazardous Material Programs

10.2.1 ALARA Program

The Health and Safety Program, documented in the *Health & Safety Manual* (LLNL 1992a), serves to maintain employee exposures to hazardous substances ALARA. All management levels of LLNL are responsible for developing and implementing procedures to protect workers against hazards in the workplace. A Facility Safety Procedure (FSP) will be prepared for the MWM Facility and will specify the safety and health procedures that must be followed by all personnel present within the building or area. Safety and health requirements specific to a hazardous waste operation that are not addressed in the FSP will be presented in Operational Safety Procedures (OSPs) as necessary. Due to the preliminary design of the MWM Facility, these procedures have not yet been developed.

10.2.2 Medical Program

The Medical Program, which is implemented by the Health Services Department, is described in Chapter 5 of the *Health & Safety Manual* (LLNL 1992a). This program meets the requirements of 29 CFR 1910.120 (CFR 1993). The objectives of the program are to provide an occupational health program that meets regulatory requirements and to ensure a safe and healthful work environment for LLNL employees.

For employees with hazardous work assignments, a more detailed medical assessment and stricter occupational medical surveillance are required. A baseline medical examination may be required to determine the health status of the employee at the beginning of the medical surveillance period. Additional examinations may be required at specified intervals. The program also includes provisions for keeping records of employees' hazardous material exposures.

10.2.3 Workplace Monitoring Program

Hazard assessments will be performed on the MWM Facility operations to identify the potential for employee exposure. An industrial hygiene monitoring plan, aimed at characterizing employee exposure, will be developed and implemented.

10.2.4 Carcinogen Control Program

Procedures and controls for the safe handling of chemical carcinogens are provided in Supplement 21.16B of the *Health & Safety Manual* (LLNL 1992a). The requirements for this supplement are based on Occupational Safety and Health Administration (OSHA) regulations and DOE Orders, including DOE Order 5480.10 (DOE 1985). The supplement summarizes various ES&H requirements for work involving carcinogens. It also establishes controls for the use of carcinogens based on the potency and application of the carcinogens. Each carcinogen and its application will be evaluated individually by an Industrial Hygienist to determine the appropriate controls. The specific carcinogens that will be located in the MWM Facility are trichloroethylene (TCE), tetrachloroethylene, lead, and vinyl chloride.

10.2.5 Health Hazard Communication Program

In compliance with 29 CFR 1910.1200 (CFR 1993), the Hazards Control Department has a written Health Hazard Communication Program, as documented in Supplement 7.02 of the *Health & Safety Manual* (LLNL 1992a). The

purpose of the program is to ensure that hazards associated with chemical, physical, and biological agents are evaluated and that this information is communicated to affected employers and employees. Other provisions of the Health Hazard Communication Program include the following: development of Health Hazards Lists, use of MSDSs, container labeling, training, and hazard evaluation.

The MWM Facility Operations Section Leader will implement the Health Hazard Communication Program for operations in the facility. The implementation of these provisions is discussed in Supplement 7.02 of the *Health & Safety Manual* and the *LLNL Training Program Manual* (LLNL 1991) and will be required by the FSP.

10.3 Identification of Hazardous Material

All waste received at the MWM Facility will conform to the procedures for identification used at the Hazardous Waste Management (HWM) facilities. Waste will be properly identified, prior to delivery from HWM, on a Waste Disposal Requisition Form. Appropriate labels are affixed to waste containers in the Waste Accumulation Area prior to delivery to the MWM Facility. These labels are cross-referenced to the accompanying Waste Disposal Requisition Form by its unique number. Potential hazardous materials are identified and documented through the following: (1) knowledge and assessment of the operations, (2) periodic walkthrough surveys, (3) review of proposed projects and facilities, (4) maintenance of a hazards inventory and tracking system, and (5) laboratory analysis. In addition to identifying waste containers, all areas where hazardous material is handled or stored must be posted with appropriate warning signs.

All programs, facilities, and buildings are subject to review and evaluation by Hazards Control personnel to assess potential hazards. The results of these reviews are forwarded to the appropriate department so that any deficiencies can be corrected. Records of reviews are maintained by Hazards Control. The programs and activities that identify, analyze, and control potential hazardous material are described in the *Health & Safety Manual* (LLNL 1992a) and the Resource Conservation and Recovery Act (RCRA) Part B Permit Application (LLNL 1992b).

10.4 Hazards Evaluation Program

As described in Section 10.3, a combination of activities to identify, evaluate, and control occupational health hazards will be used. From these activities and published DOE and LLNL guidelines, information will be obtained which will

enable professional judgments to be developed regarding the degree of hazards and the controls necessary to reduce exposures to acceptable levels. Exposures to hazardous materials are maintained below exposure limits (i.e., the lower of the OSHA Permissible Exposure Limits or American Conference of Governmental Industrial Hygienists [ACGIH] Threshold Limit Values) as defined by DOE Order 5480.4 (DOE 1993).

10.5 Control Measures

Requirements for the control of hazardous materials are described in Chapter 8 of the *Health & Safety Manual* (LLNL 1992a). In general, all operations involving the use of hazardous materials will be controlled by procedures designed to ensure safe performance. Hazardous and mixed waste generated at LLNL is controlled from the point of generation and acceptance at the HWM facilities through on-site treatment and storage and off-site treatment or disposal. This control includes the following steps:

- Identification and characterization of the waste.
- Evaluation of waste characterization data to determine proper handling and treatment requirements; incompatibilities with other wastes in storage or to be treated; or other properties requiring special handling, storage, treatment, or disposal.
- Aisle space allowances for access by personnel and emergency response equipment.
- Use of engineering, work practice, and administrative and personal protective equipment controls.
- Prevention of waste dispersal or generation of gases, mists, or vapors.
- Management of accumulated liquids.
- Equipment decontamination prior to use.

Additional information regarding these controls is provided in various chapters of the *Health & Safety Manual*.

10.6 References

- Code of Federal Regulations (1993), *Labor*, 29 CFR 1910, National Archives and Records Administration, 1993.
- Department of Energy (1983), *Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities*, U.S. Department of Energy, Washington, DC, DOE Order 5483.1A, June 22, 1983.
- Department of Energy (1985), *Contractor Industrial Hygiene Program*, U.S. Department of Energy, Washington, DC, DOE Order 5480.10, June 26, 1985.
- Department of Energy (1992), *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, DOE Order 5480.23, April 10, 1992.
- Department of Energy (1993), *Environmental Protection, Safety, and Health Protection Standards*, U.S. Department of Energy, Washington, DC, DOE Order 5480.4, Change 4, January 7, 1993.
- Department of Energy and University of California (1992), *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*, U.S. Department of Energy and University of California, Livermore, CA, DOE/EIS-0157, Volume II of V, August 1992.
- Lawrence Livermore National Laboratory (1991), *LLNL Training Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-106166, February 1, 1991.
- Lawrence Livermore National Laboratory (1992a), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.
- Lawrence Livermore National Laboratory (1992b), *Resource Conservation and Recovery Act Part B Permit Application, Hazardous Waste Treatment and Storage Facilities*, Lawrence Livermore National Laboratory, Livermore, CA, UCAR-10275-91, January 2, 1992.
- Lawrence Livermore National Laboratory (1993), Memorandum from R.K. Reed to R.T. Hadley, "RTRF Preliminary Safety Analysis Report," Lawrence Livermore National Laboratory, Livermore, CA, January 7, 1993.

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Chapter 11 Analysis of Operations

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Chapter 11. Analysis of Operations

This chapter of the Preliminary Safety Analysis Report (PSAR) provides the analysis of operation of the Mixed Waste Management (MWM) Facility in Building 494 at Lawrence Livermore National Laboratory (LLNL). As identified in Chapter 5 of this PSAR, the MWM Facility has been determined to have a facility hazard classification of Radiological for the radionuclide inventory and Low Hazard for the reagent and chemical inventory. The level of analysis performed and the methodology used in this chapter are based on these classifications.

This chapter presents the methodology, assumptions, and results of the systematic evaluation of hazards associated with the operation of the MWM Facility. A spectrum of postulated credible events that could occur involving those hazards are analyzed. These postulated events include the following:

- Exposure to radiation
- Radioactive material release to the environment
- Hazardous material release to the environment.

Section 11.1 describes the methodology used in the analysis. Section 11.2 documents the impact of the hazards associated with normal operations of the MWM Facility. Section 11.3 documents the impact of a spectrum of events that are classified as Abnormal Operational Events (AOEs). Section 11.4 provides qualitative and quantitative analyses of a spectrum of accidents, the Bounding Accidents, and the Beyond Design Basis Accidents.

The analysis shows that the MWM Facility can be operated without posing undue risk to the health and safety of facility workers, other on-site employees, or individuals at the site boundary.

11.1 Methodology

11.1.1 The Department of Energy Graded Approach

The graded approach to accident analysis, discussed in Department of Energy (DOE) Standard 1027-92 (DOE 1992a), is used for this PSAR. The graded approach recommends simple, qualitative consequence analysis for hazards identified for a Hazard Category 3 facility. Detailed event tree and fault tree analyses to obtain the probability of failure of the safety systems and their support systems are not recommended. Since the MWM Facility radionuclide classification is Radiological, no fault tree analyses were performed to obtain

system reliability for the MWM Facility. Where the quantitative estimate of the frequency of occurrence of a safety system failure is not available, a qualitative estimate of the frequency of occurrence is given instead.

In DOE-STD-1027-92, four elements are identified for accident analysis, namely, release mechanism analysis, sequence selection, engineering analysis, and consequence analysis. The hazardous material release mechanisms have been analyzed and are presented in Appendix 11A as the hazard events.

Using the graded approach, the accident analysis employs a mixture of qualitative and quantitative approaches. Frequencies are assessed qualitatively for all events except for natural phenomena. To provide a quantitative background for a qualitative description, DOE has assigned frequency ranges to qualitative descriptions. These ranges are provided in Table 11-1 (Hallinan 1989).

Consequences of accidents are determined both quantitatively and qualitatively. For each accident, the amount of material released that becomes airborne is determined. The accident with the largest airborne release is identified as a Bounding Accident because its consequences envelope all other releases. The consequence of the Bounding Accident is calculated in terms of dose using dispersion codes described in Section 11.1.3. Additionally, the consequence of each accident is given a qualitative description based on the consequence categories of Table 11-2 (Hallinan 1989).

Risk is typically defined as the product of the frequency and the consequence associated with each event. Since the frequency and the consequence in this PSAR are mainly described in a qualitative nature, the risk from each accident is described qualitatively using the risk matrix shown in Figure 11-1 (Hallinan 1989).

11.1.2 Hazard Identification

To identify hazards and the possible accident scenarios associated with the MWM Facility, a process known as Hazard and Operability (HAZOP) was used. The HAZOP process provides a methodology for (1) investigating possible deviations from design intent that could result in a hazardous situation or prevent efficient operation, and (2) providing solutions to these problems. The HAZOP process provides a structured approach to ensure complete coverage of a facility.

MWM Facility technical personnel were interviewed as part of the HAZOP process. The MWM Facility was divided into 19 different process areas. HAZOP forms to record possible deviations and consequences were developed for each

process area. The possible deviations were determined by combining a series of "guide words" and "parameters." Guide words include the words "no," "more," "less," "reverse," etc. Parameters include process conditions such as temperature and level. Many different combinations of guide words and parameters are used to determine a complete set of deviations for each process area.

The HAZOP process is very dependent on the system expertise of the individuals involved in the HAZOP meetings. LLNL system experts provided that expertise.

11.1.3 Consequence Evaluation Methodology

For the waste treatment activities performed in the MWM Facility, accidents resulting in the release of radioactive and hazardous materials have been identified. The consequences of these accidents are calculated using the following methods.

11.1.3.1 Worker Dose Evaluation Methodology

For an airborne release of radionuclides to the room air in Building 494, the dose (D) to the worker breathing contaminated air is the product of the dose commitment factor (F), the volume of air breathed (V), and the concentration of radioactivity in the air (C), as shown below:

$$D(\text{rem}) = F(\text{rem/Ci}) \times V(\text{cm}^3) \times C(\text{Ci/cm}^3)$$

Each of the terms used to calculate the worker dose is discussed in more detail below:

Dose Commitment Factor (F). Dose commitment factors are used to convert assimilated radioactive isotopes into radiation dose. These factors are a function of a particular radionuclide and its radiation type, the radiological and biological half-life, other biological factors that allow the material to distribute itself in the body, and the mode of assimilation. For the calculation of dose to the worker from airborne particulate, inhalation is the only mode of assimilation considered. The dose from external radiation is negligible because the operator exposure time is short (assumed to be one minute). The worker dose is calculated in terms of 50-year Committed Effective Dose Equivalent (CEDE).

Volume of Air Breathed (V). Adults are assumed to breathe $1\text{E}+07 \text{ cm}^3$ per eight-hour workday, which is equivalent to about $350 \text{ cm}^3/\text{sec}$ (Lamarsh 1975).

Concentration of Radioactivity in the Air (C). The analysis of the Bounding Accident considers the activity released into Building 494 as a result of the accident. The radionuclide concentration in the room air immediately following an accident is calculated based on the room volume and the amount of radionuclides released to the room air. The amount of radionuclides released to the room air is dependent on the source of the radionuclides and on the fraction of the source made airborne.

11.1.3.2 Methodology for the Calculation of Radiological Doses to On-Site and Off-Site Individuals

The methodology employed for the dose calculations is similar to the methodology employed in the LLNL sitewide Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992). The EIS/EIR provides additional details of the methodology.

For accidental airborne releases of radionuclides from the MWM Facility to the environment, the computer code GENII, Version 1.485 (Napier et al. 1988) was selected to calculate radiation dose to on-site and off-site individuals. The code was developed by the Pacific Northwest Laboratory for the DOE Richland Field Office and is available in the public domain. GENII incorporates the internal dosimetry models recommended by the International Commission on Radiological Protection (ICRP). The code is actually a coupled system of seven different programs that constitute the dosimetry system (Generation II) used at the DOE Hanford reservation. The GENII computer program has also been used in accident analyses performed for the EIS/EIR. It should be noted that the newest version of the GENII code (Version 1.485) yields results that are approximately 10% higher than the version used in the EIS/EIR (Version 1.473).

GENII calculates potential radiation doses to individuals or populations, resulting from routine or accidental releases of radionuclides to air or water and from residual contamination. The code can account for direct exposures from water, soil, and air as well as exposures from inhalation and ingestion. GENII can calculate annual doses, committed doses, and accumulated doses.

GENII uses the atmospheric dispersion model of Pasquill, as modified by Gifford, to estimate the dispersion of a radioactive plume at various distances downwind from the point of release. This model is based on Gaussian distribution of concentration in the lateral (y) and vertical (z) directions. The lateral and vertical dispersion parameters are themselves a function of the downwind distance (x).

Once the source term for an accident scenario and the atmospheric dispersion parameters are specified, GENII calculates the environmental transfer, uptake, and human exposure. Individual doses were calculated at specific distances on site, at the site boundaries, for three exposure pathways:

- External exposure from the airborne plume
- External exposure from radioactivity deposited on the ground
- Internal exposure from inhalation.

GENII uses weighting factors for various body organs to calculate an Effective Dose Equivalent (EDE), as recommended by the ICRP (ICRP 1977, 1982). Doses are calculated for the lungs, stomach, small intestine, upper large intestine, lower large intestine, bone surface, red bone marrow, testes, ovaries, muscle, thyroid, bladder, kidneys, and liver. The EDE is the summation of the dose equivalents to specific organs, weighted by the relative risk to that organ, compared to an equivalent whole-body dose. For accident scenarios, the doses calculated include EDEs from external exposure to the plume and ground surface contamination for one year, and a CEDE resulting from the internal exposure pathways of plume inhalation. To be consistent with the EIS/EIR, the sum of the EDE from external pathways and the CEDE from internal pathways is called the CEDE.

Individual doses at two distances from Building 494 (100 and 175 meters) were calculated. The on-site workers are assumed to be located at 100 meters, and the nearest site boundary (northern site boundary) is located at 175 meters.

Additional assumptions used to calculate radiation doses for the Bounding Accidents are as follows:

- The fraction of time spent in the plume was 1.0 (conservatively used for inhalation intake and external plume exposure).
- For on-site doses, parameters for the maximally exposed individual were used; soil exposure time was one year; no ingestion was assumed; and a 50-year committed dose was calculated from plume inhalation (assumes adults are exposed).
- For the nearest site boundary dose, parameters for the maximally exposed individual were used; soil exposure time was one year; no ingestion was assumed; and a 50-year committed dose was calculated from plume inhalation.
- The prevailing weather condition during the nighttime, namely F stability and 1-m/sec wind speed, was conservatively used to calculate the dispersion parameters and the radionuclide concentration in the air.

These assumptions are similar to those used in the LLNL EIS/EIR (DOE and UC 1992).

A comparison of GENII and the ARAC computer code developed at LLNL was given in the EIS/EIR (DOE and UC 1992). It was found that, in general, for the same source term and meteorological conditions, GENII calculates a higher dose due to the use of a simple straight-line Gaussian diffusion model. This model does not account for the meandering effect of a plume under the F-stability class meteorological condition, which increases horizontal diffusion and reduces plume concentrations. This effect accounts for a factor of 2 or 3 difference in the doses calculated by GENII and ARAC. The doses calculated by GENII are therefore very conservative.

11.1.3.3 Methodology for the Calculation of Airborne Chemical Concentrations

The methodology employed to analyze the consequences of an accidental airborne release of a hazardous chemical to the environment is similar to the methodology used in Chapter 5 of this PSAR. The consequences are determined by multiplying the emission rate by the appropriate atmospheric dispersion factor (χ/Q). The resultant concentrations are then compared to appropriate Emergency Response Planning Guidelines (ERPGs) or equivalent values.

The Environmental Protection Agency (EPA) Open Dump Model (EPA 1987) is used to calculate the emission rate for the postulated release of volatile chemicals. The model and associated inputs are fully described in Appendix 5A of this PSAR.

The emission rate for a postulated release of a nonvolatile chemical is calculated by multiplying the amount of material involved by the release fraction and dividing the result by 3,600 seconds. The one-hour time frame is used so that a meaningful comparison can be made to the appropriate ERPG or equivalent values. As described below, ERPG values are based on one-hour exposures.

The National Safety Council's ALOHA model, Version 5.05 (NSC 1991), is used to determine the χ/Q for all receptor points. The meteorological conditions used in this analysis are F Stability Category with a wind speed of 1 m/sec. The model and all other inputs are the same as those used in Chapter 5 of this PSAR. These inputs are conservative and ensure that the predicted exposures will bound the actual exposure of any event should the event actually occur.

Individual exposures at two distances from Building 494 (100 and 175 meters) are calculated. The on-site workers are assumed to be located at 100 meters, and the nearest site boundary (northern site boundary) is located at 175 meters.

ERPG values obtained from WSRC-MS-92-206 (Craig et al. 1993) are intended to provide estimates of a concentration at which adverse effects can be expected if exposure to a specified chemical lasts for more than one hour. ERPG-3 concentrations present the highest potential hazard, followed by ERPG-2 and ERPG-1 concentrations. ERPG limits are defined as follows:

- The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.
- The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

11.1.3.4 Protective Action and Protective Action Guides

For on-site personnel, LLNL has detailed plans for responding to accidents of the type described in this chapter. Chapter 19 of this PSAR describes emergency preparedness at LLNL.

For the off-site population, the need for any protective action would be based on the predicted radiation doses. The emergency response would be based on the guidance provided in the protective action guides developed by the EPA (EPA 1990). Generally, no protective action is required when the projected doses are less than 1 rem to the whole body or less than 5 rem to the thyroid; however, radiation levels should be monitored, and an advisory to seek shelter may be issued. For whole-body doses of 1 to less than 5 rem and thyroid doses of 5 to less than 25 rem, the public should be warned to seek shelter, access to the contaminated area should be controlled, environmental radiation levels should be monitored, and evacuation should be considered unless constraints make it impractical. For whole-body and thyroid doses higher than 5 and 25 rem, respectively, evacuation would be mandatory, access to the contaminated area would be controlled, and radiation levels would be monitored.

The underlying principle for the protective action guides is that, under emergency conditions, all reasonable measures should be taken to minimize the

radiation exposure of the general public and emergency workers. In the absence of significant constraints, protective actions may be implemented when projected doses are lower than the ranges given in the protective action guides.

The nonradiological protective actions are based on the DOE Order 5500.2B requirement that ERPG values be used for the consequence threshold for classification of operational emergencies. The ERPG value to initiate protective action (usually evacuation or sheltering) at LLNL is the boundary at which the airborne concentration of a particular toxic chemical decreases to the ERPG-2 (or equivalent) for that chemical. Chapter 19 of this PSAR provides additional information with regard to protective actions and emergency preparedness.

11.2 Impact of Normal Operations

This section documents the impacts of hazards associated with normal operations of the MWM Facility. The potential impacts to facility workers, the on-site population, and the off-site populations are identified and analyzed to determine what controls and mitigators are in place to maintain these impacts within acceptable levels. Many controls result from federal and state requirements and permits.

An Environmental Assessment (EA) (DOE 1993) is being developed to assess the potential environmental impacts from the operation of the MWM Facility. This EA is being prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended. NEPA requires the assessment of the potential consequences of all major federal actions that may affect the quality of the human environment. Based on the analysis reported in the EA, a decision will be made on whether an EIS is needed or a Finding of No Significant Impact (FONSI) can be issued.

A complete description of the LLNL environment and an assessment of the impacts of current and proposed management operations at LLNL are provided in the August 1992 EIS/EIR (DOE and UC 1992). The EIS/EIR projects the future modification of Building 494 for the demonstration of mixed waste treatment technologies in an Integrated Demonstration Facility, now designated as the MWM Facility.

11.2.1 Hazards and Consequences Associated with Normal Operations

11.2.1.1 Hazards and Consequences to Area Workers

Table 11-3 identifies the radioactive and chemical hazards to area workers during normal operations of the MWM Facility. The information in this table was derived from system design requirements and interviews with MWM Facility technical personnel. In-process radioactive material presents three different types of potential radioactive hazards: direct source, surface, and airborne. Two types of hazards may exist from hazardous chemicals: surface and airborne. The industrial safety hazards include electrical, motion, gravity mass, and pressure hazards.

11.2.1.1.1 Radiological Hazards and Consequences to Area Workers

All of the process areas, except the outside reagent chemical storage areas, will be handling radioactive material. Therefore, workers in the MWM Facility could receive an external radiation dose from in-process radioactive material. The incoming mixed waste has a low concentration of radioactive material (LLNL 1993b); therefore, the potential consequences from radioactive material are low.

A potential airborne radiation dose can take place in those process areas where the radioactive waste material is in an open container (Table 11-3). Mixed waste containers will be opened, inspected, and sorted in the Solids Feed Preparation (SFP) and Liquid Feed Preparation (LFP) process areas. Mixed waste samples will be opened for sampling purposes in the analytical laboratory process area. The final forms process area has several stages (i.e., drying, calcination, and cold pressing) where radioactive material could become airborne.

During normal operations of the MWM Facility, maintenance activities will be performed. These maintenance activities could pose potential surface and airborne radioactive hazards.

The MWM Facility will accept a defined set of waste streams drawn from the Hazardous Waste Management (HWM) inventory of mixed waste. Therefore, any HWM data will be a conservative basis for the MWM Facility. Based on data from 1990-1992, six exposures to HWM personnel were recorded. The maximum exposure to an HWM worker was 54 mrem, while the average exposure to these six individuals was 22 mrem (LLNL 1993c). The exposures are below the criteria established in DOE Order 5480.11 (DOE 1992c). Thus, the anticipated exposures to facility personnel at the MWM Facility are acceptable.

The consequences from process areas where there is a potential for radiological doses are mitigated as necessary by the following measures: offgas treatment systems; worker training; the use of protective clothing, goggles, and respirators; shielding; robotics (remote operator); waste being processed in an enclosure maintained at negative pressure; and the use of administrative controls such as operating procedures.

11.2.1.1.2 Chemical Hazards and Consequences to Area Workers

During normal operations at the MWM Facility, hazardous chemicals are found in the mixed waste being processed, reagents used for the process analysis, and the by-product materials. The process areas where there is a potential for hazards from hazardous chemicals are listed in Table 11-3. Mixed waste containers containing small amounts of hazardous chemicals will be opened, inspected, and sorted in the SFP and LFP process areas. Silver nitrate will be mixed manually in the Mediated Electrochemical Oxidation (MEO) process area. Personnel in the analytical laboratory process area will be opening mixed waste samples, which will contain hazardous chemicals, from the various process areas for sampling purposes and will be handling a small amount of reagents. The final forms process area will contain hazardous chemicals contained in the residues from the treatment process areas and a small amount of reagents. The outside reagent chemical storage areas store sodium hydroxide in 55-gallon drums. The potential exists for surface and airborne hazards while transferring the sodium hydroxide into smaller containers to be used inside the MWM Facility process areas. During normal operations, hazardous chemicals in the by-product materials will be in a closed system; therefore, minimal potential exists for surface or airborne hazards.

During normal operations of the MWM Facility, maintenance activities will be performed. These maintenance activities could pose potential surface and airborne chemical hazards.

Another comparison was made to the HWM facilities to determine if the chemical exposures are within established limits. Because wastes accepted into the MWM Facility would come from the HWM Division and reagents used in the MWM Facility are similar in type to those already used or handled by HWM, the analysis of health risks associated with routine chemical handling is comparable. As a result of LLNL waste treatment and storage emissions, the worst-case risk to a worker incurring a cancerous health effect was calculated to be $8.90\text{E-}07$ for a 70-year lifetime, based on EPA cancer potencies (LLNL 1992). Predicted chronic and acute noncarcinogenic effects were determined to be inconsequential based on calculated emissions being below maximum acceptable concentrations. Thus, worker exposure to hazardous chemicals at the MWM Facility is in the acceptable range.

The consequences from process areas where there is a potential for hazardous chemical exposures are mitigated as necessary by the following measures: offgas treatment systems; worker training; the use of protective clothing, goggles, and respirators; and the use of administrative controls such as operating procedures.

11.2.1.1.3 Industrial Safety Hazards and Consequences to Area Workers

The industrial safety hazards associated with the operations at the MWM Facility include electrical, motion, gravity mass, and pressure hazards. Nominal risks and accident rates associated with waste treatment and storage operations are anticipated. Occupational safety records, summarized for the LLNL site for the five-year period ending in 1990, reported an average accident rate of 2.1 per 200,000 hours worked, which equals the DOE average. This rate compares well to a 1989 national occupational injury rate of 3.2 injuries per 200,000 hours worked in industrial research and testing facilities. Forty-nine percent of those LLNL injuries were the result of overexertion (DOE and UC 1992).

11.2.1.2 Hazards and Consequences to On-Site and Off-Site Populations

The potential hazards to on-site personnel outside the MWM Facility and to the off-site populations are radioactive and chemical hazards. Nonarea workers are not exposed to industrial safety hazards associated with the MWM Facility.

11.2.1.2.1 Radioactive Hazards and Consequences to On-Site and Off-Site Populations

The airborne radiation hazards to nonarea workers are inhalation of offgas emissions, leakage, and surface contamination. The surface radiation hazards include the process water released through the water treatment system to the sewer. All process water will meet LLNL discharge limits.

Potential radiological consequences to nonarea workers from normal operations in the MWM Facility are negligible. The EIS/EIR (DOE and UC 1992) states that members of the public area surrounding LLNL may be exposed to low levels of hazardous air pollutants as a result of normal LLNL operations. The individual radiation doses to the public from all LLNL and SNL operations range from about 0.007 mrem at distances of several tens of miles to 0.25 mrem per year at LLNL's northeast fenceline. These calculated doses are small compared with the background radiation dose of 0.3 rem (300 mrem) per year and are well within DOE guidelines for the protection of the public (i.e., DOE Order 5400.5) and the EPA annual dose limit of 0.01 rem (10 mrem) for airborne releases under the National Emission Standard for Hazardous Pollutants listed in 40 CFR 61. They

are also lower than the negligible individual risk level of 0.001 rem (1 mrem) per year established by the National Council on Radiation Protection and Measurements. Potential contributions to LLNL's emission of hazardous air pollutants as a result of operating the MWM Facility would be minor, if any were to occur; and the potential impacts of this contribution are considered negligible when evaluating them against sitewide emissions and regulatory standards.

11.2.1.2.2 Chemical Hazards and Consequences to On-Site and Off-Site Populations

The airborne chemical hazards to nonarea workers may result from material releases in the form of offgas emissions. The surface chemical hazards include the process water released through the water treatment system to the sewer. All process water will meet LLNL discharge limits.

Potential hazardous chemical consequences to nonarea workers from normal operations in the MWM Facility are negligible. The MWM Facility will accept a defined set of waste streams drawn from the HWM inventory of mixed waste. Therefore, any HWM data will be a conservative basis for the MWM Facility. The worst-case risk to an off-site individual incurring a cancerous health effect due to LLNL waste treatment and storage emissions was calculated to be $6.6\text{E-}07$ per 70-year lifetime, based on EPA cancer potencies (LLNL 1992). Predicted chronic and acute noncarcinogenic effects were also determined to be negligible based on calculated emissions being below maximum acceptable concentrations (LLNL 1992). Operation of the MWM Facility would not significantly increase the cancer risk discussed above due to the low concentration of hazardous chemicals.

11.2.1.2.3 Industrial Safety Hazards and Consequences to On-Site and Off-Site Populations

Nonarea workers are not exposed to industrial safety hazards associated with the MWM Facility during normal operations.

11.3 Abnormal Operations

This section documents the safety and operational impact of the hazards associated with abnormal operations in the MWM Facility. For this PSAR, an Abnormal Operational Event (AOE) is defined as any unplanned loss of function of a safety or support system with the worst-case consequences resulting in a

shutdown of the facility or in limited personnel exposure to contamination or hazardous chemicals. Unplanned occurrences with more serious consequences are discussed in Section 11.4.2.

11.3.1 Scope of Abnormal Operational Events

The MWM Facility is a demonstration test bed that will be used to evaluate emerging technologies for the effective treatment of low-level organic mixed wastes presently stored at LLNL. These processes are described in Chapter 4 of this PSAR. Briefly, the waste materials are brought into the facility, separated by nature of liquid or solid, and then introduced into one of the three destruction processes: Mediated Electrochemical Oxidation (MEO), Molten Salt Oxidation (MSO), or Wet Oxidation (WOX). The effluent gases of each of these processes are treated in the offgas systems and released to the atmosphere. The various solids not destroyed by the processes are separated from the liquid and compacted into a very dense slug, packaged, and stored at the site until being sent off site for burial.

Each of these process systems requires some support systems to function properly. These support systems consist of electrical power, ventilation, Instrumentation and Control (I&C) equipment, specific MEO and MSO cleanup equipment, cooling water, fire protection, and miscellaneous support systems (effluent monitoring and instrument air). The causes, detection, frequency, and consequences of the failure of each of these support systems are evaluated in the following sections for impact on the facility operation and safety. Because the processes consist of various systems, the consequences of support system failures will be evaluated in five similar areas: (1) waste feed preparation, (2) process systems, (3) process support systems, (4) offgas treatment, and (5) auxiliary support systems (e.g., final forms, labs, and decon/shipping). The consequences of these failures were identified from reviews of system operating documentation and interviews with facility technical personnel.

Because the MWM Facility is a Radiological facility, DOE Orders allow the use of a "graded approach" accident analysis. This term implies that the "rigor" at which the accident analysis is performed should be comparable with the hazards associated with the facility. Since the facility has the lowest hazard classification, quantitative values for frequency of failures and the numerical consequence values are not provided. Therefore, qualitative, not quantitative, values are assumed for consequence, frequency, and risk.

11.3.1.1 Electrical Power Failures

Normal electrical power is used in the MWM Facility to provide lighting, power to process equipment (e.g., pumps, heaters, and instrumentation), and power to various support equipment, namely ventilation and fire protection. This normal electrical power will be supplied from an existing feeder cable from the exterior substation (two 1,500-kVA substations) to Motor Control Centers (MCCs) inside Building 494. The electrical supply voltage is lowered to the required equipment voltage through the use of transformers. Backup electrical power is provided automatically by a diesel generator for all important loads in the event normal power is lost. The important loads for backup electrical power include emergency lighting; process area Heating, Ventilation and Air Conditioning (HVAC) loads; and Uninterruptible Power Supply (UPS) for the control room instrumentation and fire alarm panels. The backup electrical power system permits an orderly shutdown of all MWM Facility processes so that the facility can achieve and be maintained in a safe condition (Keller and Gannon 1993).

11.3.1.1.1 Causes

The loss of normal electrical power to the facility can originate from natural events, such as Design Basis Earthquakes (DBEs), Design Basis Wind (DBW), or lightning strikes, or from equipment failures within the distribution system. From system operability reviews, the loss of the backup electrical power supply is assumed to originate from equipment failures, such as Automatic Transfer Switch (ATS) failures, fuel problems, or electrical malfunctions.

11.3.1.1.2 Detection

The loss of electrical power would be noted immediately by personnel within the facility due to the temporary loss of building lighting, the loss of all process system equipment, and the annunciation of various alarms. Start-up of the backup generator would also be noted.

11.3.1.1.3 Frequency

The failure frequency of the normal electrical power system is estimated to be high because the event is assumed to occur at least once per year. The high failure frequency conclusion is based upon the various causes of the failure and upon DOE industry evaluations (see Table 11-1). Backup electrical power was

provided because of this frequency determination. The loss of normal electrical power and the subsequent loss of backup electrical power are estimated to have a low frequency of occurrence due to the increased testing regime that accompanies the backup generator and its distribution system.

11.3.1.1.4 Consequences

The consequences associated with the loss of normal electrical power will have no adverse effect on facility safety because backup electrical power is provided to important equipment. From the information provided in Table 11-2, the consequence of the event is considered to be extremely low. This event will de-energize all process waste destruction systems (pumps, heaters, fans, etc.), which places the facility in a safe shutdown condition.

The feed preparation activities (i.e., pumping, material shredding, and characterization) will all cease upon the loss of electrical power. The equipment in this area is not supplied with backup electrical power; therefore, operations are assumed not to resume until normal electrical power is restored.

In the waste process systems, all processing will cease without normal electrical power. The equipment in this area is not supplied with backup electrical power; therefore, operations will not begin until normal electrical power is restored. Specifically, in the MEO system, the electrical current to the electrodes and pumps is removed causing the destruction process to be stopped. In the MSO process, the introduction of feed material is stopped, causing the temperature of the unit to slowly drop to an ambient level. However, the molten salt may freeze. The WOX process will have a response similar to the MSO process in that feed introduction will be stopped and the process will begin to cool (even though forced cooling is lost also). The cooling of the units places the process in a safer condition.

The process support systems for the MEO and MSO systems serve to recycle the spent solutions used in their major processes through cooling, heating, oxygenating, and centrifuging the process fluid. With the loss of electrical power, all of these operations will cease. The equipment in this area is not supplied with backup electrical power; therefore, operations are assumed not to begin until normal electrical power is restored.

The loss of process and building ventilation will occur with the loss of normal electrical power. However, some fan unit coastdown is assumed to provide a minimum amount of air movement until the backup electrical power supply is energized and aligned to its designated MCCs. The consequences of this event are discussed in Section 11.3.1.2.

The auxiliary support systems will also cease without electrical power. Their loss of function will not result in any safety concerns but will affect operation.

The total loss of normal and backup electrical power will cause all process and support equipment within the building to be de-energized. The only equipment operating at this time will be that powered by dc sources. This event should not cause the release of radioactive or hazardous materials because the mechanism by which explosive gases are generated and hazardous material is moved has been stopped. However, a sustained loss of the ventilation system could allow the accumulation of gases in some process system ductwork. The consequence of an explosive mix in this ductwork is discussed in Section 11.4.

11.3.1.1.5 Risk

The risk associated with the loss of normal electrical power is estimated to be low and acceptable. This conclusion is based upon the high frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.2 Ventilation Failures

The ventilation system in the MWM Facility consists of two systems: process vessel ventilation and process area ventilation (Keller and Gannon 1993). These systems are explained in greater detail in Chapter 4 of this PSAR. The basic concept in the process area design is to remove contaminants at the point of generation and to control pressures within the process areas by causing air flow to move from areas of slightly negative pressure to areas of more negative pressure. This technique is used to ensure that all effluents from the facility are filtered before being released to the environment. Fans and dampers are balanced to perform this design function. The ventilation system also provides dilution flow for the gases produced in the processes.

The ventilation system for each of the particular process vessels (e.g., MEO, MSO, WOX, and solid feed preparation) is isolated from the normal process area ventilation system. Prior to being released from the MWM Facility, the process vessel exhaust is mixed with the process area exhaust. An experimental offgas system is in series with the process vessel ventilation system. The experimental offgas system tests different nitrogen oxide (NO_x) removal techniques to determine process efficiencies prior to the NO_x being diluted with other waste streams. Each of the two ventilation systems has various High-Efficiency Particulate Air (HEPA) and carbon filters and standby fans which act as a backup supply.

11.3.1.2.1 Causes

The failure of either of the two ventilation systems would result in an abnormal condition in the facility. From system operability reviews, the causes of the AOE are assumed to mainly involve equipment events such as fan and damper failures, interlock failures, and power supply interruption.

11.3.1.2.2 Detection

The failure of either ventilation system would be noted immediately by personnel within the facility due to the annunciation of various alarms (i.e., DP gauges, low flow alarms). If any radioactive material is released, it would be noted by detection devices (i.e., Continuous Air Monitors [CAMs]) which would alarm if functioning properly. During times when personnel are not present in the building, notification would be made upon entrance because of various alarm annunciators.

11.3.1.2.3 Frequency

The frequency of the complete failure of either one of the ventilation systems is estimated to be moderate (see Table 11-1). This assumption is based upon the fact that backup equipment is provided to each of the ventilation systems. The routine testing of the ventilation system and its associated backup equipment increases the system's reliability.

11.3.1.2.4 Consequences

Because the ventilation system is used for control of airborne contaminants, dilution of gas buildup, and radioactive material filtration and confinement, various consequences are associated with a failure of either system (i.e., process vessel ventilation or process area ventilation). From the information provided in Table 11-2, the consequences associated with the event are considered to be extremely low. This section evaluates the loss of process vessel ventilation and the loss of process area ventilation separately for each of the five major processes and evaluates the total loss of all ventilation for these five processes. The equipment failure estimated to have the greatest impact on the facility is the loss of exhaust fans. The consequences of all other system failures (e.g., HEPA filter failure or bypass, duct leakage, and improper balancing) are bounded by this event.

In the feed preparation area, several storage tanks contain many different types of mixed wastes removed from storage containers. Without process vessel ventilation, Volatile Organic Compounds (VOCs) and hydrogen from the opened drums could be released into the process area room. Also, in this process area, the drums are opened and the waste material is removed and shredded inside a confinement module. Without the process ventilation, the potential to release radioactive material into the process area is present because of the pressure differential in the process area.

The loss of process area ventilation could cause a release of radioactive particulates if processing were allowed to continue. However, the protective and mitigative features provided by the system will not be available if a release occurs in the operational process. With the loss of both ventilation systems, an unfiltered release of radioactive material to the environment is possible. Abnormal operating procedures should require the cessation of operations without process vessel or process area ventilation.

The three major process areas and their support systems are evaluated together because of the similarities between their consequences. Without process vessel ventilation, the potential exists for the release of radioactive material or the buildup of explosive mixtures in the vessel exhaust ductwork. The production of hydrogen and VOC gases from waste processes will continue if the processes are not de-energized. After the processes are de-energized, the production rate will not be high enough to create an explosive mixture. It should be noted that, if the process area ventilation system is operational, its filter and dilution capabilities should prevent event progression to a more serious accident. Abnormal operating procedures should require the cessation of operations without process vessel ventilation.

The only ventilation failure which affects the experimental offgas system is a failure of the process vessel exhaust fans. Without the exhaust fans in operation, the experimental offgas system will not possess a driving force to cause the process offgases to move through the system. Therefore, the system is rendered inoperable.

The auxiliary process support systems perform the majority of their operations inside a confinement module because the material in these process areas could be the concentrated insoluble radioactive components of the waste. The consequences for the loss of process vessel ventilation and process area ventilation are similar to those discussed above (i.e., minor releases without process vessel ventilation and no releases without process area ventilation). With the loss of both ventilation systems, an unfiltered release of radioactive material to the environment is possible. Abnormal operating procedures should require the cessation of operations without process area ventilation.

11.3.1.2.5 Risk

The risk associated with the loss of process vessel or process area ventilation is estimated to be negligible and acceptable. This conclusion is based upon the moderate frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.3 Instrumentation and Control Failures

The MWM Facility processes are interconnected by the supervisory I&C system. This system is designed to centrally monitor the MWM Facility to determine the status of operations from a global view and, as needed, from detailed local views, and to carry out analyses and reporting based upon these observations. Also, the system allows remote control of local operations from a central control room and provides integrated control of all processes in the facility. In the event of system failure, operators can control the system locally. Local and supervisory safety controls are in place to terminate all operations if an emergency condition exists. These safety systems are adequately designed, implemented, verified, and periodically tested to ensure the protection of personnel and the environment.

11.3.1.3.1 Causes

The failures of this system are those normally associated with any type of electrical circuitry and instrumentation. The failures assumed to occur could involve improperly calibrated equipment, blown circuits, programming errors, and power losses.

11.3.1.3.2 Detection

The failure of the system will be immediately noted by Operations personnel when certain operating commands or responses are not obtained. Also, the control systems have internal diagnostics to indicate problems and are designed to fail safe. The actual failure of the system may otherwise cause tank overflows, improper reactions, or pump failures from low suction pressure, which would be readily known by Operations personnel.

11.3.1.3.3 Frequency

The failure frequency of the supervisory I&C system is estimated to be moderate because the event is assumed to occur at least once during the operation of the facility. The moderate failure frequency conclusion is based upon the various failure causes and upon DOE industry evaluations (see Table 11-1). Local process controls provide safety features that are redundant to those provided by the supervisory I&C system and serve as a backup to the primary systems.

11.3.1.3.4 Consequences

The malfunction of the supervisory I&C system could have various consequences because of all the parameters (e.g., temperature, level, pressure, and pH) that are used in the MWM Facility processes. From the information provided in Table 11-2, the consequences associated with the event are considered to be extremely low. In the feed preparation area, several processes are used to remotely open waste containers, separate the liquid and solid waste components, and store the accumulated waste in tanks. The failure of level monitors could cause pump failures or tank overflows of hazardous and radioactive materials. Also, a failure of the interlocks on the robot arm used for opening containers could allow the start-up of the process while personnel are in the workspace, thereby possibly causing injury.

In the primary process areas, failures of temperature monitors could cause the improper oxidation of waste material in the MSO process or excessive heat in the WOX process (design criteria). Increased pressure or temperature could also cause piping to leak or break, releasing hazardous waste and chemicals into the facility. Improper pH control in the MEO process could create a hydrogen mixture of gases at the electrodes. The assumption in each case is that the most severe failure of the system would only result in leakage of material outside the process enclosure.

The process support systems would have similar consequences from I&C failures as the process area. Leaks and spills of hazardous chemicals would be the major consequence. Improper operation of the support system could also cause the process system not to contain the required concentration and purity of chemical component. Also, improper amounts of chemical could be added to the WOX system, resulting in improper oxidation of the waste. These failures would be related more to operational efficiency than to safety. The failures associated with the supervisory I&C system should have no effect on the experimental offgas system or auxiliary process support systems.

11.3.1.3.5 Risk

The risk associated with I&C failures within the MWM Facility is estimated to be low and acceptable. This conclusion is based upon the moderate frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.4 MSO and MEO Support System Failures

The MSO and MEO support systems function to recycle the process medium (nitric acid or molten salt) to increase purity and to remove any accumulated insolubles. The systems use pumps to move material, heat to evaporate impurities, cooling to concentrate salts, and an oxygen scrub to reconstitute nitric acid. The systems are discussed in greater detail in Chapter 4 of this PSAR.

11.3.1.4.1 Causes

The failures associated with these systems are assumed to originate from various sources such as pump failures, heating or cooling inadequacies, and separation problems.

11.3.1.4.2 Detection

The loss of any portion of these support systems would be noted immediately by Operations personnel. Also, instrumentation and alarms are provided to indicate when the parameters are exceeding their established setpoints.

11.3.1.4.3 Frequency

The failure frequency of the MSO and MEO support systems is estimated to be high because the event is assumed to occur at least once per year. The high failure frequency conclusion is based upon the various failure causes and upon DOE industry evaluations (see Table 11-1).

11.3.1.4.4 Consequences

The consequences of any failures associated with these support systems are bounded by the events discussed previously. From the information provided in Table 11-2, the consequences associated with the event are considered to be

extremely low because the confinement barriers around the process will prevent any significant injury, illness, or impact on the environment. The only process areas to be affected are the MSO and the MEO systems. The most serious events would involve leaks and spills of hazardous material into the process areas. Less severe events would involve inadequate purification or concentration of process materials needed for waste destruction. These failures would not involve safety concerns but would affect operations.

11.3.1.4.5 Risk

The risk associated with the loss of the MEO and MSO support systems is estimated to be low and acceptable. This conclusion is based upon the high frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.5 Cooling Water Failures

The cooling water system is used in the MWM Facility to supply cooling water to the area heat exchangers and process condensers for exhaust gases. The cooling water will be low conductivity water and demineralized water from existing LLNL supplies (see Chapter 4 of this PSAR for more details).

11.3.1.5.1 Causes

AOEs in the cooling water system are assumed to originate from pump failures, header failures, corrosion, line breaks, pluggage, and valve leaks.

11.3.1.5.2 Detection

Any types of failures which involve the release of water from process piping will be readily known by the operators in the facility. Instrumentation is also present to inform operators when system pressure is low or when exit temperatures of condenser offgases are elevated.

11.3.1.5.3 Frequency

The failure frequency of the cooling water system is estimated to be high because the event is assumed to occur at least once per year. The high failure frequency

conclusion is based upon the various failure causes and upon DOE industry evaluations (see Table 11-1).

11.3.1.5.4 Consequences

The major consequences from failures noted in this system would be major leaks in the process areas or the lack of adequate flow to the exhaust gas condensers. Line breaks would allow large amounts of water to be released into the facility. The consequences of this event would be the same regardless of the specific process area affected. Process operations would cease, but no safety concerns were identified. From the information provided in Table 11-2, the consequences associated with the event are considered to be extremely low because no significant injury, illness, or impact on the environment is assumed to occur.

In the feed preparation area and the experimental offgas system, no cooling water is needed to perform any safety or operational functions. Therefore, no consequences are noted from failures of the system. In the process and support systems, failure of the cooling water system would allow hot exhaust process gases to leave the process without being cooled. This event could cause the HEPA or carbon filters to be rendered inoperable or to lose their efficiency. The high temperature will not cause the filter media to ignite but may allow increased radiological releases to the environment. In the final forms area, the loss of cooling water would prevent the system from operating but would not cause any safety concerns.

11.3.1.5.5 Risk

The risk associated with the loss of the cooling water system is estimated to be low and acceptable. This conclusion is based upon the high frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.6 Fire Protection Failures

Building 494 is currently equipped with a wet-sprinkler fire protection system. The existing sprinkler system is tied into the LLNL water distribution system, which draws from the Outer Loop Road through an 8-inch-diameter line. Various alarms and detectors are provided to ensure actuation of the system. The power supply to the fire control panel is provided with a separate UPS.

11.3.1.6.1 Causes

The failures of this system are assumed to be caused by electronic failures of detection equipment or by pump failure problems.

11.3.1.6.2 Detection

Periodic surveillances of system performance are required by National Fire Protection Association (NFPA) code documentation and DOE Order 5480.7A (DOE 1993b). Any failures would be noted by Operations personnel.

11.3.1.6.3 Frequency

The failure frequency of the fire protection system is estimated to be moderate. The moderate failure frequency conclusion is based upon the various failure causes and upon DOE industry evaluations (see Table 11-1).

11.3.1.6.4 Consequences

The fire protection system can fail in two ways: a premature actuation or no actuation when required. A premature actuation would only result in operational concerns. The failure of the system to operate would not create any safety problem unless there was a current, real demand on the system. The consequences of this event would be the same regardless of the specific process area affected. Process operations would cease, but no safety concerns were identified. From the information provided in Table 11-2, the consequences associated with the event are considered to be extremely low because no significant injury, illness, or impact on the environment is assumed to occur. Abnormal procedures should require the cessation of operation and provide for compensatory actions. Section 11.4.2.4 discusses the event consequences for a fire in the MWM Facility. The Fire Department has a response time of less than 5 minutes, but no credit is taken for this action in the accident analysis.

11.3.1.6.5 Risk

The risk associated with the loss of the fire protection system is estimated to be low and acceptable. This conclusion is based upon the high frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.3.1.7 Miscellaneous Support System Failures

The effluent monitoring system and the instrument air system have been combined into one section because their failures result in similar consequences and because little is known about their design. The effluent monitoring system consists of several instruments which monitor the facility exhaust after being treated by HEPA filters. The instrumentation is connected to the supervisory I&C system, which provides readings and annunciation on high levels of contaminants. The instrument air system is used to provide a motive force to open and close valves and to supply various equipment.

11.3.1.7.1 Causes

The failures of these systems are assumed to be caused by compressor failures, instrument failures, line breaks, and leaks.

11.3.1.7.2 Detection

The instrument air failures would be detected by pressure alarms and possible valve closures. Effluent monitoring failures would be detected by personnel, alarm annunciations, and periodic calibrations.

11.3.1.7.3 Frequency

The failure frequency of the two systems is estimated to be high because the event is assumed to occur several times during the facility's lifetime. The high failure frequency conclusion is based upon the various failure causes and upon DOE industry evaluations (see Table 11-1).

11.3.1.7.4 Consequences

The loss of either of these two systems may result in a facility shutdown. Valves are assumed to close due to the loss of instrument air. The loss of effluent monitoring could allow a failure of the passive filtration mechanisms (i.e., HEPA filters, scrubber, and charcoal beds) to go unnoticed, thus allowing the release of radionuclides into the environment without being properly monitored. From the information provided in Table 11-2, the consequences associated with the event are considered to be extremely low.

11.3.1.7.5 Risk

The risk associated with the loss of either system is estimated to be low and acceptable. This conclusion is based upon the high frequency and extremely low consequences associated with this event and upon the fact that risk is a product of these two parameters. Figure 11-1 provides the risk comparison criteria.

11.4 Accident Analysis

This section presents analyses of accidents that have the potential to produce measurable consequences at the MWM Facility. Section 11.4.1 summarizes the accident screening, Section 11.4.2 presents the analysis of radiological and chemical accidents including the Bounding Accidents, and Section 11.4.3 discusses the Beyond Design Basis Accidents.

11.4.1 Accident Screening

The accidents that may result in a release of hazardous or radioactive material to the environment are analyzed in the following sections. These accidents were identified by a hazard identification and characterization process and an accident screening process as described in Appendix 11A.

Once the MWM Facility hazards were identified, each process area was screened against possible accidents to determine the applicable accidents. A summary of the MWM Facility accident screening is provided in Table 11-4.

Radionuclide Source Term

The radionuclide inventory for the MWM Facility was compiled from the mixed waste streams generated at LLNL between January 1991 through June 1992 and considered for use in MWM Facility treatment demonstrations. The mixed waste streams include Trimsol, chlorinated solvents, oils, plating solutions, solvents, combustible solids, sludges, and scintillation cocktails. The acidic, basic, and neutral wastewater streams are not included since these waste streams will not be treated in Building 494.

As shown in Chapter 5 of this PSAR, the entire Fiscal Year (FY 91) radionuclide inventory is significantly less than the Hazard Category 3 threshold limits identified in DOE-STD-1027-92 (DOE 1992a);, thus, the MWM Facility radionuclide limits have been established as follows:

- 10.0 percent of the Hazard Category 3 threshold limits for each nuclide.

- The sum of the ratios for all nuclides is 10.0 percent of the Hazard Category 3 threshold limit.

These limits provide operational flexibility since the individual nuclide limits are approximately two times larger than the amounts projected in the entire one-year inventory. Thus, the radionuclide source term for the accident analysis is conservatively assumed to be 10.0 percent of the Hazard Category 3 threshold limit.

The Hazard Category 3 threshold limits apply to several hundred nuclides. As described in DOE-STD-1027-92, a release of any nuclide at the Hazard Category 3 threshold limit results in approximately the same consequences. For this analysis, Pu-239 was selected to represent all nuclides because of the availability of airborne release fractions, although during actual operations only trace quantities of Pu-239 may be present.

Ten percent of the Hazard Category 3 threshold limit for Pu-239 is 0.052 Ci. Based on a maximum of 100 nCi/g (since TRU waste will not be accepted at the MWM Facility), at least 520 kg of waste is required to contain 0.052 Ci of Pu-239. Low-level waste contains less than 100 nCi/g of TRU isotopes.

It should be noted that, due to differences in general parameters such as airborne release fractions and type of radiation, slight variations in the consequences would result upon the evaluation of different radionuclides. However, the conservative parameters used in this analysis ensure that the predicted consequences will bound the actual consequences of any accident.

Chemical Source Term

An accident in the MWM Facility can involve any of the chemicals present as wastes, reagents, or process by-product materials. Chapter 5 of this PSAR summarizes the chemical inventory. The analysis performed in this section is based on the total mixed waste inventory at LLNL between January 1991 and June 1992 (LLNL 1993b) plus the sludge and waste oil streams (LLNL 1993a), reagents, and process by-product materials.

To maintain the accident analysis at a manageable level, the list of chemicals evaluated was screened as follows:

- The chemicals that resulted in a Low Hazard classification (as opposed to Excluded) for the MWM Facility were obtained from Chapter 5 of this PSAR. These chemicals include hydrogen peroxide, silver nitrate, nitric acid, and trichlorofluoromethane.

- Trichlorofluoromethane was removed from the list of chemicals to be evaluated for the following reason: in Chapter 5 of this PSAR, the chemical was conservatively assigned a Low Hazard classification (instead of Excluded) based on the off-site evaluation because no criteria for the Excluded classification are available for the off-site evaluation. However, the on-site and ERPG-3 evaluations in Chapter 5 resulted in an Excluded classification. Based on the latter two evaluations, trichlorofluoromethane was not evaluated further.

Consequently, the chemicals evaluated in this analysis are hydrogen peroxide, silver nitrate, and nitric acid. The amount of each chemical that could be involved in each accident is shown by process area in Table 11-5. These values are conservative since they represent the maximum quantity in a container, tank, or vessel for that process area.

11.4.2 Analysis of Accidents

The accidents analyzed in this section that may result in a release of radioactive and/or hazardous material are as follows:

- Earthquake
- Extreme wind or tornado
- Flood
- Fire
- Leaks and spills
- Pressurized releases
- Criticality
- Explosion
- Aircraft crash
- Uncontrolled chemical reactions
- Bounding Accidents.

For each of the postulated accidents, the cause, detection method, frequency, consequence, and risk are discussed. A qualitative estimate of the probability of occurrence of each event is combined with an appropriate qualitative estimate of the severity of the event to determine the risk associated with each event and the overall level of facility risk.

Transportation accidents involving the shipment by truck or train of hazardous waste containers outside the MWM Facility are not considered in this PSAR. These accidents are addressed in Appendix D of the EIS/EIR (DOE and UC 1992).

Accidents occurring at nearby LLNL facilities which might have an impact on the MWM Facility include accidents involving high explosives in Buildings 164, 191, 224, 225, and 226. These events are analyzed in Appendix D of the EIS/EIR. The MWM Facility is located over 2,300 feet (700 meters) from any of these facilities. Thus, the consequences to MWM Facility operations from any accident originating at these facilities are expected to be minimal.

Accidents occurring at nearby off-site industrial facilities might have an impact on the MWM Facility. Although no evaluation has been performed for these facilities, the effect on MWM Facility operations is expected to be minimal. At most, an off-site accident may result in injury to an operator due to chemical exposure, which could lead to an operator-induced accident at the MWM Facility. However, the consequences of an off-site accident at the MWM Facility would be no greater than the consequences analyzed in the following sections.

11.4.2.1 Earthquake

The earthquake analysis involves an evaluation of all earthquakes with a magnitude up to and including the DBE. Applying the graded approach results in an evaluation of just the DBE since the consequences of the DBE are assumed to bound the consequences of all earthquakes with a smaller magnitude. An evaluation of earthquakes whose magnitude exceed the DBE is provided in Section 11.4.3.

As described in Chapter 6 of this PSAR, the DBE for a Hazard Category 3 facility at LLNL is 0.57g. The MWM Facility is located in Building 494, which is designed to withstand the DBE; therefore, no building structural failures were assumed to occur during the DBE. The process equipment including piping, waste feed holding tanks, reagent storage tanks, and spent reagent holding tanks used in the process areas are also designed to withstand the DBE without structural failure.

Small radioactive or hazardous material releases may result from the DBE due to falling of the waste drums or containers in the receiving and shipping area, liquids or solids feed preparation areas, and other process areas. Small laboratory samples may also fall and spill their contents. Table 11-4 provides the locations where a DBE may affect the MWM Facility, and Table 11-5 identifies the amounts of hazardous chemicals that may be involved.

Based on this information, the following scenarios are postulated to occur during the DBE:

- The DBE causes a spill of mixed wastes from one or more drums, releasing 0.052 Ci of Pu-239 to the ground. For conservatism, a fire is assumed to occur following the spill because of the presence of combustible constituents in the waste.
- The DBE causes small containers of laboratory reagents to fall and break open, releasing 1 gallon of nitric acid and 1 gallon of hydrogen peroxide.

No release of silver nitrate is postulated to occur during the DBE because silver nitrate is only contained within the MEO process and associated support systems, which are designed to withstand the DBE.

11.4.2.1.1 Causes

An earthquake is a natural phenomenon caused by the movement of the earth's tectonic plates or volcanic activity. A fire following the earthquake could be caused by damage to the natural gas pipeline near or at the Building 494 connection point (southwest corner of the building).

11.4.2.1.2 Detection

A 0.57g earthquake is detected by personnel and equipment in the MWM Facility. Damage to individual waste or reagent containers would be detected by facility personnel following the earthquake event.

11.4.2.1.3 Frequency

As discussed in Chapter 6 of this PSAR, the frequency of occurrence for a 0.57g earthquake is 1.0E-03/yr. In accordance with Table 11-1, this corresponds to a frequency of low.

11.4.2.1.4 Consequences

Radiological Consequences

To conservatively model the consequences of a DBE, the maximum facility radiological inventory is assumed to be released to the ground. This is equivalent to 0.052 Ci of Pu-239. Since the maximum facility inventory is assumed to be released, the number of drums that spill their contents or the concentration of Pu-239 in the waste is not relevant for this evaluation.

To ensure that the modeled consequences envelope the range of consequences associated with a DBE, a fire is assumed to occur. The associated release fraction for Pu-239 in a nonvolatile, combustible liquid is $1.3\text{E-}02$ (Ayer et al. 1988). Therefore, the maximum amount of Pu-239 released to the air is $6.8\text{E-}04$ Ci. No credit is taken for HEPA filters or other safety features.

As shown in Table 11-6, this airborne release is equal to the largest release for all postulated accidents. Section 11.4.2.11 provides further analysis and demonstrates that the radiological consequences associated with the DBE are low.

The dose to the operator for the DBE is also calculated in Section 11.4.2.11.

Nonradiological Consequences

Since the MWM Facility is designed to withstand the DBE, no large chemical leaks are postulated to occur. However, small bottles of laboratory reagents may fall and break open. Thus, during the DBE, 1 gallon of hydrogen peroxide and 1 gallon of nitric acid are assumed to be released as liquids during the DBE.

To conservatively model the consequences, the analysis assumes that the entire one gallon inventory of each chemical becomes airborne during the one-hour period following the DBE. The mechanism for the release (fire or spill) is not relevant since the entire inventory is assumed to become airborne. Additionally, no credit is taken for any safety features.

As shown in Table 11-7, the emission rates associated with these releases are smaller than the emission rates due to other events (i.e., fire or spill); thus, the consequences of the DBE are bounded by the consequences of other events.

In accordance with Table 11-2, the nonradiological consequences associated with the DBE are judged to be low because the airborne release during the DBE is smaller than the airborne release during other events and because the consequences of these other events are shown to be low.

11.4.2.15 Risk

Applying the frequency and consequence ratings to Figure 11-1, the associated risk from a DBE is negligible and in the acceptable range.

11.4.2.2 Extreme Wind or Tornado

The extreme wind analysis involves an evaluation of all winds with a wind speed up to and including the DBW. Applying the graded approach results in an evaluation of just the DBW since the consequences of the DBW are assumed to bound the consequences of all extreme winds with a lower wind speed.

The DBW for a Hazard Category 3 facility is 72 mph at 10 meters above the ground (Kennedy et al. 1990). Because straight winds of 72 mph occur with a much greater frequency than tornadoes, tornadoes are not included in the design basis for Hazard Category 3 facilities; therefore, no tornado evaluation was performed.

Building 494 is designed to withstand the DBW, and therefore damages to the building structures in the DBW were not postulated. All tanks associated with the MWM Facility located outside of Building 494 are also designed to withstand the DBW. Consequently, no radioactive or hazardous materials are assumed to be released as a result of the DBW.

Wind-generated missiles are not required to be considered in the evaluation of facilities with a Radiological/Low Hazard classification (Kennedy et al. 1990). However, an evaluation of consequences due to Beyond Design Basis Accidents, including wind-generated missiles, is included in Section 11.4.3.

11.4.2.2.1 Causes

The DBW is caused by natural phenomena.

11.4.2.2.2 Detection

The DBW is detected by MWM Facility personnel and by equipment.

11.4.2.2.3 Frequency

The frequency of the DBW for the MWM Facility is $1.0\text{E-}02/\text{yr}$ (Kennedy et al. 1990), which corresponds to a frequency of moderate in accordance with Table 11-1.

11.4.2.2.4 Consequences

Since no radioactive or hazardous materials are released as a result of the DBW, there are no on-site or off-site radiological or nonradiological consequences.

Downed power lines with a resulting loss of power at the MWM Facility may occur during the DBW. A discussion of loss of power at the MWM Facility is included in Section 11.3. Loss of power at the MWM Facility is not expected to result in any off-site releases.

11.4.2.2.5 Risk

Since there are no radiological or nonradiological consequences during a DBW, there is no risk presented by the MWM Facility due to the DBW.

11.4.2.3 Flood

The flood analysis includes an evaluation of all floods with a water level up to and including the Design Basis Flood (DBF). Applying the graded approach results in an evaluation of just the DBF since these consequences are assumed to bound the consequences of all other flooding events.

As described in Chapter 6 of this FSAR, the DBF for the MWM facility has a return period of 2,000 years. While a probabilistic flood hazard evaluation has not been performed for the LLNL site, one has been conducted for Sandia National Laboratory (SNL), Livermore (Savy and Murray 1988). That study concluded that minor flooding in some SNL locations could occur due to local precipitation and the resulting arroyo overflow. The SNL site adjoins the LLNL site to the south, and both sites are subject to the same types of local precipitation, arroyo overflow, and resulting flooding (DOE and UC 1992). Thus, some flooding of the LLNL site is expected to occur during the DBF.

11.4.2.3.1 Causes

Flooding is caused by natural phenomena.

11.4.2.3.2 Detection

Flooding at LLNL and the MWM Facility is detected by facility personnel and by equipment. MWM Facility personnel would receive prior notification through

the National Weather Service and/or other sources before the flood reaches the MWM Facility.

11.4.2.3.3 Frequency

The frequency of the DBFI for LLNL is $5.0\text{E-}04/\text{yr}$ (Kennedy et al. 1990), which corresponds to a frequency of low in accordance with Table 11-1.

11.4.2.3.4 Consequences

In the event of the DBFI, the MWM Facility could be impacted by the flood water. Although no formal analysis has been conducted for the MWM Facility, it is assumed that, prior to any flooding of the facility, there would be sufficient time for LLNL personnel to take measures to prevent any damage to mixed waste holding tanks, reagent storage tanks, spent reagent holding tanks, other process equipment, and to shutdown the waste treatment units. Furthermore, a review of the EIS/EIR evaluation of the 100-year flood indicates that overflow of either Arroyo during the 100-year flood will not impact the MWM facility (DOE and UC 1992).

In addition, the consequences of the DBFI are expected to be minimal for the following reasons:

- The height of the water above normal ground level is not expected to be large due to the natural slope of the LLNL site. Thus, storage tanks are not expected to be damaged during the flood.
- The hazardous material located in the MWM facility is stored in closed containers. Thus, the stored material will not be released to the environment.
- Normal MWM operating practices require surface contamination of the containers to be negligible. Thus, the contamination of the flood water will be minimal.

Therefore, no release of radioactive or hazardous material is postulated to occur during the DBFI. However, some facility and equipment damage is expected to occur.

11.4.2.3.5 Risk

Since the DBFI for the MWM Facility results in no radiological or nonradiological consequences, there is no risk for the DBFI.

11.4.2.4 Fire

Fire is postulated for the MWM Facility process areas where combustible materials are present. The worst fire scenario involving radionuclides is a fire in the liquids or solids feed preparation area where containers are opened and contents are removed. The combustible liquids (i.e., solvents or oils) or combustible solids in the containers are ignited and burned releasing radionuclides from the containers. A fire in these areas would be the worst-case scenario since most of the combustible liquids or solids are accumulated in these areas while awaiting transfer to the treatment areas.

Fires involving hazardous material are postulated to occur in each area shown in Table 11-4. Table 11-5 indicates the maximum amount of hazardous chemicals in each applicable process area.

Based on this information, the following fire scenarios are postulated:

- A waste solvent fire in one of the MWM Facility process areas involves 0.052 Ci of Pu-239.
- A fire in the reagent storage area outside Building 494 heats up the hydrogen peroxide storage tank, which stores 3,000 gallons of 50 percent hydrogen peroxide, releasing hydrogen peroxide through the relief valve.
- A fire occurs at the MEO unit or its support system, which contains 2,500 pounds of 13M nitric acid solution and 400 pounds of silver nitrate, releasing nitric acid and silver nitrate from the treatment vessel.

Since these events involve the maximum inventories that could be involved in a fire, these scenarios are designated as the Bounding Fires.

11.4.2.4.1 Causes

A fire within the MWM Facility could occur as a result of any of the following:

- A short in electrical equipment, or maintenance activities such as welding.

- Feed preparation operations such as shredding or grinding.
- Uncontrolled chemical reactions.
- Incorrect handling of pyrophoric materials such as uranium or lithium hydride.
- Operator error leading to puncturing or breaking open a drum during forklift operations causing a fire.

11.4.2.4.2 Detection

Fire is detected by facility personnel or equipment such as fire or smoke detectors.

11.4.2.4.3 Frequency

In accordance with Table 11-2, the overall frequency of any fire in the MWM Facility is judged to be moderate for the following reasons:

- The probability of an electrical fire or a fire caused by maintenance at Building 494 is judged to be low based on the frequency of fires at other LLNL facilities.
- The probability of a fire occurring as a result of solid waste shredding, or grinding during solid feed preparation is low because the only identified ignition sources are friction and static electricity.
- The probability of a fire occurring as a result of uncontrolled chemical reactions is low based on the fact that MWM Facility personnel will be trained and will follow written procedures.
- The probability of a uranium-based fire is low since the MWM Facility is a demonstration facility and will handle a minimum number of drums containing depleted uranium chips and Trimsol.
- The probability of a fire occurring as a result of a drum handling accident is low because the frequency of a drum or container handling accident in which the drum or container is punctured or broken open and the contents spilled on the floor is judged to be low. The probability of the contents catching fire is even lower because the only identified ignition sources are friction and static electricity (Salazar et al. 1990).

The combination of the individual fire probabilities is assumed to result in a moderate probability of any fire at the MWM Facility. However, the overall probability of any fire becoming a Bounding Fire is judged to be low because of the low combustible loading throughout the facility, facility emergency procedures, facility fire protection systems, and the response of the site fire department.

11.4.2.4.4 Consequences

Radiological Consequences

To conservatively model the consequences of the Bounding Fire, the maximum radiological inventory is assumed to be involved. This inventory is equivalent to 0.052 Ci of Pu-239. To maximize the source release fraction, the Pu-239 is assumed to be in nonvolatile, combustible liquid waste. The associated release fraction is $1.3\text{E-}02$ (Ayer et al. 1988). Therefore, the amount of Pu-239 released to the air is $6.8\text{E-}04$ Ci. No credit is taken for HEPA filters or other safety features.

As shown in Table 11-6, this airborne release is equal to the largest release for all postulated accidents. The Section 11.4.2.11 provides further analysis and demonstrates that the radiological consequences associated with the Bounding Fire are low.

Nonradiological Consequences

Silver Nitrate

Silver nitrate is used in the MEO process as a dissolved solid in a liquid. To conservatively model the consequences due to a release of silver nitrate during the Bounding Fire, the entire inventory of 400 pounds is assumed to be involved in the fire. The associated release fraction for a dissolved solid in a noncombustible liquid is $1\text{E-}04$ (LANL 1986).

Assuming the release occurs over a one-hour period, $4.0\text{E-}02$ pounds of silver nitrate are released to the air at a rate of 5.05 mg/sec. As shown in Table 11-7, this emission rate is equal to the largest emission rate for all postulated accidents. Section 11.4.2.11 provides further analysis and demonstrates that the associated consequences are low.

Hydrogen Peroxide

Hydrogen peroxide is used in the WOX process at the MWM Facility. As shown in Table 11-5, the largest amount of hydrogen peroxide is located in the storage tank outside of Building 494. The Bounding Fire scenario assumes that a fire

occurs near the storage tank, heats up the hydrogen peroxide, and releases it by evaporation through a safety or relief valve. The storage tank is assumed to remain intact during the fire.

A number of undefined parameters are required to analyze this fire scenario, the most important of which are the surface area of the hydrogen peroxide (a function of the tank dimensions), the size of the fire, and the duration of the fire. Since these parameters could vary widely, the Bounding Fire scenario was compared to the Bounding Spill scenario to identify reasonable numbers.

As shown in Appendix 11B, a fire involving approximately 387 gallons of gasoline (or equivalent fuel) is required to obtain an emission rate (3 g/sec for hydrogen peroxide) equal to the rate calculated for the Bounding Spill event. To reach this emission rate, the 387 gallons of gasoline would be consumed within minutes. At that time, the fire would end and the temperature of the hydrogen peroxide and associated emission rate would begin to decrease. This evaluation assumes a tank height of 10 feet and a radius of 3.6 feet.

During the Bounding Spill, the emission rate is assumed to remain constant for one hour. Thus, more than 387 gallons of gasoline would be required to maintain an emission rate in the Bounding Fire equal to the emission rate in the Bounding Spill. The only fuel identified near the storage tank is transient fuel associated with a forklift or other moving vehicle. No storage of any combustible material is assumed to occur near the storage tank. Since the vehicles will carry significantly less than 100 gallons of fuel, and since no storage of combustible material is allowed near the storage tank, any fire in the area will be smaller and of shorter duration than the Bounding Fire analyzed in this section.

Based on this information, the emission rate that could occur during the Bounding Fire is estimated to be less than the emission rate that could occur during the Bounding Spill event. Thus, the consequences of the Bounding Fire involving hydrogen peroxide will be less than the consequences of the Bounding Spill of hydrogen peroxide.

Nitric Acid

Nitric acid is used in the MEO process and support systems. A fire in the MEO process area is expected to melt portions of the MEO process piping, resulting in a leak of nitric acid. Nitric acid is a noncombustible liquid; thus, the release mechanism during a fire is evaporation.

There are little or no combustibles stored in the MEO process area; thus, the only combustibles in the area are associated with the MEO system itself (e.g., wiring

and plastic). Therefore, any fire in the area is assumed to only impact one process area, either the MEO primary process, the silver recovery process, or the acid recovery process.

The major variables in this evaporation calculation are the temperature of the nitric acid and the surrounding air temperature. Prior to the fire, the nitric acid is maintained at 70°C within the MEO system (Conceptual Design Report [CDR] [LLNL 1994]) and the surrounding air is conservatively assumed to be at 35°C. During the fire, the average temperature of the nitric acid and the surrounding air will change, depending on the size of the spill, and the size and location of the fire.

This analysis conservatively assumes that the average temperature of the nitric acid during and after a fire over a one-hour period will be less than the initial 70°C temperature for the following reasons:

- During the fire, the nitric acid will leak out of the affected system and collect in the sump located directly below the affected process. Since the nitric acid collects below or along side the fire, the temperature of the nitric acid will not be affected significantly.
- The combustible loading in the area is estimated to be much lower than the combustible loading analyzed in the hydrogen peroxide calculation shown in Appendix 11B. Thus, a fire involving the MEO system is expected to be small and/or of short duration.

Thus, the average temperature of the nitric acid for the hour after it is released from the affected system is expected to be less than 70°C. To conservatively model the temperature, it is assumed to remain constant at 70°C.

As shown in Appendix 11C, the associated emission rate is 2.9 g/sec. This scenario assumes that the sumps in the MEO process area limit the dimensions of the spill to 7.9 meters by 1.4 meters (LLNL 1994). Assuming the sumps limit the surface area of the spill, the quantity of nitric acid spilled is not relevant to this calculation.

As shown in Table 11-7, this emission rate is equal to the largest emission rate for all nitric acid events. Section 11.4.2.11 provides further analysis and demonstrates that the consequences associated with this event are low.

A fire involving the outdoor nitric acid storage tank is expected to leave the storage tank intact, thus a fire is expected to increase the temperature of the nitric acid. As shown in Appendix 11C, the emission rate that may occur during a fire (assuming a path to the environment exists) involving the storage tank is less

than the emission rate previously calculated for the MEO and storage tank are support systems. Thus, the consequences are bounded by consequences for the events in support systems.

the MEO and storage tank are support

11.4.2.4.5 Risk

Applying the frequency and consequence risk from a Bounding Fire is low and in the

the associated

11.4.2.5 Leaks and Spills

Leaks were postulated to occur in all waste containers independently on all types of waste containers. At any time is postulated to leak its contents.

Since leaks act on container at a

Leaks could also develop in the offgas treatment system cracks in the fan duct. Hazardous and/or system and accumulate in the process areas.

air reversal or could leak from the

Waste containers or reagents being moved by forklift and break open causing spills. Spills from waste holding tanks, reagent storage tanks, spent reagent tanks or vessels. Waste tank or reagent tank independent events; thus, it was assumed that a reagent tank can spill its contents at a time.

could fall from a waste holding tank or waste treatment tank to be caused by tank or one

Leaks are postulated to occur in each area of the facility. Table 11-5 indicates the maximum amount of hazardous waste in each process area. Based on this information, the following are postulated to occur:

Table 11-5
applicable
are postulated to

- Operator error and/or equipment failure releasing 0.052 Ci of Pu-239 to the ground
- Operator error and/or equipment failure releasing contents of the hydrogen peroxide storage tank, releasing 3,000 gallons of 50 percent hydrogen peroxide
- Operator error and/or equipment failure releasing contents of the largest nitric acid holding tank in the MEO support system, releasing 2,500 gallons

of mixed wastes,

of the entire Building 494,

of the entire associated piping in the MEO support system for nitric acid.

- Operator error and/or equipment failure causes a spill of the entire contents of silver nitrate in the MEO unit, releasing 400 pounds of silver nitrate.

Leaks in the offgas treatment system were not evaluated further because of the low concentration of gases in the offgas treatment system.

Since these events involve the maximum inventories that could be involved in a spill (or leak), these scenarios are designated as the Bounding Spills.

11.4.2.5.1 Causes

Leaks are caused by corrosion in waste containers, operator error, equipment failure in waste and reagent holding tanks, or improper maintenance.

The cause of the leakage in the offgas treatment system is due to air reversal or cracks in the welded regions and seams in the exhaust fan duct.

Waste container spills are caused by handling errors while tank spills are caused by either operator error or equipment failure.

Backflow into or contamination of the hydrogen peroxide storage tank could cause the pressure in the tank to increase, resulting in a leak. Additionally, entrapment of hydrogen peroxide in the piping between valves could result in a valve leak due to a pressure buildup.

11.4.2.5.2 Detection

Leaks and spills are detected by personnel in the MWM Facility and by process control instrumentation and equipment. Leaks in the offgas treatment system are detected by process equipment.

11.4.2.5.3 Frequency

The overall frequency of a leak or spill of any size at the MWM Facility is judged to be high. However, the overall frequency of a large leak or spill similar to those postulated above is judged to be low for the following reasons:

- The frequency of leaks in waste containers is low because waste containers will be inspected for signs of leakage before they are brought into Building

494. Regular equipment inspections and corrective maintenance as required would result in a low frequency for tank leaks and offgas treatment system leaks.

- The frequency of a waste container spill is judged to be low. While the drum handling accident frequency is moderate, actually puncturing or breaking open the drum or container and spilling the contents on the floor would occur with a low frequency.
- The frequency of spilling the contents from a waste or reagent tank is judged to be low assuming that tank operations are performed by trained operators using approved procedures and that regular maintenance is performed.
- The frequency of a leak in the hydrogen peroxide storage tank or piping due to backflow, contamination, or entrapment is judged to be low, based on the assumption that the final design will incorporate physical features (such as check valves) and careful use of elevation changes to prevent these events from occurring.

11.4.2.5.4 Consequences

Radiological Consequences

To conservatively model the consequences of a leak or a spill, the maximum radiological inventory is assumed to be released to the ground. This inventory is equivalent to 0.052 Ci of Pu-239. For a leak or spill, the release mechanism to the air is resuspension and the associated release fraction is less than 1E-04 (LANL 1986). Therefore, the amount of Pu-239 released to the air is less than 5.2E-06 Ci. As shown in Table 11-6, this airborne release is smaller than the release during the Bounding Fire; thus, the consequences of this event are bounded by the consequences of the Bounding Fire.

In accordance with Table 11-2, the radiological consequences associated with the Bounding spill are judged to be low because the airborne release during the Bounding Spill is smaller than the airborne release during the Bounding Fire and because the consequences of the Bounding Fire are shown to be low.

Nonradiological Consequences

Silver Nitrate

The silver nitrate leak scenario assumes that the entire silver nitrate inventory is released to the ground (400 pounds) as a dissolved solid in a liquid. The release

mechanism to the air is resuspension with an associated release fraction of less than $1\text{E-}04$ (LANL 1986). Thus, the amount of silver nitrate released to the air is less than $4\text{E-}02$ pounds. As shown in Table 11-7, the associated emission rate is smaller than the emission rate during the Bounding Fire. Thus, the consequences of the Bounding Spill are bounded by the consequences of the Bounding Fire.

In accordance with Table 11-2, the consequences associated with the Bounding Spill of silver nitrate are judged to be low because the emission rate during the Bounding Spill is smaller than the emission rate during the Bounding Fire and because the consequences of the Bounding Fire are shown to be low.

Hydrogen Peroxide

The hydrogen peroxide leak scenario assumes that the entire hydrogen peroxide storage tank inventory of 3,000 gallons at 50 wt% leaks to the ground as a liquid and is released to the air through evaporation. As shown in Appendix 11C, the associated emission rate is 3.0 g/sec.

This scenario assumes that a bermed area around the tank limits the size of any spill such that the longest dimension of the spill is 84 feet. Assuming a square berm and a 3,000-gallon spill, the berm height required to contain the leak is approximately 2.2 cm.

Based on the CDR (LLNL 1994), the estimated berm size is 20 feet by 20 feet. Therefore, the actual release associated with a spill from the storage tank will be bounded by the results presented in this analysis.

As shown in Table 11-7, this is the largest emission rate for all hydrogen peroxide events. Section 11.4.2.11 provides further analysis and demonstrates that the consequences associated with this event are low.

Nitric Acid

The nitric acid leak scenario assumes that the entire MEO inventory of nitric acid (2,500 pounds) leaks to the ground as a liquid and is released to the air through evaporation.

The major variables in this evaporation calculation are the temperature of the nitric acid and the temperature of the surrounding air. Within the MEO system, the nitric acid is maintained at 70°C (LLNL 1994) and the surrounding air is estimated to be at 35°C . After leaking to the ground, the nitric acid will cool down, and the emission rate will decrease.

This scenario is conservatively modeled as follows: the nitric acid is assumed to collect in the largest sump with surface dimensions of 7.9 meters by 1.4 meters,

and the nitric acid temperature is assumed to remain constant at 70°C for the duration of the event. Assuming the sumps limit the surface area of the spill, the quantity of nitric acid that is released is not relevant to this calculation.

The associated emission rate is 2.9 g/sec. This is the largest emission rate for all nitric acid leaks including a leak from the nitric acid storage tank. See Appendix 11C for additional details concerning the emission rate calculations.

As shown in Table 11-7, this is equal to the largest emission rate for all nitric acid events. Section 11.4.2.11 provides further analysis and demonstrates that the consequences associated with this event are low. In accordance with Table 11-2, the consequences associated with the Bounding Spill of nitric acid are judged to be low.

11.4.2.5.5 Risk

Applying the frequency and consequence ratings to Figure 11-1, the associated risk from a leak or a spill event is negligible and in the acceptable range.

11.4.2.6 Pressurized Releases

A pressurized release could occur at the discharge side of a transfer pump used to pump liquid waste or reagents through a waste treatment unit or its support system. Table 11-4 identifies the process areas where pressurized releases are postulated to occur. Table 11-5 identifies the amount of hazardous material that may be involved in a pressurized release.

Based on this information, the following scenarios are postulated to occur:

- Equipment failure causes a pressurized release of mixed wastes, releasing 0.052 Ci of Pu-239 to the ground.
- Equipment failure causes a pressurized release involving 3,000 gallons of 50 wt% hydrogen peroxide from the hydrogen peroxide storage tank outside Building 494.
- Equipment failure causes a pressurized release involving 2,500 pounds of nitric acid from the MEO and MEO support systems.
- Equipment failure causes a pressurized release involving 400 pounds of silver nitrate in the MEO unit.

Since these events involve the maximum inventories that could be involved in a pressurized release, these scenarios are designated as the Bounding Pressurized Releases.

11.4.2.6.1 Causes

Pressurized releases are caused by equipment failure and/or operator error.

11.4.2.6.2 Detection

Pressurized releases are detected by personnel in Building 494 and by process equipment and instrumentation.

11.4.2.6.3 Frequency

The frequency of a pressurized release is judged to be low because regular equipment inspections and corrective maintenance will be performed.

11.4.2.6.4 Consequences

There are two mechanisms for the liquid to become airborne during a pressurized release: the amount made airborne by the pressurized release, and the amount that evaporates or is resuspended as a result of evaporation of the material that accumulates on the ground.

Radiological Consequences

To conservatively model the consequences of a Bounding Pressurized Release, the maximum radiological inventory is assumed to be involved. This inventory is equivalent to 0.052 Ci of Pu-239. As shown in Appendix 11D, the associated release fraction for a pressurized release is $1\text{E-}04$. As previously identified, the release fraction associated with resuspension of the Pu-239 is less than $1\text{E-}04$. Thus, conservatively applying a release fraction of $1\text{E-}04$ to the entire inventory results in a release to the air of $5.2\text{E-}06$ Ci of Pu-239.

As shown in Table 11-6, this airborne release is smaller than the release during the Bounding Fire; thus, the consequences of this event are bounded by the consequences of the Bounding Fire.

In accordance with Table 11-2, the radiological consequences associated with the Bounding Pressurized Release are judged to be low because the airborne release

during the Bounding Pressurized Release is smaller than the airborne release during the Bounding Fire and because the consequences of the Bounding Fire are shown to be low.

Nonradiological Consequences

Hydrogen peroxide, nitric acid, and silver nitrate are released as liquids during a pressurized release. As shown in Appendix 11D, the amount that initially becomes airborne as a result of a pressurized release is a function of the break size, pressure, and the feed rate of the material involved. Assuming a maximum pressure of 125 psig in any system at the MWM Facility, the maximum amount of material that could be involved in a pressurized release is the maximum system feed rate of the system up to 5 gpm.

Silver Nitrate

As shown in Appendix 11D, the release fraction associated with a pressurized release is $1\text{E-}04$. Since this release fraction was also applied to a fire involving the entire inventory of silver nitrate, the consequences of the modeled fire will be equal to or bound the consequences of any pressurized release.

Hydrogen Peroxide

The 5-gpm maximum release rate during a pressurized release is approximately equal to the hydrogen peroxide feed rate. Thus, during any one hour, 300 gallons of hydrogen peroxide is assumed to be involved in the pressurized release. As shown in Appendix 11D, the release fraction associated with a pressurized release is $1\text{E-}04$. Thus, the amount of hydrogen peroxide released to air as a result of the pressurized release is $3\text{E-}02$ gallons at $3.8\text{E-}02$ g/sec.

In addition to the amount released as a result of the pressurized release, a portion of hydrogen peroxide not initially made airborne will evaporate. To conservatively model the amount of material that evaporates during the pressurized release, 300 gallons of hydrogen peroxide is assumed to be immediately spilled to the ground. The emission rate associated with the evaporation of 300 gallons of hydrogen peroxide is 0.97 g/sec as shown in Appendix 11C.

Thus, the total emission rate during the Bounding Pressurized Release is approximately 1.0 g/sec. As shown in Table 11-7, the emission rate associated with the Bounding Spill is larger than the emission rate associated with the Bounding Pressurized Release. Thus, the consequences of the Bounding Spill are larger than the consequences of the Bounding Pressurized Release.

Note that, if the event lasted more than one hour, eventually all 3,000 gallons of the hydrogen peroxide would accumulate on the ground and be available for evaporation. Since the amount released directly to the air during the Bounding Pressurized Release is negligible when compared to the evaporation rate of 3,000 gallons of hydrogen peroxide, the consequences of the Bounding Pressurized Release would approach the consequences of the Bounding Spill.

Nitric Acid

The feed rate of nitric acid is estimated to be less than 1 gpm. Thus, the maximum amount of this material that could be involved in a one-hour pressurized release is 60 gallons. Applying the release fraction of $1\text{E-}04$ results in an airborne release of $6\text{E-}03$ gallons at $8.8\text{E-}03$ g/sec due to the pressurized release.

In addition to the amount released as a result of the pressurized release, a portion of nitric acid not initially made airborne will evaporate. To conservatively model this scenario, 60 gallons is assumed to be immediately spilled to the ground. Similar to the leak scenario, the average temperature of the nitric acid is assumed to be 70°C , and the average temperature of the surrounding air is assumed to be 35°C .

As shown in Appendix 11C, the associated emission rate is 2.9 g/sec. This scenario assumes that a sump in the MEO process area limits the size of any spill such that the largest dimensions are 7.9 meters by 1.4 meters.

Thus, the total emission rate of nitric acid during the Bounding Pressurized Release is 2.9 g/sec. As shown in Table 11-7, this is the same emission rate postulated for a fire or spill of nitric acid. Section 11.4.2.11 provides further analysis and demonstrates that the consequences associated with this event are low.

11.4.2.6.5 Risk

Applying the frequency and consequence ratings to Figure 11-1, the associated risk from a pressurized release is negligible and in the acceptable range.

11.4.2.7 Criticality

The mixed waste streams processed in the MWM Facility may contain trace amounts of fissile materials such as U-233, U-235, and Pu-239. A criticality event is not possible because large quantities of fissile material and TRU wastes are not accepted at the MWM Facility.

11.4.2.8 Explosion

The effects of explosions inside the MWM Facility are considered in this section. Explosions inside the MWM Facility may involve explosive gas mixtures that could be present in the MWM Facility process areas due to equipment failure. Flammable gases such as VOCs and hydrogen are generated or used in the process areas during normal operation. These gases may mix with air in the process areas or in the offgas treatment system. In normal operation, the concentrations of VOCs or hydrogen would be low such that no explosion hazards are present in the facility. However, under accident conditions, an explosive mixture of VOCs or hydrogen could exist in the process areas.

Additionally, backflow into or contamination of the hydrogen peroxide tank could lead to an uncontrolled chemical reaction and subsequent explosion.

Table 11-4 shows the locations where internal explosions could occur. Table 11-5 indicates the amount of hazardous material that may be involved in an explosion. Based on this information, the following scenarios are postulated to occur:

- Equipment failure or operator error causes an explosion in the feed preparation area, 0.052 Ci of Pu-239.
- Equipment failure or operator error causes an explosion in the MEO unit involving 400 pounds of silver nitrate and 2,500 pounds of 15M nitric acid.
- Equipment failure or operator error causes an explosion in the hydrogen peroxide storage tank involving 3,000 gallons of 50 wt% hydrogen peroxide.

Since these scenarios involve the maximum amount of material available, these are the Bounding Explosion scenarios.

11.4.2.8.1 Causes

VOCs and other flammable gases are routinely vented from waste drums in a ventilated fume hood. Normally, these flammable gases are oxidized in a catalytic oxidation unit or removed by charcoal filters in the offgas treatment system. Optionally, these gases may be routed to the MSO unit for destruction. Failure of the ventilation system to vent these gases might lead to the accumulation of an explosive gas mixture.

Excess hydrogen could be generated when the concentration of nitric acid in the MEO treatment vessel becomes too low. The hydrogen is released through the offgas treatment system. Without proper ventilation, an explosive gas mixture could accumulate in the process exhaust ductwork.

Excess heat could be generated in the MEO unit if the organic feed flow rate is too high, resulting in an explosion.

Backflow into or contamination of the hydrogen peroxide tank could lead to an uncontrolled chemical reaction and subsequent explosion.

11.4.2.8.2 Detection

Explosions in the MWM Facility are detected by facility personnel and by process equipment such as pressure transmitters.

11.4.2.8.3 Frequency

The frequency of explosions inside the MWM Facility are considered to be extremely low for the following reasons:

- The ventilation system must fail for an explosive gas mixture to accumulate. This analysis assumes that, upon a loss of ventilation, all affected process areas will be shut down.
- There are no identified ignition sources under the fume hood when VOCs are vented from the waste drums. An ignition source such as a spark or hot surface is needed to ignite combustible gases such as hydrogen or VOCs.
- The probability of hydrogen generation in the MEO unit is judged to be low since the condition of low nitric acid concentration would be detected by instruments and the MEO unit would be shut down prior to the generation of any hydrogen. Additionally, the hydrogen gas concentration will be continuously monitored and the system will be shutdown if excess hydrogen gas is detected.
- The probability of excess heat generation in the MEO unit due to a high organic feed rate is judged to be low since at least three independent process parameters will be monitored. The parameters include organic feed rate and organic concentration, nitric acid solution temperature, and the amount of silver(II) in the process. Excess silver(II) should be present under normal operating conditions.

- Design features will be incorporated to prevent backflow into or contamination of the hydrogen peroxide storage tank.

11.4.2.8.4 Consequences

Radiological Consequences

To conservatively model the radiological consequences of an explosion, a fire is assumed to occur after the explosion. Thus, the radiological consequences of an explosion are expected to be similar to those of a fire. The release fraction associated with a fire is equal to or larger than the release fraction associated with an explosion for events that involve materials that are not in a powder form. Modeling an explosion involving TRU drums as a fire is conservative because the TRU drum contents are not in a powder form. A fire resulted in a release of $6.8\text{E-}04$ Ci of Pu-239.

In accordance with Table 11-2, the radiological consequences associated with an explosion are judged to be low because the release during an explosion is similar to the release during the Bounding Fire and because the consequences of the Bounding Fire are shown to be low.

Nonradiological Consequences

An explosion is postulated to occur in the MEO unit, cracking the unit and releasing 400 pounds of silver nitrate and 2,500 pounds of nitric acid to the ground. To conservatively model this event, a fire is assumed to occur following the explosion. Thus, the consequences of an explosion are assumed to be similar to the consequences of a fire. Note that no credit was taken for any pressure relief devices within the MEO unit.

An explosion involving the hydrogen peroxide storage tank will be mitigated by pressure relief valves or covers. However, a major leak could occur, resulting in a release of the entire tank contents. Thus, the consequences of an explosion would be similar to those of the postulated leak event. Therefore, the consequences are assumed to be similar to those of a leak. Section 11.4.2.5 provides additional detail on the consequences of a leak in the hydrogen peroxide storage tank.

In accordance with Table 11-2, the nonradiological consequences associated with an explosion are judged to be low because the airborne release during an explosion is equal to the airborne release during the Bounding Fire and because the consequences of the fire are shown to be low.

11.4.2.8.5 Risk

Applying the frequency and consequence rating to Figure 11-1, the associated risk from an explosion is negligible and in the acceptable range.

11.4.2.9 Aircraft Crash

LLNL is located approximately 6 miles from the Livermore Airport, a general aviation field on the west side of the city of Livermore, and more than 20 miles from all other area airports. LLNL is not located near any military training routes and is more than 2 miles from the nearest federal flyway. Approximately 200,000 runway operations take place at the Livermore Airport each year.

11.4.2.9.1 Causes

The causes of aircraft crashes are human errors and aircraft equipment failures.

11.4.2.9.2 Detection

An aircraft crash is detected by facility personnel.

11.4.2.9.3 Frequency

Small aircraft crashes have been determined to be credible events at LLNL (LLNL 1991). Based on the size of Building 494, the frequency is estimated to be approximately $3\text{E-}06$ per year (LLNL 1991). Additional conditional probabilities, such as the probability that radioactive or hazardous material is present during the crash, and the probability that the material is actually impacted further reduce the probability of having a radioactive or hazardous material release.

The crash of a commercial or military aircraft at LLNL is an incredible event (LLNL 1991).

11.4.2.9.4 Consequences

The consequences of a small aircraft crash could involve the damage of reagent storage tanks, waste containers, treatment systems, and/or the building. There is a potential for subsequent dispersal of hazardous and/or radioactive materials due to a fire or spill. The consequences of small aircraft crashes are assumed to be similar to those of a fire or a spill.

In accordance with Table 11-2, the radiological and nonradiological consequences associated with an aircraft crash are judged to be low because the release during an aircraft crash is similar to the release of other events whose consequences have been shown to be low.

11.4.2.9.5 Risk

Applying the frequency and consequence ratings to Figure 11-1, the associated risk from an airplane crash is negligible and in the acceptable range.

11.4.2.10 Uncontrolled Chemical Reactions

Chemical reaction by-product materials are generated from the waste treatment units during normal operations. These by-product materials include hydrochloric acid, carbon monoxide, sodium chloride, and silver. The amount of these materials expected to be generated during routine operations in the MWM Facility is below the reportable quantities as shown in Chapter 5 of this PSAR.

However, uncontrolled chemical reactions could occur in the waste treatment units under adverse conditions. Two types of conditions were investigated. The first type involves equipment failure causing waste treatment unit operating parameters, such as temperature, pressure, flow, and concentrations, to deviate from normal operating conditions. The second type involves the mixing of incompatible chemicals due to operator error, including the accidental mixing of incompatible mixed waste streams or reagents.

The following five specific uncontrolled reactions have been identified:

- Hydrogen could be generated in the MEO unit if the concentration of nitric acid in the MEO electrochemical cells drops too low.
- Solid deposits could form on the MSO vessel walls if the concentrations of silica and alumina in the mixed waste are too high. This event could occur at concentrations above 15 percent with excess oxygen.
- Runaway production of gases could occur if there is backflow of organic material or other contamination of the hydrogen peroxide storage tank.
- Excess heat could be generated in the MEO process if the organic waste feed rate is too high.

- Excess heat could be generated while mixing chemicals and wastes in the feed preparation area if incompatible wastes are mixed.

These five events are evaluated in this section.

11.4.2.10.1 Causes

Uncontrolled chemical reactions are caused by equipment failure and/or by operator error.

11.4.2.10.2 Detection

Instrumentation and controls designed for the process equipment would detect any deviation of the process parameters from normal operating conditions.

11.4.2.10.3 Frequency

The overall frequency of uncontrolled chemical reactions at the MWM Facility is judged to be low, based on the assumptions that process design and instrumentation will reduce the probability of uncontrolled reactions from occurring and that operators will be trained and work from approved procedures.

The probability of hydrogen generation in the MEO unit is judged to be low since the condition of low nitric acid concentration would be detected by instruments and the MEO unit would be shut down prior to the generation of any hydrogen. Additionally, the hydrogen gas concentration will be continuously monitored and the system will be shutdown if excess hydrogen gas is detected.

The probability of forming solid deposits in the MSO unit is low since the concentrations of silica and alumina in the LLNL mixed waste streams are extremely low or nonexistent.

The probability of backflow into or contamination of the hydrogen peroxide storage tank is judged to be low based on the assumption that design features will be incorporated into the process to prevent backflow or contamination from occurring.

The probability of excess heat generation in the MEO unit due to a high organic feed rate is judged to be low since at least three independent process parameters will be monitored. The parameters include organic feed rate and organic

concentration, nitric acid solution temperature, and the amount of silver(II) in the process. Excess silver(II) should be present under normal operating conditions.

The probability of mixing incompatible waste streams or reagents in the feed preparation area due to operator error is judged to be low since they are mixed by trained operators using approved procedures.

11.4.2.10.4 Consequences

The consequences of each of the five identified uncontrolled reactions are discussed in this section. The consequences of these events bound the consequences of all other uncontrolled reactions.

The bounding consequence associated with excess hydrogen generation in the MEO process is an explosion. Section 11.4.2.8 provides information on the consequences of an explosion in the MEO unit.

The bounding consequence associated with the formation of deposits on the MSO vessel walls is "freezing" of the molten salt and process shutdown. This event could cause incomplete oxidation of the waste feed to the MSO unit, resulting in elevated VOC gas concentrations. However, these gases would be routinely treated in the offgas treatment system.

The bounding consequence associated with backflow into or contamination of the hydrogen peroxide storage tank is an explosion caused by high pressure due to excessive gas generation. Because the consequences of an explosion would be mitigated by a pressure relief device on the storage tank, the bounding consequence of an explosion is judged to be a major leak in the tank or connecting piping. Section 11.4.2.5 provides additional information on the consequences of a leak in the hydrogen peroxide storage tank.

The bounding consequence associated with high organic feed rate into the MEO unit is an explosion in the MEO unit. The consequences of an explosion in the MEO unit are described in Section 11.4.2.8.

The consequence associated with mixing incompatible chemicals depends on the chemicals involved. Generally, fires or the release of toxic gases could occur. Table 11-8 identifies incompatible waste groups and the possible consequences associated with mixing incompatible wastes.

11.4.2.10.5 Risk

Applying the frequency and consequence rating to Figure 11-1, the associated risk from the uncontrolled chemical reaction is low and in the acceptable range.

11.4.2.11 Bounding Accidents

This section summarizes the Bounding Accidents identified for the MWM Facility. Bounding Accidents are analyzed for radionuclides and each chemical that passed the screening criteria described previously.

Included is a discussion of the resulting consequences, a comparison to appropriate limits, and identification of potential mitigating features. The causes, detection, frequency, and risk are discussed in the individual accident sections of this chapter.

11.4.2.11.1 Radiological Bounding Accident

Consequences

As shown in Table 11-6, the Bounding Accident for radionuclides is caused by the Bounding Fire (which may occur in connection with other accidents). In the Bounding Fire, it is conservatively assumed that the entire inventory of radionuclides is involved in the fire. This inventory is equivalent to 0.052 Ci of Pu-239. Furthermore, it was conservatively assumed that the Bounding Fire involved combustible liquids, which maximizes the release fraction. The corresponding release fraction for Pu-239 in a combustible liquid is 1.3E-02 (Ayer et al. 1988). Thus, the amount of material initially released to the air is 6.8E-04 Ci of Pu-239.

Several additional factors will influence the amount of material released and the resulting consequences. These factors include plume rise, leakpath, and plume depletion. These factors are based on the physical characteristics of the actual event.

Plume rise occurs during a fire due to the release of hot gases and particles and varies with the size and intensity of the fire. The effect of plume rise is to disperse the release over a larger area resulting in lower χ/Q 's and resulting exposures. At a distance of 175 meters, plume rise reduces the χ/Q by approximately 50 to 80% (ABB 1992) for a 10 meter and 30 meter line release, respectively.

The leakpath factor is the fraction of particles that remain airborne as the particles exit the building. The leakpath factor is based on gravity and is a function of particle size, surface area exposed to the release, and flow rate out of the building. Leakpath factors range from 1 (no effect on the release) to nearly $1\text{E-}06$ (DOE 1993c).

Plume depletion is the fraction of particles that remain airborne as the particles travel downwind away from the release. It is based on gravity and is mainly a function of particle size. At a distance of 175 meters, plume depletion factors range from 1 to approximately 0.4 (ABB 1992). Plume depletion is negligible at 175 meters for elevated releases.

A calculation of specific values for each factor requires detailed analysis and is beyond the scope of this graded approach PSAR. However, the combined effect of these factors is conservatively estimated to be a factor of 0.5. Thus, the amount of material evaluated in the bounding fire is estimated to be $3.4\text{E-}04$ Ci of Pu-239 (0.052 Ci $\times$ $1.3\text{E-}02$ $\times$ 0.5).

The radiological consequences of a $3.4\text{E-}04$ Ci release of Pu-239 to the atmosphere were analyzed using GENII. Individual doses at two distances away from the MWM Facility (100 and 175 meters) were calculated. The on-site workers are assumed to be located at 100 meters and the nearest site boundary (northern site boundary) is located at 175 meters. The airborne dispersion factor, χ/Q , was calculated internally by GENII using F stability and 1-m/sec wind speed in the joint frequency input file. Additional assumptions are discussed in Section 11.1. The GENII input data are summarized in Table 11-9, and the associated input and output files are provided in Appendix 11E.

The GENII analysis results shown in Table 11-10 indicate that inhalation is the controlling pathway. The CEDE to the maximally exposed individual at the nearest site boundary (175 meters) is 0.4 rem, and on site at 100 meters is 1.1 rem.

The dose to the operator during the Bounding Fire is estimated to be 0.29 rem. Appendix 11F describes the operator calculation in detail.

The results of this analysis are conservative and bound the potential consequences of an actual event for the following reasons:

- The source release fraction applied ($1.3\text{E-}02$) is a factor of 10 higher than most source release fractions identified for fires in DOE HDBK-0013-93 (DOE 1993b). A conservative release fraction was applied in this analysis because the exact waste form and type is a variable.

- The source term was assumed to involve the entire radionuclide inventory in the MWM Facility.
- The analysis conservatively credited building deposition, plume rise, and plume depletion.

For comparison purposes, the consequences of a Bounding Fire involving the estimated one-year inventory (instead of 10 percent of the Hazard Category 3 limit) were determined. The FY1991 radionuclide inventory was compiled from the mixed waste streams generated at LLNL as described in Chapter 5 of this PSAR. The radionuclides listed were screened to eliminate those radionuclides with insignificant radiological consequences. The 17 radionuclides shown in Table 11-11 represent the FY1991 inventory. The appropriate release fractions and resulting airborne source terms are also shown in Table 11-11. All other methodology and inputs shown in Table 11-12 are the same as those used for the Pu-239 calculation.

The GENII analysis results shown in Table 11-13 indicate that inhalation is the controlling pathway. The CEDE to the maximally exposed individual at the nearest site boundary (175 meters) is 0.2 rem. Thus, the Bounding Accident is conservative by a factor of two with respect to a release involving the entire one-year radionuclide inventory in the MWM Facility.

Comparison to Appropriate Limits

Current DOE criteria to compare to the radiological consequences of an accident analysis are not clearly defined. However, based on an interpretation of several DOE Orders, current methodology defines an acceptable consequence range of exposure to the maximally exposed individual at the site boundary as follows:

Low frequency events (1E-06 to 1E-04 per year)	25 rem
Moderate frequency events (1E-04 to 1E-02 per year)	5 rem
High frequency events (1E-02 to 1 per year)	0.5 rem

The frequency associated with the Bounding Fire is judged to be substantially lower than 1E-02 per year due to the assumptions incorporated into the analysis (Section 11.4.2.4 provides further discussion of the frequency). Thus, the acceptable consequence limit for the Bounding Fire is 5.0 rem to the maximally exposed individual at the site boundary. Based on this methodology, the consequences of the extremely conservative Bounding Fire for the MWM Facility (0.4 rem) are judged to be acceptable.

A comparison to the EIS/EIR (DOE and UC 1992) was also made. In the EIS/EIR, the consequences to the maximally exposed individual at the site boundary due to a release from the HWM Facility is approximately 4 rem. Thus,

the consequences at the site boundary to the maximally exposed individual for the MWM Facility Bounding Fire compare favorably.

An additional comparison was made to EPA criteria. These criteria indicate that the consequences at the nearest site boundary are less than the whole-body dose range (1 to 5 rem) at which some protective action is recommended by the EPA for accidents (EPA 1990).

Potential Mitigating Features

Potential mitigating features that may be applied at the MWM Facility include the following:

- Fire detection and suppression systems
- HEPA filters and ventilation systems
- Offgas stacks
- Process instrumentation
- Berms/sumps
- Onsite fire department
- Operator actions.

11.4.2.11.2 Nonradiological Bounding Accidents

Consequences

The chemical consequences for each Bounding Accident were analyzed using the methodology described in Section 11.1. Maximum individual exposures were calculated at two distances: 100 meters and 175 meters. These distances represent the on-site worker and the nearest site boundary, respectively. The airborne dispersion factors (χ/Q) were calculated using F stability and 1-m/sec wind speed. Additional assumptions and the calculations are presented in Appendix 11C.

Table 11-7 summarizes the releases associated with the accidents analyzed. The nonradiological consequences of these releases are determined by multiplying the emission rate by the appropriate χ/Q value. The Bounding Accidents for each chemical are summarized below.

Silver Nitrate

The Bounding Accident for silver nitrate is a fire. It was conservatively assumed that the entire inventory (400 pounds) in the MEO unit is involved in a fire. The silver nitrate is assumed to be a dissolved solid in a liquid with a corresponding release fraction for a fire of 1E-04 (LANL 1986).

The release is assumed to occur over a one-hour period. This assumption allows the resultant concentrations to be compared to the ERPG or equivalent criteria, which assumes the concentration exists for a one-hour period. Thus, 4.0E-02 pounds of silver nitrate is released to the air at a rate of 5.05 mg/sec. Table 11-14 provides the resultant concentrations.

Hydrogen Peroxide

The Bounding Accident for hydrogen peroxide is a spill. It was conservatively assumed that the entire inventory (3,000 gallons of 50 percent hydrogen peroxide) in the storage tank is released to the ground. The release mechanism to the air is evaporation.

This scenario assumes that a berm limits the maximum spill dimension to 84 feet. The associated emission rate is 3 g/sec. The resultant concentrations are provided in Table 11-14.

Based on information in the CDR (LLNL 1994), the berm is estimated to have dimensions of 20 feet by 20 feet. Thus, the expected emission rates following a spill from the hydrogen peroxide storage tank will be significantly smaller than the rate presented in this analysis.

It should be noted that the emission rate calculations are not dependent on the amount of liquid involved in the spill, assuming that a berm is in place, and that the spill involves the entire surface area of the berm (small spills may not cover the entire surface area of the bermed area). Assuming the appropriate berm is in place, the amount of hydrogen peroxide stored in the tank is not limited by this accident analysis. However, the quantity of hydrogen peroxide stored in the entire facility is limited to the amount specified in Chapter 5 of this PSAR for a Low Hazard facility.

Nitric Acid

The Bounding Accident for nitric acid is caused by several events which result in a spill. It was conservatively assumed that the entire inventory (2,500 pounds of 13M nitric acid) in the MEO unit is released to the ground. The release mechanism to the air is evaporation.

The scenario assumes that a sump limits the dimensions of the spill to 7.9 meters by 1.4 meters. The associated emission rate is 2.9 g/sec. The resultant concentrations are provided in Table 11-14.

The sump dimensions were obtained from the CDR (LLNL 1994). Any increases in the sump dimensions would require additional analysis.

Similar to the hydrogen peroxide calculations, the nitric acid emission rate calculations are not dependent on the amount of liquid involved in the spill, assuming that a sump is in place. Assuming the appropriate sump is in place, the amount of nitric acid stored in the facility is not limited by this accident analysis. However, the quantity of nitric acid stored in the entire facility is limited to the amount specified in Chapter 5 of this PSAR for a Low Hazard facility.

Comparison to Limits

Current DOE criteria to compare to the nonradiological consequences of an accident analysis are not clearly defined. However, based on current DOE guidance, the limit for the maximally exposed individual at the site boundary is an ERPG-2 or equivalent; the limit for the maximally exposed on-site individual (100 meters) is an ERPG-3 or equivalent.

As shown in Table 11-14, the consequences at the site boundary to the maximally exposed individual are all less than the appropriate limit. Thus, the consequences for the nonradiological Bounding Accidents are acceptable.

Potential Mitigating Features

Potential mitigating features that may be applied at the MWM Facility include the following:

- Fire detection and suppression systems
- HEPA filters and ventilation systems
- Offgas stacks
- Berms/sumps
- Process instrumentation
- On-site fire department
- Operator actions.

11.4.3 Beyond Design Basis Accidents

A Beyond Design Basis Accident is an event that is normally not considered in the design of the facility or given consideration in the accident analysis. It is characterized by an extremely low probability of occurrence and may have high consequences.

Beyond Design Basis Accidents that could occur at the MWM Facility include a Beyond Design Basis Earthquake or Wind.

The Beyond Design Basis Earthquake for the MWM Facility is any earthquake with a magnitude greater than 0.57g. The earthquake will cause damage to building structures, to the process equipment, and to the reagent storage tanks.

The Beyond Design Basis Wind is a wind greater than 72 mph. It could cause direct damage to the building, to the process equipment, and to the reagent storage tanks. Additionally, it could cause wind-generated missiles. However, the consequences associated with the Beyond Design Basis Wind would be less than those occurring during the Beyond Design Basis Earthquake because of the greater dispersion of the releases due to the meteorological conditions.

A Beyond Design Basis Fire was not postulated due to the low combustible loading within the MWM Facility.

In either Beyond Design Basis Accident, Building 494 is likely to suffer structural damage. Falling debris from the damaged structures could rupture waste containers or waste holding tanks. In addition, pipe ruptures in the MSO, MEO, and WOX systems and their support systems could occur, and failure of the piping connected to the hydrogen peroxide and nitric acid storage tanks outside Building 494 could occur. During the Beyond Design Basis Accident, small localized fires could also result.

It was conservatively assumed that the Beyond Design Basis Accident causes the following:

- A drum rupture causes a spill of the maximum facility radionuclide inventory (0.052 Ci of Pu-239). Additionally, the radionuclide inventory is involved in a fire of combustible liquids which maximizes the airborne source term.
- A pipe rupture causes a spill of 3,000 gallons of 50 wt% hydrogen peroxide from the storage tank and 50 gallons of 50 wt% hydrogen peroxide from the WOX unit. No credit is taken for berms.
- A pipe rupture causes a spill of 2,500 pounds of 13M nitric acid solution from the MEO unit and support systems, and a release of 299 pounds of 15M nitric acid solution from the storage tank. No credit is taken for sumps.
- A pipe rupture causes a spill of 400 pounds of silver nitrate from the MEO unit. Additionally, the silver nitrate inventory is involved in a fire which maximizes the airborne source term.

The amounts involved are the maximum inventory allowed in the MWM Facility; thus, the consequences of these releases envelope the consequences of all Beyond Design Basis Accidents.

Radiological Consequences

The radiological consequences of the Beyond Design Basis Accident are the same as the consequences for the Bounding Accident described previously (see Section 11.4.2.11 for additional details).

Nonradiological Consequences

During the Beyond Design Basis Accident, structural failure of the MWM Facility could occur. Thus, this scenario assumes that the entire quantity of each of the three chemicals analyzed is involved and that no berms or sumps remain intact.

The consequences due to the release of silver nitrate following the Beyond Design Basis Accident are the same as the consequences due to the Bounding Accident. Both events release the maximum facility inventory using the maximum release fraction associated with a fire. The resultant concentrations are presented in Table 11-15.

The consequence due to a release of hydrogen peroxide following the Beyond Design Basis Accident is the summation of the consequences associated with two releases as follows: a 3,000-gallon release from the storage tank at 35°C assuming a pool depth of 1 cm, and a 50-gallon release from the WOX system at 100°C assuming a pool depth of 1 cm. The hydrogen peroxide released from the WOX system is assumed to be diluted by 50% due to the other liquids in the reactor vessel. The combined resultant concentrations are presented in Table 11-15.

The consequences due to a release of nitric acid following the Beyond Design Basis Accident is the summation of the consequences associated with two releases as follows: a 2,500-pound release of 13M nitric acid from the MEO unit and support systems at 70°C assuming a pool depth of 1 cm and a 299-pound release of 15M nitric acid from the storage tank at 35°C assuming a pool depth of 1 cm. The combined resultant concentrations are presented in Table 11-15.

The consequences of releases of hydrogen peroxide and nitric acid from other areas due to the Beyond Design Basis Accident are assumed to be negligible.

Appendix 11C presents the calculations for this analysis.

Comparison to Appropriate Radiological Limits

DOE has not promulgated criteria for Beyond Design Basis Accidents. However, since the radiological consequences of the Beyond Design Basis Accident are the same as those for the Bounding Accident, and the consequences of the Bounding Accident are acceptable, the consequences of the Beyond Design Basis Accident are acceptable.

Comparison to Appropriate Nonradiological Limits

As previously stated, DOE has not promulgated criteria for Beyond Design Basis Accidents. Thus, for informational purposes only, the consequences of the Beyond Design Basis Accident were compared to appropriate EPRG-3 and ERPG-2 values. Table 11-15 presents the comparison.

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Figure 11-1. Risk Matrix

Table 11-1. Probability Levels (DOE-SF 1989)

Probability Level			Estimate Range of Occurrence Rate (Per Year)
Category	Symbol	Description	
Incredible	A	Probability of occurrence is so small that a reasonable scenario is not conceivable. These events are not considered in design or Safety Analysis Document (SAD) accident analysis.	<1E-06
Extremely Low	B	Probability of occurrence is extremely unlikely or event is not expected to occur during the life of the facility or operation.	≥1E-06 and <1E-04
Low	C	Probability of occurrence is unlikely, or event is not expected to occur but may occur during the life of the facility or operation.	≥1E-04 and <1E-02
Moderate	D	Event is likely to occur during the facility or operation lifetime.	≥1E-02 and <1E-01
High	E	Event is likely to occur several times during the facility or operation lifetime.	≥1E-01

Table 11-2. Consequence Levels (Hallinan 1989)

Consequence Level	Category	Maximum Consequence
1	High	Serious impact on site or off site. May cause death or loss of the facility/operation. Major impact on the environment.
2	Moderate	Major impact on site and/or minor impact off site. May cause severe injury or severe occupational illness to personnel or major damage to a facility/operation or minor impact on the environment. Capable of returning to operation.
3	Low	Minor impact on site with no off-site impact. May cause minor injury or minor occupational illness or minor impact on the environment.
4	Extremely Low	Will not result in a significant injury, occupational illness, or impact on the environment.

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Table 11-3. Radioactive and Chemical Hazards to Area Workers During Normal Operations

MWM Facility Process Areas	Radioactive			Chemical	
	Direct Source	Surface	Airborne	Surface	Airborne
Receiving and Shipping	X	—	—	—	—
Solids Feed Preparation	X	X	X	X	X
Liquids Feed Preparation	X	X	X	X	X
Process Transport and Storage System	X	—	—	—	—
MSO Unit	X	X ^a	X ^a	X ^a	X ^a
Salt Recycle	X	X ^a	X ^a	X ^a	X ^a
Wet Oxidation	X	X ^a	X ^a	X ^a	X ^a
UV Photolysis	X	X ^a	X ^a	X ^a	X ^a
MEO Unit	X	X ^a	X ^a	X	X
MEO Support System	X	X ^a	X ^a	X ^a	X ^a
Offgas Treatment	X	X ^a	X ^a	X ^a	X ^a
Experimental Offgas Treatment	X	X ^a	X ^a	X ^a	X ^a
Analytical Laboratory	X	X	X	X	X
Final Forms	X	X	X	X	X
Water Treatment	X	X	X ^a	X ^a	X ^a
Analytical Lab Transport and Storage	X	—	—	—	—
Decon and Shipping	X	—	—	—	—
Refurbishment	X	—	—	—	—
Outside Reagent Chemical Storage Areas	—	—	—	X	X

Key to Chart:

- X - Can occur during normal operations
- X^a - Due to maintenance activities
- - Not postulated to occur during normal operations

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Table 11-4. MWM Facility (Building 494) Accident Screening^{a,b}

MWM Facility Process Areas	DBE	Bounding Fire	Leaks & Spills	Pressurized Liquid Release	Explosions	Uncontrolled Chemical Reactions
Receiving and Shipping	X	X	X	NC	NC	NC
Solids Feed Preparation	X	X	X	NC	X	NC
Liquids Feed Preparation	X	X	X	X	X	X
Process Transport and Storage System	D	X	X	NC	NC	NC
MSO Unit	D	X	X	NC	NC	X
Salt Recycle	D	X	X	NC	N	NC
Wet Oxidation	D	X	X	X	N	X
UV Photolysis	D	X	X	NC	NC	NC
MEO Unit	D	X	X	X	X	X
MEO Support System	D	X	X	X	X	NC
Offgas Treatment	D	X	X	NC	NC	NC
Experimental Offgas Treatment	D	X	X	NC	NC	NC
Analytical Laboratory	X	X	X	NC	NC	X
Final Forms	D	X	X	NC	NC	NC
Water Treatment	D	X	X	X	NC	X
Analytical Lab Transport and Storage	X	X	X	NC	NC	NC
Decon and Shipping	X	X	NC	NC	NC	NC
Refurbishment	X	X	NC	NC	NC	NC
Outside Reagent Chemical Storage Areas	D	X	X	X	X	X

^a The DBW and DBFI consequences are not included because no consequences are postulated for these events.

^b A criticality event is not included because administrative controls governing inventory are in place. An aircraft crash is not included because it can affect any area.

Key to Chart:

- X - The accident is applicable to the process area, and the consequences are analyzed in this PSAR.
- D - The event is applicable to the process area, but the system is designed to withstand the event; therefore, no consequences are analyzed.
- NC - The event is not deemed credible for the process area and therefore no consequences are postulated.

Table 11-5. Maximum Available Hazardous Material Inventory in Each Process Area^a

MWM Facility Process Areas	Silver Nitrate ^b	Hydrogen Peroxide ^d	Nitric Acid ^e
Receiving and Shipping	— ^c	—	—
Solids Feed Preparation	—	—	—
Liquids Feed Preparation	—	—	—
Process Transport and Storage System	—	—	—
MSO Unit	—	—	—
Salt Recycle	—	—	—
Wet Oxidation	—	500 lb (at 50%)	—
UV Photolysis	—	<20 lb (at 50%)	—
MEO Unit	400 lb	—	2,500 lb ^f (at 13M)
MEO Support System	—	<20 lb (at 50%)	2,500 lb ^f (at 13M)
Offgas Treatment	—	—	—
Experimental Offgas Treatment	—	—	—
Analytical Laboratory	—	<10 lb (at 50%)	11.5 lb (at 15M)
Final Forms	—	—	—
Water Treatment	—	—	—
Analytical Lab Transport and Storage	—	—	—
Decon and Shipping	—	—	—
Refurbishment	—	—	—
Outside Reagent Chemical Storage Areas	—	30,000 lb (at 50%)	299 lb (at 15M)

^a Table 11-4 identifies the affected areas by accident type.

^b The conversion factor to gallons is 0.028 gal/lb.

^c "—" means the chemical is not present in the process area that is susceptible to the event.

^d The conversion factor to gallons is 0.1 gal/lb.

^e The conversion factor to gallons is 0.087 gal/lb.

^f This amount of nitric acid is the total amount contained in both process areas.

Table 11-6. Summary of Pu-239 Release During Postulated Accidents

Accident	Amount of Pu-239 Released to Ground (Ci)	Airborne Release Fraction	Amount of Pu-239 Released to the Air (Ci)
Earthquake	0.052	1.3E-02 ^{a,b}	6.8E-04
Extreme Wind	0	NR	0.0E+00
Flood	0	NR	0.0E+00
Fire	0.052	1.3E-02 ^b	6.8E-04
Leaks and Spills	0.052	<1.0E-04 ^c	5.2E-06
Pressurized Release	0.052	1.0E-04 ^d	5.2E-06
Explosion	0.052	1.3E-02 ^{a,b}	6.8E-04
Aircraft Crash	0.052	1.3E-02 ^{a,b}	6.8E-04
Uncontrolled Chemical Reaction	0.052	1.3E-02 ^{a,b}	6.8E-04

^a Assumes a fire also occurs during this event and is the release mechanism (LANL 1986)

^b Ayer et al. 1988

^c LANL 1986

^d DOE 1993

NR Not Required because no release is postulated.

Table 11-7. Summary of Chemical Releases During the Postulated Events

Event	Silver Nitrate		Hydrogen Peroxide		Nitric Acid	
	Material Involved (pounds)	Release Rate (g/sec)	Material Involved (pounds)	Release Rate (g/sec)	Material Involved (pounds)	Release Rate (g/sec)
Earthquake	0	NR	< 10	1.3	11.7	1.4
Wind	0	NR	0	NR	0	NR
Flood	0	NR	0	NR	0	NR
Fire	400 ^a	5E-03	30,000 ^b	< 3	2,500 ^c	2.9
Spill	400	< 5E-03	30,000	3.0	2,500	2.9
Pressurized Release	400	< 5E-03	3,000	1.0	700	2.9
Explosion	400	5E-03	30,000	3.0	2,500	2.9
Aircraft Crash	400	5E-03	30,000	< 3	2,500	2.9
Uncontrolled Chemical Reaction	400	5E-03	30,000	3.0	2,500	2.9

NR - Not Required because no release is postulated

^a Approximately 11 gallons

^b Approximately 3,000 gallons

^c Approximately 218 gallons

Table 11-8. Incompatible Wastes*

Group 1-A	Group 1-B
Acetylene sludge Alkaline caustic liquids Alkaline cleaner Alkaline corrosive battery fluid Caustic waste water Lime sludge and other corrosive alkalis Lime waste water Lime and water Spent caustic	Acid sludge Acid and water Battery acid Chemical cleaners Electrolyte, acid Etching acid liquid and other corrosive acids Spent acid Spent mixed acid Spent sulfuric acid Potential consequences: heat generation, violent reaction
Group 2-A	Group 2-B
Aluminum Beryllium Calcium Lithium Magnesium Potassium Sodium Zinc Powder Other reactive metals and metal hydrides	Any waste in Group 1-A or 1-B Potential consequences: fire or explosion, generation of flammable hydrogen gas
Group 3-A	Group 3-B
Alcohols Water	Concentrated Group 1-A or 1-B waste Calcium Lithium Metal hydrides Potassium SO_2Cl_2 , SOCl_2 , PCl_3 , CH_2SiCl_3 Other water-reactive waste Potential consequences: fire, explosion, or heat generation; generation of flammable or toxic gases
Group 4-A	Group 4-B
Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other reactive organic compounds and solvents	Concentrated Group 1-A or 1-B wastes Group 2-A wastes Potential consequences: fire, explosion, or violent reaction

Table 11-8. Incompatible Wastes* (continued)

Group 5-A	Group 5-B
Spent cyanide and sulfide solutions	Group 1-B wastes Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas
Group 6-A	Group 6-B
Chlorates Chlorine Chlorites Chromic acid Hypochlorites Nitrates Nitric acid, fuming Perchlorates Permanganates Peroxides Other strong oxidizers	Acetic acid and other organic acids Concentrated mineral acids Group 2-A wastes Group 4-A wastes Other flammable and combustible wastes Potential consequences: heat generation, violent reaction

- * According to 40 CFR 264, Appendix V, "Examples of Potentially Incompatible Waste." The mixing of a Group A waste with a Group B waste may have the potential consequence noted.

Table 11-9. GENII Input Data for the Bounding Accident (Fire) at the MWM Facility

Input Parameters	Values
Release Radionuclide	Pu-239
Source Term, Ci	3.4E-04
Release Height	Ground release
Meteorology Class	F stability
Wind Speed	1 m/sec
Maximum Individual Distances	100 and 175 meters
λ/Q , s/m ³ 100 meters 175 meters	Joint frequency table using F stability and 1-m/sec λ/Q values calculated internally by GENII using the joint frequency table input. ^a
Intake Ends After	1 year
Dose Calculation Ends After	50 years for maximally exposed individual at 100 meters; 50 years for maximally exposed individuals at 175 meters.
Fraction of Time Spent in Cloud	1
Hours of Exposure to Ground Contamination	8,760 hours for individual at 100 meters and 175 meters
Exposure Pathways	Air immersion, ground contamination, inhalation

^a λ/Q at 100 meters = 3.07E-02
 λ/Q at 175 meters = 1.16E-02

Table 11-10. Maximum Individual Doses for the Bounding Accident (Fire) at the MWM Facility

Distance from MWM Facility (meters)	Inhalation CEDE (rem)	Air Immersion EDE (rem)	Ground Surface EDE (rem)	Total CEDE (rem)
100 (on site)	1.1E+00	<1E-06	<1E-06	1.1E+00
175 (nearest boundary)	3.9E-01	<1E-06	<1E-06	3.9E-01

Key to Chart:

CEDE - Committed Effective Dose Equivalent

EDE - Effective Dose Equivalent

Table 11-11. Source Terms for a Fire Involving the One-Year Radionuclide Inventory at the MWM Facility (FY 91)

Radionuclide	FY 91 Inventory (Ci)	Release Fraction ^a	Source Term ^b (Ci)
H-3	2.31E-02	1.0E+00	1.2E-02
C-14	5.32E-04	1.0E-02	2.7E-06
Co-60	3.98E-05	7.7E-03	1.6E-07
Sr-90	2.70E-06	7.7E-03	1.1E-08
Ru-106	9.19E-04	1.0E-02	4.6E-06
Cs-137	5.08E-05	1.0E-02	2.6E-07
Th-228	2.37E-08	7.7E-03	9.0E-11
Th-232	6.61E-10	7.7E-03	2.6E-12
U-235	7.36E-05	1.3E-02	4.8E-07
U-238	5.15E-02	1.3E-02	3.4E-04
Pu-239	2.12E-05	1.3E-02	1.4E-07
Pu-242	2.54E-09	1.3E-02	1.7E-11
Am-241	2.54E-04	7.7E-03	1.0E-06
Am-243	2.01E-09	7.7E-03	8.0E-12
Cm-244	2.40E-06	7.7E-03	9.0E-09
K-40	1.58E-03	8.4E-01	7.0E-04
S-35	2.50E-03	8.4E-01	1.1E-03

^a Burning of combustion liquids (Ayer et al. 1988)

^b Includes a factor of 0.5 to account for several parameters effecting the release

Table 11-12. GENII Input Data for a Fire Involving the One-Year Radionuclide Inventory at the MWM Facility

Input Parameters	Values
Release Radionuclides	See Table 11-10
Source Term, Ci	See Table 11-10
Release Height	Ground release
Meteorology Class	F stability
Wind Speed	1 m/sec
Maximum Individual Distances	100 and 175 meters
λ/Q , s/m ³ 100 meters 175 meters	Joint frequency table using F stability and 1-m/sec λ/Q values calculated internally by GENII using the joint frequency table input. ^a
Intake Ends After	1 year
Dose Calculation Ends After	50 years for maximally exposed individual at 100 meters; 50 years for maximally exposed individuals at 175 meters.
Fraction of Time Spent in Cloud	1
Hours of Exposure to Ground Contamination	8,760 hours for individual at 100 meters and 175 meters.
Exposure Pathways	Air immersion, ground contamination, inhalation

^a λ/Q at 100 meters = 3.07E-02
 λ/Q at 175 meters = 1.16E-02

Table 11-13. Maximum Individual Doses for the Release of the One-Year Radionuclide Inventory at the MWM Facility

Distance from MWM Facility (meters)	Inhalation CEDE (rem)	Air Immersion EDE (rem)	Ground Surface EDE (rem)	Total CEDE (rem)
100 (on site)	4.2E-01	<1.0E-06	8.9E-05	4.2E-01
175 (nearest boundary)	1.6E-01	<1.0E-06	3.4E-05	1.6E-01

CEDE - Committed Effective Dose Equivalent
EDE - Effective Dose Equivalent

Table 11-14. Results of Nonradiological Bounding Accident Analysis

Chemical	Event	Amount Involved	Conc. at 100 meters (ppm)	Conc. at 175 meters (ppm)	ERPG-2 (or equivalent) (ppm)	ERPG-3 (or equivalent) (ppm)
Silver Nitrate	Fire	400 lb ^a	1.2E-01 ^a	4.7E-02 ^a	5.0E-02 ^b	N/A
Hydrogen Peroxide	Spill	30,000 pounds ^c at 50 wt%	<5.0E+01	<2.0E+01	2.5E+01	5.0E+01
Nitric Acid	Spill	2,500 lb ^d at 13M	2.6E+01	1.0E+01	1.5E+01	3.0E+01

^a approximately 11 gallons

^b mg/m³

^c approximately 3,000 gallons

^d approximately 218 gallons

N/A - not available

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Table 11-15. Summary of Nonradiological Analysis for Beyond Design Basis Accidents

Chemical	Total Amount Released	Calculated Conc. at 100 meters (ppm)	Calculated Conc. at 175 meters (ppm)	ERPG-2 (ppm)	ERPG-3 (ppm)
Silver Nitrate	400 lb	1.2E-01 ^a	4.7E-02 ^a	5.0E-02 ^a	N/A
Hydrogen Peroxide	30,000 pounds at 35°C and 500 pounds at 100°C, both at 50 wt%	1.3E+02	5.2E+01	2.5E+01	5.0E+01
Nitric Acid	2,500 lb at 13M and 299 lb at 15M	8.0E+01	3.2E+01	1.5E+01	3.0E+01

^a mg/m³

N/A - not available

APPENDIX 11A
HAZARD IDENTIFICATION

11A.1 Introduction

A hazards analysis was performed to identify the hazard events for the Mixed Waste Management (MWM) Facility using a generic hazard energy source list (Hallinan 1989). The hazard events identified were then characterized by describing causes, preventive features, mitigative features, methods of detection, and potential impacts. Those events which resulted in personnel exposure to radionuclides or hazardous chemicals or which resulted in a potential release of radionuclides or hazardous chemicals to the environment were analyzed further as accidents in Chapter 11 of this Preliminary Safety Analysis Report (PSAR).

11A.2 Hazard Listing

A list of generic hazards applicable to nuclear facilities was used in the hazards analysis for the MWM Facility as part of a systematic process to ensure that all significant hazards were identified. The generic hazards considered for the MWM Facility are as follows:

- Fire.
- Explosion.
- Nuclear criticality.
- Natural phenomena.
- External events.
- Radioactive material and chemical releases (i.e., leaks, spills, and pressurized releases).
- Direct radiological exposure.

The natural phenomena considered include earthquake, extreme wind, tornado, and flood. External events include an aircraft crash. Additionally, explosions inside and outside the facility were evaluated. Radioactive material and chemical releases can exist as isolated hazards or as the consequences of any of the listed categories.

Industrial safety hazards were also considered in addition to the above-listed hazard categories. Industrial safety hazards were identified by referring to a generic hazard energy source list (Hallinan 1989) and identifying the hazard sources applicable to the MWM Facility.

Table 11A-1 presents a portion of the hazard energy source list and highlights hazard sources applicable to the MWM Facility, for example:

- Electrical Source - Shocks or burns from energized electrical equipment are undesirable events in any facility employing electrical power.
- Kinetic Energy (Motion) - Items in motion (linear, rotational and under pressure) pose hazards to personnel whenever the interaction between people and equipment occurs. Using tools and portable equipment, manually positioning equipment and supplies, and moving in and around congested areas provide the potential for personnel injury.
- Potential Energy (Mass-Gravity-Height) - Situations requiring lifting, climbing, and carrying pose hazards to personnel. Drops, spills, and falls can result in events causing personnel injury.
- Thermal Energy (Heat) - Heat sources include steam systems, operating electrical and mechanical equipment, and welding activities. Spurious contact with thermally hot surfaces can result in personnel injury.
- Radiant Sources - Radiation exposures can produce serious injury and death at high exposure levels. Unnecessary radiation exposure at low levels is also undesirable.

Maintenance and repair activities conducted by personnel using manual tools and equipment are major contributors to major industrial injury in the workplace. This is true for all facilities. These injuries occur sitewide and are not representative of any specific operation or proceduralized activity. Skilled craftsmen, doing work for which they are trained and qualified, occasionally experience these minor injuries.

The generic hazards and the hazard sources identified in Table 11A-1 are characterized in the next section.

11A.3 Hazard Characterization

This section characterizes the generic hazards and hazard sources identified in the previous section. The characterization provides additional information regarding the hazards and allows a determination of the hazards to be addressed as accidents in Chapter 11 of this PSAR. The hazards are characterized in Table 11A-2 for each of the hazard categories defined in Section 11A.2.

The industrial hazard sources applicable to the MWM Facility operations listed in Table A-1 are also characterized in Table 11A-2.

The following information is presented for each hazard category:

- Potential causes for the hazard
- Design features that prevent or mitigate the hazard
- Administrative features that prevent or mitigate the hazard
- The method of detecting a hazardous event
- The potential impact of a hazardous event.

Among the causes of hazardous events, those causes which result in personnel exposure to radionuclides or hazardous chemicals or which result in a potential release of radionuclides or hazardous chemicals to the environment are further analyzed as accidents in Chapter 11 of this PSAR.

11A.4 References

Hallinan, E. J. (1989), *A Guide to Performing and Documenting Safety Analyses*, Lawrence Livermore National Laboratory, Livermore, CA, M-243, February 1989.

Table 11A-1. Hazard Sources Applicable to the MWM Facility

<p>Electrical Sources Transformers Static electricity</p> <p>Motion Sources Pulleys belts, gears Shears, sharp edges, pinch points Machinery (including robotics) Vehicles Mass in motion</p> <p>Gravity-Mass Sources Falling Falling objects Lifting Tripping, slipping Earthquakes</p> <p>Pressure Sources Compressed air Stressed mechanical systems Centrifugation</p>	<p>Chemical Sources Toxic materials Corrosive materials Flammable materials Reactive materials Carcinogenic materials</p> <p>Heat Sources Electrical Steam Flames Friction Chemical reactions</p> <p>Radiant Sources Ionizing radiation UV light</p> <p>Cold Sources Ice, snow, wind, rain</p>
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Table 11A-2. MWM Facility Hazard Characterization

Hazard Event	Causes	Preventive Features		Method of Detection	Mitigative Features		Potential Impact
		Design	Administrative		Design	Administrative	
Earthquake	Natural Phenomena	Building and process equipment designed to withstand DBE; DOT-specification containers	Health & Safety Manual; Facility Safety Procedures (FSP), training, UBC H-3	Personnel observation	Waste processed in enclosure maintained at negative pressure; HEPA filter; charcoal filter	LLNL seismic program; FSP; Emergency Preparedness and Response Plan; on-site medical assistance; limited quantity of material to react	Personnel injury; equipment or facility damage; personnel exposure to hazardous materials; potential release to environment
Fire	Ignition of combustibles, electrical fault; personnel error	Fire-resistant containers; facility designed to meet UBC; electrical system compliance with acceptable standards	Health & Safety Manual; FSP; facility fire inspections, training	Personnel observation; smoke or heat detectors	Automatic fire sprinkler systems; fire extinguishers; exterior fire hydrants	FSP; Emergency Preparedness and Response Plan; employee training; fire department response; on-site medical assistance	Inhalation hazard; potential burns; equipment or facility damage; loss of use of affected area; potential release to environment
Leaks and Spills	Personnel error; equipment failure; container failure	DOT-specification containers; DOE 6430.1A / ASME Code process vessels and equipment	Health & Safety Manual; FSP, training	Personnel observation; change of process system indicators; radiation monitoring	Protective clothing; drip pans; bermed containment; remote operator; waste processed in enclosure maintained at negative pressure; HEPA filter; charcoal filter	FSP; Emergency Preparedness and Response Plan; on-site hazardous material response team; on-site medical assistance	Personnel exposure to hazardous and radioactive materials; potential release to environment
Pressurized Release	Personnel error; equipment failure	DOE 6430.1A / ASME Code process vessels and equipment	Health & Safety Manual; FSP, training	Personnel observation; change of process system indicators; radiation monitoring	Protective clothing; drip pans; bermed containment; remote operator; waste processed in enclosure maintained at negative pressure; HEPA filter; charcoal filter	FSP; Emergency Preparedness and Response Plan; on-site hazardous material response team; on-site medical assistance; limited quantity of radioactive material in facility	Personnel exposure to hazardous and radioactive materials; potential release to environment

Table 11A-2. MWMM Facility Hazard Characterization (continued)

Hazard Event	Causes	Preventive Features		Method of Detection	Mitigative Features		Potential Impact
		Design	Administrative		Design	Administrative	
Chemical Reaction	Personnel error; equipment failure	None identified	Health & Safety Manual; FSP, training	Personnel observation	HEPA filter; charcoal filter	FSP; Emergency Preparedness and Response Plan; on-site medical assistance	Personnel exposure to hazardous and radioactive materials; potential release to environment
Explosion	Personnel error; equipment failure	Combustible gas venting in fumehood	Health & Safety Manual; FSP, training	Personnel observation	HEPA filter; charcoal filter	FSP; Emergency Preparedness and Response Plan; on-site medical assistance	Equipment or facility damage; personnel exposure to hazardous and radioactive materials; potential release to environment
Industrial accident involving robotics, machinery or falling objects	Personnel error; equipment failure	Compliance with ANSI/RIA 15.06	Health & Safety Manual; FSP, training	Personnel observation	Limit controls	FSP; on-site medical assistance	Personnel injury; equipment or facility damage
Electrical shock	Electrical short; improper maintenance; personnel error	Electrical installation according to acceptable standards; ground fault interruption circuits	Health & Safety Manual; FSP, training	Personnel observation; loss of power locally	Circuit breakers, shielding, protective cabinets	FSP; on-site medical assistance	Personnel injury; equipment or facility damage
Exposure to Penetrating Radiation	Personnel error; equipment failure; container failure	DOT-specification containers; DOE 6430.1A/ASME Code process vessels and equipment, shielding	Health & Safety Manual; FSP, training	Personnel observation; change in process system indicators; radiation monitor	Protective clothing; respiratory protection equipment; HEPA filter; charcoal filter; shielding	FSP; Emergency Preparedness and Response Plan; on-site medical assistance	Personnel exposure to radioactive material

Notes:

1. Flood is not considered a hazard event since the Design Basis Flood would not result in any significant releases.
2. Wind is not considered a hazard event since the structures of Building 494 are designed to withstand a Design Basis Wind of 72 mph.
3. Criticality is considered an incredible event in Building 494.
4. See Table 11-4 of this PSAR for the area where the hazard event occurs.

APPENDIX 11B

COMPARISON OF HYDROGEN PEROXIDE EMISSION RATE DURING THE BOUNDING FIRE TO THE EMISSION RATE DURING THE BOUNDING SPILL

11B.1 Introduction

The fire scenario discussed in the Mixed Waste Management Facility Preliminary Safety Analysis Report concluded that the consequences of a release of hydrogen peroxide during the Bounding Fire are bounded by the consequences of the Bounding Spill. The purpose of this calculation is to confirm this conclusion.

11B.2 Methodology

In the Bounding Fire, the temperature of the hydrogen peroxide storage tank could rise above the 35°C assumed for the Bounding Spill. Since the hydrogen peroxide emission rate increases with temperature, there is a potential for higher emission rates for the Bounding Fire than the Bounding Spill.

The hydrogen peroxide emission rates for the Bounding Spill and Bounding Fire are calculated using the Environmental Protection Agency (EPA) Open Dump Model (EPA 1987) as shown in Appendix 11C. The inputs to the model that differ include the size of the spill and any temperature-dependent parameters such as vapor pressure.

There is a temperature at which the emission rate of hydrogen peroxide for the Bounding Fire is equal to that for the Bounding Spill. This threshold temperature and the heat required to heat hydrogen peroxide to this threshold temperature are calculated below.

11B.3 Analysis

Emission Rate Calculations

The major input parameters for the Bounding Spill calculation are as follows: hydrogen peroxide temperature is 35°C, surrounding air temperature is 35°C, and the longest spill dimension is 84 feet (pool depth is approximately 2.2 cm). As shown in Appendix 11C, the associated emission rate is approximately 3 g/sec.

During the Bounding Fire, the tank is assumed to remain intact. Assuming a tank height of 10 feet results in a pool diameter of 7.15 feet. Using this assumption, all temperature-dependent inputs in the EPA Open Dump Model (EPA 1987) were varied until the calculated emission rate was approximately 3 g/sec. As shown in Appendix 11C, the associated temperature is 118°C. The major input parameters for the Bounding Fire calculation are as follows: hydrogen peroxide temperature is 118°C, surrounding air temperature is 118°C, and the longest spill dimension is 7.15 feet (pool depth is approximately 10 feet).

Thus, if enough combustible material is present to heat the hydrogen peroxide in the tank to at least 118°C and to maintain that temperature for one hour, the consequences of the Bounding Fire would be greater than the consequences of the Bounding Spill.

Combustible Loading Calculations

It is assumed that a combustible material, such as gasoline, is spilled near the hydrogen peroxide storage tank and catches fire. In a fire involving gasoline, only a small portion of the radiant heat from the fire would reach the hydrogen peroxide storage tank. The fraction of the heat of combustion that appears as radiation is 0.18 (Cote et al. 1986) for gasoline. Depending on the fire diameter and height, and the distance of the fire to the storage tank, the fraction of radiant heat reaching the storage tank ranges from 0.01 to 0.4 (Cote et al. 1986). Thus, less than 10 percent (0.18×0.4) of the heat of combustion will be absorbed by the hydrogen peroxide storage tank.

Assuming an initial temperature of 35°C, and assuming the heat capacity of the mixture is at least as large as the heat capacity of pure water, the heat content of the fuel required to heat up the hydrogen storage tank from 35°C to 118°C is calculated as follows:

$$\begin{aligned} Q &= 10MC_p(T_f - T_i) = 10 \times 3,000 \text{ gal} \times 3.785 \text{ L/gal} \times 1.2 \text{ kg/L} \times 1,000 \text{ g/kg} \times \\ &\quad 1 \text{ cal/g} \cdot ^\circ\text{C} \times (118^\circ\text{C} - 35^\circ\text{C}) \\ &= 1.13\text{E}+10 \text{ cal} \\ &= 4.49\text{E}+07 \text{ Btu} \end{aligned}$$

where

- Q = heat content (cal),
- M = mass of liquid (g),
- C_p = heat capacity (C_p = cal/g · °C for water is assumed),
- T_f = final temperature (°C),
- T_i = initial temperature (°C).

The factor of 10 on the right side of the equation accounts for the conservative assumption that 10 percent of the heat of combustion is absorbed by the tank.

For gasoline, the heat of combustion, ΔH_c , is 43.7 MJ/kg or 18,789 Btu/lb and the density is 46.2 lb/ft³ (Cote et al. 1986). The amount of gasoline required to heat up the hydrogen peroxide to 118°C is calculated as follows:

$$M_{\text{gasoline}} = Q / \Delta H_c = (4.49\text{E}+07 \text{ Btu}) / (18,789 \text{ Btu/lb}) = 2,390 \text{ lb}$$

The volume of the gasoline is calculated as follows:

$$V = [(2,390 \text{ lb}) / (46.2 \text{ lb/ft}^3)] \times (7.481 \text{ gal/ft}^3) = 387 \text{ gallons}$$

The time to burn 387 gallons is based on the burning rate for gasoline, 0.055 kg/m²-sec (Cote et al. 1986) and the size of the pool. Various pool sizes were evaluated as shown in Table 11B-1.

11B.4 Summary and Conclusions

The above calculation shows that the amount of gasoline required to heat up hydrogen peroxide to 118°C is at least 387 gallons. Additionally, this amount of fuel will last approximately from 2 to 40 minutes. At that time, more fuel is required to maintain the temperature at 118°C.

The only fuel identified near the hydrogen peroxide storage tank is transient fuel associated with a forklift or other moving vehicle. No storage of any combustible materials is assumed to occur near the storage tank. Since the vehicles are expected to carry less than 387 gallons of fuel, any fire in the area will be smaller and of shorter duration than the fire modeled in this analysis. Thus, the emission rate during the Bounding Fire will be less than the emission rate during the Bounding Spill.

11B.5 References

Cote, A.E., et al. (1986), *Fire Protection Handbook*, National Fire Protection Association, Quincy, MA, Sixteenth Edition, 1986.

Environmental Protection Agency (1987), *Hazardous Waste Treatment, Storage And Disposal Facilities (TSDF) - Air Emission Models*, U.S. Environmental Protection Agency, Washington, DC, EPA-450/3-87-026, December 1987.

Table 11B-1. Time to Burn 387 Gallons of Gasoline

Pool Area (ft ²)	Pool Area (m ²)	Pool Depth (cm)	Time to Burn (sec)	Time to Burn (min)
100	9.3	15.8	2,119	35.3
300	27.9	5.3	708.5	11.8
500	46.5	3.2	425.1	7.1
1,000	92.9	1.6	212.5	3.5
1,500	139.4	1.1	141.7	2.4

APPENDIX 11C
EVAPORATION CALCULATIONS FOR THE MWM FACILITY
PSAR

11C.1 Introduction

This appendix documents the results of the analysis conducted to determine the ambient chemical concentrations resulting from the postulated releases of hydrogen peroxide and nitric acid at the Mixed Waste Management (MWM) Facility. Further discussion about scenarios, assumptions, and conclusions is provided in Chapter 11.

The ambient concentrations are calculated at two receptor points: on site (100 meters from the point of release) and off site (site boundary, 175 meters from the point of release).

11C.2 Input Data

The U.S. Environmental Protection Agency's (EPA) Open Dump Model (EPA 1987) was used to calculate the emission rates for the postulated releases. The model and its associated inputs are fully described in Appendix 5A of this Preliminary Safety Analysis Report (PSAR). The inputs used in this appendix are provided in Tables 11C-2 through 11C-7.

The National Safety Council's (NSC) Areal Locations Of Hazardous Atmospheres (ALOHA) model, Version 5.05, (NSC 1991) was used to determine the atmospheric dispersion factors (χ/Q_s) for both the on-site and off-site receptor points. The meteorological conditions used in this analysis include an F Stability Category and a wind speed of 1 m/sec. The model and all other inputs are the same as those used in Chapter 5 of this PSAR.

Emergency Response Planning Guideline 2 and 3 (EPRG-2 and -3) values for hydrogen peroxide are 25 and 50 ppm, respectively. The ERPG-2 and -3 values for nitric acid are 15 and 30 ppm, respectively, as described in Chapter 5 of this PSAR.

Calculations of nitric acid concentration are shown in Chapter 5 of this PSAR. Thirteen molar (M) nitric acid is equivalent to a 60 wt% solution, and 15M nitric acid is equivalent to a 67 wt% solution.

The conversion factors used in the determination of the χ/Q values (NIOSH 1990) at 68°F and 1 atmosphere pressure are as follows:

<u>Chemical</u>	<u>ppm</u>	<u>mg/m³</u>
Hydrogen Peroxide	1	1.41
Nitric Acid	1	2.62
Trichloroethylene	1	5.46
Tetrachloroethylene	1	6.89
Trichlorofluoromethane	1	5.71
Vinyl Chloride	1	2.60

11C.3 Assumptions

As a spill of nitric acid solution evaporates, it forms an azeotrope (i.e., a point at which the water preferentially evaporates while the nitric acid concentration remains the same). At the azeotrope, the nitric acid concentration remains unchanged since the water preferentially evaporates. The azeotrope for nitric acid occurs at 67 wt% (Weast 1991). Thus, all nitric acid evaporation rate calculations were performed in this analysis assuming a nitric acid solution concentration of 67 wt%.

11C.4 Analytical Methods, Calculations, and Results

The calculation of ambient concentrations of hydrogen peroxide and nitric acid at 100 and 175 meters down wind following an accident requires χ/Q values and emission rates. For many chemicals, the ALOHA code performs the entire calculation. However, hydrogen peroxide and nitric acid solutions are not contained in the ALOHA database at the desired concentrations. Only chemical physical data for pure compounds are listed in the ALOHA database. Therefore, the ambient concentrations for these solutions are calculated using the methods described below.

The χ/Q factors used in this analysis were obtained from results calculated by the ALOHA model from the analysis of four chemicals (trichloroethylene, tetrachloroethylene, trichlorofluoromethane, and vinyl chloride). These χ/Q values are essentially chemical-independent.

The equation used to calculate ambient chemical concentrations can be written as follows:

$$C = \chi/Q \times E$$

where

- C = ambient chemical concentration (mg/m³),
- χ/Q = atmospheric dispersion factor (sec/m³),
- E = effective source emission rate (mg/sec).

To calculate a χ/Q , this equation can be rearranged as follows:

$$\chi/Q = C / E$$

The 100- and 175-meter concentrations calculated with ALOHA (for the four selected chemicals) were divided by the respective emission rates (also calculated by the ALOHA model) to obtain the χ/Q values shown in Table 11C-1. The associated ALOHA input/output files are provided in Section 11C.7. Using these results, the following average χ/Q values were calculated: 2.32E-02 sec/m³ and 9.3E-03 sec/m³ for 100 and 175 meters, respectively. These χ/Q values were used in all of the calculations in this appendix.

The Open Dump Model (EPA 1987) was used to determine the emission rates of hydrogen peroxide and nitric acid for several postulated release scenarios, including the following:

1. Various releases of 50 wt% hydrogen peroxide.
2. A release of 300 gallons of 50 wt% hydrogen peroxide.
3. A fire involving 3,000 gallons of 50 wt% hydrogen peroxide.
4. A leak or fire involving 2,500 pounds of 13M nitric acid.
5. A leak of 299 pounds of 15M nitric acid.
6. A fire involving 299 pounds of 15M nitric acid.

Each scenario is discussed in more detail below.

Case 1: Various releases of 50 wt% hydrogen peroxide

Table 11C-2 presents the input data used and the calculated ambient concentrations produced by various spills of 50 wt% hydrogen peroxide. These calculations are used in the evaluation of a spill from the hydrogen peroxide storage tank.

The spill is assumed to occur for an average hydrogen peroxide solution with a temperature of 35°C and an average air temperature of 35°C.

In part 1 of the calculation, several pool sizes were evaluated to determine how a berm would affect the magnitude of the resultant ambient chemical concentrations. The results indicate that, for a 3,000-gallon spill of 50 wt% hydrogen peroxide, a maximum spill dimension (pool diameter) of 84 feet will result in an on-site ambient concentration that is equivalent to the EPRG-3 limit of 50 ppm. The pool depth associated with this pool size is approximately 2.2 cm.

In part 2, the pool depth was varied to determine the amount of hydrogen peroxide that would produce the same on-site concentration. The pool

diameter (largest spill dimension) remained constant; only the pool depth was increased with increasing quantities of hydrogen peroxide. The results indicate that, for any quantity of hydrogen peroxide, if the maximum spill dimension is 84 feet or less, the on-site concentration will be equal to or less than the EPRG-3 limit. Under these conditions, the concentration calculated at the site boundary will be less than the ERPG-2 limit of 25 ppm.

In part 3, the pool depth was varied to determine the quantity of hydrogen peroxide that would produce the same ambient chemical concentration at the site boundary. The results indicate that, for any quantity of hydrogen peroxide, if the maximum spill dimension is 98 feet or less, the concentration at the site boundary will be less than the limit. However, under these conditions, the on-site limits were exceeded.

In part 4, a release from the Wet Oxidation (WOX) reactor vessel of 50 gallons at 100°C was modeled. No berm was assumed. These calculations were used in the analysis of the Beyond Design Basis Accidents.

Case 2: A release of 300 gallons of 50 wt% hydrogen peroxide

Table 11C-3 presents the input data used and the calculated ambient concentrations produced by a 300-gallon spill of 50 wt% hydrogen peroxide. These calculations were used in the evaluation of a pressurized release from the hydrogen peroxide storage tank. The maximum amount released, 300 gallons, was determined in Appendix 11D.

For this release, the calculated on-site and off-site concentrations were 16 ppm and 6.4 ppm, respectively. These results indicate that a berm is not required to contain this size of spill to preclude an exceedance of the on-site or site boundary concentration limits.

Case 3: A fire involving 3,000 gallons of 50 wt% hydrogen peroxide

Table 11C-4 presents the input data used and the calculated ambient concentrations produced by a release of hydrogen peroxide at elevated temperatures. These calculations were used in the evaluation of a fire involving the hydrogen peroxide storage tank. Appendix 11B provides more information on this scenario.

A fire involving the hydrogen peroxide storage tank is assumed to leave the tank intact. Thus, assuming a tank height of 10 feet, the diameter of a tank holding 3,000 gallons of 50 wt% hydrogen peroxide is 7.15 feet.

The hydrogen peroxide temperature at which the emission rate for this pool size equals the emission rate of the spill evaluated in Case 1 was determined. The

emission rate associated with the maximum allowable release, as determined in Case 1, is approximately 3 g/sec.

As shown in Table 11C-4, the input parameters that vary with temperature are component density, vapor pressure, and diffusivity. The results indicate that a hydrogen peroxide temperature and air temperature of 118°C will result in an emission rate of approximately 3 g/sec.

Case 4: A leak or fire involving 2,500 pounds of 13M nitric acid

Table 11C-5 presents the input data used and the calculated ambient concentrations produced by a 2,500-pound spill of nitric acid at various liquid temperatures. These calculations were used to evaluate a spill from the Mediated Electrochemical Oxidation (MEO) process and support systems.

The input data include a liquid temperature of 70°C (LLNL 1994), sump dimensions of 790 cm by 140 cm (LLNL 1994), and an average indoor air velocity of 50 fpm (ASHRAE 1989).

For a spill of nitric acid at 70°C, the calculated ambient on-site concentration is 26 ppm and the ambient concentration at the site boundary is 10 ppm. These values are below the ERPG on-site and off-site limits of 30 and 15 ppm, respectively.

A release was also modeled in which it was assumed that the sump is not in place. This calculation was used in the analysis of the Beyond Design Basis Accidents.

Case 5: A leak of 299 pounds of 15M nitric acid

Table 11C-6 presents the input data used and the calculated ambient concentrations produced by a 299-pound spill of nitric acid at various temperatures. These calculations were used to evaluate a nitric acid spill from the storage area and as part of the Beyond Design Basis Accident calculation.

The calculations indicate that, for a 299-pound spill of nitric acid at any temperature less than 65°C, a berm is not required to maintain the on-site and site boundary concentrations within the associated limits (1 cm is the minimum spill depth assumed for any emission rate calculation).

Case 6: A fire involving 299 pounds of 15M nitric acid

Table 11C-7 presents the input data used and the calculated ambient concentrations produced by a fire involving 299 pounds of 15M nitric acid at

various temperatures. These calculations were used to evaluate a fire involving the nitric acid storage tank.

The nitric acid storage tank is assumed to remain intact during a fire and the tank is conservatively assumed to have a 2-foot diameter. However, a release path to the environment is postulated to exist.

The calculations indicate that at any temperature less than 125°C, the release rate and resultant ambient concentrations are less than the corresponding values associated with nitric acid releases from the MEO and indoor support systems.

A temperature of 125°C is assumed to conservatively represent the bounding temperature because at standard atmospheric pressure, nitric acid boils at 86°C.

11C.5 Conclusions

Case 1 demonstrated that, for any size of leak of hydrogen peroxide, the on-site and site boundary criteria will not be exceeded if the maximum spill dimension is assumed to be 84 feet.

Case 4 demonstrated that, for any size of leak of nitric acid, the on-site and site boundary criteria will not be exceeded if the spill dimensions are assumed to be equal to or less than 790 cm by 140 cm and if the average temperature of the nitric acid is assumed to be equal to or less than 70°C.

11C.6 References

- American Society of Heating, Refrigerating and Air Conditioning Engineers Inc., (1989), *1989 ASHRAE Handbook, Fundamentals*, I-P Edition, Atlanta, GA, 1989.
- Environmental Protection Agency (1987), *Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) - Air Emission Models*, U.S. Environmental Protection Agency, Washington, DC, EPA-450/3-87-026, December 1987.
- Lawrence Livermore National Laboratory (1994) *Mixed Waste Management Facility Conceptual Design Report*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-PROP-116761, Draft, 1994.
- National Institute for Occupational Safety and Health (1990), *NIOSH Pocket Guide to Chemical Hazards*, U.S. Department of Health and Human Services, Washington, DC, June 1990.
- National Safety Council (1991), *Areal Locations of Hazardous Atmospheres*, Version 5.05, National Safety Council, Washington, DC, September 1991.
- Perry, R.H., D.W. Green, and J.O. Maloney (eds.) (1984), *Perry's Chemical Engineers' Handbook*, Fifth Edition, McGraw Hill Book Co., New York, NY, 1984.
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Table 11C-1. Dispersion Factor Calculations

Chemical	Release Rate (mg/sec) ^a	100-meter Conc. (mg/m ³) ^a	175-meter Conc. (mg/m ³) ^a	100-meter χ/Q (sec/m ³)	175-meter χ/Q (sec/m ³)
Trichloroethylene	2.12E+04	2.98E+02	1.25E+02	1.41E-02	5.90E-03
Tetrachloroethylene	9.70E+03	2.01E+02	8.47E+01	2.07E-02	8.73E-03
Trichlorofluoromethane	2.72E+03	5.77E+01	2.66E+01	2.12E-02	9.78E-03
Vinyl Chloride	7.10E+02	2.60E+01	9.07E+00	3.66E-02	1.28E-02
Average				2.32E-02	9.30E-03

^a Data obtained from attached ALOHA runs

Table 11C-2. Concentration Calculations for 50 wt% Hydrogen Peroxide Using EPA Open Dump Model

Quantity of H ₂ O ₂ gal @ 50 wt%	Pool Depth (in)	Pool Depth (cm)	Comp Density (kg/L) ^a	Pool Area (cm ²)	Pool Diameter (cm)	Pool Diameter (ft)	MWi (g/mole)	Vapor Pressure (mm Hg) ^a	X _i	Y _i	Liquid Temp (°C)	Air Temp (°C)
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Part 1 - Various pool dimensions

3000	0.39	1.00	1.20E+00	1.14E+07	3.80E+03	1.25E+02	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
3000	0.85	2.17	1.20E+00	5.23E+06	2.58E+03	8.47E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
3000	1.00	2.54	1.20E+00	4.47E+06	2.39E+03	7.83E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
3000	6.00	15.24	1.20E+00	7.45E+05	9.74E+02	3.20E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
3000	12.00	30.48	1.20E+00	3.73E+05	6.89E+02	2.26E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01

Part 2 - Onsite maximums

1380	0.39	1.00	1.20E+00	5.22E+06	2.58E+03	8.46E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
3500	1.00	2.54	1.20E+00	5.22E+06	2.58E+03	8.45E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
21000	6.00	15.24	1.20E+00	5.22E+06	2.58E+03	8.45E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01

Part 3 - Site boundary maximums

1850	0.39	1.00	1.20E+00	7.00E+06	2.99E+03	9.80E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
4700	1.00	2.54	1.20E+00	7.00E+06	2.99E+03	9.80E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01
28200	6.00	15.24	1.20E+00	7.00E+06	2.99E+03	9.80E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01

Part 4 - For Beyond Design Basis Accident Calculation

50	0.39	1.00	1.20E+00	1.89E+05	4.91E+02	1.61E+01	3.40E+01	1.16E+02	1.50E-01	2.29E-02	1.00E+02	3.50E+01
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^a Perry et al. 1984

Table 11C-2. Concentration Calculations for 50 wt% Hydrogen Peroxide Using EPA Open Dump Model (continued)

Quantity of H ₂ O ₂ gal @ 50 wt%	Pool Depth (in)	Wind Speed (cm/sec)	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&I %/Q @ 100	F&I %/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
Part 1 - Various pool dimensions											
3000	39.37	1.00E+02	3.07E-01	9.98E-01	2.82E-02	1.93E+02	5.44E+00	2.32E-02	9.30E-03	9.0E+01	3.6E+01
3000	39.37	1.00E+02	3.07E-01	9.98E-01	1.91E-02	1.59E+02	3.04E+00	2.32E-02	9.30E-03	5.0E+01	2.0E+01
3000	1.00	1.00E+02	3.07E-01	9.98E-01	1.77E-02	1.53E+02	2.71E+00	2.32E-02	9.30E-03	4.5E+01	1.8E+01
3000	6.00	1.00E+02	3.07E-01	9.98E-01	7.23E-03	9.77E+01	7.06E-01	2.32E-02	9.30E-03	1.2E+01	4.7E+00
3000	12.00	1.00E+02	3.07E-01	9.98E-01	5.11E-03	8.21E+01	4.20E-01	2.32E-02	9.30E-03	6.9E+00	2.8E+00
Part 2 - Onsite maximums											
1380	39.37	1.00E+02	3.07E-01	9.98E-01	1.91E-02	1.59E+02	3.04E+00	2.32E-02	9.30E-03	5.0E+01	2.0E+01
3500	1.00	1.00E+02	3.07E-01	9.98E-01	1.91E-02	1.59E+02	3.04E+00	2.32E-02	9.30E-03	5.0E+01	2.0E+01
21000	6.00	1.00E+02	3.07E-01	9.98E-01	1.91E-02	1.59E+02	3.04E+00	2.32E-02	9.30E-03	5.0E+01	2.0E+01
Part 3 - Site boundary maximums											
1850	39.37	1.00E+02	3.07E-01	9.98E-01	2.22E-02	1.71E+02	3.79E+00	2.32E-02	9.30E-03	6.2E+01	2.5E+01
4700	1.00	1.00E+02	3.07E-01	9.98E-01	2.22E-02	1.71E+02	3.79E+00	2.32E-02	9.30E-03	6.2E+01	2.5E+01
28200	6.00	1.00E+02	3.07E-01	9.98E-01	2.22E-02	1.71E+02	3.79E+00	2.32E-02	9.30E-03	6.2E+01	2.5E+01
Part 4 - For Beyond Design Basis Accident Calculation											
50	0.39	1.00E+02	4.09E-01	9.83E-01	3.02E-02	8.06E+01	2.44E+00	2.32E-02	9.30E-03	4.0E+01	1.6E+01

a Perry et al. 1984

Table 11C-3. Concentration Calculation for 50 wt% Hydrogen Peroxide Using EPA Open Dump Model for a Pressurized Release

Quantity of H ₂ O ₂ gal @ 50 wt%	Pool Depth (in)	Pool Depth (cm)	Comp Density (kg/L) ^a	Pool Area (cm ²)	Pool Diameter (cm)	Pool Diameter (ft)	MWi (g/mole)	Vapor Pressure (mm Hg) ^a	X _i	Y _i	Liquid Temp (°C)	Air Temp (°C)
For pressurized release calculation												
300	0.39	1.00	1.20E+00	1.14E+06	1.20E+03	3.94E+01	3.40E+01	6.05E+00	3.46E-01	2.75E-03	3.50E+01	3.50E+01

^a Perry et al. 1984

Table 11C-3. Concentration Calculation for 50 wt% Hydrogen Peroxide Using EPA Open Dump Model for a Pressurized Release (continued)

Quantity of H ₂ O ₂ gal @ 50 wt%	Pool Depth (in)	Wind Speed (cm/sec)	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&1 X/Q @ 100	F&1 X/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
300	39.37	1.00E+02	3.07E-01	1.00E+00	8.92E-03	1.08E+02	9.67E-01	2.32E-02	9.30E-03	1.6E+01	6.4E+00

For pressurized release calculation

a Perry et al. 1984

Table 11C-4. Concentration Calculations for 3,000 Gallons of 50 wt% Hydrogen Peroxide Within a 10-Foot Tank During a Fire Using EPA Open Dump Model

Liquid and Air Temp (°C)	Pool Depth (in)	Pool Depth (cm)	Component Density (kg/L) ^a	Pool Area (cm ²)	Pool Diameter (cm)	Pool Diameter (ft)	MWi (g/mole)	Vapor Pressure (mm Hg) ^a	X _i	Y _i	Wind Speed (cm/sec)
140	120.00	304.80	1.20E+00	3.73E+04	2.18E+02	7.15E+00	3.40E+01	4.45E+02	3.46E-01	2.03E-01	1.00E+02
130	120.00	304.80	1.20E+00	3.73E+04	2.18E+02	7.15E+00	3.40E+01	3.44E+02	3.46E-01	1.57E-01	1.00E+02
120	120.00	304.80	1.20E+00	3.73E+04	2.18E+02	7.15E+00	3.40E+01	2.68E+02	3.46E-01	1.22E-01	1.00E+02
110	120.00	304.80	1.20E+00	3.73E+04	2.18E+02	7.15E+00	3.40E+01	1.92E+02	3.46E-01	8.74E-02	1.00E+02
118	120.00	304.80	1.20E+00	3.73E+04	2.18E+02	7.15E+00	3.40E+01	2.53E+02	3.46E-01	1.15E-01	1.00E+02

^a Perry et al. 1984

Table 11C-4. Concentration Calculations for 3,000 Gallons of 50 wt% Hydrogen Peroxide Within a 10-Foot Tank
During a Fire Using EPA Open Dump Model (continued)

Liquid and Air Temp (°C)	Pool Depth (in)	Pool Depth (cm)	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&I X/Q @ 100	F&I X/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
140	120.00	304.80	4.77E-01	8.51E-01	8.87E-02	6.23E+01	5.53E+00	2.32E-02	9.30E-03	9.1E+01	3.6E+01
130	120.00	304.80	4.60E-01	8.85E-01	7.02E-02	6.00E+01	4.21E+00	2.32E-02	9.30E-03	6.9E+01	2.8E+01
120	120.00	304.80	4.43E-01	9.11E-01	5.61E-02	5.81E+01	3.26E+00	2.32E-02	9.30E-03	5.4E+01	2.1E+01
110	120.00	304.80	4.26E-01	9.36E-01	4.12E-02	5.62E+01	2.32E+00	2.32E-02	9.30E-03	3.8E+01	1.5E+01
118	120.00	304.80	4.39E-01	9.16E-01	5.32E-02	5.77E+01	3.07E+00	2.32E-02	9.30E-03	5.0E+01	2.0E+01

a Perry et al. 1984

Table 11C-5. Concentration Calculations for 13M Nitric Acid at Various Temperatures Using EPA Open Dump Model

Quantity of HNO ₃ lb @ 13 M ^a	Nitric Acid Temp (°C)	Comp Density (kg/L) ^b	Quantity of HNO ₃ gal @ 13M	Longest Dimension (cm) ^c	Shortest Dimension (cm) ^c	Pool Depth (cm)	Indoor Wind Speed (cm/sec) ^d	Air Temp (°C)	MWi (g/mole)	Vapor pressure (mm Hg) ^b	X _i	Y _i
2500	35	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	5.48E+00	1.00E+00	7.21E-03
2500	45	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	9.57E+00	1.00E+00	1.26E-02
2500	55	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	1.61E+01	1.00E+00	2.12E-02
2500	65	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	2.68E+01	1.00E+00	3.53E-02
2500	70	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	3.38E+01	1.00E+00	4.45E-02
2500	75	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	4.28E+01	1.00E+00	5.63E-02
2500	85	1.38E+00	217	790	140	7.4	25.4	3.50E+01	6.30E+01	6.59E+01	1.00E+00	8.67E-02

For Beyond Design Basis Accident Calculation

2500	70	1.38E+00	217	900	900	1.01	25.4	3.50E+01	6.30E+01	3.38E+01	1.00E+00	4.45E-02
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^a Modeled at 67%

^b Perry et al. 1984

^c LLNL 1994

^d ASHREA 1989

Table 11C-5. Concentration Calculations for 13M Nitric Acid at Various Temperatures Using EPA Open Dump Model
(continued)

Quantity of HNO ₃ lb @ 13 M ^a	Nitric Acid Temp (°C)	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&I %/Q @ 100	F&I %/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
2500	35	2.05E-01	9.95E-01	2.84E-02	1.53E+01	4.34E-01	2.32E-02	9.30E-03	3.8E+00	1.5E+00
2500	45	2.15E-01	9.91E-01	4.97E-02	1.57E+01	7.78E-01	2.32E-02	9.30E-03	6.9E+00	2.8E+00
2500	55	2.25E-01	9.85E-01	8.35E-02	1.61E+01	1.34E+00	2.32E-02	9.30E-03	1.2E+01	4.8E+00
2500	65	2.36E-01	9.74E-01	1.39E-01	1.65E+01	2.30E+00	2.32E-02	9.30E-03	2.0E+01	8.2E+00
2500	70	2.41E-01	9.68E-01	1.75E-01	1.68E+01	2.94E+00	2.32E-02	9.30E-03	2.6E+01	1.0E+01
2500	75	2.46E-01	9.59E-01	2.22E-01	1.70E+01	3.79E+00	2.32E-02	9.30E-03	3.4E+01	1.3E+01
2500	85	2.57E-01	9.37E-01	3.42E-01	1.76E+01	6.02E+00	2.32E-02	9.30E-03	5.3E+01	2.1E+01

For Beyond Design Basis Accident Calculation

2500	70	2.41E-01	9.68E-01	2.00E-01	4.26E+01	8.50E+00	2.32E-02	9.30E-03	7.5E+01	3.0E+01
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- a Modeled at 67%
- b Perry et al. 1984
- c LLNL 1994
- d ASHREA 1989

Table 11C-6. Concentration Calculations for 15M Nitric Acid at Various Temperatures Using EPA Open Dump Model

Quantity of HNO ₃ lb @ 15 M ^a	Quantity of HNO ₃ gal @ 15 M	Pool Depth (cm)	Nitric Acid (°C)	Air Temp (°C)	Wind Speed (cm/sec)	Comp Density (kg/L) ^b	Pool Area (cm ²) ^c	Pool Diameter (cm)	Pool Diameter (ft)	MWi (g/mole)	Vapor Pressure (mm Hg) ^b	X _i
299	26	1.00	35	3.50E+01	1.00E+02	1.38E+00	9.83E+04	3.54E+02	1.16E+01	6.30E+01	5.48E+00	1.00E+00
299	26	1.00	45	3.50E+01	1.00E+02	1.38E+00	9.83E+04	3.54E+02	1.16E+01	6.30E+01	9.57E+00	1.00E+00
299	26	1.00	55	3.50E+01	1.00E+02	1.38E+00	9.83E+04	3.54E+02	1.16E+01	6.30E+01	1.61E+01	1.00E+00
299	26	1.00	65	3.50E+01	1.00E+02	1.38E+00	9.83E+04	3.54E+02	1.16E+01	6.30E+01	2.68E+01	1.00E+00

^a Modeled at 67%

^b Perry et al. 1984

^c Assumes tank leaks, maximum spill area with 1 cm depth

Table 11C-6. Concentration Calculations for 15M Nitric Acid at Various Temperatures Using EPA Open Dump Model
(continued)

Quantity of HNO ₃ @ 15 M ^a	Quantity of HNO ₃ gal @ 15 M	Y ₁	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&1 X/Q @ 100	F&1 X/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
299	26	7.21E-03	2.05E-01	9.95E-01	1.27E-02	4.82E+01	6.13E-01	2.32E-02	9.30E-03	5.43E+00	2.2E+00
299	26	1.26E-02	2.15E-01	9.91E-01	2.22E-02	4.94E+01	1.10E+00	2.32E-02	9.30E-03	9.73E+00	3.9E+00
299	26	2.12E-02	2.25E-01	9.85E-01	3.74E-02	5.07E+01	1.90E+00	2.32E-02	9.30E-03	1.68E+01	6.7E+00
299	26	3.53E-02	2.36E-01	9.74E-01	6.23E-02	5.22E+01	3.25E+00	2.32E-02	9.30E-03	2.88E+01	1.2E+01

a Modeled at 67%

b Perry et al. 1984

c Assumes tank leaks, maximum spill area with 1 cm depth

Table 11C-7. Concentration Calculations for 15M Nitric Acid at Various Temperatures For Outside Storage Tank
Using EPA Open Dump Model

Quantity of HNO ₃ lb @ 15 M ^a	Nitric Acid Temp (°C)	Comp Density (kg/L) ^b	Quantity of HNO ₃ gal @ 15 M	Longest Dimension (cm) ^c	Shortest Dimension (cm) ^c	Pool Depth (cm)	Wind Speed (cm/sec)	Air Temp (°C)	MWi (g/mole)	Vapor Pressure (mm Hg) ^b	Xi
299	35	1.38E+00	26	61	61	26.4	100	35	6.30E+01	5.48E+00	1.00E+00
299	45	1.38E+00	26	61	61	26.4	100	45	6.30E+01	9.57E+00	1.00E+00
299	55	1.38E+00	26	61	61	26.4	100	55	6.30E+01	1.61E+01	1.00E+00
299	65	1.38E+00	26	61	61	26.4	100	65	6.30E+01	2.68E+01	1.00E+00
299	70	1.38E+00	26	61	61	26.4	100	70	6.30E+01	3.38E+01	1.00E+00
299	75	1.38E+00	26	61	61	26.4	100	75	6.30E+01	4.28E+01	1.00E+00
299	85	1.38E+00	26	61	61	26.4	100	85	6.30E+01	6.59E+01	1.00E+00
299	95	1.38E+00	26	61	61	26.4	100	95	6.30E+01	1.00E+02	1.00E+00
299	100	1.38E+00	26	61	61	26.4	100	100	6.30E+01	1.23E+02	1.00E+00
299	110	1.38E+00	26	61	61	26.4	100	110	6.30E+01	1.80E+02	1.00E+00
299	120	1.38E+00	26	61	61	26.4	100	120	6.30E+01	2.56E+02	1.00E+00
299	125	1.38E+00	26	61	61	26.4	100	125	6.30E+01	3.05E+02	1.00E+00

^a Modeled at 67%

^b Perry et al. 1984

^c Assumes tank surface area of 4 square feet

Table 11C-7. Concentration Calculations for 15M Nitric Acid at Various Temperatures For Outside Storage Tank
Using EPA Open Dump Model (continued)

Quantity of HNO ₃ lb @ 15 M ^a	Nitric Acid Temp (°C)	Y _i	Diffusivity (cm ² /sec)	Fv	Factor 1 (g/cm ²)	Factor 2 (cm ² /sec)	Release Rate (g/sec)	F&I X/Q @ 100	F&I X/Q @ 175	Conc. @ 100 m (ppm)	Conc. @ 175 m (ppm)
299	35	7.21E-03	2.05E-01	9.95E-01	2.20E-03	2.00E+01	4.39E-02	2.32E-02	9.30E-03	3.9E-01	1.6E-01
299	45	1.26E-02	2.15E-01	9.91E-01	3.71E-03	2.05E+01	7.62E-02	2.32E-02	9.30E-03	6.7E-01	2.7E-01
299	55	2.12E-02	2.25E-01	9.85E-01	6.06E-03	2.11E+01	1.28E-01	2.32E-02	9.30E-03	1.1E+00	4.5E-01
299	65	3.53E-02	2.36E-01	9.74E-01	9.79E-03	2.17E+01	2.12E-01	2.32E-02	9.30E-03	1.9E+00	7.5E-01
299	70	4.45E-02	2.41E-01	9.68E-01	1.22E-02	2.20E+01	2.67E-01	2.32E-02	9.30E-03	2.4E+00	9.5E-01
299	75	5.63E-02	2.46E-01	9.59E-01	1.52E-02	2.23E+01	3.39E-01	2.32E-02	9.30E-03	3.0E+00	1.2E+00
299	85	8.67E-02	2.57E-01	9.37E-01	2.27E-02	2.31E+01	5.24E-01	2.32E-02	9.30E-03	4.6E+00	1.9E+00
299	95	1.32E-01	2.68E-01	9.03E-01	3.36E-02	2.40E+01	8.05E-01	2.32E-02	9.30E-03	7.1E+00	2.9E+00
299	100	1.62E-01	2.73E-01	8.81E-01	4.07E-02	2.45E+01	9.98E-01	2.32E-02	9.30E-03	8.8E+00	3.5E+00
299	110	2.37E-01	2.84E-01	8.25E-01	5.80E-02	2.59E+01	1.50E+00	2.32E-02	9.30E-03	1.3E+01	5.3E+00
299	120	3.37E-01	2.95E-01	7.49E-01	8.04E-02	2.77E+01	2.22E+00	2.32E-02	9.30E-03	2.0E+01	7.9E+00
299	125	4.01E-01	3.01E-01	7.00E-01	9.46E-02	2.89E+01	2.73E+00	2.32E-02	9.30E-03	2.4E+01	9.7E+00

^a Modeled at 67%

^b Perry et al. 1984

^c Assumes tank surface area of 4 square feet

ALOHA INPUT DECKS

CHEMICAL

Trichloroethylene receptor distance = 100 m

Trichloroethylene receptor distance = 175 m

Tetrachloroethylene receptor distance = 100 m

Tetrachloroethylene receptor distance = 175 m

Vinyl Chloride receptor distance = 100 m

Vinyl Chloride receptor distance = 175 m

Trichlorofluoromethane receptor distance = 100 m

Trichlorofluoromethane receptor distance = 175 m

Text Summary

2836996370

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROETHYLENE	Molecular Weight: 131.39 kg/kmol
TLV-TWA: 50.00 ppm	IDLH: 1000.00 ppm
Footprint Level of Concern: 1000.00 ppm	
Boiling Point: 86.95° Celsius	
Vapor Pressure at Ambient Temperature: 0.15 atm	
Ambient Saturation Concentration: 154,596 ppm or 15.5%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Puddle Area: 9.6 square meters
Average Puddle Depth: 1 centimeter
Soil Type: Default
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 1.27 kilograms/min
Max Average Sustained Release Rate: 1.27 kilograms/min
(averaged over a minute or more)
Total Amount Released: 75.9 kilograms

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (1000.00 ppm)
Max Threat Zone for LOC: 19 meters
Note: Footprint wasn't drawn because effects of near-field patchiness make plume presentation unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 54.6 ppm
Indoor: 19.3 ppm
Max Dose:
Outdoor: 3,130 (ppm,min)
Indoor: 594 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
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Text Summary

2836994752

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROETHYLENE Molecular Weight: 131.39 kg/kmol
TLV-TWA: 50.00 ppm IDLH: 1000.00 ppm
Footprint Level of Concern: 1000.00 ppm
Boiling Point: 86.95° Celsius
Vapor Pressure at Ambient Temperature: 0.15 atm
Ambient Saturation Concentration: 154,596 ppm or 15.5%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s No Inversion Height
Stability Class: F Air Temperature: 95° Fahrenheit
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 1 tenths

SOURCE STRENGTH INFORMATION:

Puddle Area: 9.6 square meters
Average Puddle Depth: 1 centimeter
Soil Type: Default Ground Temperature: 95° Fahrenheit
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 1.27 kilograms/min
Max Average Sustained Release Rate: 1.27 kilograms/min
 (averaged over a minute or more)
Total Amount Released: 75.9 kilograms

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (1000.00 ppm)
Max Threat Zone for LOC: 19 meters
Note: Footprint wasn't drawn because effects of
 near-field patchiness make plume presentation
 unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 22.9 ppm
 Indoor: 7.92 ppm
Max Dose:
 Outdoor: 1,280 (ppm,min)
 Indoor: 237 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Text Summary

2836993523

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TETRACHLOROETHYLENE	Molecular Weight: 165.83 kg/kmol
TLV-TWA: 50.00 ppm	IDLH: 500.00 ppm
Footprint Level of Concern: 500.00 ppm	
Boiling Point: 121.25° Celsius	
Vapor Pressure at Ambient Temperature: 0.041 atm	
Ambient Saturation Concentration: 41,386 ppm or 4.14%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Puddle Area: 10.5 square meters
Average Puddle Depth: 1 centimeter
Soil Type: Default
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 585 grams/min
Max Average Sustained Release Rate: 582 grams/min
(averaged over a minute or more)
Total Amount Released: 32.5 kilograms

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (500.00 ppm)
Max Threat Zone for LOC: 18 meters
Note: Footprint wasn't drawn because effects of near-field patchiness make plume presentation unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 29.2 ppm
Indoor: 9.53 ppm
Max Dose:
Outdoor: 1,540 (ppm,min)
Indoor: 281 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2836991104

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TETRACHLOROETHYLENE	Molecular Weight: 165.83 kg/kmol
TLV-TWA: 50.00 ppm	IDLH: 500.00 ppm
Footprint Level of Concern: 500.00 ppm	
Boiling Point: 121.25° Celsius	
Vapor Pressure at Ambient Temperature: 0.041 atm	
Ambient Saturation Concentration: 41,386 ppm or 4.14%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Puddle Area: 10.5 square meters
Average Puddle Depth: 1 centimeter
Soil Type: Default
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Computed Release Rate: 585 grams/min
Max Average Sustained Release Rate: 582 grams/min
(averaged over a minute or more)
Total Amount Released: 32.5 kilograms

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (500.00 ppm)
Max Threat Zone for LOC: 18 meters
Note: Footprint wasn't drawn because effects of
near-field patchiness make plume presentation
unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 12.3 ppm
Indoor: 3.95 ppm
Max Dose:
Outdoor: 633 (ppm,min)
Indoor: 114 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Text Summary

2836998872

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: VINYL CHLORIDE	Molecular Weight: 62.50 kg/kmol
TLV-TWA: -unavail-	IDLH: 1.00 ppm
Footprint Level of Concern: 1.00 ppm	
Boiling Point: -13.37° Celsius	
Vapor Pressure at Ambient Temperature: greater than 1 atm	
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Direct Source: .7056 grams/sec	Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour	
Release Rate: 42.3 grams/min	
Total Amount Released: 2.54 kilograms	
Note: This chemical may flash boil and/or result in two phase flow.	

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (1.00 ppm)
Max Threat Zone for LOC: 318 meters
For more detailed information check the Time Dependent
Conc/Dose information at specific locations.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 10 ppm
Indoor: 3.54 ppm
Max Dose:
Outdoor: 576 (ppm,min)
Indoor: 109 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

Text Summary

2836999029

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: VINYL CHLORIDE	Molecular Weight: 62.50 kg/kmol
TLV-TWA: -unavail-	IDLH: 1.00 ppm
Footprint Level of Concern: 1.00 ppm	
Boiling Point: -13.37° Celsius	
Vapor Pressure at Ambient Temperature: greater than 1 atm	
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Direct Source: .7056 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 42.3 grams/min
Total Amount Released: 2.54 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (1.00 ppm)
Max Threat Zone for LOC: 318 meters
For more detailed information check the Time Dependent
Conc/Dose information at specific locations.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 3.49 ppm
 Indoor: 1.22 ppm
Max Dose:
 Outdoor: 197 (ppm,min)
 Indoor: 36.8 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

Text Summary

2836989325

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROFLUOROMETHANE	Molecular Weight: 137.37 kg/kmol
TLV-TWA: 1000.00 ppm	IDLH: 10000.00 ppm
Footprint Level of Concern: 10000 ppm	
Boiling Point: 23.82° Celsius	
Vapor Pressure at Ambient Temperature: greater than 1 atm	
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%	

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s	No Inversion Height
Stability Class: F	Air Temperature: 95° Fahrenheit
Relative Humidity: 50%	Ground Roughness: Open country
Cloud Cover: 1 tenths	

SOURCE STRENGTH INFORMATION:

Direct Source: 2.72 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 163 grams/min
Total Amount Released: 9.79 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (10000 ppm)
Max Threat Zone for LOC: less than 10 meters (10.9 yards)
Note: Footprint wasn't drawn because effects of
near-field patchiness make plume presentation
unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 100 meters
Off Centerline: 0 meters
Max Concentration:
 Outdoor: 10.1 ppm
 Indoor: 3.55 ppm
Max Dose:
 Outdoor: 576 (ppm,min)
 Indoor: 109 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

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Lawrence Livermore National Laboratory

2836989516

Text Summary

SITE DATA INFORMATION:

Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.46 (Unsheltered single storied)
Date & Time: Fixed at July 4, 1993 & 1700 hours

CHEMICAL INFORMATION:

Chemical Name: TRICHLOROFLUOROMETHANE Molecular Weight: 137.37 kg/kmol
TLV-TWA: 1000.00 ppm IDLH: 10000.00 ppm
Footprint Level of Concern: 10000 ppm
Boiling Point: 23.82° Celsius
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 1.0 meters/sec from s No Inversion Height
Stability Class: F Air Temperature: 95° Fahrenheit
Relative Humidity: 50% Ground Roughness: Open country
Cloud Cover: 1 tenths

SOURCE STRENGTH INFORMATION:

Direct Source: 2.72 grams/sec Source Height: 0
Release Duration: ALOHA limited the duration to 1 hour
Release Rate: 163 grams/min
Total Amount Released: 9.79 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

FOOTPRINT INFORMATION:

Model Run: Heavy Gas
User specified LOC: equals IDLH (10000 ppm)
Max Threat Zone for LOC: less than 10 meters (10.9 yards)
Note: Footprint wasn't drawn because effects of
near-field patchiness make plume presentation
unreliable for short distances.

TIME DEPENDENT INFORMATION:

Concentration/Dose Estimates at the point:
Downwind: 175 meters
Off Centerline: 0 meters
Max Concentration:
Outdoor: 4.66 ppm
Indoor: 1.6 ppm
Max Dose:
Outdoor: 258 (ppm,min)
Indoor: 47.4 (ppm,min)
Note: Indoor graphs are shown with a dotted line.

APPENDIX 11D

**EVALUATION OF PRESSURIZED RELEASE OF REAGENTS AT
THE MWM FACILITY**

11D.1 Evaluation of Pressurized Release of Reagents at the MWM Facility

The purpose of this calculation is to determine the quantity of material that could be released to the air during a pressurized release at the Mixed Waste Management (MWM) Facility.

There are two mechanisms for the liquid to become airborne during a pressurized release, the amount made airborne by the pressurized release; and the amount that evaporates or is resuspended as a result of evaporation of the material that accumulates on the ground. This evaluation quantifies the amount that is released to the air via the pressurized release, and the amount of material that is released to the ground. The evaporation calculation for the material released to the ground is provided in Appendix 11C.

D.2 Analysis

A pressurized release could occur at the discharge side of a transfer pump used to pump liquid waste or reagents through a waste treatment unit or its support system. An analysis of the pressurized liquid release is performed to determine the Airborne Release Fraction (ARF) and Respirable Fraction (RF) that are used to estimate the chemical source term as follows:

$$\text{Source Term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{LPF} \times \text{RF}$$

where

MAR = Material at Risk; the total amount of material of a specified form at a specific location within a facility,

DR = Damage Ratio; the fraction of the MAR that has the potential to be impacted under specific accident conditions,

ARF = Airborne Release Fraction; the fraction of the affected MAR that would become airborne within the facility under specific accident conditions,

LPF = Leak Path Factor; the fraction of material that is airborne within the facility and that is expected to be released to the environment,

RF = Respirable Fraction; the fraction of a given release that has a particle size of 10 μ or less Aerodynamic Equivalent Diameter which could be inhaled.

The DR and LPF are conservatively assumed to be 1 in this analysis. The ARF and RF are conservatively estimated from DOE-HDBK-0013-93 (DOE 1993). The bounding values of 1E-04 and 1.0 (DOE 1993) are recommended for ARF and RF, respectively, for a pressurized release of liquid via a breach under the liquid surface level below the boiling point. These bounding values are estimated using the mass fraction of droplets 10 micrometers (μm) and less in diameter formed by commercial spray nozzles (device designed to produce small drops) under conditions that will exceed those anticipated for most accident situations (3.25-mm-diameter orifice at 200-psig upstream pressure). The bounding value of ARF is based on the drop size distributions for the commercial spray nozzles measured by Mishima et al., as shown in Figure 3-5 of DOE-HDBK-0013-93 (DOE 1993). The MWM Facility process system pressures are well below 200 psig used in the experiment. Even though the break size for the MWM Facility could be larger or smaller than 3.25 mm (0.128 inches) in diameter, the drop sizes are not expected to be smaller than those generated by a 3.25-mm-diameter commercial spray nozzle, which is designed to produce fine drops, at 200-psig upstream pressure.

The rate of liquid released via the break is a function of the break size and pressure. The drop size increases with the increasing break size (diameter) and decreasing pressure. For break sizes larger than 3.25 mm, the release rates are high, but the drop sizes are large. For example, for the break diameter of 6.5 mm (0.26 inches) and pressure at 200 psig, an extrapolation of the Figure 3-5 (DOE 1993) data shows that the fraction of drop sizes less than 10 μm is approximately 1E-05. Therefore, only break sizes smaller than 3.25 mm are considered.

The liquid volumetric release rate Q (ft^3/sec) for the MWM Facility is calculated below:

$$Q = VA = CA(2g_c(P_i - P_o)/r_o)^{1/2}$$

where

- V = velocity (ft/sec),
- A = break area (ft^2),
- C = coefficient (conservatively assumed to be 1),
- g_c = gravitational acceleration = $32.17 \text{ ft}\cdot\text{lb}_m/\text{lb}_f\cdot\text{sec}^2$,
- P_i = upstream (stagnation) pressure (lb_f/ft^2),
- P_o = local static pressure (lb_f/ft^2),
- r_o = density (lb_m/ft^3).

For the break size of 3.25 mm in diameter

$$A = D^2/4 = 3.1416(3.25/304.8)^2/4 = 8.93\text{E-}05\text{ft}^2$$

In the above calculation, the density of 50% hydrogen peroxide of 1.2 kg/L or 74.9 lb_m/ft³ (Perry et al. 1984) is conservatively used to represent the density of reagent, hydrogen peroxide, nitric acid, or silver nitrate solution. The calculation shows that the liquid release rate is 1 to 5 gpm for a break size equal to 3.25 mm and pressure ranging from 5 to 125 psig. The MWM Facility system pressure is expected to be below 125 psig.

The 1-gpm release rate is large compared to the maximum nitric acid feed rate of 2 L/hr and the maximum silver nitrate feed rate of 2 g/hr (LLNL 1993) in the Mediated Electrochemical Oxidation (MEO) process. The 5-gpm release rate is approximately equal to the maximum hydrogen peroxide feed rate of 1,347 kg/hr (LLNL 1993) in the Wet Oxidation (WOX) process. Therefore, the 1 gpm is the bounding pressurized release rate for nitric acid and silver nitrate, and 5 gpm is the bounding pressurized release rate for hydrogen peroxide. Any release rates larger than the bounding pressurized release rates would cause the system pressure to drop significantly and thus produce large drops.

Thus, during any one hour, the maximum pressurized releases are 60 gal/hr for nitric acid and silver nitrate, and 300 gal/hr for hydrogen peroxide. The source term is calculated as follows:

For nitric acid and silver nitrate

$$\text{Source Term} = \text{MAR} \times \text{ARF} \times \text{RF} = 60 \text{ gal} \times 1\text{E-}04 \times 1 = 6\text{E-}03 \text{ gal}$$

Using the density of nitric acid of 1.4 kg/L (Perry et al. 1984), the rate of releasing 10-μm drops which become airborne is

$$\begin{aligned} \text{Release Rate} &= (6\text{E-}03 \text{ gal/hr}) \times (3.785 \text{ L/gal}) \times (1.4 \text{ kg/L} \times (1,000 \text{ g/kg}) / \\ &\quad (3,600 \text{ sec/hr}) \\ &= 8.8\text{E-}03 \text{ g/sec} \end{aligned}$$

For hydrogen peroxide

$$\text{Source Term} = \text{MAR} \times \text{ARF} \times \text{RF} = 300 \text{ gal} \times 1\text{E-}04 \times 1 = 3\text{E-}02 \text{ gal}$$

Using the density of hydrogen peroxide of 1.2 kg/L, the rate of releasing 10-μm drops which become airborne is

$$\begin{aligned} \text{Release Rate} &= (3\text{E-}02 \text{ gal/h}) \times (3.785 \text{ L/gal}) \times (1.2 \text{ kg/L}) \times (1,000 \text{ g/kg}) / \\ &\quad (3,600 \text{ sec/hr}) \\ &= 3.8\text{E-}02 \text{ g/sec.} \end{aligned}$$

11D.3 Results

The calculation shows that during a one-hour release, no more than 3E-02 gallons of reagents used in the MWM Facility could become airborne and have drop sizes less than 10 μm which could be inhaled by individuals downstream of the pressurized release. The associated pressurized release rates are 8.8E-03 g/sec for nitric acid and silver nitrate and 3.8E-02 g/sec for hydrogen peroxide.

D.4 References

- Department of Energy (1993), *Recommended Values and Technical Bases for Airborne Release Fractions (ARFs), Airborne Release Rates (ARRs), and Respirable Fractions (RFs) at DOE Non-Reactor Nuclear Facilities*, U.S. Department of Energy, Washington, DC, DOE-HDBK-0013-93, July 1993.
- Lawrence Livermore National Laboratory (1993), *MWMF Process Data Table*, Lawrence Livermore National Laboratory, Livermore, CA, 1993.
- Perry, R.H., D.W. Green, and J.O. Maloney (eds.) (1984), *Perry's Chemical Engineers' Handbook*, Fifth Edition, McGraw Hill Book Co., New York, NY, 1984.

APPENDIX 11E
GENII INPUT AND OUTPUT FILES

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability
Executed on: 08/05/94 at 12:27:34

Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Ground, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

===== FILENAMES AND TITLES OF FILES/LIBRARIES USED =====

Input file name: \GENII\MWM\PU39 1.in	8-05-94
GENII Default: Parameter Values (28-Mar-90 RAP)	4-03-90
Radionuclide Master Library (11/28/90 RAP)	11-29-90
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R	5-08-90
Internal Dose Increments, PNL Solubility Choices Rerun 12/3/90 PDR	12-03-90

=====

-----Release Terms-----			
Release	Surface Buried		
Radio-	Air	Water	Source
nuclide	Ci/yr	Ci/yr	Ci/m3
PU239	3.4E-04	0.0E+00	0.0E+00

===== AIR TRANSPORT =====
3.1E-02 Input E/Q value (s/m3)

===== EXTERNAL EXPOSURE =====
1.0E+00 Fraction of time spent in cloud
8.8E+03 Hours of exposure to ground contamination

===== INHALATION =====
Resuspension not considered
=====

Input prepared by: _____ Date: _____
Input checked by: _____ Date: _____
=====

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:28:03

Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	1.5E-01	2.5E-01	3.7E-02
Breast	1.1E-06	1.5E-01	1.6E-07
R Marrow	8.4E-01	1.2E-01	1.0E-01
Lung	4.0E+00	1.2E-01	4.8E-01
Thyroid	1.0E-06	3.0E-02	3.1E-08
Bone Sur	1.1E+01	3.0E-02	3.3E-01
Liver	2.0E+00	6.0E-02	1.2E-01
LL Int.	3.5E-04	6.0E-02	2.1E-05
UL Int.	1.2E-04	6.0E-02	7.0E-06
S Int.	2.1E-05	6.0E-02	1.2E-06
Stomach	9.1E-06	6.0E-02	5.4E-07
Internal Effective Dose Equivalent			1.1E+00
External Dose			1.1E-08
Annual Effective Dose Equivalent			1.1E+00

Controlling Organ: Bone Sur
Controlling Pathway: Inh
Controlling Radionuclide: PU239

Total Inhalation EDE: 1.1E+00
Total Ingestion EDE: 0.0E+00

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:28:03

Page C. 2

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

		Dose Commitment Year					
		1	2	3	...		
Internal	:						
Intake	:						
Year:	3	0.0E+00 ...					
		+					
	2	0.0E+00 0.0E+00 ...				Internal	
		+				Effective	
	1	1.0E-01 + 7.3E-02 + 5.5E-02 + ... = 1.1E+00				Dose	
						Equivalent	
Internal							
Annual		1.0E-01 + 7.3E-02 + 5.5E-02 + ... = 1.1E+00				Cumulative	
Dose						Internal	
		+ + + +				Dose	
External							
Annual		1.1E-08 0.0E+00 0.0E+00 ... 1.1E-08					
Dose							
Annual		1.0E-01 + 7.3E-02 + 5.5E-02 + ... = 1.1E+00				Cumulative	
Dose						Dose	
						Maximum	
						Annual	
						Dose Occurred	
						In Year 1	

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

 GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability
 Executed on: 08/05/94 at 12:28:03

Page C. 3

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	4.0E+00	9.1E-06	2.1E-05	1.2E-04	3.5E-04	1.1E+01	8.4E-01	1.5E-01
Total	4.0E+00	9.1E-06	2.1E-05	1.2E-04	3.5E-04	1.1E+01	8.4E-01	1.5E-01

Pathway	Ovaries	Muscle	Thyroid	Liver
Inhale	1.5E-01	1.1E-06	1.0E-06	2.0E+00
Total	1.5E-01	1.1E-06	1.0E-06	2.0E+00

External Dose by Exposure Pathway

Pathway	
Plume	2.2E-10
Sur Soil	1.1E-08
Total	1.1E-08

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:35:46

Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Ground, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

===== FILENAMES AND TITLES OF FILES/LIBRARIES USED =====

Input file name: \GENII\MWM\PU39 2.in	8-05-94
GENII Default Parameter Values (28-Mar-90 RAP)	4-03-90
Radionuclide Master Library (11/28/90 RAP)	11-29-90
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R	5-08-90
Internal Dose Increments, PNL Solubility Choices Rerun 12/3/90 PDR	12-03-90

-----Release Terms-----
Release Surface Buried
Radio- Air Water Source
nuclide Ci/yr Ci/yr Ci/m3

PU239 3.4E-04 0.0E+00 0.0E+00

===== AIR TRANSPORT =====
1.2E-02 Input E/Q value (s/m3)

===== EXTERNAL EXPOSURE =====
1.0E+00 Fraction of time spent in cloud
8.8E+03 Hours of exposure to ground contamination

===== INHALATION =====
Resuspension not considered
=====

Input prepared by: _____ Date: _____
Input checked by: _____ Date: _____
=====

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:36:15

Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	5.5E-02	2.5E-01	1.4E-02
Breast	3.9E-07	1.5E-01	5.9E-08
R Marrow	3.1E-01	1.2E-01	3.8E-02
Lung	1.5E+00	1.2E-01	1.8E-01
Thyroid	3.8E-07	3.0E-02	1.1E-08
Bone Sur	4.1E+00	3.0E-02	1.2E-01
Liver	7.3E-01	6.0E-02	4.4E-02
LL Int.	1.3E-04	6.0E-02	7.8E-06
UL Int.	4.3E-05	6.0E-02	2.6E-06
S Int.	7.7E-06	6.0E-02	4.6E-07
Stomach	3.4E-06	6.0E-02	2.0E-07
Internal Effective Dose Equivalent			3.9E-01
External Dose			4.3E-09
Annual Effective Dose Equivalent			3.9E-01

Controlling Organ: Bone Sur
Controlling Pathway: Inh
Controlling Radionuclide: PU239

Total Inhalation EDE: 3.9E-01
Total Ingestion EDE: 0.0E+00

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:36:15

Page C. 2

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

	Dose Commitment Year				
	1	2	3	...	
Internal Intake Year:	3				
			0.0E+00	...	
			+		
	2	0.0E+00	0.0E+00	...	Internal Effective Dose Equivalent
		+	+		
	1	3.8E-02	2.7E-02	2.1E-02 + ...	= 3.9E-01
Internal Annual Dose		3.8E-02	2.7E-02	2.1E-02 + ...	= 3.9E-01
		+	+	+	+
External Annual Dose		4.3E-09	0.0E+00	0.0E+00 ...	4.3E-09
Annual Dose		3.8E-02	2.7E-02	2.1E-02 + ...	= 3.9E-01
					3.8E-02
					Maximum Annual Dose Occurred In Year 1

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Pu Release - 175 meter - 8760 HR GRND - 1 m/s-F Stabili
ty

Executed on: 08/05/94 at 10:36:15

Page C. 3

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	1.5E+00	3.4E-06	7.7E-06	4.3E-05	1.3E-04	4.1E+00	3.1E-01	5.5E-02
Total	1.5E+00	3.4E-06	7.7E-06	4.3E-05	1.3E-04	4.1E+00	3.1E-01	5.5E-02

Pathway	Ovaries	Muscle	Thyroid	Liver
Inhale	5.5E-02	3.9E-07	3.8E-07	7.3E-01
Total	5.5E-02	3.9E-07	3.8E-07	7.3E-01

External Dose by Exposure Pathway

Pathway	
Plume	8.8E-11
Sur Soil	4.2E-09
Total	4.3E-09

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:36:21

Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Ground, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

===== FILENAMES AND TITLES OF FILES/LIBRARIES USED =====

Input file name: \GENII\MWM\MWM_1.IN 8-05-94
GENII Default Parameter Values (28-Mar-90 RAP) 4-03-90
Radionuclide Master Library (11/28/90 RAP) 11-29-90
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R 5-08-90
Internal Dose Increments, PNL Solubility Choices Rerun 12/3/90 PDR 12-03-90

=====

-----Release Terms-----			
Release	Air	Surface	Buried
Radio-		Water	Source
nuclide	Ci/yr	Ci/yr	Ci/m3
H 3	1.2E-02	0.0E+00	0.0E+00
C 14	2.7E-06	0.0E+00	0.0E+00
CO60	1.6E-07	0.0E+00	0.0E+00
SR90	1.1E-08	0.0E+00	0.0E+00
RU106	4.6E-06	0.0E+00	0.0E+00
CS137	2.6E-07	0.0E+00	0.0E+00
TH228	9.0E-11	0.0E+00	0.0E+00
TH232	2.6E-12	0.0E+00	0.0E+00
U 235	4.8E-07	0.0E+00	0.0E+00
U 238	3.4E-04	0.0E+00	0.0E+00
PU239	1.4E-07	0.0E+00	0.0E+00
PU242	1.7E-11	0.0E+00	0.0E+00
AM241	1.0E-06	0.0E+00	0.0E+00
AM243	8.0E-12	0.0E+00	0.0E+00
CM244	9.0E-09	0.0E+00	0.0E+00
K 40	7.0E-04	0.0E+00	0.0E+00
S 35	1.1E-03	0.0E+00	0.0E+00

===== AIR TRANSPORT =====
3.1E-02 Input E/Q value (s/m3)

===== EXTERNAL EXPOSURE =====
1.0E+00 Fraction of time spent in cloud
8.8E+03 Hours of exposure to ground contamination

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

===== INHALATION =====
Resuspension not considered
=====

Input prepared by: _____ Date: _____
Input checked by: _____ Date: _____

=====

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 1

Acute release
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	1.3E-03	2.5E-01	3.3E-04
Breast	1.0E-04	1.5E-01	1.5E-05
R Marrow	6.8E-03	1.2E-01	8.2E-04
Lung	3.4E+00	1.2E-01	4.1E-01
Thyroid	1.0E-04	3.0E-02	3.0E-06
Bone Sur	8.6E-02	3.0E-02	2.6E-03
Liver	1.5E-02	6.0E-02	9.2E-04
Kidneys	6.7E-04	6.0E-02	4.0E-05
LL Int.	4.5E-04	6.0E-02	2.7E-05
UL Int.	2.1E-04	6.0E-02	1.3E-05
S Int.	1.2E-04	6.0E-02	7.4E-06
Internal Effective Dose Equivalent			4.2E-01
External Dose			9.0E-05
Annual Effective Dose Equivalent			4.2E-01

Controlling Organ: Lung
Controlling Pathway: Inh
Controlling Radionuclide: U 238

Total Inhalation EDE: 4.2E-01
Total Ingestion EDE: 0.0E+00

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 2

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

	Dose Commitment Year				
	1	2	3	...	
Internal Intake Year:	3				
			0.0E+00	...	
			+		
	2	0.0E+00	0.0E+00	...	Internal Effective Dose Equivalent
		+	+		
	1	8.6E-02	+ 5.9E-02	+ 4.2E-02 + ...	= 4.2E-01
Internal Annual Dose		8.6E-02	+ 5.9E-02	+ 4.2E-02 + ...	= 4.2E-01
		+	+	+	+
External Annual Dose		9.0E-05	0.0E+00	0.0E+00 ...	9.0E-05
Annual Dose		8.6E-02	+ 5.9E-02	+ 4.2E-02 + ...	= 4.2E-01
					8.6E-02
					Maximum Annual Dose Occurred In Year 1

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

 GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 3

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	3.4E+00	1.1E-04	1.2E-04	2.1E-04	4.5E-04	8.6E-02	6.8E-03	1.3E-03
Total	3.4E+00	1.1E-04	1.2E-04	2.1E-04	4.5E-04	8.6E-02	6.8E-03	1.3E-03

Pathway	Ovaries	Muscle	Thyroid	Kidneys	Liver
Inhale	1.3E-03	1.0E-04	1.0E-04	6.7E-04	1.5E-02
Total	1.3E-03	1.0E-04	1.0E-04	6.7E-04	1.5E-02

External Dose by Exposure Pathway

Pathway	
Plume	7.4E-07
Sur Soil	8.9E-05
Total	9.0E-05

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 4

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Radionuclide

Radionuclide	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
H 3	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.4E-05	1.4E-05	1.1E-05
C 14	5.9E-08	5.9E-08	5.9E-08	5.9E-08	5.9E-08	7.2E-08	7.4E-08	5.9E-08
S 35	2.1E-04	2.9E-06	2.3E-06	4.9E-06	1.1E-05	2.2E-06	2.2E-06	1.8E-06
K 40	1.3E-04	8.5E-05	8.5E-05	8.3E-05	8.5E-05	9.6E-05	9.6E-05	8.3E-05
CO 60	2.1E-06	1.6E-07	4.0E-08	5.4E-08	4.5E-08	7.8E-08	9.8E-08	7.4E-09
SR 90	5.7E-10	1.5E-10	1.6E-10	3.9E-10	1.3E-09	2.6E-07	1.2E-07	1.3E-10
Y 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RU 106	1.8E-04	3.7E-07	4.9E-07	2.1E-06	6.4E-06	1.9E-07	2.1E-07	1.1E-07
CS 137	8.9E-08	8.6E-08	9.1E-08	9.0E-08	9.1E-08	8.1E-08	8.4E-08	8.8E-08
TH 232	9.5E-08	7.9E-13	8.4E-13	1.4E-12	2.9E-12	5.0E-07	4.0E-08	7.2E-13
RA 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 228	2.4E-06	1.7E-10	1.6E-10	2.3E-10	4.4E-10	7.8E-07	6.0E-08	1.5E-10
RA 224	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PB 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BI 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 235	5.0E-03	3.1E-08	3.6E-08	1.7E-07	5.3E-07	3.3E-07	3.8E-08	6.3E-09
TH 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
FR 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RA 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 238	3.4E+00	1.3E-05	2.3E-05	1.1E-04	3.4E-04	2.2E-04	1.9E-05	4.0E-06
TH 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 242	1.9E-07	4.2E-13	9.4E-13	5.4E-12	1.7E-11	4.8E-07	4.0E-08	6.7E-09
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	6.9E-06	5.8E-10	9.5E-10	3.7E-09	1.1E-08	4.0E-04	3.2E-05	5.3E-06
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AM 241	6.7E-04	6.3E-08	1.0E-07	4.1E-07	1.1E-06	8.1E-02	6.3E-03	1.1E-03
AM 243	5.5E-09	7.3E-13	1.0E-12	3.6E-12	1.0E-11	6.6E-07	5.3E-08	9.4E-09
NP 239	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 239	1.6E-03	3.6E-09	8.3E-09	4.7E-08	1.4E-07	4.4E-03	3.4E-04	5.9E-05
Total	3.4E+00	1.1E-04	1.2E-04	2.1E-04	4.5E-04	8.6E-02	6.8E-03	1.3E-03

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 5

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Radionuclide

Radionuclide	Ovaries	Muscle	Thyroid	Kidneys	Liver
H 3	1.1E-05	1.1E-05	1.1E-05	0.0E+00	0.0E+00
C 14	5.9E-08	6.0E-08	5.9E-08	0.0E+00	0.0E+00
S 35	1.8E-06	1.8E-06	1.8E-06	0.0E+00	0.0E+00
K 40	8.5E-05	8.3E-05	8.3E-05	0.0E+00	0.0E+00
CO 60	2.6E-08	1.0E-07	9.2E-08	0.0E+00	2.0E-07
SR 90	1.3E-10	1.3E-10	1.3E-10	0.0E+00	0.0E+00
Y 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RU 106	1.4E-07	1.9E-07	1.7E-07	0.0E+00	0.0E+00
CS 137	8.2E-08	8.0E-08	8.0E-08	0.0E+00	0.0E+00
TH 232	7.2E-13	7.3E-13	7.3E-13	0.0E+00	4.8E-10
RA 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 228	1.5E-10	1.6E-10	1.6E-10	0.0E+00	4.0E-09
RA 224	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PB 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BI 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 235	9.1E-09	1.7E-08	1.2E-08	9.8E-07	0.0E+00
TH 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
FR 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RA 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 238	4.3E-06	5.2E-06	4.9E-06	6.7E-04	0.0E+00
TH 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 242	6.8E-09	5.3E-14	4.8E-14	0.0E+00	9.0E-08
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	5.3E-06	3.4E-10	3.4E-10	0.0E+00	8.1E-05
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AM 241	1.1E-03	3.7E-08	3.6E-08	0.0E+00	1.4E-02
AM 243	9.3E-09	4.6E-13	3.6E-13	0.0E+00	1.2E-07
NP 239	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 239	5.9E-05	4.2E-10	4.1E-10	0.0E+00	7.8E-04
Total	1.3E-03	1.0E-04	1.0E-04	6.7E-04	1.5E-02

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 100 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 10:40:53

Page C. 6

Acute release
 Uptake/exposure period: 1.0
 Dose commitment period: 50.0
 Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	1.1E-05	0.0E+00	8.7E-15	1.1E-05	1.1E-05
C 14	5.8E-08	0.0E+00	1.4E-13	5.8E-08	5.8E-08
S 35	2.7E-05	0.0E+00	7.9E-10	2.7E-05	2.7E-05
K 40	8.6E-05	0.0E+00	8.4E-05	8.6E-05	1.7E-04
CO 60	3.2E-07	0.0E+00	2.7E-07	3.2E-07	5.9E-07
SR 90	2.2E-08	0.0E+00	9.0E-13	2.2E-08	2.2E-08
Y 90	0.0E+00	0.0E+00	4.8E-11	0.0E+00	4.8E-11
RU 106	2.2E-05	0.0E+00	5.7E-07	2.2E-05	2.3E-05
CS 137	8.1E-08	0.0E+00	1.1E-07	8.1E-08	1.9E-07
TH 232	3.1E-08	0.0E+00	1.3E-16	3.1E-08	3.1E-08
RA 228	0.0E+00	0.0E+00	3.7E-22	0.0E+00	3.7E-22
AC 228	0.0E+00	0.0E+00	1.1E-13	0.0E+00	1.1E-13
TH 228	3.2E-07	0.0E+00	5.8E-14	3.2E-07	3.2E-07
RA 224	0.0E+00	0.0E+00	4.8E-13	0.0E+00	4.8E-13
PB 212	0.0E+00	0.0E+00	6.1E-12	0.0E+00	6.1E-12
BI 212	0.0E+00	0.0E+00	8.1E-11	0.0E+00	8.1E-11
U 235	6.1E-04	0.0E+00	2.7E-08	6.1E-04	6.1E-04
TH 231	0.0E+00	0.0E+00	1.6E-09	0.0E+00	1.6E-09
PA 231	0.0E+00	0.0E+00	9.6E-14	0.0E+00	9.6E-14
AC 227	0.0E+00	0.0E+00	2.6E-18	0.0E+00	2.6E-18
TH 227	0.0E+00	0.0E+00	2.2E-15	0.0E+00	2.2E-15
FR 223	0.0E+00	0.0E+00	1.4E-17	0.0E+00	1.4E-17
RA 223	0.0E+00	0.0E+00	6.1E-15	0.0E+00	6.1E-15
U 238	4.1E-01	0.0E+00	7.2E-09	4.1E-01	4.1E-01
TH 234	0.0E+00	0.0E+00	4.5E-06	0.0E+00	4.5E-06
PA 234	0.0E+00	0.0E+00	7.0E-07	0.0E+00	7.0E-07
PU 242	5.0E-08	0.0E+00	2.2E-16	5.0E-08	5.0E-08
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	2.3E-05	0.0E+00	1.1E-13	2.3E-05	2.3E-05
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	6.4E-18	0.0E+00	6.4E-18
AM 241	4.4E-03	0.0E+00	3.3E-09	4.4E-03	4.4E-03
AM 243	3.6E-08	0.0E+00	9.8E-14	3.6E-08	3.6E-08
NP 239	0.0E+00	0.0E+00	7.4E-13	0.0E+00	7.4E-13
PU 239	4.3E-04	0.0E+00	4.5E-12	4.3E-04	4.3E-04

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:33:24

Page A. 1

This is a far-field (wide-scale release, multiple site) scenario.
Release is acute
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Infinite plume, external
Ground, external
Inhalation uptake

THE FOLLOWING TIMES ARE USED:
Intake ends after (yr): 1.0
Dose calculations ends after (yr): 50.0

===== FILENAMES AND TITLES OF FILES/LIBRARIES USED =====

Input file name: \GENII\MWM\MWM 2.IN 8-05-94
GENII Default Parameter Values (28-Mar-90 RAP) 4-03-90
Radionuclide Master Library (11/28/90 RAP) 11-29-90
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R 5-08-90
Internal Dose Increments, PNL Solubility Choices Rerun 12/3/90 PDR 12-03-90

=====

-----Release Terms-----
Release Surface Buried
Radio- Air Water Source
nuclide Ci/yr Ci/yr Ci/m3

H 3 1.2E-02 0.0E+00 0.0E+00
C 14 2.7E-06 0.0E+00 0.0E+00
CO60 1.6E-07 0.0E+00 0.0E+00
SR90 1.1E-08 0.0E+00 0.0E+00
RU106 4.6E-06 0.0E+00 0.0E+00
CS137 2.6E-07 0.0E+00 0.0E+00
TH228 9.0E-11 0.0E+00 0.0E+00
TH232 2.6E-12 0.0E+00 0.0E+00
U 235 4.8E-07 0.0E+00 0.0E+00
U 238 3.4E-04 0.0E+00 0.0E+00
PU239 1.4E-07 0.0E+00 0.0E+00
PU242 1.7E-11 0.0E+00 0.0E+00
AM241 1.0E-06 0.0E+00 0.0E+00
AM243 8.0E-12 0.0E+00 0.0E+00
CM244 9.0E-09 0.0E+00 0.0E+00
K 40 7.0E-04 0.0E+00 0.0E+00
S 35 1.1E-03 0.0E+00 0.0E+00

===== AIR TRANSPORT =====
1.2E-02 Input E/Q value (s/m3)

===== EXTERNAL EXPOSURE =====
1.0E+00 Fraction of time spent in cloud
8.8E+03 Hours of exposure to ground contamination

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

===== INHALATION =====
Resuspension not considered
=====

Input prepared by: _____

Date: _____

Input checked by: _____

Date: _____

=====

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

 GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 1

 Acute release
 Uptake/exposure period: 1.0
 Dose commitment period: 50.0
 Dose units: Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	5.2E-04	2.5E-01	1.3E-04
Breast	3.9E-05	1.5E-01	5.9E-06
R Marrow	2.7E-03	1.2E-01	3.3E-04
Lung	1.3E+00	1.2E-01	1.5E-01
Thyroid	3.9E-05	3.0E-02	1.2E-06
Bone Sur	3.4E-02	3.0E-02	1.0E-03
Liver	6.1E-03	6.0E-02	3.7E-04
Kidneys	2.5E-04	6.0E-02	1.5E-05
LL Int.	1.7E-04	6.0E-02	1.0E-05
UL Int.	8.1E-05	6.0E-02	4.8E-06
S Int.	4.7E-05	6.0E-02	2.8E-06
Internal Effective Dose Equivalent			1.6E-01
External Dose			3.4E-05
Annual Effective Dose Equivalent			1.6E-01

 Controlling Organ: Lung
 Controlling Pathway: Inh
 Controlling Radionuclide: U 238

 Total Inhalation EDE: 1.6E-01
 Total Ingestion EDE: 0.0E+00

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 2

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

	Dose Commitment Year				
	1	2	3	...	
Internal Intake Year:	3				
			0.0E+00	...	
			+		
	2	0.0E+00	0.0E+00	...	Internal Effective Dose Equivalent
		+	+		
	1	3.2E-02	+ 2.2E-02	+ 1.6E-02 + ...	= 1.6E-01
Internal Annual Dose		3.2E-02	+ 2.2E-02	+ 1.6E-02 + ...	= 1.6E-01
		+	+	+	+
External Annual Dose		3.4E-05	0.0E+00	0.0E+00 ...	3.4E-05
Annual Dose		3.2E-02	+ 2.2E-02	+ 1.6E-02 + ...	= 1.6E-01
					3.2E-02
					Maximum Annual Dose Occurred In Year 1

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

 GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 3

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	1.3E+00	4.4E-05	4.7E-05	8.1E-05	1.7E-04	3.4E-02	2.7E-03	5.2E-04
Total	1.3E+00	4.4E-05	4.7E-05	8.1E-05	1.7E-04	3.4E-02	2.7E-03	5.2E-04

Pathway	Ovaries	Muscle	Thyroid	Kidneys	Liver
Inhale	5.1E-04	3.9E-05	3.9E-05	2.5E-04	6.1E-03
Total	5.1E-04	3.9E-05	3.9E-05	2.5E-04	6.1E-03

External Dose by Exposure Pathway

Pathway	
Plume	2.9E-07
Sur Soil	3.4E-05
Total	3.4E-05

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 4

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Radionuclide

Radionuclide	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
H 3	4.4E-06	4.4E-06	4.4E-06	4.4E-06	4.4E-06	5.5E-06	5.5E-06	4.4E-06
C 14	2.3E-08	2.3E-08	2.3E-08	2.3E-08	2.3E-08	2.8E-08	2.9E-08	2.3E-08
S 35	8.3E-05	1.2E-06	9.3E-07	2.0E-06	4.6E-06	8.8E-07	9.0E-07	7.2E-07
K 40	4.9E-05	3.3E-05	3.3E-05	3.2E-05	3.3E-05	3.7E-05	3.7E-05	3.2E-05
CO 60	8.2E-07	6.3E-08	1.6E-08	2.1E-08	1.8E-08	3.1E-08	3.9E-08	2.9E-09
SR 90	2.3E-10	5.9E-11	6.3E-11	1.5E-10	5.0E-10	1.1E-07	4.7E-08	5.4E-11
Y 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RU 106	6.8E-05	1.4E-07	1.9E-07	8.0E-07	2.5E-06	7.3E-08	8.0E-08	4.4E-08
CS 137	3.3E-08	3.2E-08	3.4E-08	3.3E-08	3.4E-08	3.0E-08	3.1E-08	3.3E-08
TH 232	3.5E-08	2.9E-13	3.1E-13	5.2E-13	1.1E-12	1.8E-07	1.5E-08	2.7E-13
RA 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 228	9.3E-07	6.5E-11	6.3E-11	8.9E-11	1.7E-10	3.1E-07	2.4E-08	5.7E-11
RA 224	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PB 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BI 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 235	2.0E-03	1.2E-08	1.4E-08	6.7E-08	2.0E-07	1.3E-07	1.5E-08	2.5E-09
TH 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
FR 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RA 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 238	1.3E+00	4.7E-06	8.7E-06	4.1E-05	1.3E-04	8.2E-05	7.2E-06	1.5E-06
TH 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 242	7.6E-08	1.7E-13	3.7E-13	2.1E-12	6.7E-12	1.9E-07	1.6E-08	2.6E-09
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	2.7E-06	2.3E-10	3.7E-10	1.5E-09	4.1E-09	1.6E-04	1.3E-05	2.1E-06
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AM 241	2.7E-04	2.5E-08	4.0E-08	1.6E-07	4.6E-07	3.2E-02	2.5E-03	4.6E-04
AM 243	2.2E-09	2.8E-13	3.9E-13	1.4E-12	3.9E-12	2.6E-07	2.0E-08	3.7E-09
NP 239	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 239	6.3E-04	1.4E-09	3.3E-09	1.8E-08	5.5E-08	1.7E-03	1.3E-04	2.3E-05
Total	1.3E+00	4.4E-05	4.7E-05	8.1E-05	1.7E-04	3.4E-02	2.7E-03	5.2E-04

Mixed Waste Management Facility Preliminary Safety Analysis Report
Lawrence Livermore National Laboratory

 GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 5

Acute release

Uptake/exposure period:

1.0

Dose commitment period:

50.0

Dose units:

Rem

Committed Dose Equivalent by Radionuclide

Radionuclide	Ovaries	Muscle	Thyroid	Kidneys	Liver
H 3	4.4E-06	4.4E-06	4.4E-06	0.0E+00	0.0E+00
C 14	2.3E-08	2.4E-08	2.3E-08	0.0E+00	0.0E+00
S 35	7.2E-07	7.2E-07	7.2E-07	0.0E+00	0.0E+00
K 40	3.3E-05	3.2E-05	3.2E-05	0.0E+00	0.0E+00
CO 60	1.0E-08	4.0E-08	3.6E-08	0.0E+00	7.8E-08
SR 90	5.4E-11	5.2E-11	5.4E-11	0.0E+00	0.0E+00
Y 90	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RU 106	5.2E-08	7.3E-08	6.7E-08	0.0E+00	0.0E+00
CS 137	3.0E-08	2.9E-08	2.9E-08	0.0E+00	0.0E+00
TH 232	2.7E-13	2.7E-13	2.7E-13	0.0E+00	1.8E-10
RA 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 228	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 228	6.0E-11	6.1E-11	6.1E-11	0.0E+00	1.6E-09
RA 224	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PB 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BI 212	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 235	3.5E-09	6.5E-09	4.6E-09	3.8E-07	0.0E+00
TH 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 231	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AC 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH 227	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
FR 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RA 223	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 238	1.6E-06	1.9E-06	1.8E-06	2.5E-04	0.0E+00
TH 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PA 234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 242	2.7E-09	2.1E-14	1.9E-14	0.0E+00	3.5E-08
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	2.1E-06	1.3E-10	1.3E-10	0.0E+00	3.2E-05
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
AM 241	4.5E-04	1.5E-08	1.5E-08	0.0E+00	5.8E-03
AM 243	3.6E-09	1.8E-13	1.4E-13	0.0E+00	4.6E-08
NP 239	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 239	2.3E-05	1.7E-10	1.6E-10	0.0E+00	3.1E-04
Total	5.1E-04	3.9E-05	3.9E-05	2.5E-04	6.1E-03

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GENII Dose Calculation Program
 (Version 1.485 3-Dec-90)

Case title: MWMF Release - 175 meter - 8760 HR GRND - 1 m/s-F Stability

Executed on: 08/05/94 at 12:37:55

Page C. 6

Acute release
 Uptake/exposure period: 1.0
 Dose commitment period: 50.0
 Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	4.3E-06	0.0E+00	3.3E-15	4.3E-06	4.3E-06
C 14	2.3E-08	0.0E+00	5.2E-14	2.3E-08	2.3E-08
S 35	1.1E-05	0.0E+00	3.1E-10	1.1E-05	1.1E-05
K 40	3.3E-05	0.0E+00	3.2E-05	3.3E-05	6.5E-05
CO 60	1.3E-07	0.0E+00	1.1E-07	1.3E-07	2.3E-07
SR 90	8.9E-09	0.0E+00	3.5E-13	8.9E-09	8.9E-09
Y 90	0.0E+00	0.0E+00	1.9E-11	0.0E+00	1.9E-11
RU 106	8.4E-06	0.0E+00	2.3E-07	8.4E-06	8.6E-06
CS 137	3.0E-08	0.0E+00	4.3E-08	3.0E-08	7.3E-08
TH 232	1.2E-08	0.0E+00	5.0E-17	1.2E-08	1.2E-08
RA 228	0.0E+00	0.0E+00	1.4E-22	0.0E+00	1.4E-22
AC 228	0.0E+00	0.0E+00	4.2E-14	0.0E+00	4.2E-14
TH 228	1.2E-07	0.0E+00	2.3E-14	1.2E-07	1.2E-07
RA 224	0.0E+00	0.0E+00	1.9E-13	0.0E+00	1.9E-13
PB 212	0.0E+00	0.0E+00	2.4E-12	0.0E+00	2.4E-12
BI 212	0.0E+00	0.0E+00	3.1E-11	0.0E+00	3.1E-11
U 235	2.3E-04	0.0E+00	1.0E-08	2.3E-04	2.3E-04
TH 231	0.0E+00	0.0E+00	6.1E-10	0.0E+00	6.1E-10
PA 231	0.0E+00	0.0E+00	3.6E-14	0.0E+00	3.6E-14
AC 227	0.0E+00	0.0E+00	1.1E-18	0.0E+00	1.1E-18
TH 227	0.0E+00	0.0E+00	8.9E-16	0.0E+00	8.9E-16
FR 223	0.0E+00	0.0E+00	5.5E-18	0.0E+00	5.5E-18
RA 223	0.0E+00	0.0E+00	2.4E-15	0.0E+00	2.4E-15
U 238	1.5E-01	0.0E+00	2.7E-09	1.5E-01	1.5E-01
TH 234	0.0E+00	0.0E+00	1.8E-06	0.0E+00	1.8E-06
PA 234	0.0E+00	0.0E+00	2.8E-07	0.0E+00	2.8E-07
PU 242	2.0E-08	0.0E+00	8.2E-17	2.0E-08	2.0E-08
NP 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
CM 244	8.9E-06	0.0E+00	4.4E-14	8.9E-06	8.9E-06
PU 244	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U 240	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU 240	0.0E+00	0.0E+00	2.6E-18	0.0E+00	2.6E-18
AM 241	1.8E-03	0.0E+00	1.3E-09	1.8E-03	1.8E-03
AM 243	1.4E-08	0.0E+00	3.7E-14	1.4E-08	1.4E-08
NP 239	0.0E+00	0.0E+00	2.8E-13	0.0E+00	2.8E-13
PU 239	1.7E-04	0.0E+00	1.8E-12	1.7E-04	1.7E-04

APPENDIX 11F

OPERATOR DOSE FOR THE BOUNDING ACCIDENT

11F.1 Operator Dose for the Bounding Accident

The radiological dose to an operator during the Bounding Accident is calculated in this appendix. The Bounding Accident assumes that a fire is started in the liquids feed preparation area or solids feed preparation area where containers are opened and contents are removed.

The maximum inventory for Pu-239 is 0.052 Ci, and the source release fraction is 1.3E-02 (Ayer et al. 1988) resulting in a source term of 6.8E-04 Ci of Pu-239. An unprotected operator or worker is assumed to be present for one minute during the fire. The dose (D) the operator receives due to inhalation after one minute is conservatively calculated by the following equation:

$$D(\text{rem}) = F(\text{rem/Ci}) * V(\text{cm}^3) * C(\text{Ci/cm}^3)$$

where

F = conversion factor, 5.1E+08 for Pu-239 (DOE 1988)

V = volume of air breathed, 60 seconds*350 cm³/sec = 2.1E+04 cm³,
(350 cm³/sec is an adult breathing rate),

C = concentration, curies released/room volume.

Building 494 Volume = 120 ft*250 ft*30 ft = 900,000 ft³ = 2.55E+10 cm³.

C = (6.8E-04 Ci) / (2.55E+10 cm³) = 2.7E-14 Ci/cm³.

Dose = (5.1E+08 rem/Ci) * (2.1E+04 cm³) * (2.7E-14 Ci/cm³)

= 0.29 rem.

11F.2 References

Ayer, J.E., A.T. Clark, P. Loysen, M.Y. Ballinger, J. Mishima, P.C., Owczarski, W.S. Gregory, and B.D. Nichols (1988), *Nuclear Fuel Cycle Facility Accident Analysis Handbook*, U.S. Nuclear Regulatory Commission, Washington, DC, NUREG-1320, May 1988.

Department of Energy (1988), *Internal Dose Conversion Factors for Calculation of Dose to the Public*, U.S. Department of Energy, Washington, DC, July 1988.

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Chapter 12

Management, Organization, and the Institutional Safety Provisions

September 1994

Lawrence Livermore National Laboratory
University of California Livermore, California 94551

Chapter 12. Management, Organization, and the Institutional Safety Provisions

This chapter of the Preliminary Safety Analysis Report (PSAR) discusses the responsibilities and methods of safe operation of the Mixed Waste Management (MWM) Facility (Building 494). This discussion includes organizational structure; administrative controls and procedures; configuration control and document control programs; occurrence reporting; operational experience evaluation; corrective action; staffing and qualifications; and programs for self-assessment, monitoring, enhancing operational personnel performance, and corrective action.

12.1 Organizational Structure

Lawrence Livermore National Laboratory (LLNL) is a multiprogram laboratory operated by the University of California for the Department of Energy (DOE). To accomplish its mission, LLNL operates through a matrix system, with each major organization headed by an appropriate programmatic Associate Director (AD) or Program Leader (LLNL 1991). The MWM Facility is operated under the responsibility of the LLNL AD Environmental Programs.

Appendix C (Section C.2) of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (DOE and UC 1992) discusses the LLNL organizations that have Environmental, Safety, and Health (ES&H) responsibilities. The primary responsibility for formal, active implementation of health and safety programs rests with the ADs and Program Leaders.

The MWM Facility organizational responsibilities are outlined in Section 3 of the *LLNL MWM Facility Quality Assurance Plan* (LLNL 1993c).

Support organizations, their responsibilities, and interfaces with the MWM Facility will be described in the *MWM Facility Project Plan*.

Additional information on support organizations is provided in Chapters 9, 13, 15, 18, and 19 of this PSAR.

12.2 Administrative Controls and Procedures

LLNL provides a comprehensive safety program to meet DOE regulatory, legislative, and operational requirements. The program is designed to encourage and train employees to develop an attitude of "thinking safety," so they can apply

their skills and knowledge to provide maximum protection for themselves, fellow employees, LLNL facilities, and the public (LLNL 1992a).

The safety program for the MWM Facility will be administered through a series of hierarchical documents that promulgate responsibilities and give direction for safe operations. The *Health & Safety Manual* (LLNL 1992a) is the chief administrative safety document, serving as the basis for LLNL's general safety policy. All programs at LLNL are subject to the requirements outlined in the manual. The next level of administrative safety documentation is the MWM Facility Safety Procedure (FSP) followed by Operational Safety Procedures (OSPs) and engineering safety notes, if necessary. At a minimum, the FSP is reviewed every three years, and the OSPs every year, to ensure that their contents are appropriate for current operations. Chapter 2 of the *Health & Safety Manual* discusses these documents in more detail.

Chapter 13 of this PSAR describes the procedures program in more detail.

12.3 Configuration Control and Document Control Programs

According to Supplement 6.06 of the *Health & Safety Manual* (LLNL 1992a), when a facility is significantly modified, the safety documentation must be updated. Any changes in operations in the MWM Facility that alter the scope of the FSP or that decrease the safety and/or environmental controls specified in the FSP will not be made until a revision or addendum to the FSP has been approved by the Department Heads of the Environmental Protection Department (EPD) and the Hazards Control Department. Other changes in operations that do not decrease the safety and/or environmental controls require the joint approval of the Laser and Environmental Program Division and the ES&H Team Leader.

Documents are controlled to ensure that the correct versions are available for use by personnel. Project documents are identified with a unique control number and revision status. Documents and changes to these documents receive an appropriate level of technical review and management approval.

Proposed changes in building safety and environmental control systems require a design review and approval by the appropriate level of management.

12.4 Occurrence Reporting, Operational Experience Evaluation, and Corrective Action

DOE Order 5000.3B (DOE 1993) requires that LLNL notify DOE and, in some cases, federal or state regulatory agencies of specific occurrences, incidents, and accidents. This Order also establishes a system for reporting operations

information related to DOE-owned or -operated facilities. DOE Order 5484.1 (DOE 1990) establishes the requirements and procedures for investigation of occurrences having environmental protection, safety, or health protection significance. Chapter 4 of the *Health & Safety Manual* (LLNL 1992a) describes how notifications are made at LLNL following an incident, what reports must be prepared, the methodology of incident analysis, and the corrective action required to minimize the likelihood of the recurrence of a similar incident. Corrective action activities include investigation of the problem and probable root cause, evaluation of evidence, and correction of both the problem and its cause. Chapter 4 of the *Health & Safety Manual* (and its supplements) conforms to the requirements of DOE Orders 5000.3B and 5484.1. The MWM staff is responsible for the initial reporting and for writing the occurrence reports (LLNL 1993b).

The ES&H Team for the area and the Laboratory Occurrence Reporting Office (ORO) assist LLNL management in meeting the requirements of Chapter 4 of the *Health & Safety Manual*. The *Laser Programs Occurrence Reporting Procedure* (LLNL 1993b) provides additional information on occurrence reporting and incident analysis.

Operational experience evaluation will be developed later in the Final Safety Analysis Report (FSAR).

12.5 Staffing and Qualifications

12.5.1 Staffing Levels, Qualifications, and Fitness-For-Duty Requirements

Resources for operation of the MWM Facility have not been established but will be developed in the FSAR. Work is planned by procedures, and determinations of adequate staffing levels and qualifications will be made following procedure development.

The Program AD is responsible for carrying out the program's technical work and for ensuring that LLNL health and safety policies are integrated into the program's activities and plans. The Program AD has the primary responsibility for the safe conduct of all activities connected with the program work and for ensuring that the program training responsibilities required by the *LLNL Training Program Manual* (LLNL 1991) are carried out, that the LLNL workforce is properly trained to carry out the work, and that the facilities and procedures used are appropriate for the work.

The Health Services Department is responsible for the fitness-for-duty evaluations, and LLNL managers at all organizational levels are responsible for ensuring that their employees are qualified and fit for duty (LLNL 1992a).

12.5.2 Minimum Shift Crew Composition

The minimum shift crew composition is discussed in Chapter 16 of this PSAR.

12.5.3 Allocation of Emergency Response Personnel

LLNL maintains a large staff of emergency response personnel, including a fire department, ambulatory services, security services, and a fully staffed medical facility.

Chapter 3 of the *Health & Safety Manual* (LLNL 1992a) provides general guidelines regarding the individual duties required in most emergencies and describes the emergency notification system and emergency response organization. In addition, Chapter 19 of this PSAR provides information regarding the recently implemented *Draft Emergency Plan* (LLNL 1993a). The *Draft Emergency Plan* sets forth the crisis management structure, the response procedures, and the personnel roles for all major emergencies and disasters occurring on LLNL properties and off site with the potential for impact on LLNL. The FSP will also describe specific requirements for emergency response personnel at the MWM Facility.

12.6 Programs for Self-Assessment, Monitoring, Enhancing Operational Personnel Performance, and Corrective Action

LLNL has established various programs for self-assessment, monitoring, enhancing operational personnel performance, and corrective action to ensure that the facility is operated in a safe manner. Periodically, several levels of LLNL management review safety procedures and operations to ensure their continued effectiveness. The Hazards Control Department is responsible for providing guidance needed by management in all phases of health and safety (LLNL 1992a). The safe operation of the MWM Facility will be monitored by the ES&H Team, which ensures that management is aware of risks and that necessary risks are minimized. Other safety-related programs are as follows (LLNL 1992a, 1993a):

- Directorate Self-Assessment Programs
- Management Prestart and Operational Readiness Reviews
- Responsible Individual and Supervisor Monitoring

- Periodic Review and Revision of Safety Procedures
- Conduct of Operations
- Environmental Safety and Health Self-Assessment Program
- Quality Assurance System Monitoring
- Corrective Action and Nonconformance Reports
- As Low As Reasonably Achievable (ALARA) Program
- Industrial Safety and Hygiene Program.

Many of these programs are implemented by the following LLNL documents (LLNL 1993c):

- *Laser Programs Quality Policy* (LLNL 1990a)
- *Quality Management Plan for LLNL Laser Programs* (LLNL 1990b)
- *Laser Programs ES&H Self-Assessment Program Plan* (LLNL 1992b).

12.7 References

- Department of Energy (1990), *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*, U.S. Department of Energy, Washington, DC, DOE Order 5484.1, Change 7, October 17, 1990.
- Department of Energy (1993), *Occurrence Reporting and Processing of Operations Information*, U.S. Department of Energy, Washington, DC, DOE Order 5000.3B, Change 1, July 2, 1993.
- Department of Energy and University of California (1992), *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*, U.S. Department of Energy and University of California, Livermore, CA, DOE/EIS-0157, August 1992.
- Lawrence Livermore National Laboratory (1990a), *Laser Programs Quality Policy*, Lawrence Livermore National Laboratory, Environmental Protection Hazardous Waste Management Division, Livermore, CA, L10343, January 1990.
- Lawrence Livermore National Laboratory (1990b), *Quality Management Plan for LLNL Laser Programs*, Lawrence Livermore National Laboratory, Livermore, CA, L10580, Revision 5, February 1990.
- Lawrence Livermore National Laboratory (1991), *LLNL Training Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-106166, February 1, 1991.
- Lawrence Livermore National Laboratory (1992a), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.
- Lawrence Livermore National Laboratory (1992b), *Laser Programs ES&H Self-Assessment Program Plan*, Lawrence Livermore National Laboratory, Livermore, CA, L-14352, January 1, 1992.
- Lawrence Livermore National Laboratory (1993a), *Draft Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-113311, September 1993.
- Lawrence Livermore National Laboratory (1993b), *Laser Programs Occurrence Reporting Procedure*, Lawrence Livermore National Laboratory, Livermore, CA, Revision 0, 1993.

12.7 References (continued)

Lawrence Livermore National Laboratory (1993c), *Lawrence Livermore National Laboratory Mixed Waste Management Facility Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, M-078-097, Revision 0, October 1993.

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Chapter 13 Procedures and Training

September 1994

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Chapter 13. Procedures and Training

This chapter of the Preliminary Safety Analysis Report (PSAR) addresses procedures and training applicable to the operation of the Mixed Waste Management (MWM) Facility (Building 494). Since neither procedures nor a training program exist for the MWM Facility at this time, this chapter only describes the general requirements of safety procedures and training at Lawrence Livermore National Laboratory (LLNL). This description includes the processes by which the technical content of procedures and training will be developed, verified, and validated; the processes by which the form and content of procedures and training elements will be developed, verified, and validated; the mechanisms that will be used to identify and correct technical or human factors deficiencies in procedures and training programs; and the commitment of LLNL to training programs.

13.1 Technical Content: Procedure and Training Development, Verification, and Validation

Department of Energy (DOE) Order 5480.19 (DOE 1992) requires that operations procedures be developed to provide specific direction for operating systems and equipment during normal and abnormal conditions as well as emergency conditions. The Order includes the technical content development, verification, and validation requirements for procedures. The requirements of this Order will be implemented at the MWM Facility through the use of Supplement 2.19 of the *Health & Safety Manual* (LLNL 1992). This supplement requires that a Facility Safety Procedure (FSP) and, if necessary, Operational Safety Procedures (OSPs) be developed for activities that do not conform to the existing codes, standards, and guidelines provided in the *Health & Safety Manual*. The FSP provides general facility safety policies and rules, identifies hazards and environmental concerns, and specifies the Environmental, Safety, and Health (ES&H) controls for long-term experiments, operations, and work performed in the facility. The FSP also contains emergency instructions (e.g., evacuation procedures) and specifies the maintenance, inspection, and quality assurance requirements for safety systems. OSPs contain the basic controls needed for safe operation beyond those contained in the *Health & Safety Manual*, the *Environmental Protection Handbook* (LLNL 1990), and the applicable FSP.

Personnel will receive both on-the-job training and classroom training to ensure that they are familiar with all aspects of their positions. The requirements of this Order will be implemented at the MWM Facility through Chapter 7 of the *Health & Safety Manual* and the *LLNL Training Program Manual* (LLNL 1991). These manuals require that the content of the training be such that employees can

perform their responsibilities and apply their skills and knowledge to provide maximum protection for themselves, fellow employees, LLNL facilities, and the public. Detailed information on the technical content development of training program requirements is contained in Appendix B of the *LLNL Training Program Manual*. In general, training program content requirements will be identified in the FSP for the facility.

13.2 Form and Content of Procedures and Training

DOE Order 5480.19 (DOE 1992) provides the requirements for the format and content development, verification, and validation of procedures. These requirements will be implemented at the MWM Facility through Chapter 2 of the *Health & Safety Manual* (LLNL 1992). This chapter requires that safety procedures contain the following elements: (1) introduction, (2) reason for issue, (3) responsibilities, (4) training requirements, (5) hazards analysis, (6) controls, and (7) authorizing signatures. The requirements for each of these elements are described further in the *Health & Safety Manual*.

These requirements will be implemented at the MWM Facility through Chapter 7 of the *Health & Safety Manual* and the *LLNL Training Program Manual* (LLNL 1991). Training will consist of on-the-job training and classroom training as necessary. As noted in Section 13.1, training program content requirements will generally be identified in the FSP.

13.3 Mechanisms for Identifying and Correcting Procedure and Training Deficiencies

Mechanisms for identifying and correcting procedure deficiencies are provided in Chapter 2 of the *Health & Safety Manual* (LLNL 1992). In general, an FSP is reviewed every three years, and an OSP is reviewed annually. The purpose of the review is to ensure that the contents of the procedures still reflect current operations and comply with any new ES&H regulations that may have been issued since the last review. If no changes are required, a memo to that effect will be prepared and signed by the responsible individual. This memo will be controlled and disseminated in accordance with Section 2.13 of the *Health & Safety Manual*.

Situations may arise that require a limited but prompt change to a safety procedure before the next review date (e.g., to establish new or revised controls based on changes in regulatory requirements). Such changes to a safety procedure are accomplished by issuing an addendum to an FSP and a supplement to an OSP. The review, approval, and distribution requirements for

issuing addenda and supplements are the same as for the original procedure. During the next revision, the addenda or supplements will be incorporated as necessary into the original safety procedure.

Revision of an FSP may be necessary for any of the following reasons: changes in authorized operations; introduction of new hazards or hazardous materials into the facility; new or more stringent environmental and/or health and safety regulations affecting the facility, its operations, and its environmental protection systems; incorporation of addenda into the FSP; or altered responsibility assignments. In addition, an FSP may be revised to remain consistent with the Operational Safety Requirements (OSRs) from a new or revised safety analysis. OSPs may need to be revised for some of the same reasons.

If a safety procedure needs to be revised during the review period, the revised safety procedure will be prepared, reviewed, and approved in the same manner as the original procedure. The safety procedure will be reissued in its entirety when revised.

Procedures for identifying and correcting training program deficiencies are contained in Appendix B of the *LLNL Training Program Manual* (LLNL 1991).

13.4 Commitment to Training Programs

The goal of the LLNL Training Program is to ensure that all employees have the skills and knowledge necessary to carry out the responsibilities of their work assignments safely and effectively. The objectives of the LLNL Training Program are to determine all training requirements, to provide mechanisms to ensure that required training is accomplished, to document and make available all appropriate training-related information, to ensure that the program is structured to permit adequate review and analysis of its effectiveness, and to maintain a manual that provides guidance for implementing the program. The *LLNL Training Program Manual* (LLNL 1991) provides additional information on the LLNL Training Program.

13.5 References

Department of Energy (1992), *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, DC, DOE Order 5480.19, Change 1, May 18, 1992.

Lawrence Livermore National Laboratory (1990), *Environmental Protection Handbook*, Lawrence Livermore National Laboratory, Environmental Guidance Division, Livermore, CA, 1990.

Lawrence Livermore National Laboratory (1991), *LLNL Training Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-106166, February 1, 1991.

Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 14 Human Factors

September 1994

Lawrence Livermore National Laboratory
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Chapter 14. Human Factors

This chapter discusses the human factors for the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL).

As a less than Hazard Category 3 facility, the MWM Facility has no criticality hazards. Therefore, no human factors analyses pertaining to criticality were required to be performed.

The postulated events with the potential for releasing radioactive material are described in Chapter 11 of this Preliminary Safety Analysis Report. The consequences of the bounding accidents presented in Chapter 11 did not require any human actions to keep them at the level documented. Thus, no human factors analyses were required. These events are mitigated as discussed in the *Health & Safety Manual* (LLNL 1992).

14.1 References

Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*,
Lawrence Livermore National Laboratory, Livermore, CA, M-010,
February 1992.

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Chapter 15

Initial Testing, Inservice Surveillance, and Maintenance

September 1994

Lawrence Livermore National Laboratory
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Chapter 15. Initial Testing, Inservice Surveillance, and Maintenance

This chapter of the Preliminary Safety Analysis Report (PSAR) discusses initial testing, inservice surveillance, and maintenance program requirements for the Mixed Waste Management (MWM) Facility at Lawrence Livermore National Laboratory (LLNL).

15.1 Initial Testing

The minimum initial tests required prior to delivery of new equipment or systems will be specified in the equipment or system procurement specification. The vendor may also perform additional acceptance tests to verify proper operation.

In addition to these initial tests, an Operational Readiness Assessment will be conducted before placing equipment or systems into operation. The purpose of the assessment is to ensure that the hardware is capable of performing its intended function and that operating procedures have been developed and approved. The assessment requirements are discussed further in Chapter 2 of the *Health & Safety Manual* (LLNL 1992).

15.2 Surveillance Test Program

As determined in Chapter 5 of this PSAR, the MWM Facility is classified as being less than a Hazard Category 3 facility and, therefore, does not have any safety class equipment. As such, a surveillance test program is not required for this facility.

15.3 Maintenance Management Program

Department of Energy (DOE) Order 4330.4A (DOE 1992) provides the guidelines for establishing an effective maintenance program. These guidelines include maintenance organization and administration, maintenance procedures, types of maintenance, control of maintenance activities, and other maintenance management requirements that combine to produce an effective program. LLNL will develop a procedure to describe the maintenance philosophy, objectives, and organization of the Maintenance Management Program that will be applied to the MWM Facility.

15.4 References

Department of Energy (1992), *Maintenance Management Program*, U.S. Department of Energy, Washington, DC, DOE Order 4330.4A, Change 4, May 18, 1992.

Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

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Chapter 16 Operational Safety Requirement Derivation

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Chapter 16. Operational Safety Requirement Derivation

This chapter of the Preliminary Safety Analysis Report (PSAR) documents the derivation of the Operational Safety Requirement (OSR) limits that bound the operation of the Mixed Waste Management (MWM) Facility (Building 494) and develops the operational limits that protect the safety envelope defined in the PSAR.

16.1 Background Information

16.1.1 Purpose of OSR Derivation

The OSR was developed using the criteria derived and outlined in Appendix 16A. The development criteria ensure adequate protection for the off-site and on-site populations resulting from an uncontrolled release of radioactive material, hazardous chemicals, or a criticality event (DOE 1992b). Additionally, the development methodology addresses the criteria needed to minimize the risk to the workers at the MWM Facility.

This chapter uses the system descriptions addressed in Chapter 4, the hazards analysis addressed in Chapter 5, and the accident analysis presented in Chapter 11 of this PSAR as source documentation for the OSR derivation.

This chapter provides guidance to facility management regarding the limits needed to ensure that the facility hazard classification remains valid and that the MWM Facility is operated safely.

16.1.2 Application of the OSR Development Criteria

Appendix 16A outlines the OSR development criteria, provides the bases thereof, and defines the development methodology. The following simplifications of the methodology are made for the MWM Facility.

The functions of the MWM Facility include the acceptance, handling, treatment, packaging, and storage of mixed radioactive wastes. Section 16.2.1 provides greater detail of the facility's mission. Many operations and various missions are performed in Building 494 and the associated storage areas of the MWM Facility; therefore, it is prudent to designate several individual process areas within the MWM Facility based on the specific process function of an area. Section 16.2.2 defines the individual process areas.

The accident analysis presented in Chapter 11 of this PSAR was conducted using a graded approach. Since the MWM Facility is considered to be a Radiological facility, a simple qualitative consequence analysis was conducted. No fault tree analyses were performed to obtain system reliabilities. Bounding Accidents were identified that envelope all credible events; therefore, consequences for all of the credible accidents that result in consequences less severe than those of the Bounding Accidents were not calculated.

16.2 System Analysis

16.2.1 Description of the MWM Facility Operation

The MWM Facility was designed to demonstrate different emergent technologies for processing low-level mixed waste into forms acceptable at a low-level waste disposal site such as the Nevada Test Site (NTS) or forms that can be more readily treated and/or disposed of in conventional ways. The MWM Facility is composed of Building 494 (a 31,250-ft² [120 feet by 250 feet] single-story structure) and the immediately adjacent areas used for ancillary facilities and service access.

Building 494 will initially house four experimental primary process systems: Wet Oxidation (WOX), Ultraviolet Photolysis (UVP), Mediated Electrochemical Oxidation (MEO), and Molten Salt Oxidation (MSO). These systems will be used in demonstrating the processing of low-level mixed wastes brought to the facility from Lawrence Livermore National Laboratory's (LLNL) Hazardous Waste Management (HWM) facilities. Building 494 will also house other systems that directly support the operation of those primary systems or otherwise support the overall mission of the MWM Facility. Additionally, process chemical storage tanks which support MWM operations are located outside the building structure.

Containerized solid and liquid mixed wastes will include both newly generated waste and previously stored and characterized waste. All of these wastes will be generated at LLNL but will be representative of wastes produced at other DOE sites.

The operations to be conducted at the MWM Facility include handling, treatment, packaging, and short-term storage of low-level mixed wastes. The receiving area will accept waste containers to be off-loaded by HWM personnel. Limited storage is provided in the receiving area. Wastes accepted and characterized for treatment at the MWM Facility will be transferred from interim storage in the waste receiving area to the Solids Feed Preparation (SFP) or Liquids Feed Preparation (LFP) areas of the MWM Facility. Wastes will be segregated, prepared, and batched in these areas for subsequent transfer to

specific treatment systems. Sorting, shredding, grinding, blending, filtering, precipitation, and centrifugal separation of wastes will be conducted as necessary.

The wastes will be sorted into three primary treatment lines: an organic liquids treatment line, an organic/aqueous liquids treatment line, and a combustible solids treatment line. Interim storage of wastes in tanks or drums would occur in the waste characterization and feed preparation areas after initial characterization, sorting, and feed preparation until a week's processing inventory became available.

Once sufficient waste feed is accumulated in a primary treatment line, that waste would then be fed into the designed primary experimental treatment system. The primary experimental process systems in the MWM Facility are as follows:

- Wet oxidation with ultraviolet photolysis
- Molten salt oxidation with salt recycle
- Mediated electrochemical oxidation.

These process systems are discussed in greater detail in Section 4.5 of this PSAR.

The output solids, liquids, and gases from these primary experimental processes would require further processing before being released to the environment or sent to HWM for storage or off-site disposal. The additional processing of waste consists of water treatment, final forms solidification, and offgas filtration. These processes are discussed in further detail in Section 4.4 of this PSAR. For this demonstration project, a small stream of the offgas from a treatment process would be channeled into an experimental offgas system. This system can be placed in line with any of the process systems. Proposed research areas include nitrogen oxide catalytic converter, nitrogen oxide advanced wet scrubbing, and metal High-Efficiency Particulate Air (HEPA) filter designs. The effluent from these experimental systems would be routed to the facility offgas systems for treatment.

The principal objective of the final forms treatment is to stabilize and solidify the outputs from primary and secondary waste treatment processes, and residues from offgas treatment systems into final forms that will meet the requirements for disposal as low-level radioactive waste at NTS (NVO-325).

16.2.2 Process Areas

The PSAR has defined the process areas for the facility and has described them in greater detail in Chapter 4. The specific process areas addressed by the OSR include SFP and LFP areas, a waste treatment (WOX, UVP, MEO, and MSO)

process area with interim storage, a water treatment area, an analytical laboratory, and final forms packaging areas. In addition, process support areas include receiving and shipping, equipment staging, facility offgas, refurbishment, and decontamination.

16.2.3 Hazards Due to Normal Operations

The normal operations to be conducted in the MWM Facility involve the processing, movement, and storage of hazardous chemicals and radioactive material. Therefore, hazards are inherent to these activities. In general, these hazards are mitigated by implementation of the *Health & Safety Manual* supplements (LLNL 1992) and the Facility Safety Procedure (FSP). Therefore, normal operations do not pose a risk that requires operating limits to be established to protect the health and safety of the public or the facility worker. However, to ensure that the risk to the facility worker is minimized, management controls are in place to ensure that a worker's dose is As Low As Reasonably Achievable (ALARA). The Radiological Controls Program and the ALARA concept are addressed in Appendix 16A.

16.2.4 Hazards Due to Abnormal Operational Events

An Abnormal Operational Event (AOE) is defined as any loss of function of a safety or support system with the worst case resulting in a shutdown of the facility or in limited personnel contamination. These events are analyzed in Chapter 11 of this PSAR.

Causes of AOE's for the MWM Facility include equipment failures and personnel errors. AOE's cause disruptions of unit operation, treatment process failure, or shutdown of the unit with no significant on-site or off-site radiological or nonradiological consequences. Therefore, abnormal operations do not pose a risk that requires operating limits to be established to protect the health and safety of the public or the worker. The consequences of leaks, spills, pressurized releases, and uncontrolled chemical reactions are discussed in Section 16.2.5.

16.2.5 Review of the Accident Analysis

The accident analysis is performed for those events that have the potential to produce significant consequences at the MWM Facility. There are ten possible events described in the accident analysis that are initiated within the facility (internal events) or due to outside influence (external events). For each event analyzed, the source term or amount of radioactive material present and

available for release was the maximum amount the facility is allowed to possess at any one time (10 percent of the Hazard Category 3 threshold values).

Additionally, the MWM Facility will process hazardous waste and chemicals. Chapter 5 of this PSAR documents the assumed amounts or source terms of individual chemicals and compounds. A ranking methodology based upon Emergency Response Planning Guideline (ERPG) criteria was performed on the MWM Facility inventories to determine the chemicals and compounds that pose a risk to the on-site and off-site personnel. Three chemicals were identified that need to be evaluated in each accident scenario. Tables 11-4 and 11-5 of this PSAR provide information detailing the amount and type of hazardous chemicals assumed to be released during the various accidents. The following sections summarize the accidents described in Chapter 11 of this PSAR and their accompanying assumptions.

Design Basis Earthquake

The PSAR assumes that a Design Basis Earthquake (DBE) for the Hazard Category 3 facility has a maximum ground acceleration of 0.57g and a frequency of $1.0\text{E-}03$ occurrences per year. The MWM Facility is located in Building 494, which is designed to withstand the DBE. Therefore, no building structural failures were assumed. Also, the process equipment including piping, waste feed holding tanks, and outside reagent storage tanks are assumed to withstand a DBE, resulting in no releases. Insignificant hazardous material releases may result, however, from the DBE due to the falling of waste drums or containers in the receiving and shipping area, LFP or SFP areas, and other facility process areas.

For conservatism, the PSAR accident analysis assumes that the releases could consist of radionuclides at 10 percent of the Hazard Category 3 threshold values.

Typically, the consequences of a DBE are similar to those of a spill. However, since the radionuclides may be part of combustible organic waste, a fire is conservatively assumed to occur after the DBE. Thus, the radiological consequences of the DBE are similar to those of the Bounding Fire.

Chapter 11 of this PSAR also assumes that an insignificant amount of laboratory reagent chemicals (nitric acid and hydrogen peroxide) will be released. These small releases produce consequences that are bounded by a major leak or spill of these chemicals.

The nonradiological consequences of the hazardous waste material listed in Table 11-7 of this PSAR are considered to be low because the amount released during the DBE and the emission rate are much less than those assumed for a leak/spill event.

Design Basis Wind

The Design Basis Wind (DBW) event for a Hazard Category 3 facility has winds of 72 mph at 10 meters above ground and is conservatively applied to this Radiological facility. The PSAR assumes that all buildings and outside storage tanks have been designed and built to specifications that will withstand the event. Therefore, the release of any radiological or nonradiological material inside or outside the building is not assumed to be caused by this event. Without an assumed release, no consequences are evaluated.

Design Basis Flood

The PSAR assumes that the flood plain for LLNL is at 643 feet above mean sea level (msl). The Building 494 floor level is 595 feet above msl. During the event, all waste feed and reagent storage tanks and process areas impacted by the flood water. The release of any radiological or hazardous materials is not postulated for this event; therefore, no consequences exist.

Bounding Fire

Table 11-4 of this PSAR assumes that a Bounding Fire can occur in all of the MWM Facility process areas. No mitigation of the event is assumed in the PSAR. Table 11-5 also estimates the amount of hazardous materials in each of the affected process areas. For the radionuclide inventory, the most conservative amount is 10 percent of the Hazard Category 3 threshold values.

The 10 percent assumption is based upon the release consequences of any one of these radionuclide groups. Because it is possible that more than one radionuclide is present in the release event, a ratio of 1 is established to ensure that the consequences of this accident will be less than 10 percent of the Hazard Category 3 radionuclide inventory. To represent the limiting radionuclide for the MWM Facility, 0.052 Ci of Pu-239 was used. The radionuclide release will result in a committed effective dose equivalent of 0.82 rem at the nearest site boundary and 2.1 rem to the on-site receptor.

For hazardous chemical inventories, a Bounding Fire can involve 3,000 gallons of 50 percent hydrogen peroxide, 400 pounds of silver nitrate, and 2,500 pounds of 13M nitric acid. The hazardous chemical release results in on-site and off-site exposures that are less than the ERPG-3 and ERPG-2 limits, respectively, for each chemical.

Leaks and Spills

The PSAR assumes that leaks or spills are low energy events. Leaks are postulated to occur in all tanks and waste containers. Because leaks act

independently, only one container at a time is postulated to leak. Spills can occur from DBE events, tank overfilling, and transfer errors involving containers of waste or hazardous chemicals. The accident analysis assumes that a spill of one container could allow the maximum amount of radionuclides (0.052 Ci of Pu-239) to be released. Because the release fraction used in the GENII model is less for a spill ($1.0\text{E-}04$) than a fire ($1.3\text{E-}02$), the radiological consequences are bounded by the Bounding Fire.

A leak or spill of hazardous material or mixed waste can originate from any of the MWM Facility process areas. Table 11-5 of this PSAR has identified that a maximum of 400 pounds of silver nitrate, 3,000 gallons of hydrogen peroxide, and 2,500 pounds of 13M nitric acid can be released. The hazardous chemical release results in on-site and off-site exposures that are less than the ERPG-3 and ERPG-2 limits, respectively, for each chemical.

Pressurized Releases

A pressurized release can occur at the discharge side of pumps or process systems that are at pressures above atmospheric pressure. The release amounts and process areas affected are detailed in Table 11-5 of this PSAR. The pressurized release can involve 0.052 Ci of Pu-239, 3,000 gallons of 50 wt% hydrogen peroxide, 2,500 pounds of nitric acid, and 400 pounds of silver nitrate. These release amounts are the bounding releases. The radionuclide release is bounded by the Bounding Fire event because of the small release fraction associated with the pressurized release. The nonradiological consequences associated with the release of silver nitrate are equal to those of the Bounding Fire. The consequences associated with the hydrogen peroxide release are bounded by the spill event. The consequences associated with a nitric acid pressurized release are equal to those of a fire or spill event.

Criticality

The criticality event is deemed to be incredible in the accident analysis. The criticality event assumed the presence of administrative controls limiting the quantity of fissile material allowed to be present in a storage container to values below any possible criticality concern.

Explosion

The accident analysis indicates that an explosion within the MWM Facility is a credible event. The explosion event is assumed to be initiated when explosive gas mixtures are ignited within a process area. During normal operation, the generated Volatile Organic Compounds (VOCs) and hydrogen are diluted and swept away by the ventilation system. Also, the pH of the MEO acidic reactant is controlled to limit the production of hydrogen. The accident analysis assumes

that the actual explosion can cause the failure of piping and adjacent waste storage containers. This failure will allow radioactive, hazardous, or mixed waste products and/or reagent chemicals to leak or spill from the MEO and LFP process piping and tanks. A subsequent fire is assumed to occur to accelerate the release. The radiological and nonradiological releases are bounded by the Bounding Fire event because the released amounts are the same in each event.

Aircraft Crash

Two types of air crash events are evaluated for the MWM Facility: the small plane crash and the commercial or large plane crash. The PSAR calculates that the small plane crash is credible but that the large plane crash is incredible. The consequences of the small plane crash will be the dispersal of hazardous material and a subsequent fire. These consequences are bounded by previous analyses performed for a Bounding Fire or spill event.

Uncontrolled Chemical Reactions

Uncontrolled reactions can occur in the MWM Facility. Two causes of these events are equipment failures, which cause abnormal operating parameters (e.g., temperature, pressure, and flow), and operator errors. The consequences of any uncontrolled reaction are bounded by, or are similar to, the consequences of a spill, fire, or explosion.

16.2.6 Chemical Hazards

A variety of research and development activities that use toxic chemicals and produce chemical wastes are performed at the LLNL site. Because a wide variety of research and development activities are performed, the amounts and concentrations of the chemicals vary. In most cases, the quantities are small and the chemicals are in dilute form.

To select the chemicals to be included in this analysis, guidance, as set forth in WSRC-MS-92-206 (Craig et al. 1993), was utilized. This screening process was used to determine the hazard classification of the MWM Facility, as discussed in Chapter 5 of this PSAR.

The analysis of accidents involving these volatile and nonvolatile chemicals demonstrated that (1) no chemical concentrations exceeded their ERPG-3 limits on site, (2) several chemical concentrations exceeded their ERPG-2 limits on site, and (3) no chemical concentrations exceeded their ERPG-2 limits at the nearest site boundary. Since these results are consistent with a hazard classification of Low Hazard, controls must be established on the amount of these chemicals allowed in the facility to maintain the facility classification as Low Hazard. The

criteria in Table 16A-1 of Appendix 16A indicate that ERPG-1 limits must be exceeded off site for controls to be warranted. In this case, the chemicals that exceed ERPG-1 limits are the same as those controlled to protect the ERPG-2 hazard classification criteria.

16.2.7 Support Systems

Chapter 5 of this PSAR shows only the potential for localized consequences based on the inventory of materials in the MWM Facility. Therefore, the MWM Facility has been classified as a Radiological facility. All of the support equipment and systems listed in this section have been reviewed for their impact on preventing or mitigating a Design Basis Accident (DBA). The review of Chapter 11 of this PSAR concluded that, since these systems are not classified as safety class components, safety class systems, or engineered safety features, no credit is taken for their operation in the mitigation of any DBAs.

16.3 Conclusions

16.3.1 Modes of Operation

Based on the review of the proposed operation of the MWM Facility and the hazards associated with the operation of the facility, the following modes are proposed:

- Operation

A mode in which all applicable requirements have been met and the facility is capable of, or is presently, performing its intended missions of handling, collecting, packaging, treating, processing, and/or storing hazardous and/or mixed wastes. Hazardous and/or mixed wastes are permitted in the facility and are allowed to be moved during this mode.

- Standby

A mode in which all applicable requirements have been met. The movement, handling, collection, packaging, processing, or treatment of hazardous and/or mixed wastes is prohibited in the facility during this mode. Hazardous and/or mixed wastes are permitted to be stored in the facility during this mode.

- Shutdown

A mode in which the facility is not capable of performing its missions. Hazardous and/or mixed wastes are not permitted in the facility during this mode.

16.3.2 Safety Limits

The PSAR accident analysis results indicate that the Bounding Fire accident scenario could exceed the OSR radiological significance criteria stated to protect the off-site public. However, because this release event is not caused directly by an exceedance of a process parameter (temperature, pressure, volume, etc.) from within the process and because there are no assumed mitigative features for the event, no Safety Limits (SLs) were identified for the MWM Facility. Limits will be placed in the Limiting Conditions for Operation (LCOs) to maintain the assumptions of the accident event which will bound the dose consequences.

16.3.3 Limiting Control Settings

Since no SLs were identified, there is no need for a Limiting Control Setting (LCS). Therefore, there will be no LCSs for the MWM Facility.

16.3.4 Limiting Conditions for Operation

The following items are proposed as LCOs. The basis for each item is given as well as the potential limit.

LCO 1. The radionuclide waste stored and processed in the MWM Facility shall satisfy the limits listed in Table 16-1. Additionally, the sum of all the radionuclide ratios present in the MWM Facility shall be less than 1.0 for the MWM Facility to remain within the PSAR analysis.

This LCO is only applicable when radionuclide material is contained in the MWM Facility, and, based on the mode definitions, this is during the Operation and Standby modes.

Basis:

This LCO ensures that the assumptions made in the PSAR about the radionuclide source term are maintained. Table 16-1 is a duplication of the limits provided in the accident analysis and is provided to show the detailed list of radionuclides and their respective maximum amounts.

This maximum amount is equal to 10 percent of the Hazard Category 3 threshold values. Table 16-1 is based upon the maximum amount of each radionuclide that can be present in the facility and allows the facility to remain within the assumed radiological off-site consequences. If the MWM Facility has only one radionuclide present, the maximum value in Table 16-1 for that radionuclide cannot be exceeded if the facility is to remain within the assumed radiological off-site consequences.

However, because the hazard classification is based upon a specific dose consequence from one radionuclide and there are many different radionuclides, the second part of this LCO is necessary to normalize the dose consequence of all radionuclides to a specific dose value. This process is done by ratioing the actual radionuclide inventory and the maximum inventory in Table 16-1. The combined ratio of all radionuclides present must be less than or equal to 1.0 for the assumed radiological consequence to remain as described in the PSAR. The combined ratio total is the sum of all the radionuclide ratios.

- LCO 2. The hazardous chemical reagents and waste stored and processed in the MWM Facility shall satisfy the limits listed in Table 16-2.

Additional administrative controls are provided to ensure that present chemical source term values are maintained and that additions to these amounts are evaluated for potential impacts.

This LCO is only applicable when hazardous chemical material is contained in the MWM Facility, and, based on the mode definitions, this is during the Operation and Standby modes.

Basis:

This LCO ensures that the chemical requirements for a Low Hazard facility are maintained by limiting the inventory of certain chemical/compound inventories in accordance with the hazard classification of the facility as noted in WSRC-MS-92-206 (Craig et al. 1993). Table 16-2 lists the specific chemicals/compounds to be controlled and their maximum inventory. This maximum value is based upon the amount of material that can be released and the associated specific event consequence to remain below the ERPG-2 off-site criteria. Different maximum values are present for different chemicals because each chemical possesses different characteristics.

16.3.5 Surveillance Requirements

The Surveillance Requirements (SRs) support the proposed LCOs discussed in Section 16.3.4. SRs shall provide assurance that the conditions specified in the LCOs are maintained with a high degree of confidence. All LCOs require for proper compliance that the inventories of radionuclides and chemicals be controlled prior to their placement into the MWM Facility. An inventory control program will address the means for ensuring that material does not accumulate above LCO values.

16.3.6 Administrative Controls

The following programs were determined to be necessary for the MWM Facility:

- A radiological controls program should be included to ensure that ALARA concepts are employed at the MWM Facility. Procedures for personnel radiation protection shall be prepared consistent with the requirements of DOE Orders 5480.11 (DOE 1992a) and 5400.5 (DOE 1993b) and shall be approved, maintained, and adhered to for operations involving personnel radiation exposure.
- A chemical hazard management program shall be included to ensure that the chemical hazards stay below the values assumed in the PSAR for a Low Hazard facility.

A program shall be in place that provides controls to ensure the capability to safely store, transport, handle, or release hazardous chemicals that are not presently in the source term assumptions. In accordance with the PSAR, this program shall ensure the following:

- a. The present inventory of chemicals is evaluated against the reportable quantities of Title 40 Code of Federal Regulations (CFR) Part 302 (Table 302.4) (CFR 1992b), the threshold planning quantities of 40 CFR 355 (CFR 1992c), and the threshold quantities of 29 CFR 1910.119 (CFR 1992a).
- b. All new hazardous chemicals brought into the MWM Facility are evaluated against the criteria in item a. above.
- c. The chemicals which exceed the inventory limits of Item a. or b. above shall have an ERPG-2 maximum quantity determination, and the need for a revision to a chemical control LCO revision shall be evaluated.

- A fire loading management program shall be included to ensure that the fire inspections are performed and that fire loading remains low for the MWM Facility process areas. A program shall be in place to maintain in effect all provisions of DOE Order 5480.7A (DOE 1993a). This program shall also maintain the assumption of the PSAR by ensuring that the MWM Facility is maintained as a low fire loading area.

16.3.7 Minimum Staffing Requirements

Based on the proposed function of the facility, necessary staffing requirements state that two operators must be present anytime waste containers are moved. The facility is not required to be staffed during the Standby and Shutdown modes, since waste is not allowed to be moved in the facility during these modes. The minimum staff requirements are identified in Table 16.3.

16.4 References

- Code of Federal Regulations (1992a), *Labor*, 29 CFR 1910.119, Appendix A, "List of Highly Hazardous Chemicals, Toxics, and Reactives," National Archives and Records Administration, July 1, 1992.
- Code of Federal Regulations (1992b), *Protection of Environment*, 40 CFR 302, Table 302.4, National Archives and Records Administration, July 1, 1992.
- Code of Federal Regulations (1992c), *Protection of Environment*, 40 CFR 355, Appendix A, "List of Extremely Hazardous Substances and Their Threshold Planning Quantities," National Archives and Records Administration, July 1, 1992.
- Craig, D.K., J.S. Davis, L.G. Lee, P.J. Lein, and P. Hoffman (1993), *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, WSRC-MS-92-206, Rev. 1 (April 1993 Recommendations of the Westinghouse M & O Subcommittee on Nonradiological Risk Acceptance Guide Development), April 1993.
- Department of Energy (1992a), *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington DC, DOE Order 5480.11, Change 3, June 17, 1992.
- Department of Energy (1992b), *Technical Safety Requirements*, U.S. Department of Energy, Washington, DC, DOE Order 5480.22, February 25, 1992.
- Department of Energy (1993a), *Fire Protection*, U.S. Department of Energy, Washington, DC, DOE Order 5480.7A, February 17, 1993.
- Department of Energy (1993b), *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, DC, DOE Order 5400.5, Change 2, January 7, 1993.
- Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

Table 16-1. MWM Facility Radionuclide Inventory Limits

Radionuclide ^a	Radionuclide Inventory Limit (Ci)
H-3	1.00E+02
Be-7	1.40E+03
C-14	4.20E+01
S-35	7.80E+00
K-40	1.70E+01
Sc-46	3.60E+01
Mn-54	8.80E+01
Co-57	6.00E+02
Co-58	9.00E+01
Co-60	2.80E+01
Y-88	2.80E+01
Sr-90	1.60E+00
Nb-95	9.60E+01
Zr-95	7.00E+01
Rh-102m	6.20E+01
Rh-106	1.96E+02
Ru-106	1.00E+01
Cd-109	1.80E+01
Sb-120m	3.20E+01
Sb-125	1.20E+02
Ba-133	1.10E+02
Cs-134	4.20E+00
Cs-137	6.00E+00
Ce-141	1.00E+02
Ce-144	1.00E+01
Pm-144	4.80E+01
Nd-147	1.20E+02
Eu-152	2.00E+01
Eu-154	2.00E+01
Eu-155	9.40E+01
Tm-168	NL
Ta-182	6.20E+01
Re-183	NL
Re-184	9.00E+01
W-188	2.80E+01
Au-195	3.20E+02
Pt-195m	5.00E+02

Table 16-1. MWM Facility Radionuclide Inventory Limits (continued)

Radionuclide ^a	Radionuclide Inventory Limit (Ci)
Hg-203	3.60E+01
Bi-205	8.80E+01
Th-228	1.00E-01
Th-232	1.00E-02
U-235	1.47E-03 ^b
U-238	4.20E-01
Np-239	7.80E+02
Pu-239	5.20E-02
Am-241	5.20E-02
Pu-242	6.20E-02
Am-243	5.20E-02
Cm-244	1.04E-01
Cf-249	5.20E-02

^a Radionuclides not listed in this table are not allowed to be added to the facility inventory until the radionuclide has been evaluated properly and subsequent OSR changes have been approved.

^b The fissile material limit of 700 grams is conservatively used.

NL - No Limit has been determined.

Table 16-2. MWM Facility Chemical Inventory Limits

Chemical/Compound	Amount Allowed
Hydrogen peroxide	16,600 gallons of 50 percent solution (or equivalent)
Nitric acid	36,000 pounds of 13M solution (or equivalent)
Silver nitrate	400 pounds

Table 16.3. MWM Facility Minimum Shift Crew Composition

MODE	SS	OP	AO
Operation	1	3	1
Standby	0	0	0
Shutdown	0	0	0

SS - Shift Supervisor
OP - Operator
AO - Auxiliary Operator

APPENDIX 16A

**OPERATIONAL SAFETY REQUIREMENT
DEVELOPMENT METHODOLOGY**

16A.1 Introduction

Presently, the Department of Energy (DOE) does not require Technical Safety Requirements (TSRs) for facilities with a hazard classification of Radiological. However, because DOE Order 5480.22 (DOE 1992c) provides the most current criteria for preparing safety requirements, it will be used for the Mixed Waste Management (MWM) Facility as guidance only. The document will be an Operational Safety Requirement (OSR) instead of a TSR to prevent confusion in interpreting Order applicability.

16A.2 Background

The OSR shall define the operating limits, Surveillance Requirements (SRs), the basis thereof, and the management or administrative controls necessary to protect the health and safety of the public and to minimize the potential risk to workers from a significant uncontrolled release of radioactive or other hazardous materials and from radiation exposure due to an inadvertent criticality. The operating limits will consist of Safety Limits (SLs), Limiting Control Settings (LCSs), and Limiting Conditions for Operation (LCOs).

DOE Order 5480.22 (DOE 1992c) defines SLs as limits on process variables associated with those physical barriers, generally passive, that are necessary for the intended facility function and that are found to be required to guard against the uncontrolled release of radioactive and other hazardous materials. Selection of SLs would then be those process variables that, if exceeded, could directly cause the failure of one or more of the barriers that prevent the significant uncontrolled release of radioactive or other hazardous materials. Generally, containment and confinement systems should not be considered as barriers that require SLs since they are mitigative in nature; however, these systems will be considered in the development of LCOs.

DOE Order 5480.22 defines LCSs as the settings on safety systems that control process variables to prevent exceeding SLs. This section shall contain the settings for automatic alarms and automatic or manual initiation of protective actions related to those variables having significant safety functions. The specific settings shall be chosen such that, if they are exceeded, sufficient time is available to automatically or manually correct the condition prior to exceeding the SL.

DOE Order 5480.22 defines LCOs as the lowest functional capability or performance level of safety-related structures, systems, components, and their support systems required for normal safe operation of the facility. LCOs are selected on the following basis:

- Installed instrumentation that is used to detect and indicate in the control room or other control location an inadvertent criticality or a significant degradation of any of the physical barriers that prevent the uncontrolled release of radioactive or other hazardous materials.
- Structures, systems, and components that are assumed in the safety analysis to function or actuate to mitigate accidents, or transients that either involve the assumed failure of, or present a challenge to, the integrity of a physical barrier that prevents the uncontrolled release of radioactive materials or other hazardous materials.
- Process variables that are initial conditions for those Design Basis Accidents (DBAs) or transient analyses that involve the assumed failure of, or present a challenge to, the integrity of a radioactive material barrier.
- Experiments and experimental facilities that could provide a path for the uncontrolled release of radioactive or other hazardous materials or that could affect criticality.
- Systems and equipment that are used for handling fissile material. LCOs written to cover equipment that meets this description shall incorporate the double contingency principle in terms of criticality event prevention.

SRs are defined as the requirements relating to testing, calibration, or inspection to ensure that the necessary operability and quality of safety-related structures, systems, components, and their support systems required for safe operation of the facility are maintained. If SRs are not successfully completed within their required frequency, the systems or components involved shall be assumed to be inoperative and actions defined by the LCO or LCS shall be taken until the systems or components can be shown to be operable.

In addition to the above operating limits, the OSR shall contain an Administrative Controls section that delineates the provisions relating to organization and management, procedures, record keeping, reviews, and audits necessary to ensure safe operation of the facility.

16A.3 Operational Safety Requirement Significance Criteria

From the interpretation of DOE Order 5480.22 (DOE 1992c), several criteria are identified which serve as the basis for determining the necessary equipment or initial conditions needed to ensure that the safety envelope of the Preliminary Safety Analysis Report (PSAR) is maintained. This determination involves the evaluation of the Chapter 11 accident analysis consequence for all credible accidents on the off-site public, the on-site worker not associated with the

operation of the facility, and the facility worker. From interpretation of the Order, the three different types of consequences that affect the above-listed populations are radiological, chemical, and criticality. Because the Order requires controls to be in place which prevent an uncontrolled release, this term must be defined. Therefore, by definition, an uncontrolled release is one that exceeds the radiological or hazardous chemical criteria listed in Table 16A-1. The values listed in Table 16A-1 represent proposed OSR criteria and are based upon the safe operating philosophy of establishing more stringent controls for all analyzed accidents that may have an impact on the off-site public.

The OSR significance criteria for radiological exposure consequences are given in terms of the Effective Dose Equivalent (EDE) in rem. EDE accounts for the effect that radiation has on individual organs, since International Commission on Radiological Protection, Publication 30 (ICRP-30) weighting factors are used to calculate the EDE. EDE also accounts for contributions from both internal and external sources. The cancer risk associated with radiological exposure at the proposed levels is comparable to that of the chronic health hazard criteria.

For off-site radiological exposure, EDE describes the dose that a hypothetical "maximally exposed off-site individual" would receive. This person is assumed to reside along the sector of the Lawrence Livermore National Laboratory (LLNL) boundary that is in the direct path of any radiological release plume, under worst-case meteorological conditions. DOE Order 5400.5 (DOE 1993) establishes 0.5 rem annual EDE as a public exposure limit.

For on-site radiological exposure, the "maximally exposed on-site individual" is assumed to be located 100 meters from the MWM Facility, in the direct path of any radiological release plume, under worst-case meteorological conditions. DOE Order 5480.11 (DOE 1992b) establishes 5 rem annual EDE as the maximum limit of radiological exposure for routine operations.

The on-site radiological criteria are also conservatively applied to the facility worker even though the Occupational Safety and Health Administration (OSHA) and the Nuclear Regulatory Commission (NRC) tolerate higher exposure risk levels for workers than for the general public.

The chemical hazard criteria are based upon the same safe operating philosophy of establishing more stringent controls when the off-site public may be affected. The two criteria listed are Emergency Response Planning Guideline (ERPG) and Immediately Dangerous to Life and Health (IDLH). The off-site criterion of ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor. ERPG-1 is also the lowest of the three ERPG criteria. The on-site consequences in ERPG-2 are somewhat more adverse and are accepted in

that training and equipment are available to the on-site worker. The on-site criterion of ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

In addition to the ERPG values, the National Institute for Occupational Safety and Health (NIOSH) has published data that define hazardous material concentrations that are immediately dangerous to life and health, assuming a 30-minute exposure. The IDLH values are established as criteria dictating proper respirator selection in the event of an emergency release of hazardous materials. The protocol is to use ERPG-based criteria first. The off-site value of 0.1 IDLH is a very conservative number and should provide an adequate margin of safety. If the chemicals do not have ERPG levels defined, then IDLH-based criteria shall be used for the chemicals.

It is incumbent upon DOE to ensure that its facilities are operated in a manner that minimizes the risk to workers and limits exposures to hazardous materials to levels permitted by federal or state regulations and relevant DOE Orders.

Because of the necessary and inherent presence of hazardous and radioactive materials at DOE nuclear facilities and the workers' proximity to these materials, it is impractical to reduce worker risk to an insignificant level through selection of operating limits in OSRs. For this reason, As Low As Reasonably Achievable (ALARA) and safety and health programs are addressed in the Administrative Controls section of the OSR. These programs accommodate workers' risk from hazardous and radioactive materials normally encountered in performing their duties in the facility.

The OSR shall develop safety requirements for those systems, components, and equipment that (1) are barriers preventing the uncontrolled release of radioactive and other hazardous materials, (2) mitigate such releases, and (3) prevent exposure to life-threatening doses of ionizing radiation (i.e., inadvertent criticality or exposure to a high source of x rays).

The level of acceptable risk is different for each of these groups. By accepting employment at the site, an individual accepts a higher risk factor. This risk is offset by training that quantifies the individual's risk and teaches the employee how to minimize or mitigate the risk. The off-site public is unaware of the potential hazards and therefore shall be protected by establishing a lower acceptable risk for that population group.

16A.4 Application of the OSR Selection Methodology

The following methodology was developed and applied to implement the requirements of DOE Order 5480.22 (DOE 1992c). Protection of the off-site public and on-site worker not associated with the operation of the facility involves ensuring the following: (1) the bounds of the safety analysis are maintained; (2) the physical barriers that present risks or hazards to the public are maintained; and (3) the equipment necessary to protect the boundaries, to mitigate the consequences, or to detect the breach of a barrier is available both with a high degree of confidence and in a manner assumed by the safety analysis. The following paragraphs briefly explain the need for OSR-level control on specific operations.

The first consideration in the application of the methodology is the identification of the facility boundary. This information is critical in the process because the accidents and consequences analyzed in the PSAR are based on this information. The facility boundary should be placed at the last confinement barrier that can provide some type of mitigation of the accident or hazard. For Hazard Category 3 facilities, it is noted that a confinement barrier is not required.

After the facility boundary is determined, individual process areas within the boundary are defined. The process areas should be individual areas that are somewhat independent from other process areas; that is, their function could possibly continue if another process area is not operating. This step is necessary since the applicability of the OSR LCOs and SLs is based upon individual process areas. For small facilities that perform only one mission, there is no need for a designation of several process areas and, therefore, the process area would be defined as the facility.

The next consideration is the identification of the hazards or accidents that place each of the population groups at risk. Chapter 11 of this PSAR, DOE Order 5480.23 (DOE 1992a), and the Preliminary Hazards Analysis (Chapter 11) are reviewed for any events that may affect any of the identified population groups. Because the accidents are based upon a failure rate of some type of equipment or human error, a frequency for the event can be assumed that allows for the determination of the credibility of the event.

The next step evaluates whether the event is credible. An event is said to be incredible (not likely to occur) if the frequency of occurrence is less than $1\text{E-}06/\text{yr}$, or the probability that one occurrence will happen every million years. The OSR protects only those events deemed credible, unless there are assumptions made in the accident analysis fault tree that are necessary to be in place to ensure that the event remains incredible.

The next step is to quantify the dose or hazardous chemical consequence of the credible event on the various population groups. The magnitude of the consequence of the event is compared with the OSR significance criteria to determine whether controls are warranted. An uncontrolled release is defined as a release that exceeds the stated dose consequence for a given population group.

To meet the intent of DOE Order 5480.22, three population groups were defined as follows: the off-site public, the on-site worker (not associated with the operation of the facility), and the facility worker. As stated in Section 16A.3, individuals are classified by their location or distance from the facility or the process area. The off-site public is located at the site boundary, the on-site worker is located approximately 100 meters from the facility, and the facility worker is located in the facility. This information (i.e., group and location) is necessary for proper computer dose modeling of a radiological airborne release.

Evaluations shall be performed for those events deemed incredible or that do not exceed the criteria to determine if any assumptions made regarding equipment operability need to be placed in the OSR. Those events that exceed the OSR significance criteria shall be considered candidates for SL protection. The barrier that requires protection must be defined, and the process parameters needed to protect the process barrier shall be established as an SL. Any interlocks or protective functions based on the SL process parameters shall be established as LCSs. The LCS shall be an automatic setpoint placed at some value below the SL that will provide indication in time to correct the problem prior to exceeding the SL. The instrumentation required by the LCS shall then be required to be operable and shall be protected in an LCO. If there are no systems that could be quantified as an LCS, then an LCO shall be established that places limits on the SL parameters but at a much lower level. The margin between the SL and LCO limit will be based on providing adequate protection to allow Operations personnel time to correct the problem without exceeding the SL value. The advantage to this approach ensures that SRs are present with a frequency to provide measure and confirmation of limits. This process provides a defense-in-depth approach.

The analysis shall then be reviewed to see if there is any equipment that is needed to mitigate the consequences of the accident (or is assumed to be operable to support positive results of an Emergency Procedure). Equipment that meets this criterion shall be controlled by an LCO. SRs shall be established that define and ensure the operability requirements of the equipment.

In addition to the mitigative equipment, DOE Order 5480.22 requires equipment that monitors the final confinement barrier for significant releases to be controlled in the OSR. Therefore, instrumentation that detects a release across the boundary shall be identified and controlled by an LCO. Some events, which

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do not have controllable parameters or specific equipment, can rely on the application of management controls and programs. These controls shall be addressed in the Administrative Controls section of the OSR.

16A.5 References

Department of Energy (1992a), *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, DOE Order 5480.23, April 10, 1992.

Department of Energy (1992b), *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, DC, DOE Order 5480.11, Change 3, June 17, 1992.

Department of Energy (1992c), *Technical Safety Requirements*, U.S. Department of Energy, Washington, DC, DOE Order 5480.22, Change 1, September 15, 1992.

Department of Energy (1993), *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, DC, DOE Order 5400.5, Change 2, January 7, 1993.

Table 16A-1. OSR Significance Criteria

Affected Population	Radiological Consequence (rem)	Hazardous Chemical Consequence
Off-Site Public	≥ 0.5	$\geq$ ERPG-1, ≥ 0.1 IDLH
On-Site Worker (not associated with the operation of the facility)	≥ 5.0	$\geq$ ERPG-2, ≥ 1.0 IDLH
Facility Worker	≥ 5.0	$\geq$ ERPG-2, ≥ 1.0 IDLH

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Chapter 17 Operational Safety

September 1994

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Chapter 17. Operational Safety

This chapter of the Preliminary Safety Analysis Report (PSAR) describes the bases for the Conduct of Operations Program and the Facility Safety Procedure (FSP) at the Lawrence Livermore National Laboratory (LLNL) Mixed Waste Management (MWM) Facility. Since the MWM Facility is not in operation and neither an operational safety program nor operations procedures exist at this time, this chapter only presents the requirements of the safety program and procedures and describes the manner in which they will be implemented at the MWM Facility.

17.1 Bases for Conduct of Operations Program

The requirements for the conduct of operations at the MWM Facility are contained in Department of Energy (DOE) Order 5480.19 (DOE 1992). To ensure compliance with this Order, the MWM Facility will be operated in accordance with the requirements of Supplement 2.19 of the *Health & Safety Manual* (LLNL 1992). This supplement contains requirements for many operations, including the following:

- Organization and administration
- Operating practices and safety procedures
- Control room operations
- Communications
- On-the-job training
- Investigation of abnormal operational events
- Notifications
- Control of the status of equipment and systems
- Lockouts and tagouts
- Independent verification
- Recordkeeping
- Shift turnover
- Indirect monitoring of operating parameters
- Required reading
- Instruction to employees
- Equipment operating procedures
- Operator aid postings
- Equipment and piping labeling.

17.2 Facility Safety Procedure for MWM Facility

The FSP for the MWM Facility will be prepared in accordance with the requirements of the *Health & Safety Manual* (LLNL 1992). The FSP is an Environmental, Safety, and Health (ES&H) document that identifies potential hazards associated with a specific operation and requisite controls, and specifies such things as responsibilities and training requirements. The FSP also contains controls for conducting a job safely. For specific operations that may be beyond the scope of the FSP, supplemental Operational Safety Procedures (OSPs) will be developed.

Instructions for preparing, processing, reviewing, approving, and implementing safety procedures (i.e., FSPs and OSPs) are contained in Chapter 2 of the *Health & Safety Manual*. Safety procedures currently require the following elements: (1) introduction, (2) reason for issue, (3) responsibilities, (4) training requirements, (5) hazards analysis, (6) controls, and (7) authorizing signatures. The Facility Manager and/or Project Leaders are responsible for developing safety procedures and for ensuring that employees are properly trained to understand the safety procedures.

17.3 References

Department of Energy (1992), *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, DC, DOE Order 5480.19, Change 1, May 18, 1992.

Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

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Chapter 18 Quality Assurance

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Chapter 18. Quality Assurance

This chapter describes the Quality Assurance (QA) Program for the Mixed Waste Management (MWM) Facility (Building 494) at Lawrence Livermore National Laboratory (LLNL) and demonstrates compliance with Department of Energy (DOE) Order 5700.6C (DOE 1991). This chapter demonstrates that adequate QA measures will be taken during the design, construction, testing, operation, maintenance, and modifications of the MWM Facility.

18.1 Management

18.1.1 Program

The MWM Facility is operated by the Environmental Restoration/Waste Management - Applied Technology Program, which is under the responsibility of the LLNL Associate Director for Laser and Environmental Programs. The MWM Facility must comply with the *LLNL MWM Facility QA Plan* (LLNL 1993), which prescribes the QA Program necessary to achieve the MWM project objectives and quality goals. The QA Program, as described in the QA Plan, is designed to meet the requirements of DOE Order 5700.6C (DOE 1991), *Laser Programs Quality Policy* (LLNL 1990a), and *Quality Management Plan for LLNL Laser Programs* (LLNL 1990b).

The QA Plan serves as the primary QA reference for personnel assigned to or assisting in performing project activities within the MWM Facility. The QA Plan also serves as the basis for audits, reviews, and evaluations of the QA system; identifies formal controls and documentation requirements; and provides a means of feedback to verify the effectiveness of the controls and achievement of quality goals. The QA Plan is implemented through procedures, instructions, drawings, and procurement documents. Detailed QA procedures may be prepared, as necessary and appropriate, to supplement the requirements of the QA Plan.

Section 3 of the QA Plan describes the organizational structure, functional responsibilities, levels of authority, and interfaces of the MWM Facility project.

An Operational Readiness Review (ORR) is not required for the MWM Facility since it is classified as a nonnuclear facility. However, in its place, an Operational Readiness Assessment will be conducted in accordance with DOE Order 5480.31 (DOE 1993) before placing equipment or systems into operation. The purpose of the assessment is to ensure that the hardware is capable of performing its intended function and that operating procedures have been

developed and approved. The assessment requirements are discussed further in Chapter 2 of the *Health & Safety Manual* (LLNL 1992a).

Section 1.06 and Supplement 1.11 of the *Health & Safety Manual* give any LLNL employee the right to order any activity stopped immediately if, in the employee's judgment, the procedure or circumstance represents an imminent, high-risk threat to human safety or health.

18.1.2 Personnel Training and Qualification

The main purpose of the LLNL Training Program is to provide appropriate instructional support to assist employees in developing and maintaining competencies to successfully execute their work assignments. The *LLNL Training Program Manual* (LLNL 1991) provides guidance for developing and managing individual directorate training programs, including the following:

- Determination of job categories, specific qualification requirements, and training requirements and responsibilities.
- Documentation of training information.
- Qualification of course materials and instructors.
- Evaluation of the training program.

Facility-specific MWM training provides all MWM personnel with a basic knowledge of regulatory requirements, hazards, and facility emergency response activities. The training also provides instruction on specific duties and responsibilities relative to an individual's job activities.

Additional details regarding personnel training are available in Chapter 13 of this Preliminary Safety Analysis Report (PSAR).

18.1.3 Quality Improvement

Self-assessment programs are developed and conducted to enhance the quality of all activities, to ensure compliance with LLNL Environmental, Safety, and Health (ES&H) policy, and to ensure that ES&H goals and intents are being met. Each directorate is expected to strengthen its oversight of operations and facilities by conducting formal self-assessments. Self-assessment programs encompass all organizational elements, facilities, activities, and infrastructures for which the directorate is responsible. Deficiencies or nonconformances uncovered by self-

assessments are recorded and tracked; required corrective actions are scheduled and executed; and completion of the corrective actions taken is verified.

ES&H self-assessments of the MWM Facility project and facility are conducted in accordance with the *Laser Programs ES&H Self-Assessment Program Plan* (LLNL 1992b). Supplement 1.08 of the *Health & Safety Manual* (LLNL 1992a) provides more detailed requirements and guidance on self-assessment programs.

In addition to self-assessments, safety appraisals and safety reviews are conducted periodically. Safety appraisals involve the review of safety procedures to ensure that all operations meet the requirements of existing safety standards or to establish such standards. Safety reviews are conducted to ensure the effectiveness of the ES&H policy in supporting Operations personnel. In addition, walkthroughs, inspections, and surveillances are encouraged to supplement formal self-assessments and safety appraisals and reviews.

Through self-assessments, safety appraisals and reviews, audits, and surveillances, nonconforming items are identified and isolated to prevent inadvertent use or misuse. The cause of the nonconformance and corrective actions taken are documented in a nonconformance report.

Corrective action includes investigation of the problem and probable root cause, evaluation of evidence, and correction of both the problem and its cause. The thoroughness and range of corrective action are commensurate with the severity of the effects of the problem and the probability of repetition.

Section 4.10 of the *LLNL MWM Facility QA Plan* (LLNL 1993) prescribes the requirements for developing and implementing a proceduralized QA Assessment Program for the MWM Facility.

18.1.4 Documents and Records

18.1.4.1 Documents

Section 4.8.1 of the *LLNL MWM Facility QA Plan* (LLNL 1993) prescribes the requirements for the control of the preparation, review, approval, issuance, use, recall, and revision of documents to ensure that the documentation is correct and that the correct document and revision are available and used when needed.

18.1.4.2 Records

Section 4.8.2 of the *LLNL MWM Facility QA Plan* (LLNL 1993) ensures that sufficient records are specified, prepared, reviewed, approved, and maintained to provide an auditable history of completed work or evidence of the quality of items or activities affecting quality.

18.2 Performance

18.2.1 Work Processes

18.2.1.1 Work

Chapter 2 of the *Health & Safety Manual* (LLNL 1992a) prescribes the process for planning, authorizing, and accomplishing work under controlled conditions. Chapter 2 of the manual also provides guidance for developing, approving, and disseminating safety procedures and instructions and for monitoring ongoing activities and related information to ensure that the desired quality is being achieved.

Section 4.5 of the *LLNL MWM Facility QA Plan* (LLNL 1993) provides guidance on the development and control of operating procedures. Chapter 13 of this PSAR describes the MWM Facility program for procedure development, verification, and validation. This program also pertains to instructions and drawings.

18.2.1.2 Identification and Control of Items

LLNL's level of effort required to retain the identification and control of an item specific to its unique physical or chemical characteristics is directly proportional to the importance of the item's prescribed function. Controls are in place that require a unique serial number for specific items and supporting documentation to ensure that only correct and accepted items are installed. This documentation contains all the information necessary to identify, control, and maintain the specific item to ensure appropriate traceability.

18.2.1.3 Handling, Storage, and Shipping

The handling, storage, and shipping of items are controlled to prevent damage or loss and to minimize deterioration of the items. Handling, storage, and shipping

are conducted in accordance with established work and inspection instructions, drawings, specifications, shipment instructions, subcontracts or purchase orders, or other documents that prescribe and control these activities.

18.2.1.4 Calibration and Maintenance of Monitoring and Data Collection Equipment

Written procedures are used to identify calibration standards. These procedures and the calibration records are maintained by the organization responsible for performing the calibration.

18.2.2 Design Control

All LLNL equipment and facilities are designed and constructed to provide a safe work environment. Engineering designs are documented in formal design criteria, specifications, engineering drawings, engineering notes, and engineering safety notes. The technical adequacy of these documents is reviewed by persons other than those who prepared the documents, and these documents receive an appropriate level of management approval. The design documentation includes applicable criteria from DOE Orders, codes and standards, and Laboratory requirements.

Formal design reviews are held at key phases in the design (e.g., conceptual, preliminary, and final design). The design presented is reviewed against the approved design criteria. Design review meetings are documented with a list of attendees, copies of presentation materials, and action items. Action items are tracked through to completion. A written resolution for each action item is required to close out the action item. The project engineers are responsible for ensuring that design reviews are scheduled, performed, documented, and properly closed out.

The following procedure controls changes to equipment in the field. The responsible engineer or principal investigator reviews the change for adequacy, and signs or initials and dates the change on a field print. Periodically, the engineer/principal investigator submits field prints for incorporation into new drawing revisions. If the field print was used for the recording of inspections, the print is submitted to the project QA records file.

18.2.3 Procurement Control

Items are procured in accordance with approved procedures to ensure a systematic approach to the procurement process. Procurement specifications

include quality control requirements, acceptance methods/criteria, and the documentation required to be furnished by the vendor. The procurement process provides for the integration of procurement documents; preparation, review, and change control; selection of procurement sources; bid evaluation and award; verification (surveillance, inspection, or audit) activities; acceptance criteria; and identification, retention, and delivery of required documents and records.

Vendor evaluations are performed and documented to ensure that the vendors operate under an adequate system of quality control for the specified items being procured. Purchase specifications require suppliers to have a QA program consistent with the requirements of each procurement.

18.2.4 Inspection and Acceptance Testing

18.2.4.1 Inspection

Inspections are performed to determine whether an item or activity conforms to specified requirements. There are three types of inspection: self-checks, peer verifications, and independent inspections. Determination of the type of inspection necessary is based upon the importance of the item, product, or activity with respect to the following: the mission of the department, safety, equipment reliability, protection of the environment, or other MWM criteria.

Incoming items to the MWM Facility are received in the equipment staging area of the building. Those items requiring inspection are segregated and not released until the inspection is performed. Nonconforming items are tagged and segregated.

Inspection procedures document the attributes or activities to be verified or inspected with the acceptance criteria and assign the responsibilities for the item or activity. These procedures also include any special considerations that must be made (i.e., regarding the environment, safety, lockouts, etc.) and list any instructions, equipment, and Measuring and Test Equipment (M&TE) required for the inspection.

Equipment vital to the effective and safe operation of the MWM Facility receives periodic inspection and preventive maintenance. Maintenance activities are defined, scheduled, and tracked. Maintenance procedures are developed and used, as appropriate, commensurate with the level of complexity of the maintenance task. Records are maintained documenting preventive maintenance.

18.2.4.2 Acceptance Testing

Acceptance testing is performed on equipment and systems installed by the construction organization or fabricated by an outside source prior to acceptance by the requesting department. This testing is performed to verify that the items conform to specified requirements, to demonstrate that the items will perform satisfactorily in service, or to generate design input data. Test procedures are generated and maintained by the organization performing the tests. These procedures describe the requirements, acceptance criteria, and responsibilities for planning, performing, and documenting required tests. These procedures include or reference the objectives and provisions for ensuring that prerequisites (i.e., calibrated instruments, qualified personnel, and provisions for data acquisition) for the given test have been met; that required instrumentation is identified, available, and used; that necessary monitoring is performed; and that the required environmental conditions are maintained during the test period.

18.2.4.3 Measuring and Test Equipment

Equipment vital to the effective and safe operation of the MWM Facility will receive periodic inspection and preventive maintenance. Maintenance activities will be defined, scheduled, and tracked. Maintenance procedures will be prepared and used, as appropriate, commensurate with the level of complexity of the maintenance task. Maintenance intervals are derived from recommended intervals specified by the equipment manufacturer and adjusted through experience. Personnel and equipment safety interlocks will be tested quarterly to verify operability. Records will be maintained documenting when preventive maintenance was performed. The Operations Manager will assign the responsibility for the management of preventive maintenance activities to a member of the facility staff (LLNL 1993).

M&TE used for inspection and/or acceptance or providing a safety monitoring or control function will be controlled, calibrated, and adjusted to maintain accuracy within necessary limits (LLNL 1993).

18.3 Assessment

18.3.1 Management Assessment

The Laser and Environmental Programs Assurance Manager schedules and initiates a management assessment of the QA Program as necessary to evaluate the effectiveness of the program in achieving the supported objectives and quality goals of the MWM Facility. The primary objective of a management

assessment is to preclude any major quality problem and to anticipate the need for change by identifying the weaknesses or strengths of the QA Program.

The details regarding management assessments of the MWM Facility project are available in the *Laser Programs ES&H Self-Assessment Program Plan* (LLNL 1992b).

18.4 References

Department of Energy (1991), *Quality Assurance*, U.S. Department of Energy, Washington, DC, DOE Order 5700.6C, August 21, 1991.

Department of Energy (1993), *Startup and Restart of Nuclear Facilities*, U.S. Department of Energy, Washington, DC, DOE Order 5480.31, September 15, 1993.

Lawrence Livermore National Laboratory (1990a), *Laser Programs Quality Policy*, Lawrence Livermore National Laboratory, Livermore, CA, L10343, January 1990.

Lawrence Livermore National Laboratory (1990b), *Quality Management Plan for LLNL Laser Programs*, Lawrence Livermore National Laboratory, Livermore, CA, L10580, February 1990.

Lawrence Livermore National Laboratory (1991), *LLNL Training Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-106166, February 1, 1991.

Lawrence Livermore National Laboratory (1992a), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, February 1992.

Lawrence Livermore National Laboratory (1992b), *Laser Programs ES&H Self-Assessment Program Plan*, Lawrence Livermore National Laboratory, Livermore, CA, L-14352, January 1, 1992.

Lawrence Livermore National Laboratory (1993), *Lawrence Livermore National Laboratory Mixed Waste Management Facility Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, M-078-097, Revision 0, October 1993.

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Chapter 19 Emergency Preparedness

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Chapter 19. Emergency Preparedness

This chapter of the Preliminary Safety Analysis Report (PSAR) provides a summary of the Emergency Preparedness Program for the Mixed Waste Management (MWM) Facility at Lawrence Livermore National Laboratory (LLNL). Since specific procedures and policies regarding emergency preparedness have not yet been developed for the MWM Facility, this chapter provides only the general requirements of the emergency plan as described in the *Health & Safety Manual* (LLNL 1992) and the recently implemented *Draft Emergency Plan* (LLNL 1993).

19.1 Emergency Preparedness Program

Department of Energy (DOE) Order 5500.3A (DOE 1992) requires LLNL to prepare and maintain a comprehensive emergency plan. LLNL's *Draft Emergency Plan* (LLNL 1993) satisfies the requirements of this Order and integrates requirements from other applicable DOE Orders as presented in the *Draft Emergency Plan*.

The purpose of the *Draft Emergency Plan* is to describe LLNL's Emergency Management System, a system designed to respond to and mitigate potential consequences of on-site and significant nearby emergencies that could threaten laboratory workers, the public, national security, or the environment. The *Draft Emergency Plan* describes the system's organizational elements, interfaces, authorities, responsibilities, resources, and actions to be taken in response to emergencies. This plan, along with the Emergency Plan Implementing Procedures (EPIPs), provides the framework for the institutional emergency plan. The EPIPs prescribe the actions necessary to implement the commitments and responsibilities set forth in the *Draft Emergency Plan*.

In addition, the Facility Safety Procedure (FSP) will contain detailed emergency procedures for the MWM Facility in accordance with Chapter 2 of the *Health & Safety Manual* (LLNL 1992). The FSP will identify possible emergencies within the boundaries of the MWM Facility and include a plan for responding to these emergencies. Requirements for safe shutdown procedures for hazardous operations and processes will also be identified. An appendix to the FSP will include the names, addresses, and phone numbers of individuals who may be needed in the event of an emergency. Finally, the FSP will also contain the evacuation plan for MWM Facility personnel in the event of an emergency.

Various elements of the *Draft Emergency Plan*, as well as the FSP, are discussed in more detail in the following sections.

In addition to the *Draft Emergency Plan* and the FSP, the need for developing a flood control program for the MWM Facility will be assessed in the future.

19.2 Activation of the Emergency Response Organization

Based on the *Draft Emergency Plan* (LLNL 1993), the laboratory organization responsible for the initial and ongoing response to, and mitigation of, an actual operational emergency at LLNL is the On-site Emergency Response Organization (OERO). This organization assembles and becomes operational at the direction of the Incident Commander (IC). Responsibilities for various OERO departments are provided in Chapter 2 of the *Draft Emergency Plan*.

Specific responsibilities for activation of the OERO during an emergency at the MWM Facility will be provided in the FSP. The FSP will include the responsibilities of the MWM Facility emergency response personnel in addition to the OERO. As stated in Section 19.1, the FSP will also include the names, addresses, and phone numbers of personnel who may be needed in the event of an emergency.

19.3 Classification and Notification of Accidents

Chapter 4 of the *Draft Emergency Plan* (LLNL 1993) defines and describes the operational emergency classifications (i.e., Alert, Site Area Emergency, and General Emergency). An Alert is an event involving an actual or potential substantial reduction of facility safety and protection. A Site Area Emergency is an event involving an actual or likely major failure of facility safety or safeguards systems needed for the protection of on-site personnel, the public, the environment, or national security. A General Emergency is an event involving an actual or imminent substantial reduction of facility safety systems such that releases of radioactive or toxic materials could exceed permissible limits, thus requiring protective actions for the public. The IC is responsible for making the initial emergency classification determination.

Chapter 5 of the *Draft Emergency Plan* describes the mechanisms and communication systems in place for prompt notification of emergency response personnel and organizations. Off-site agencies are notified when LLNL declares an emergency, or in anticipation of possible significant changes that could require off-site assistance or action. The Emergency Dispatcher, under the direction of the IC, begins the notification process. The OERO Communications Specialist, under the direction of the Deputy Emergency Manager (DEM), issues updates and changes in classification by facsimile. This person also receives notifications. In addition, the Laboratory Emergency Duty Officer (LEDO) or DEM performs the following:

- Concurrently notifies the DOE Headquarters (DOE-HQ) Emergency Operations Center and the DOE Oakland (DOE-OAK) Office of the emergency within 15 minutes of classification. These offices are also notified of classification changes within 15 minutes of the change.
- Provides written reports concerning the event within 24 hours of classification.
- Notifies appropriate local, state, and federal agencies within 15 minutes of classification.
- Notifies DOE-HQ, DOE-OAK, and local, state, and federal agencies within 15 minutes of termination of incidents.

For on-site notifications, the IC notifies and coordinates with the LEDO. The LEDO is responsible for notifying the Director (or designee). The LEDO notifies the on-site DOE-OAK Duty Officer and directs the activation of the OERO and Emergency Management Commander (EMC). Key personnel are notified by telephone, radio, pager, and/or the public address system.

Chapter 7 of the *Draft Emergency Plan* describes the specific, predetermined actions at LLNL for responding to emergency conditions. Chapter 7 includes a discussion of the Protective Action Guide (PAG) value and the Emergency Response Planning Guideline (ERPG) value to initiate protective action, as well as other requirements regarding response to emergency conditions (e.g., personnel accountability, evacuation, reentry, communication, termination, and shutdown of operations).

19.4 Emergency Facilities and Equipment

The LLNL facilities that are available to support emergency responses are described in Chapter 11 of the *Draft Emergency Plan* (LLNL 1993). The following facilities are included:

- The Emergency Management Center is the master coordination and control point for all operational emergency efforts.
- The Alternate Emergency Management Center (AEMC) is the secondary control point for operational emergencies.
- The Technical Support Center (TSC) consists of various technical and service support facilities across LLNL.

- Medical Facilities handle casualties and complex emergency medical situations.

A detailed list of equipment that is available to support emergency responses is also provided in Chapter 11 of the *Draft Emergency Plan*. The following types of equipment are included:

- Communication equipment
- Heavy construction equipment
- Alarm equipment
- Rescue team equipment
- Sanitation and survival equipment
- Personal protective equipment
- Gas and liquid monitoring equipment
- Emergency power equipment
- Logistic support equipment.

The FSP will contain a list of the emergency equipment available at the MWM Facility. This list will include communications equipment, alarm equipment, and other equipment available in the event of an emergency.

19.5 Training Requirements

Chapter 12 of the *Draft Emergency Plan* (LLNL 1993) describes the general training provided to all workers regarding operational emergencies and the specialized training available to all workers and local, state, and federal emergency response organizations. A list of the available courses is also provided in Chapter 12 of the plan.

All personnel including visitors, vendors, and subcontractors are provided briefings on their responsibilities in the event of an emergency. Beyond these briefings, training requirements are determined by a needs and task analysis of the function or position that a person is expected to fulfill.

In addition to training, LLNL conducts a coordinated program of drills and exercises to provide realistic training and to establish a method for evaluating LLNL's emergency response capability and readiness. Drills are conducted to develop and maintain personnel skills, expertise, and response capability. An integrated drill is also conducted annually to test communications and notifications between the various emergency response organizations. In addition, the Emergency Response Exercise Program involves an annual full-participation exercise rotated among various scenarios involving natural disasters, security, or hazardous material incidents.

19.6 Evacuation Plan

Procedures for promptly evacuating MWM Facility personnel to safe locations will be contained in the facility Self-Help Plans. These plans will describe how employees are notified of an evacuation and will diagram the evacuation routes and assembly points. In addition, evacuation routes and assembly points will be located conspicuously throughout the facility and indicated in the FSP.

19.7 Recovery and Reentry

In general, the Emergency Manager (EM) is responsible for downgrading or terminating the state of emergency. Upon downgrading or terminating the emergency situation, the EM or IC establishes reentry provisions. Reentry is a planned activity to determine or verify the status of the facility. Additional provisions regarding reentry, including dose limits, are provided in Chapter 9 of the *Draft Emergency Plan* (LLNL 1993).

Recovery provisions are also presented in the *Draft Emergency Plan* to ensure continued management control and performance of those actions necessary to return the facility to normal operations. The IC, with concurrence from the EM, is responsible for determining when an emergency situation is sufficiently stable to enter the recovery phase. The EM is responsible for coordinating recovery activities by appointing a Recovery Manager who is responsible for developing and coordinating recovery operations. Additional responsibilities of the Recovery Manager are provided in the *Draft Emergency Plan*.

19.8 References

- Department of Energy (1992), *Planning and Preparedness for Operational Emergencies*, U.S. Department of Energy, Washington, DC, DOE Order 5500.3A, Change 1, February 27, 1992.
- Lawrence Livermore National Laboratory (1992), *Health & Safety Manual*, Lawrence Livermore National Laboratory, Livermore, CA, M-010, December 1992.
- Lawrence Livermore National Laboratory (1993), *Draft Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-113311, September 1993.

Mixed Waste Management Facility Preliminary Safety Analysis Report

Chapter 20

Provisions for Decontamination and Decommissioning

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Chapter 20. Provisions for Decontamination and Decommissioning

This chapter discusses the provisions for decontaminating and decommissioning the Mixed Waste Management (MWM) Facility in Building 494. This discussion includes facility closure, final facility status, and post-decommissioning activities.

A formal decontamination and decommissioning plan will be developed prior to facility closure. In accordance with the requirements of Department of Energy (DOE) Order 5820.2A (DOE 1988), planning for the decontamination and decommissioning of the MWM Facility will be initiated prior to the termination of facility operations. The decommissioning plan will be developed to comply with applicable federal and state requirements and regulations, as well as to provide information relevant to decommissioning project planning. Chapter 5 of DOE Order 5820.2A provides guidance on the development of facility decommissioning plans.

Upon completion of the Research, Development, and Demonstration (RD&D) of technologies for the treatment of mixed wastes, the MWM Facility would be evaluated for future use. Decontamination and decommissioning of the facility would eventually be conducted for the facility as a whole. Decontamination of unit operations changed out and replaced with other candidate technologies would be conducted periodically during the RD&D phases, as appropriate, in a manner that would minimize waste and the potential for worker exposures. Wastes generated during decontamination activities would be recycled for treatment at the MWM Facility (DOE 1994). The MWM Facility will not present any significant or unusual decontamination and decommissioning concerns.

Prior to initiating decommissioning activities, the project organization will ensure that adequate surveillance and maintenance are performed for the facility to:

- Meet applicable radiation protection, hazardous chemical, and safety standards.
- Maintain physical safety and security.
- Reduce potential hazards to the public and the environment.

20.1 Closure of the MWM Facility

DOE Order 5820.2A (DOE 1988) requires that facilities be designed to simplify decontamination and decommissioning. The MWM Facility closure plan will include the following requirements:

- Direct radiation exposure to personnel will be kept to a minimum by the incorporation of As Low As Reasonably Achievable (ALARA) practices.
- All radioactive, hazardous, and mixed wastes (i.e., all waste containers) will be removed from the facility.
- The exterior surfaces of process areas will be decontaminated (if required) to the extent, as a minimum, that normal contact maintenance and dismantling activities may be carried out or to the levels normally required for the removal of contaminated equipment. These decontamination activities will be conducted before the equipment is removed from its present location.
- Any material created by combustion or chemical reaction, or any hazard to the structural integrity of the facility, will be removed.

20.2 Final Facility Status

The decommissioning option selected for the MWM Facility will be included in the facility decommissioning plan. Decommissioning alternatives include the following:

- Dismantling the facility.
- Releasing the facility from DOE ownership and returning it to the public domain if the facility meets the applicable release criteria for residual radioactivity and hazardous chemicals.
- Reusing the facility for other program activities that may or may not involve radioactive or hazardous materials.
- Placing the facility in safe storage. If this alternative is selected, necessary long-term maintenance and surveillance or other safety controls will be addressed.

20.3 Post-Decommissioning Activities

After decommissioning operations have been completed, a final radiological and chemical survey report and a project final report will be prepared. The final reports will include a description of the project, the final status of the property, and the lessons learned from the project.

A Project Data Package consisting of the Record of Completion, the Radiological and Chemical Survey Report, and the Project Final Report will be compiled and retained permanently.

20.4 References

Department of Energy (1988), *Radioactive Waste Management*, U.S. Department of Energy, Washington, DC, DOE Order 5820.2A, September 26, 1988.

Department of Energy (1994), *Environmental Assessment for the Mixed Waste Management Facility at Lawrence Livermore National Laboratory*, Draft, U.S. Department of Energy Office of Environmental Restoration and Waste Management, Washington, DC, May 1994.